The Sizewell C Project

6.14 Environmental Statement Addendum
Volume 3: Environmental Statement Addendum Appendices
Chapter 2 Main Development Site
Appendix 2.17.A Marine Ecology and Fisheries

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APPENDIX 2.17.A SUPPLEMENTARY INFORMATION ON FISH ASSESSMENTS

REPORT NO. SPP103

Consideration of potential effects on selected fish stocks at Sizewell

Consideration of potential effects on selected fish stocks at Sizewell

Table of contents

List of Tables and Figures

Tables

Figures

Executive Summary

EDF Energy plans to build a new coastal nuclear power station (Sizewell C), adjacent to the operational Sizewell B and decommissioned Sizewell A sites in Suffolk. The station will be of a once-through design, abstracting large volumes of seawater for cooling the condenser steam. Water abstraction can lead to the entrapment (entrainment and impingement) of fish at different life-history stages. As part of the Development Consent Order (DCO) application for the operation of the new station, EDF Energy is required to evaluate the effects of water abstraction on fish.

To determine the effects of entrapment of fish, two assessment approaches have been considered:

1. **Population level effects:** Annual losses due to entrapment are compared with the size of the relevant population to determine the potential for entrapment to have significant effects on population sustainability. This is to say that the rates and timing of increases and decreases in spawning population size, with and without the additional effects of Sizewell C entrapment, would be almost indistinguishable.

2. **Local level effects:** Assessments consider the potential for the station to cause localised depletion in fish numbers at the scale of the Sizewell Bay. Local depletion assessments are independent but complement the assessment of population level effects and are used to assess the potential for food-web effects mediated through local reductions in prey availability.

This report considers both assessment approaches. **Section 2** addresses comments from statutory stakeholders on the relevant stock units for contextualising entrapment losses to determine population-level effects. **Section 3** provides an additional assessment in the ecological impact assessment toolkit aimed at determining localised depletion of fish and the potential for food-web effects.

The predicted population level effects of fish entrapment in the Sizewell C (SZC) cooling water system are provided in **BEEMS Technical Report TR406.v7** [AS-238]. The assessment methodology used in that report is based on well-established fisheries science principles and relies on comparison of the calculated Sizewell C fish losses with the relevant spawning stock biomass estimates produced by the International Council for the Exploration of the Sea (ICES) for the appropriate internationally agreed stock areas. This is how the much larger environmental effects of fishing are internationally assessed and managed and represents the use of the most up to date peer reviewed methodologies and scientific evidence.

Sizewell C stakeholders have indicated that in principle they agree with the assessment methodology used to determine the effects on fish at the stock level, however, some stakeholders have questioned the application of ICES stock units for assessing potential effects of a coastal power station at local scales.

This report has been produced in response to these comments and provides two separate sets of evidence:

a. Additional narrative information on the appropriate scale of assessment for contextualising population level effects on fish species entrapped at Sizewell. In addition, the latest ICES spawning stock biomass (SSB) estimates and fisheries landings statistics have been reviewed and are provided in Section 2 of this report. These figures provide the denominator for contextualising population level effects.

b. In response to stakeholder comments and feedback, an additional assessment methodology is provided in Section 3 to augment the Environment Impact Assessment (EIA) toolbox that focuses on very local effects. This assessment determines the predicted depletion of different fish species due to Sizewell C operating alone and in conjunction with Sizewell B at three spatial scales; within the Greater Sizewell Bay and tidal excursion around the intakes, the ICES statistical rectangle containing Sizewell (33F1), and ICES Division 4c which contains ICES rectangle 33F1. These assessment areas are smaller than the stock areas for most assessed species.

Conclusions of predicted effects of fish abstraction on local fish abundance at Sizewell.

Local level depletion of fish has been considered by applying a simplified conceptual model of impingement relative to replenishment. Whilst the model necessitates making assumptions relating to fish distribution and behaviour it is possible to approximate the likely size of effects at local scales. The table below shows the predicted annual effects for representative species from the pelagic, demersal and epibenthic species groups found at Sizewell (a more comprehensive list is presented in Section 3 of this report).

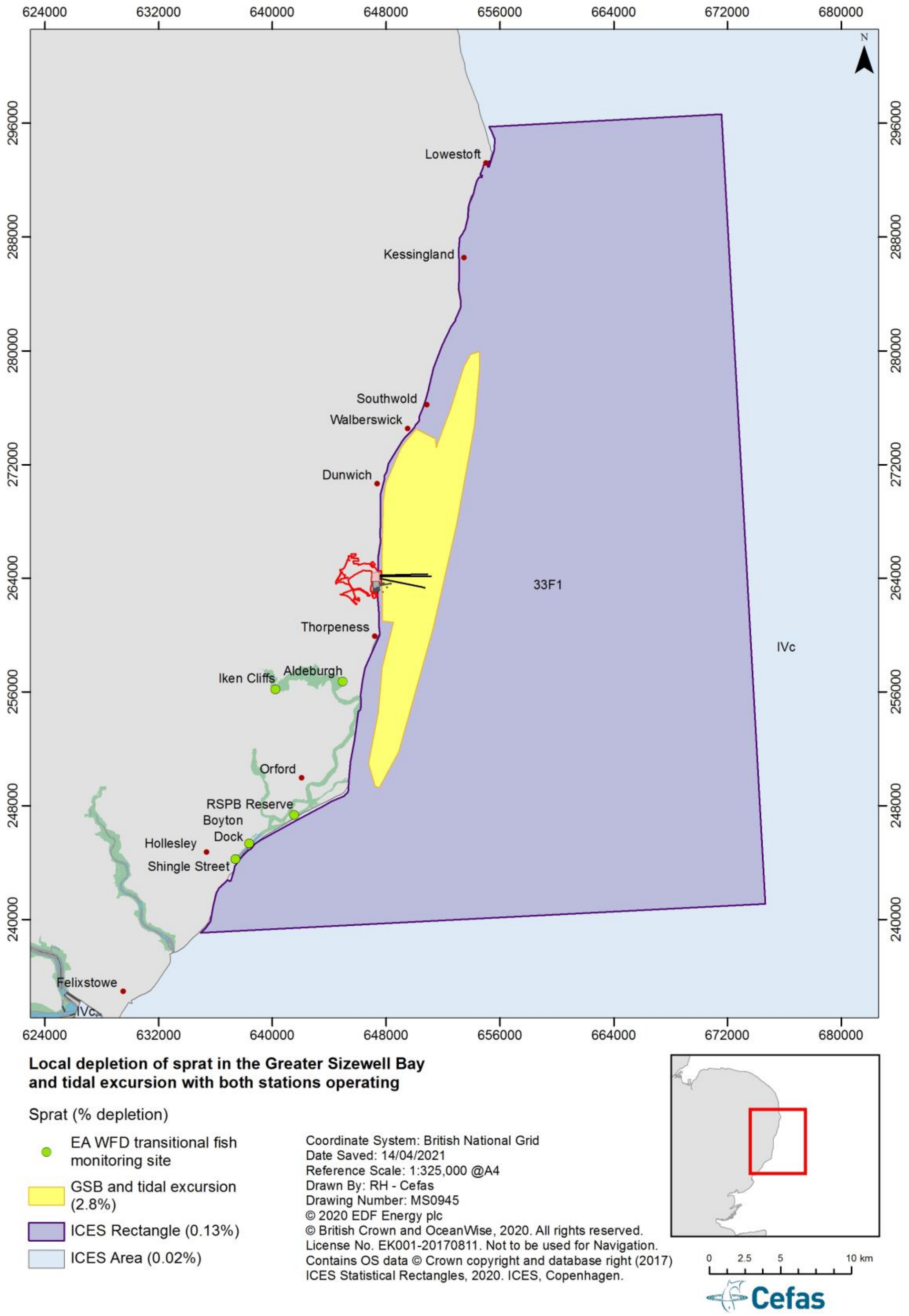
In response to stakeholder comments regarding the uncertainties in the operational efficiency of mitigation measures, this report provides further confidence in the local effects assessment by removing any benefit of the low velocity side entry (LVSE) heads for demersal and epibenthic species and only applying the capped mitigation factor for pelagic species. Furthermore, the assessment incorporates the Environment Agency (TB008) realistic best- and worst-case range of fish recovery and return (FRR) efficiencies applied during the Hinkley Point Inquiry for a similar FRR system. The sensitivity of the local depletion therefore considered a range of mitigation efficiencies. For some species, the worst case results represent a near unmitigated scenario and are considered precautionary.

In the immediate local area of the Greater Sizewell Bay and tidal excursion, both stations operating in-combination is predicted to result in depletion of pelagic fish (e.g. sprat and herring) of less than 3% relative to that without any power station operating. In the adjacent ICES rectangle 33F1 which extends from Lowestoft to just north of Felixstowe, the expected reduction in pelagic species falls to 0.13% and outside of that area in ICES division 4c the expected loss falls to approximately 0.02%. A Figure for sprat showing how effects are concentrated within the local area and rapidly dilute with distance is provided below.

The purpose of this local assessment to determine if there could be any local effects that are sufficiently large to affect the conservation objectives of HRA protected species (e.g. via the prey of marine birds and marine mammals) or the Water Framework Directive (WFD) status of the nearest transitional water bodies (which are in 33F1) via the Transitional Fish Classification Index.

Local depletion due to impingement is orders of magnitude below natural variability in abundance to which predator-prey relationships are adapted to. It is therefore concluded that impingement from Sizewell B and Sizewell C would not have any adverse food-web effects on designated features of HRA sites nor on the classification of nearby transitional water bodies under the WFD.

Species Group	Species	Predicted % depletion in each area due to Sizewell B + Sizewell C. Predicted FRR efficiency (TR406.v7 [AS-238])	FRR mitigation range applied in uncertainty analysis based on Environment Agency HPC values (TB008)	
		GSB + tidal excursion	Realistic best case	Realistic worst case
Pelagic	Sprat	**2.8**	2.8	2.8
	Herring	**2.8**	2.6	2.8
	Smelt	**2.9**	2.7	2.9
Demersal	Sea bass	**6.6**	4.6	9.6
	Cod	**11.4**	6.4	11.5
Epibenthic	Sand goby	**4.6**	NA	NA
	Dover sole	**4.6**	1.8	4.6
	Dab	**9.4**	4.7	9.4
	Plaice	**4.7**	2.2	4.7



Areas of localised depletion for sprat assessed with both stations acting in-combination during the period December to March. The GSB + tidal excursion (yellow), ICES statistical rectangle 33F1 (purple) and part of ICES Statistical Area 4c (blue) are shown.

Changes in Revision 3 of this report.

Preliminary written feedback on version 2 of this report was provided by the Environment Agency on 21st September 2020. Further comments were received when the findings of version 2 were presented to statutory stakeholders during the Marine Technical Forum (MTF) held on the 23rd September 2020. Responses to specific comments on version 2 of this report were provided in this revision 3.

In addition to the specific comments on version 2, this report considered the following key stakeholder concerns raised at the MTF;

- Stakeholders questioned whether the use of evidence for fisheries management purposes differs from the use of evidence for Habitats Regulations Assessment (HRA), Water Framework Directive (WFD), and EIA purposes.
- Stakeholders reiterated the desire to see impacts from the power station considered at the ‘local scale’, particularly for *“locally isolated and static subpopulations residing close to the power station”*.

These two points were considered in the new assessment methodology presented in Section 3.

Version 3 of this report was submitted to PINS as part of the DCO Supplementary Fish Package in January 2021. Edits to this report in response to regulatory comments were transposed into an updated version of BEEMS Technical Report TR406 (version 7) that was also submitted as part of the Supplementary Fish Package.

Changes in Revision 4 of this report.

Written feedback on version 3 of this report was provided by the Environment Agency on 5th March 2021. Version 4 of this report is in response to the written feedback along with comments following bilateral meetings with the Eastern IFCA (08/10/2020), MMO (14/10/2020) and Natural England (18/01/2021), and a specific presentation on local effects assessment between EDF Energy, Natural England and the Environment Agency (12/03/2021).

The report includes:

- Formal responses to additional comments regarding species stock assessment areas (Section 2).
- A review of the latest ICES working group reports with updates to spawning stock biomass (SSB) and or landings statistics (Table 1).
- An updated local effects assessment following stakeholder feedback. The updated local effects assessment incorporates a) changes to Sizewell B full operational abstractions (from $51.5m^3s^{-1}$ to $56.7m^3s^{-1}$), b) greater evaluation of the assumptions and limitations of the conceptual model, c) a simple refinement to the assumption of homogenous distribution in the water column for epibenthic and demersal species, and d) responses to stakeholder comments (Section 3).

A copy of the spreadsheet calculation used to determine local effects was provided to the Environment Agency, Natural England, Eastern IFCA and the MMO in conjunction with Revision 4 of this report: ‘SPP103.v4 Local Depletion Spreadsheet Model (version 1)’.

Changes in Revision 5 of this report.

This report has been updated in response to Deadline 2 written submissions and has been provided at Deadline 6 in parallel to the following documents:

- SPP116 Quantifying uncertainty in entrapment predictions for Sizewell C (Doc Ref. 9.67);
- Technical Note on Equivalent Adult Values (EAVs) and Stock Sizes (Appendix D of Doc Ref. 963)

1 Background

EDF Energy plans to build a new coastal nuclear power station (Sizewell C), adjacent to the operational Sizewell B and decommissioned Sizewell A sites in Suffolk. The station will be of a once-through design, abstracting large volumes of seawater for cooling the condenser steam. Water abstraction can lead to the entrapment (entrainment + impingement) of fish at different life-history stages. As part of the Development Consent Order (DCO) application for the operation of the new station, EDF Energy is required to evaluate the effects of water abstraction on fish.

To determine the effects of entrapment of fish, two assessment approaches have been considered:

3. **Population level effects:** Annual losses due to entrapment are compared with the size of the relevant population to determine the potential for entrapment to have significant effects on population sustainability. This is to say that the rates and timing of increases and decreases in spawning population size, with and without the additional effects of Sizewell C entrapment, would be almost indistinguishable.

4. **Local level effects:** Assessments consider the potential for the station to cause localised depletion in fish numbers at the scale of the Sizewell Bay. Local depletion assessments are independent but complement the assessment of population level effects and are used to assess the potential for food-web effects mediated through local reductions in prey availability.

This report considers both assessment approaches. **Section 2** addresses comments from statutory stakeholders on the relevant stock units for contextualising entrapment losses to determine population-level effects. **Section 3** provides an additional assessment in the ecological impact assessment toolkit aimed at determining localised depletion of fish and the potential for food-web effects.

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- SPP116 Quantifying uncertainty in entrapment predictions for Sizewell C (Doc Ref. 9.67);
- Technical Note on Equivalent Adult Values (EAVs) and Stock Sizes (Doc Ref. 9.63; Appendix F);

1.1 Population comparators

Entrapment predictions for the proposed Sizewell C development are based on the comprehensive impingement monitoring programme (CIMP) dataset collected from Sizewell B between 2009 and 2017 and the comprehensive entrainment monitoring programme (CEMP) dataset collected from Sizewell B between May 2010 and May 2011. The results of the impingement and combined entrapment predictions are presented in **BEEMS Technical Report TR406.v7** [AS-238]. In addition to making impingement predictions, the report contextualises losses against the most relevant stock unit and/or population units to determine if entrapment by the station represents a significant effect on the stock.

Fish mortality due to impingement at Sizewell C can be considered as a form of harvesting. The International Council for the Exploration of the Sea (ICES) provides advice on fishing opportunities and stock status for individual stocks. For many species, annual analytical assessments are carried out that utilise information on life history, fishing effort and catches to assess the size of the stock, in particular the spawning stock biomass (SSB). In cases where a full analytical assessment is available for a species entrapped at Sizewell, and the SSB has been estimated, the predicted losses due to entrapment are compared with the ICES estimated SSB for the stock area (BEEMS Technical Report TR406). These SSB estimates provide the most robust peer reviewed scientific evidence. In the case of species where there is insufficient data for ICES to carry out a full analytical assessment to establish absolute SSB, predicted losses are compared with international landings for the stock area. Such a comparison is unrealistically conservative as landings will be much less than the stock size. For an unexploited stock, landings will typically be much less than 20% of the adult stock size and, even for a heavily exploited stock, landings will rarely exceed 50% of the stock size. A detailed description of the assessment methods is provided in BEEMS Technical Report TR406.

Population structures of marine fish species fall along a continuum from panmictic (e.g. European eel, *Anguilla anguilla*) to numerous sub-populations (e.g. North Sea herring, *Clupea harengus*). The majority of species exhibit complex population structures. In the open sea, sub-populations of many species mix to a considerable extent; especially during summer feeding and on nursery areas, with harvesting affecting multiple components of the overall population simultaneously. ICES' definition of stock units integrates all of the information on site fidelity to spawning, nursery and feeding areas together with knowledge of migration patterns and the degree of intermixing that takes place between any sub populations. Stock assessment units are not static and change when the weight of evidence indicates that a change would likely lead to better assessments and management advice.

ICES keeps stock definitions under continuous review and makes adjustments to these definitions when the weight of scientific evidence indicates that a change is appropriate. Impingement predictions are based on monitoring at Sizewell B between 2009 and 2017. As such, mean SSB or landings statistics from this period are used as a comparator for the predicted effects of impingement from Sizewell C on the relevant stocks. As additional landings data sources become available or models refined to improve fore/hindcasting of annual SSB, ICES updates their advice. A review of the latest ICES Working Group Reports have been completed and revised SSB estimates and landings data are provided in Table 1.

Further details on EAVs and Stock Sizes is set out together with Cefas' position on the application of ICES stock areas and the appropriateness of these stock areas for determining population-level effects in **Appendix D** of **Technical Note on EAV and Stock Size** (Doc Ref 9.63). In summary, ICES stock areas are considered to be the most robust application of the evidence for determining population units for commercially harvested data-rich species. ICES has a remit to develop science and advice to support the sustainable use of the seas and oceans. ICES is a network of around 5,000 experts from around 700 institutes and organisations in 20 member countries and beyond, facilitated by a secretariat based in Copenhagen. In determining the relevant stock units, ICES assesses all the available evidence across the entire life-history of the species of concern throughout its full life-cycle including spawning migrations, larval dispersal and patterns of recruitment. The ICES approach is a multistage international process with internal and external peer review that brings together experts in fish biology. Methods of assessments of each stock and its structure is considered by dedicated international working groups. Meeting every 3-5 years at so-called 'Benchmarks' all the new evidence on the species ecology and distribution is taken into account. The ICES Benchmark process is in addition to annual assessments and evaluates current assessments and data methodologies and proposes improvements.

Where such evidence is available, Cefas refers to the higher authority of ICES.

It is noteworthy that in their Deadline 2 submission, the **MMO** [REP2-140] state, emphasis added:

> *"In relation to the scale of assessment, the MMO notes that the Applicant continues to justify the use of the International Council for Exploration of the Sea ("ICES") stock areas as using the best available evidence. The MMO concludes that the use of ICES stock areas for commercial fish species represents the current best scientific evidence available. There is currently no robust information that would support use of more local stock areas in the assessment."*

For non-commercial species and those not covered by ICES advice, or where more appropriate population comparators are available, these have been applied by Cefas, this is particularly the case for conservation species and unexploited species.

Section 2 of this report is intended to specifically address concerns by stakeholders on the population comparators used to contextualise entrapment losses due to the proposed Sizewell C station.

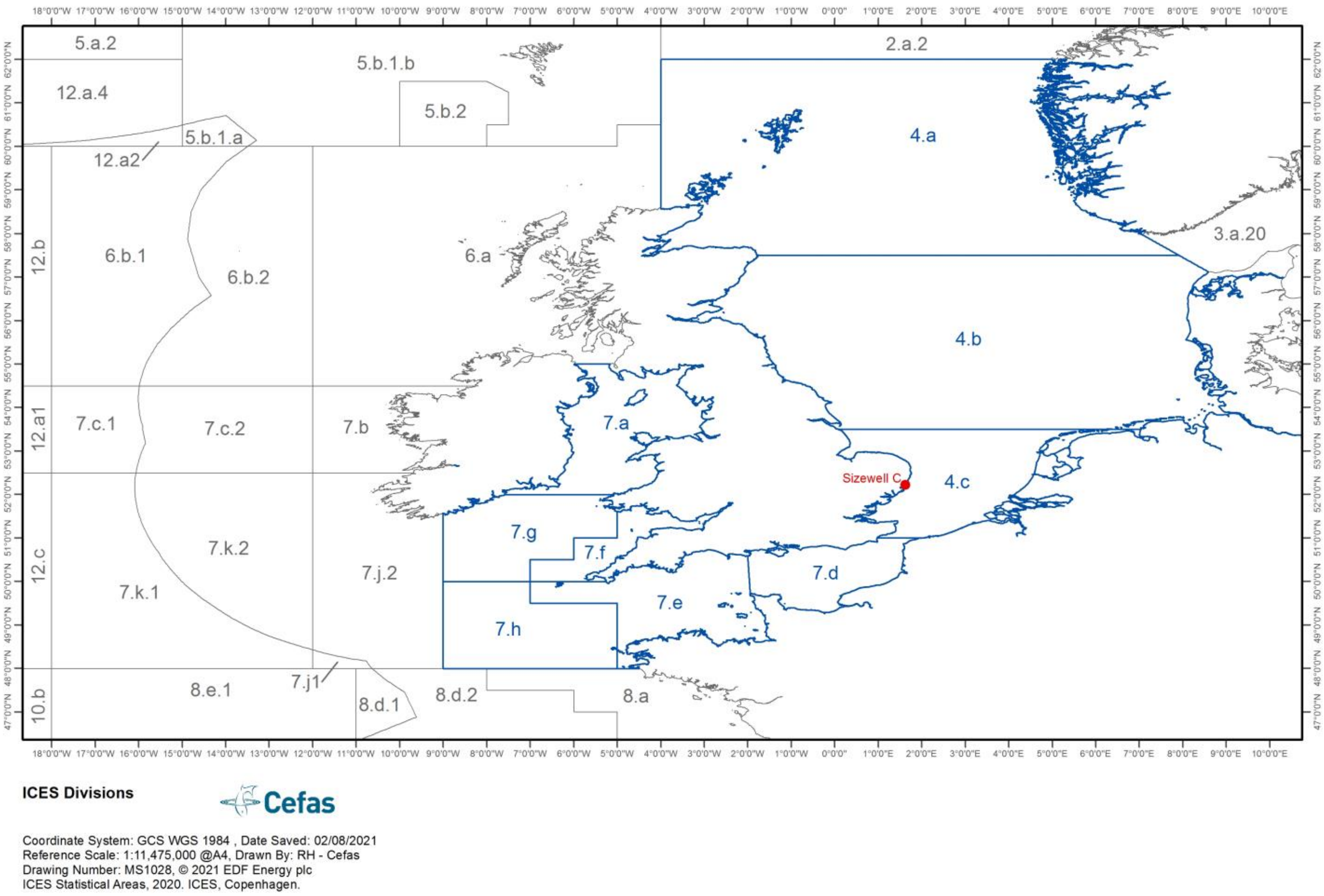

Figure 1. ICES statistical divisions, illustrating the areas of interest for the key species at Sizewell.

1.2 Local effects assessment

Sizewell C stakeholders have requested further evidence to support the understanding of local level effects from the proposed development. Section 3 of this report provides a simplified conceptual framework of impingement relative to tidal replenishment to determine local depletion. Whilst the model necessitates making assumptions relating to fish distribution and behaviour, it is possible to approximate the likely size of effects at a range of scales from the Greater Sizewell Bay and tidal excursion to wider effects in relevant ICES Statistical areas.

The local effect assessment is an additional tool in the evidence toolbox to enable a framework for contextualising the scale of local depletion whilst acknowledging the limitations of the approach. Local assessment is independent but complementary to the assessments of the effects of Sizewell C on the sustainability of each stock presented in **BEEMS Technical Report TR406.v7** [AS-238]. The local effects approach is intended to identify if localised depletion is sufficiently large to affect the conservation objectives of HRA designated features (e.g. via the prey of marine birds and marine mammals) or the WFD status of the nearest transitional water bodies (which are in 33F1) via reductions in the Transitional Fish Classification Index.

The local effects assessment has been updated in response to Deadline 2 written submissions and has been provided at Deadline 6.

Table 1 Relevant stock units, mean SSB and landing statistics between 2009-2017 for the key species at Sizewell. SSB is provided as a weight (t) or population estimate (individuals underlined), landings are provided in weight (t). Comparators in blue have reduced from the previous edition of BEEMS Technical Report TR406.v7 following the latest ICES advice, whilst comparators in green have increased. An explanation of any changes is provided for each species below. Comparators and variation in the population size between 2009-2017 is considered in the entrapment uncertainty analysis (SPP116 [Doc Ref. 9/67]).

Species	ICES Working Group	Stock unit	Assessment type	Impingement effect comparator	SSB	Landings	Reference
Sprat[1]	HAWG	Subarea 4 and Division 3.a (North Sea, Skagerrak & Kattegat).	Analytical assessment	SSB	192,852	160,422	ICES 2020a
Herring[2]	HAWG	Subarea 4 & Divisions 3.a & 7.d (North Sea, Skagerrak & Kattegat, Eastern Channel).	Analytical assessment	SSB	2,421,962	390,933	ICES 2020b
Whiting[3]	WGNSSK	Subarea 4, Division 7.d (North Sea, Eastern Channel).	Analytical assessment	SSB	143,759	18,306	ICES 2020c.
Sea bass[4]	WGCSE	Divisions 4.b-c, 7.a, & 7.d-h (Central & southern N Sea, Irish Sea, English Channel, Bristol Channel & Celtic Sea).	Analytical assessment	SSB	13,996	3,197	ICES 2020d
Sand goby	-	Not defined	Not assessed	Population abundance	<u>205,882,353</u>	NA	Rogers and Millner (1996)
Sole[5]	WGNSSK	Subarea 4 (North Sea).	Analytical assessment	SSB	29,665	12,471	ICES 2020e
Dab[6]	WGNSSK	Updated: Revised stock area Subarea 4 (North Sea).	Trends only	Landings	NA	5,188	ICES 2020c
Anchovy[7]	WGHANSA	Given as 'Northerly anchovy'.	Not assessed	Landings	NA	3,112	ICES, 2020e
Thin lipped grey mullet[8]	-	Not defined	Not assessed	Landings	563.2	112.6	ICES, 2020e
Flounder[9]	WGNSSK	Subarea 4 & 3.a (North Sea & Skagerrak and Kattegat).	Trends only	Landings	NA	2,313	ICES 2020c
Plaice[10]	WGNSSK	Subarea 4 IV & Subdivision 20 (North Sea & Skagerrak).	Analytical assessment	SSB	967,222	82,841	ICES, 2020c
Cucumber Smelt	-	Primary assessment is based on conservative UK landings and SSB. Not defined but includes the East Anglian coast and rivers on the European coast from the Elbe to the Scheldt.	Estimated SSB (t) based on EA landings.	EA landings Elbe populations	53.9t / <u>*23,861,520*</u>	8.63t	BEEMS Scientific Position Paper SPP100 EA, 2018, 2017a, 2017b, 2015, 2014, 2013a, 2013b, 2013c;
Cod[11]	WGNSSK	Subarea 4 & Subdivisions 7.d & 20 (North Sea, Eastern Channel, Skagerrak & Kattegat).	Analytical assessment	Landings	NA	11,124	ICES, 2020c
Thornback ray[12]	WGEF	Subarea 4 and Division 2.a (North Sea and Norway).	Trends only	Landings	NA	677	ICES 2020e

River lamprey	-	Humber catchment	Estimated run numbers	Numbers converted to weight	62	1	EA, 2018, 2017a, 2017b, 2015, 2014, 2013a, 2013b, 2013c
Eel	WGEEL	Anglian River Basin District (RBD).	Biomass estimated	Estimated silver eel biomass	79	14	(Defra, 2015, 2018)
Twaite shad[13]	-	Not defined but includes the River Elbe and Belgian River Scheldt. A separate spawning population on the river Weser has not been included in the assessment.	Estimated adult numbers migrating upriver	European populations in the Elbe. ICES Landings	Elbe 5,124,119 Scheldt 66,715	1.3	BEEMS Scientific Position Paper SPP100 ICES 2020e
Horse mackerel[14]	WGWIDE	Divisions 3.a, 4.b, c & 7.d (North Sea).	Trends only	Landings	NA	20,456	ICES, 2020f
Mackerel[15]	WGWIDE	Subareas 1–8 and 14, & Division 9.a (the Northeast Atlantic & adjacent waters).	Analytical assessment	SSB	4,296,467	1,017,332	ICES, 2020f
Tope[16]	WGEF	North east Atlantic.	Not assessed	Landings	NA	505.8	ICES, 2020g
Sea trout	-	Not defined	Assessment based on CPUE	EA Catch numbers, UK	NA	39,795	EA, 2018, 2017a, 2017b, 2015, 2014, 2013a, 2013b, 2013c
Allis shad[17]	-	Garonne	Analytical assessment	Adult stock in 2009, ICES Landings	27,397	6.6	BEEMS Scientific Position Paper SPP071/s) ICES 2020e
Sea lamprey	-	Not defined	Not assessed	-	NA	NA	
Salmon	WGNAS	North Atlantic.	North Atlantic	EA Catch numbers, UK	NA	38,456	EA, 2018, 2017a, 2017b, 2015, 2014, 2013a, 2013b, 2013c

Working group acronyms:
HAWG - Herring Assessment Working Group for the Area South of 62°N
WGNSSK - Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak
WGCSE - Working Group on Celtic Seas Ecoregion
WGHANSA - Working Group on Southern Horse Mackerel, Anchovy and Sardine
WGEF - Working Group on Elasmobranch Fishes
WGEEL - Joint EIFAAC/ICES/GFCM Working Group on Eels
WGNAS - Working Group on North Atlantic Salmon
WGWIDE - Working Group on Widely Distributed Stocks

1 – Sprat: between 2018 and 2020 ICES changed the stock assessment scale for sprat and expanded perceived limits of the North Sea stock by incorporating sprat from Kattegat and Skagerrak (ICES Subdivision 3.a) (ICES, 2018a). Annual landings between 2009 and 2017 increased by 6.0% while the estimated SSB decreased by 12.6% due to an updated SMS stock assessment model (see section 2.9).

2 – Herring: In the latest ICES advice the estimated mean SSB of herring between 2009-2017 increased by 10.2% due to performance of state space model (SAM, in the FLR environment) when it was updated with new data from 2017-2019. Average landings marginally changed (-2.3%) as ICES landings figures were updated.

3 – Whiting: In the latest ICES advice the estimated mean SSB of whiting between 2009-2017 decreased by 5.3% due to performance of state space model (SAM, in the FLR environment) when it was updated with new data from 2017-2019. Average landings increased (4.2%) as ICES landings figures were updated.

4 – Sea bass: In the latest ICES advice the estimated mean SSB of bass in 2009-2017 declined by 6.0% due to updated performance Age- and length-based analytical assessments (Stock Synthesis 3; NOAA Toolbox). Landings increased by 4.8% as updated by ICES.

5 – Dover sole: In the latest ICES advice estimated mean sole SSB declined by 31.5%. New parametrisation of the Aart-Poos assessment model and additional data are believed to have driven the change (ICES 2020c). Landings decreased by 2.6%.

6 – Dab: Mean annual landings of dab decreased by 2.3% as ICES landings figures were updated.

7 – Anchovy: Assessment of anchovy by WGHANSA did not progress in 2019-2020. Updated landings of “northerly anchovy” were applied. Total landings in the area nearly doubled (+91.5%) due to the large catch of the species in the North Sea by the Danish fleet in 2017 that was not accounted for during the previous assessment.

8 – Thin lipped grey mullet: Mean annual landings decreased by 0.8% due to updated ICES statistics. The SSB that was conservatively expected to represent 5 times of landings (BEEMS Technical Report TR406) reduced respectively.

9 – Flounder: Mean annual landings of flounder decreased by 0.3% as ICES landings were updated.

10 – Plaice: The estimation of SSB of plaice increased by 40% due to updated information for Aart-Poos assessment model and mean annual landings increased as ICES landings figures were updated.

11 – Cod: Further details on cod estimates are provided in Section 2.5.

12 – Thornback ray: Annual landings of thornback ray decreased by 2.6% as ICES landings figures were updated.

13 – Twaite shad: Landings of twaite shad were updated to 1.3t to account for the species catches in Denmark, Netherlands and France.

14 – Horse mackerel: Annual landings of horse mackerel decreased by 1.6% as ICES landings figures were updated.

15 – Mackerel: The SSB of mackerel increased due to performance of state space model (SAM, in the FLR environment) when it was updated with new data. Mean annual landings slightly decreased as ICES were updated.

16 – Tope: Annual landings of tope slightly increased by 1.6% as ICES landings figures were updated.

17 – Allis shad: Mean annual landings of allis shad increased from zero (North Sea TR 406 v.7) to 6.6t (ICES subareas 4,7, and 8 combined) to reflect the uncertainty of the origin of the fish impinged and to account for the possibility of it coming from either the Garonne or a wider area.

2 Species of concern for which additional information has been requested

This section reviews each of the species where further information was requested from stakeholders regarding the stock area or scale of assessment for individual species. The stock units for effect comparisons applied in the uncertainty analyses submitted at Deadline 6 (BEEMS Scientific Paper SPP116 [Doc Ref. 9.67]) are provided in Table 1.

Following engagement with the Environment Agency at a technical meeting on fish on the 19th March 2020, they raised a number of species of concern., Further clarification on the species of concern was provided during a meeting on the 27th April 2020. Version 3 of this report provided additional information for the population of 12 species as requested by the Environment Agency, these include:

- Allis shad;
- Twaite shad;
- Herring;
- Cucumber smelt;
- Sea lamprey;
- Sprat;
- Sea bass;
- Sand goby;
- Dab;
- Flounder;
- Thornback ray; and,
- Sandeel.

The **Environment Agency** in their **Deadline 2 Written Representations** [REP2-135] confirmed agreement in the population comparator for river lamprey and European Eel. The Environment Agency raised no further concerns in relation to the stock comparator for, allis shad, dab, flounder, sandeel, thornback ray. Further information on these species has been moved to Appendix A allowing focus on the species where the stock/population comparator has not been agreed. In their **Deadline 2 Written Representations** [REP2-135], the Environment Agency also introduced a lack of agreement with regards to the stock comparator for other key species including Dover sole, plaice and thin-lipped mullet (**Table 2** of [REP2-135]).

Natural England in their **Deadline 2 submission** [REP2-153] comment that finer population structure and highly localised behaviours is not taken into account when the following species are assessed against ICES stock units:

- Cod;
- Whiting;
- Sea bass;
- Herring and;
- Plaice

SZC Co. responded to **Natural England's** concerns at Deadline 5 (**Appendix K** of Doc Ref. 9.54).

This report therefore focuses on the species where further information relating to stock/population comparators has been requested, including:

- Twaite shad;
- Herring;
- Cucumber smelt;
- Sprat;
- Sea bass;
- Sand goby;
- Thin-lipped mullet;
- Cod;
- Whiting; and,
- Plaice

As part of the Deadline 6 further detail on **Equivalent Adult Values (EAVs) and Stock Sizes** (**Appendix D** of Doc Ref. 9.63) has been prepared summarising Cefas' position in relation to stock areas.

2.1 Twaite Shad

Comment: Statutory stakeholders recommended that "*The company should assess all losses as though they come from each of the mainland continental rivers in turn, rather than assessing against the combined stock from those rivers (evidence from Unlocking the Severn is that there is a high degree of spawning site fidelity)".*

Further comment on version 2: The Environment Agency noted that; *"While it may be unlikely that all impinged twaite shad would originate from one river, such an assessment would provide a precautionary quantitative approach, the likelihood of this outcome occurring can then be discussed qualitatively."*

Response:

Spawning site fidelity is noted, however the proposed development is hundreds of kilometres away from the main European spawning rivers of the Scheldt, Weser and Elbe in mainland Europe (BEEMS Technical Report TR406 Figure 9). There are no known UK east coast spawning sites for twaite shad. Genetic analyses of twaite shad from Sizewell demonstrate that they do not originate from the Severn catchment (Jolly *et al.,* 2012). Sabatino and Alexandrino (2012) identified a North Sea twaite shad population with low genetic diversity between fish sampled off Belgium (Scheldt) and Denmark and also the Solway Firth. These analyses also identified separation between the Baltic and North Sea populations. The twaite shad caught at Sizewell range from >1 yr old juveniles to sexually mature adults that are probably a part of the North Sea mixed population widely dispersed across feeding grounds. In contrast to allis shad, this species is iteroparous so adults may return to the sea to forage several times during their lifetime after each seasonal spawning. Given the distance of the proposed development from the spawning rivers in mainland Europe and the likelihood of population mixing during feeding in the marine environment it is not logical to associate all the fish impinged at Sizewell to a single river system. Given the geography, it is much more likely that the origin of fish caught at Sizewell would be approximately in proportion to the size of the spawning populations in the European Rivers. The assessment in BEEMS Technical Report TR406 considers the two main rivers: the Elbe and the Scheldt (only) and is therefore is likely to be precautionary. Between 2009 and 2017, an estimated annual average of 5.2 million adult twaite shad passed through these two river systems (BEEMS Scientific Position Paper SPP100) with the majority being in the Elbe. Sizewell C is expected to impinge fish from different European rivers on a pro-rata basis according to their abundance and it is therefore considered highly unlikely that there would be a significant effect on the population in any given river.

Between the periods 1992−1993 and 2009−2010, spawner' densities in the most important Elbe population increased significantly (at least ten-fold, though with a high level of uncertainty) and spawning grounds expanded (Magath, Thiele, 2013). The Elbe population was still increasing in recent years (Tulp *et al.*, 2017). The Belgian population of the Scheldt estuary also is exhibiting signs of "genuine improvement" (Wilson, Venerata, 2019) although recovery is later than in the Elbe after action to improve water quality and more recently to improve access to spawning grounds. Very large numbers of migrating twaite shad have been reported in the Scheldt in 2020 with "vast areas of spawning in the river" (pers. comm: Pieterjan Verheist, University of Ghent, 8 May 2020). Numbers of a small population of twaite shad in the Weser Estuary are stable without clear trends in the recent years (Tulp *et al*., 2017). This process of quick stock recovery occurred during unimpeded functional activity of Sizewell B. Therefore, the proposed development at Sizewell C is not predicted to have any meaningful effect on the twaite shad populations.

Natural England Deadline 2 submission [REP2-153] comment: Natural England welcomed the additional data on twaite shad in the River Elbe and Scheldt but question the methodology used to obtain the population estimate. Furthermore, Natural England disagree with the Applicant's assumption that twaite shad impinged at Sizewell B are part of a mixed southern North Sea population and likely to be captured on a pro-rata basis from their source rivers. Natural England state that this approach is not consistent with a precautionary HRA approach.

Response: SZC Co. has provided formal responses to **Natural England's Deadline 2** submissions at Deadline 5 (**Appendix K** of Doc Ref. 9.54). The information relevant to Twaite Shad is provided below.

Natural England welcomed the addition of the twaite shad information and population in BEEMS Technical Report SPP100 [AS-238] and the update to the Habitats Regulations Assessment (HRA) addendum [AS-178]. The HRA has scoped in European sites designated for twaite shad where the site is recorded as having breeding populations. These include:

- Schelde - en Durmeëstuarium van de Nederlandse grens tot Gent SCI, (Scheldt) is located 197km from Sizewell C;
- Unterweser SCI – (Weser) 479km from Sizewell C;
- Weser bei Bremerhaven SCI - (Weser) 483km from Sizewell C;
- Nebenarme der Weser mit Strohauser Plate und Juliusplate SCI – (Weser) 475km from Sizewell C;
- Schleswig-Holsteinisches Elbästuar und angrenzende Flächen SCI – (Elbe) 509km from Sizewell C;
- Unterelbe SCI – (Elbe) 508km from Sizewell C.
- Mühlenberger Loch/Neßsand SCI – (Elbe) 563km from Sizewell C;
- Rapfenschutzgebiet Hamburger Stromelbe SCI – (Elbe) 565km from Sizewell C;
- Hamburger Unterelbe SCI – (Elbe) 582km from Sizewell C;
- Elbe zwischen Geesthacht und Hamburg SCI – (Elbe) 584km from Sizewell C;
- Marais du Cotentin et du Bessin - Baie des Veys SAC - 396km from Sizewell C;
- Tregor Goëlo SAC – 532km from Sizewell C.

Natural England recommend that consistent with a precautionary HRA approach, predicted losses of twaite shad from Sizewell C should be assigned against each breeding population given genetic information is not available to determine the source population.

Natural England cite Jolly *et al.,* (2012) stating "In particular, samples from Looe Bay and Hastings-Sizewell exhibited the strongest genetic divergence. While this suggests that movement within the marine environment is limited, the lack of significant genetic differences between the [twaite shad] populations of the Solway Firth and River Tywi also suggests that some migration could occur over spatial scales as great as 300 km". Cefas does not refute the log-range migratory behaviour of twaite shad. The twaite shad impinged at Sizewell range from >1 yr old juveniles to sexually mature adults that are probably part of a North Sea mixed population widely dispersed across feeding grounds. Sabatino and Alexandrino (2012) showed North Sea twaite shad had low genetic diversity between fish sampled off Belgium (Scheldt) and Denmark and also the Solway Firth.

Fish monitoring programmes in German and Belgian estuaries are undertaken to determine trends in fish populations. However, to the best of our knowledge, absolute population estimates are not available for the designated sites. The Wadden Sea status report (Tulp *et al.,* 2017) provides an overview of North Sea twaite shad populations in the nearby German rivers of the Ems, Eider, Elbe and Weser (summarised in **BEEMS Technical Report SPP100** [AS-238]). The Elbe contributes most of the twaite shad numbers and reproduction in German estuaries. In contrast to the other Wadden Sea estuaries, numbers in the Elbe appeared to be increasing in recent years. Numbers of a small population of twaite shad in the Weser Estuary are stable without clear trends in the recent years (Tulp *et al.,* 2017). Scheldt Estuary in Belgium is exhibiting signs of "genuine improvement" (Wilson, Venerata, 2019). Twaite shad were in very poor condition in the Scheldt prior to improvements in water quality which has allowed recovery and a return of spawning adults from 2012.

In the absence of population estimates for the designated sites, Cefas estimated the shad population of the Elbe and Scheldt based on data provided by European organisations. The population estimate methodology and limitations of the approach are described in **BEEMS Technical Report SPP100** [AS-238]. **Natural England** [REP2-153] and the **Environment Agency** [REP2-135] questioned the uncertainty in the methods applied to determine the population estimate pointing to factors such as diurnal migration patterns, shoaling behaviours and assumptions of the distribution of fish across the estuary when scaling up estimates for the migratory period. The population estimate methodology and limitations of the approach are described in **BEEMS Scientific Position Paper SPP100** [AS-238]. The concerns raised will be considered in further detail and the request for confidence intervals in the populations size is acknowledged. Data applied for the population estimate was from two Elbe stations, one of which (Kollmar) is situated at the mainstream and another one (Krausand/Gluckstadt) relatively close to shoreline. Assessments were done for both stations independently, and respective values were found to be very similar. The final value was taken as average between two situations (**BEEMS Scientific Position Paper SPP100 Table 1**). Therefore, the assumption of homogenous distribution may not be unreasonable, at least for the lower part of the Elbe Estuary. Moreover, the Elbe is a highly engineered water body and there is no clear evidence to provide an alternative to this approach. Anchor nets were set during daylight hours and numbers were scaled to 24 hours. Diurnal patters of upstream migration in the lower tidal stretches of the estuaries are not well established. However, observations further upstream in fresh waters do suggest fish migrate more at day than at night. Night-time migration intensity is approximately half of that observed during the day (Hillman, 2003). Periods of darkness in late April and early May represent less than a third of daylength, therefore scaling to 24 hours may introduce an overestimation. However, it is worth noting that the population estimates also included some precautionary steps such as assuming no avoidance behaviour to the anchor nets i.e., 100% catch efficiency and restricted the migratory period to 30 days when it may be longer (Hillman, 2003). The annual migration of the North Sea twaite shad stock into the lower Elbe Estuary was observed from April to June (Thiel *et al.,* 1996). The population estimate should be treated with a degree of uncertainty and steps will be undertaken in an attempt to quantify that uncertainty, however, as described below the level of impact from the station is well below levels that could have ecologically meaningful effects.

If the impacts of Sizewell C are apportioned to each river population sequentially as requested by Natural England, the relative level of effect varies depending on the reference population. Given the distance of the proposed development from the spawning rivers (hundreds of kilometres) and the fact it is in the open coastal environment, it is highly unlikely all fish impinged at Sizewell would come from any given system. However, such a scenario is considered below for two European systems where the population estimates have been made by Cefas: The Elbe, approximately 500km from Sizewell C, and the Scheldt approximately 200km away. Unmitigated losses of 2,693 shad by Sizewell C are predicted based on the precautionary assumption of all fish being adults (with an EAV of 1). This is considered precautionary as 46% of impinged shad are estimated to be 1- to 3-year-old fish with very low maturity rates at this age. Notwithstanding the uncertainty in the population estimate of the Elbe (ca. 5.1 million adult fish (**BEEMS Technical Report SPP100** [AS-238]), unmitigated losses account for approximately 0.05% of the population if all fish impinged at Sizewell C were from this single river system. Uncertainty analysis submitted at Deadline 6 (**BEEMS Scientific Position Paper SPP116** [Doc Ref. 9.67]), includes the annual variability in the estimated population sizes to provide further consideration of the variability in the population estimates.

The average population of the Scheldt following recovery of a breeding population in 2012 was estimated at 66,715 fish between 2012 and 2017 (**BEEMS Technical Report SPP100** [AS-238]). If all the twaite shad predicted to be impinged by Sizewell C were from the Scheldt alone, the losses would account for 4% of the estimated Scheldt population. Impingement monitoring at Sizewell B has recorded twaite shad throughout the monitoring period (2009-2017), recovery in the Scheldt occurred in 2012 with no spawning adults recorded in 2011. Therefore, it is not possible that all the twaite shad impinged at Sizewell originate from this single river. It is likely that the Scheldt breeding population become re-established from fish derived from surrounding systems such as the Elbe.

As the Environment Agency point out [REP2-135], whilst there is population mixing and genetic homogeneity in the southern North Sea, the river systems support 'biological stocks'. Impingement has the potential to cause effects on a given river system if impingement mortality exceeds immigrations rates. Twaite shad exhibit spawning site fidelity with >90% fish returning to home rivers to reproduce (Davies *et al.,* 2020). Since recovery numbers of shad in Scheldt are ~ 1% of those in the Elbe and may represent an extension of Elbe population into the Scheldt. Cefas acknowledges that it is not possible to determine exactly what river system the twaite shad impinged at Sizewell originate from. However, the genetic information from North Sea shad demonstrates mixing which is consistent with the assumption that the Weser and Scheldt population recoveries have been seeded form fish originating in the Elbe.

The predicted scale of losses from Sizewell C are therefore considered to have negligible impacts on the breeding populations of shad in European rivers.

2.2 Thin-lipped grey mullet

Comment: In response to ExQ1 Bio.1.244 the Environment Agency at Deadline 3 commented that "*We do not consider that there is sufficient evidence made available to justify the decision to use a SSB prediction of 600t. We cannot confirm that this is sufficiently precautionary or that there will not be a potential for a decline in WFD status."*

Response by SZC Co. at Deadline 5:

Cefas is aware that the population abundance of widely distributed thin-lipped grey mullet remains undetermined. The thin-lipped grey mullet of the North Sea area is largely unexploited, and its population recently began to expand in range to Norway and Poland (Wilson and Veneranta, 2019; Panicz and Keszka, 2016). However, species-specific stock assessment and time-series data do not exist (Wilson and Veneranta 2019). Consequently, landings statistics form the only guide of the relative abundance of the species.

Cefas has provided evidence that fishing mortality rates of 10-20% are sustainable for commercially exploited fish stocks [AS-238 **TR406.v7 Section 5.1** pdf page 121]. This rate of 20% was applied to North Sea commercial landings of grey mullet only (mean of approximately 120t) to estimate the SSB from landings. This assumes that the stock is commercially exploited and ignores recreational catches that were estimated in the UK as a mean of 216t annually (National Mullet Club, 2006). At the time of assessment, most of the recreational catch (86%) was released with unknown mortality. Across the UK, the mean recreational catch was 43% higher than the average commercial landings of 151t in 2006-2017 as reported by MMO (Butterworth & Burt, 2018). Mullet was not a heavily targeted species but in recent times the demand and price for mullet has increased (Butterworth & Burt, 2018).

Given the relatively low exploitation level of thin-lipped grey mullet in the North Sea, Cefas considers the assumed SSB of ca. 600t to be highly precautionary. As such there are not concerns regarding the impacts of the station on the sustainability of thin-lipped grey mullet populations. This position was echoed by the **MMO** in their Deadline 2 submission (para. 3.2.7 [REP2-140]), emphasis added:

> *"Notwithstanding these uncertainties, the entrapment estimates indicate that even in the absence of LVSE and FRR mitigation measures, only 4 species exceed the 1% threshold: bass, for which density adjustment substantially reduces assessment of impact; sand goby, for which mortality rate >1% Spawning Stock Biomass (SSB) is not a concern at population level; thin-lipped mullet, for which value is an artefact of the low level of landings and absence of SSB; and eel, for which the applied Equivalent Adult Value (EAV) of 1 is unrealistically high, and is a species most likely to benefit from the FRR. On this basis, the MMO consider there is a good level of confidence that actual impacts to all fish species will not be significant. Therefore, the MMO support the conclusions of the ES."*

In relation to the Environment Agency concern pertaining to a potential decline in WFD status, Cefas addressed these concerns as part of the supplementary fish information submitted in January 2021 (**SPP108** in [AS-238]) and presented the results to the Environment Agency at a WFD meeting on the 16th March 2021. The Environment Agency previously raised concerns about reductions in thin-lipped grey mullet and the consequences for the transitional fish classification index (TFCI), a measure of the fish quality of the Alde-Ore under the WFD. One of the scenarios tested by Cefas involved artificially removing all thin-lipped grey mullet and all Dover sole from the TFCI. Such a manipulation falls beyond the bounds of 'reasonable worst-case'. Irrespective of this, the status of the water body (as determined by the TFCI) remained 'good' showing a 4% reduction in the TFCI metric. It can therefore be concluded that the impacts of the station on thin-lipped grey mullet would not impact the WFD status.

2.3 Herring

Comment: "*Detail covered in our gap analysis and discussed with EDF on 19th March, including the Blackwater herring. For herring, the way the assessment is done has changed, but this has not been explained, but never explained why to justify the scale being used. There is some inconsistency in whether herring stocks are regarded as separate or not.*"

Response:

The assessment unit for herring reflects the latest ICES advice. The small Blackwater population is not included in the ICES stock assessment. BEEMS Technical Report TR406 details the potential for effects on the Blackwater population and concludes that: *"The weight of evidence therefore indicates that Sizewell impingement is from main North Sea stock (as assessed by ICES and used in this report) and not the Thames estuary Blackwater stock".*

Whilst it is feasible that the proposed development would impinge Blackwater herring, the proportion of Blackwater herring in the mixed southern North Sea population is very small and impacts on the Blackwater SSB are likely to be minimal.

Response to Natural England Deadline 2 submission [REP2-153]:

SZC Co. responded to **Natural England's** concerns at Deadline 5 (**Appendix K** Doc Ref. 9.54). Information regarding the latest position on herring is provided below.

The ICES stock unit for herring is the North Sea, Skagerrak & Kattegat, Eastern Channel (Subarea 4 & Divisions 3.a & 7.d). The SSB for the herring is applied as a comparator for impingement assessments (Figure 2). The current understanding of North Sea herring and the wider stock is summarised below and also described in **BEEMS Technical Report TR406.v7** [**Section 6.6.5** of AS-238].

The North Sea herring stock is generally understood as representing a complex of multiple spawning components (Iles and Sinclair, 1982; Heath *et al.,* 1997) predominantly comprised autumn/winter spawners, with small spring-spawning components (Dickey-Collas et al., 2010) mainly found as coastal groups in areas such as The Wash, Thames Estuary, Danish Fjords and the now extinct Zuiderzee herring (Fox, 2001; Roel *et al.,* 2004; Berges, 2018). The stock is commonly referred to as North Sea Autumn spawners (NSAS). The potential for impacts on Blackwater herring as part of the Thames Estuary spring spawners is considered in **[Section 6.6.5** of **TR406.v7** AS-238]. Blackwater herring spawning on the Eagle Bank in the greater Thames Estuary occurs in February-April, which is coincident with the period of maximum herring impingement (Q1) at Sizewell B approximately 60km to the north.

Autumn/winter spawning herring largely consists of four genetically homogenous components or sub-stocks (Mariani *et al.,* 2005) and contributions of these individual components to the total stock differ over time (Berges, 2018). These components are identified by their separate spawning grounds; Orkney/Shetland, Buchan, Banks (central North Sea) and Downs (southern North Sea and eastern English Channel). Mixing of autumn spawning herring and spring spawning herring occurs on summer feeding grounds.

Cefas' scientific hypothesis theorises North Sea herring breed in a meta-spawning migration that includes all autumn-, winter- and spring- components spawning at their distinct grounds on route, progressing steadily southwards with time for the four main grounds and then northwards along the coast for the coastal spring-spawning grounds. The migration would start in August at Orkney/Shetland, herring would proceed via the Banks to the Downs in January, followed by northwards direction into the Thames in February and then continuing north along the East Anglia coast to The Wash and Humber. This is supported by the suggested maturation cycle; all spawning types start maturation in April-May and keep developing until autumn-spawning or stop development until just prior to winter- and spring-spawning (van Damme et al., 2009).

The separation of Downs and other components (including coastal spring-spawners) of the NSAS has not been implemented to date and the current definition of the North Sea stock of NSAS and winter spawners has operated well in the past despite changes to the relative strengths of different spawning components (Reiss *et al.,* 2009; Berges, 2018).

The most recent benchmark of the North Sea herring assessment in 2018 confirmed there was currently no need to revisit the stock identity (ICES, 2018). This herring stock can effectively be viewed as a meta-population consisting of at least four sub-stocks (and potentially more, especially when considering the coastal spring-spawners) and therefore herring impinged at Sizewell would be part of the North Sea stock. The NSAS stock components are genetically homogenous (Mariani *et al.,* 2005; Reiss *et al*., 2009) and consequently the Cefas considers the ICES North Sea herring population comparator to be the most appropriate unit for assessment of impacts from the station.

Unmitigated losses from Sizewell C are predicted to account for approximately 0.01% of the SSB for herring. Landings of the North Sea stock between 2009-2017 equated to over 16% of the mean SSB whilst losses associated with the station are predicted to be less than 0.08% of landings. This reflects the very low impact of the station on the sustainability of herring populations.

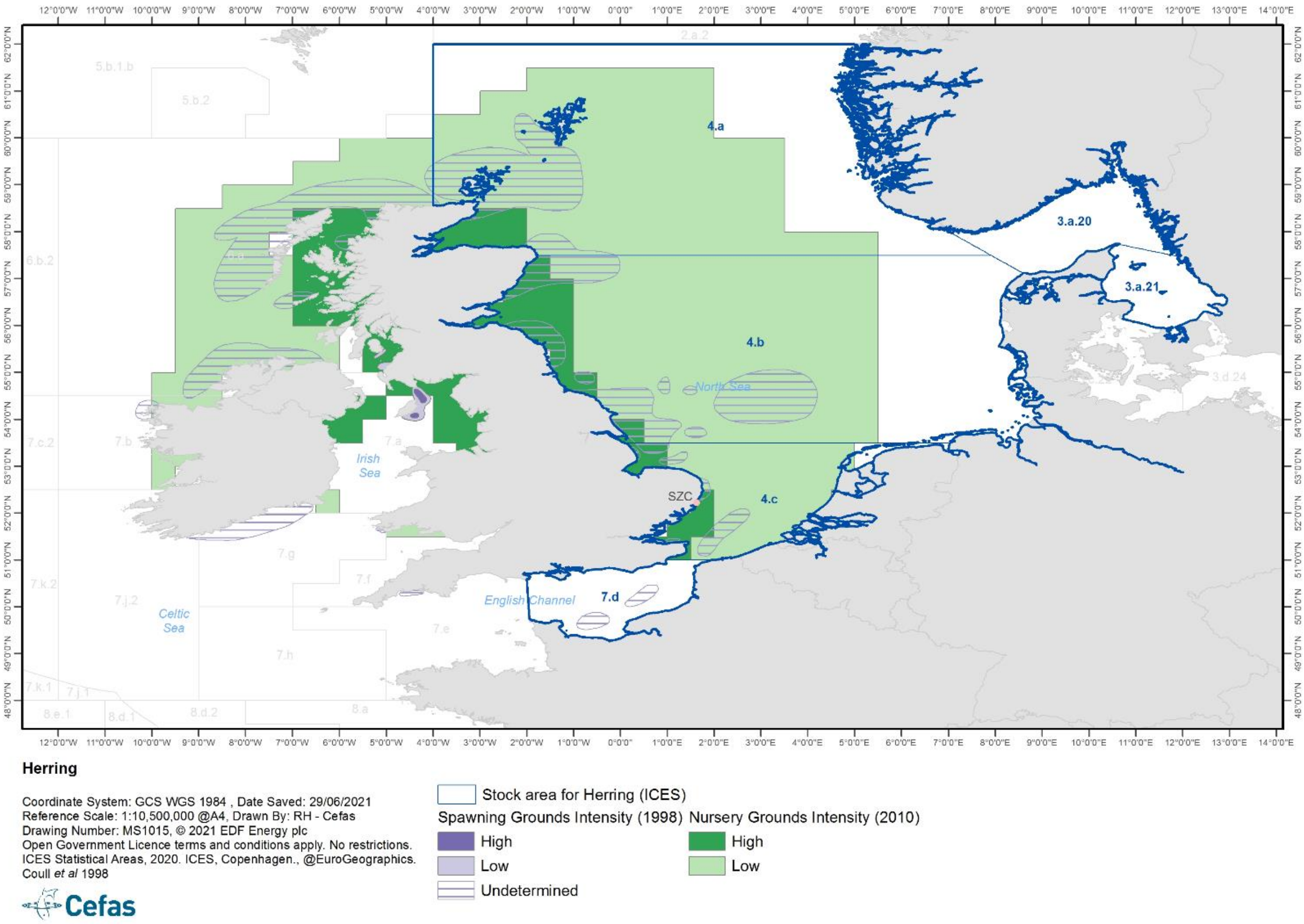

Figure 2. ICES stock area for herring showing spawning and nursery areas relative to Sizewell C.

2.4 Plaice

Response to Natural England Deadline 2 submission [REP2-153]:

Sizewell C Co. responded to **Natural England's** concerns at Deadline 5 (**Appendix K** Doc Ref. 9.54). Information regarding the latest position on plaice is provided in this section. The ICES stock unit for plaice is Division 4 and 3.2 subdivision 20 (North Sea & Skagerrak) (Figure 3). The SSB and landings are available for plaice populations in this stock unit and have been used as a comparator for impingement assessments.

Plaice is a well-studied stock by ICES. The North Sea and Skagerrak population is seasonally mobile. In summer, some plaice come to forage in Skagerrak where they represent a large share of catches in the area. Genetic and tagging studies show plaice from the North Sea & Skagerrak population mix with the western component of a smaller local resident stock (Ulrich *et al.,* 2017; ICES 2020). Some adult plaice from the North Sea & Skagerrak population migrate to the eastern English Channel during Q1 for spawning representing around half of adult fish captured there in this season before returning to the North Sea (Houghton, Harding, 1976; ICES, 2020) (Figure 3).

ICES stock assessments and calculations of TAC take into account this seasonal “infringement” of management borders and respective modelling (two models used) provides a reliable tool for monitoring abundance of this stock - the North Sea plaice, not the plaice in the North Sea. Models use six different seasonal survey indices covering the entire area of the stock distribution and age structure of catches.

Plaice was benchmarked in 2015, 2017, and recently in 2020. In spite of the recent assessment, an accumulation of evidence for further improvement of stock monitoring is underway (ICES 2020). This adaptive approach exemplifies the ability of ICES to account for the latest available evidence as soon as it becomes available.

The use of the North Sea plaice stock as a comparator for losses caused by Sizewell activities is robust because: a) plaice are a widely distributed and mobile stock with the widest distribution of eggs and larvae with oceanic currents; b) there is no evidence of more discrete populations that might be impinged at Sizewell nor any evidence for other stocks that might be impinged there.

With FRR mitigation in place, mean annual losses of plaice equate to 0.38t from an SSB of 967,222t. The effects of impingement on plaice is therefore considered negligible.

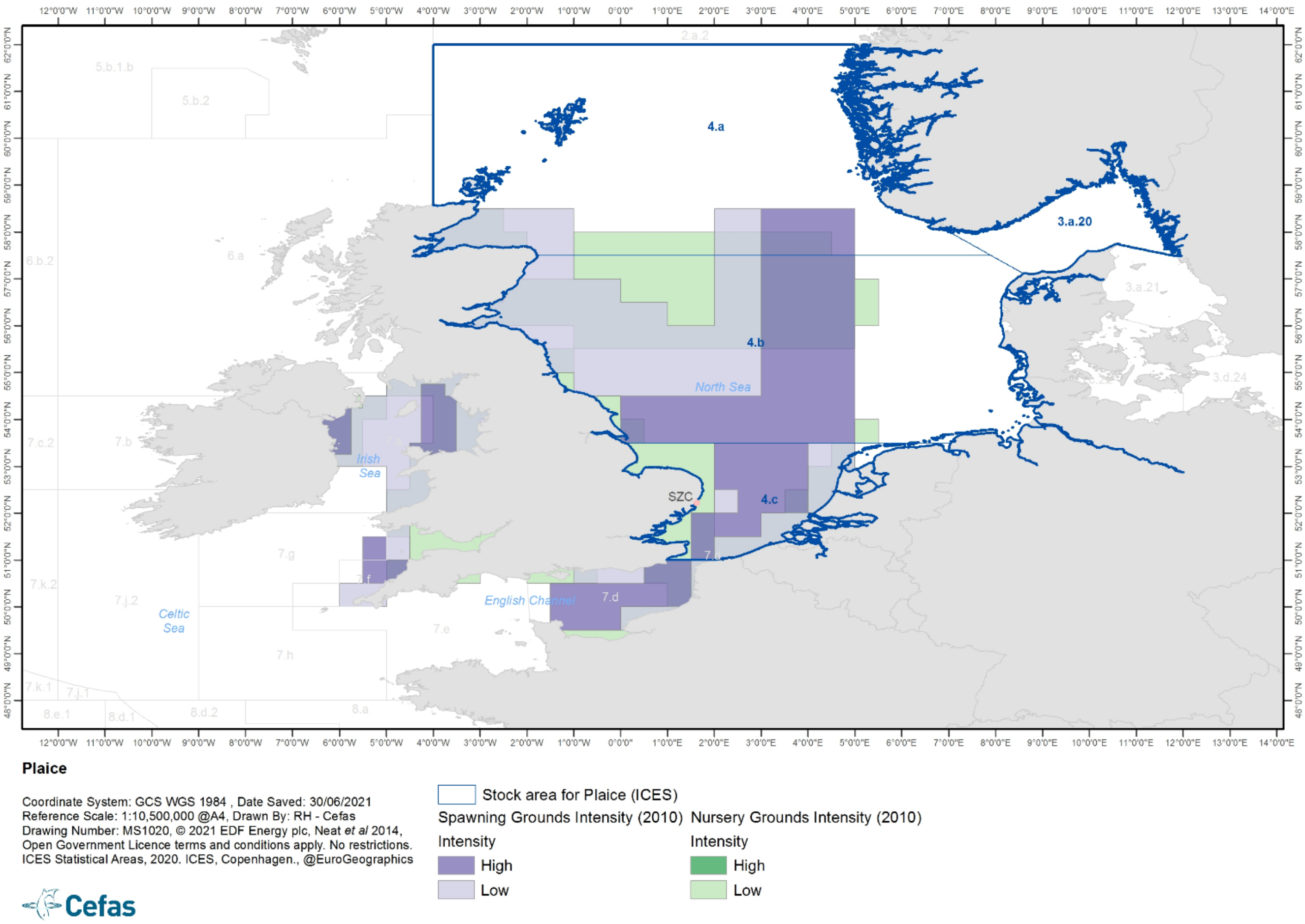

Figure 3. ICES stock area for plaice showing spawning and nursery areas relative to Sizewell C.

2.5 Cod

Response to Natural England Deadline 2 submission [REP2-153]:

SZC Co. responded to **Natural England**'s concerns at Deadline 5 (**Appendix K** Doc Ref. 9.54). Information regarding the latest position on cod is provided in this section.

The ICES stock unit for cod used as a comparator for impingement assessments is Subarea 4 & Subdivisions 7.d & 20 (North Sea, Eastern Channel, Skagerrak & Kattegat) (Figure 4).

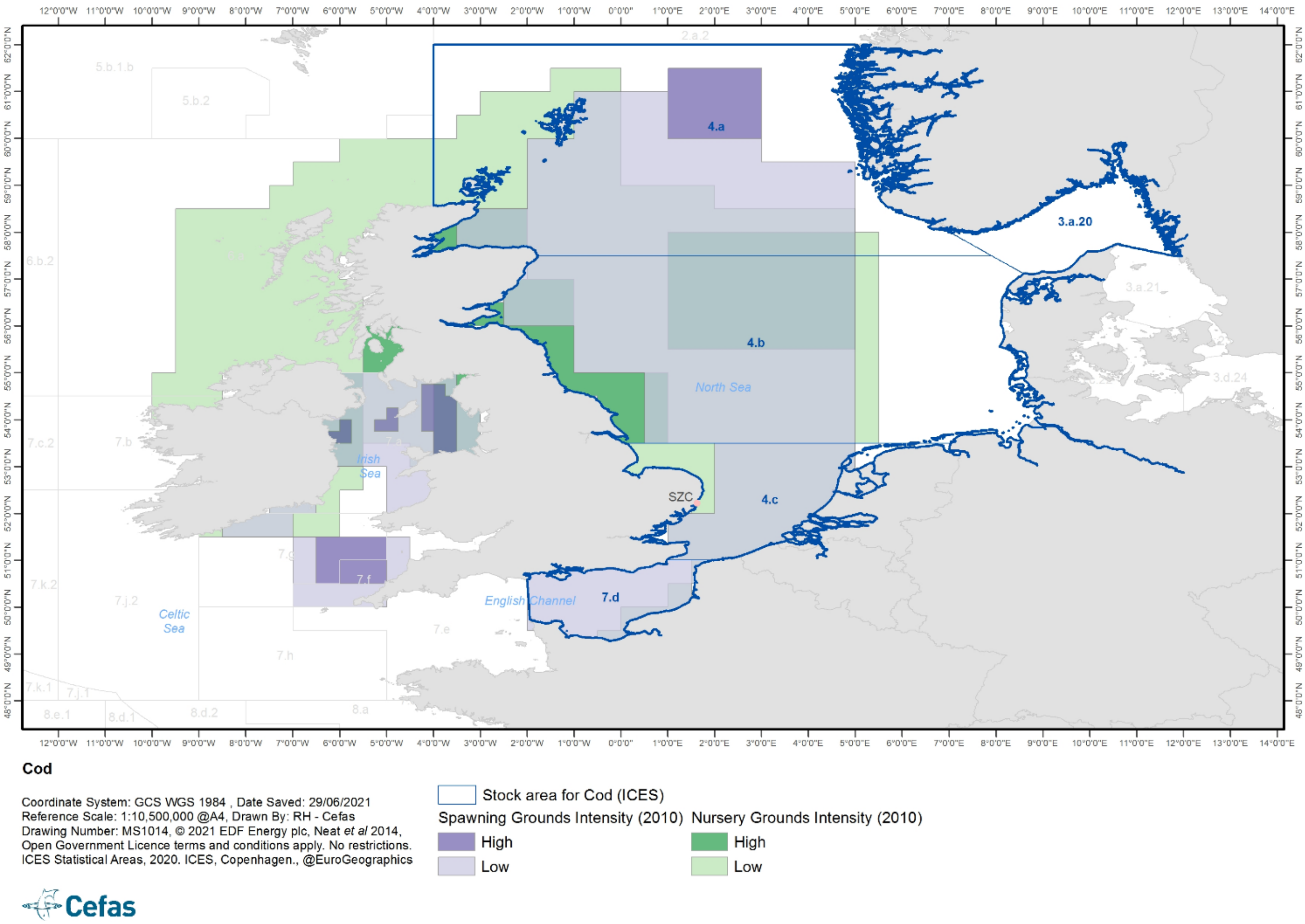

Figure 4. ICES stock area for cod showing spawning and nursery areas relative to Sizewell C.

The cod stock is widely distributed throughout the North Sea, but there is growing evidence of subpopulation structure inhabiting different regions of the North Sea with limited mixing (ICES 2020). The Workshop on stock Identification of North Sea Cod (WKNSCodID) was held in August 2020 and concluded that North Sea cod includes two reproductively isolated populations: Viking and Dogger cod. Viking cod inhabit the northeast North Sea (on and around Viking Bank, 4.a). The spatial distribution of Viking cod extends westward to the Shetlands (western part of 4.a) and southward to the Fischer and Jutland Banks (northern part of 4.b), with a nursery area in the Skagerrak (20). Some Viking cod juveniles also inhabit the Kattegat. The Dogger cod population inhabits the south–central North Sea (on and around Dogger Bank, 4.b), along the Scottish coast to the north of Scotland (northern part of 6.a), and in the eastern English Channel (7.d), with some adults seasonally migrating to the western English Channel (7.e–k) and the Dogger population extends into northwest of Scotland. Within the Dogger cod, there are phenotypic differences in the northern and southern North Sea, indicating further population structure.

As a result of further evidence for structuring of the population in the North Sea and adjacent areas, ICES is currently developing an assessment that accounts for this sub-stock structure, with the aim of another benchmark assessment around 2023. Data are now being collated that are best suited for assessments of sub-stocks of cod. Figure 5 shows the latest understanding of the population structure of cod in the North Sea. Skagerrak (area 20; shaded in pink) is a nursery ground of juvenile Viking cod with some mixing of juvenile southern Dogger cod. The approximate area of distribution of northern Dogger cod is shown in blue, and southern Dogger cod in green, roughly separated by the isobath of 50m. The sub-populations of Dogger cod exhibit differing rates of growth and maturity, with limited mixing between them resulting in some phenotypic differences.

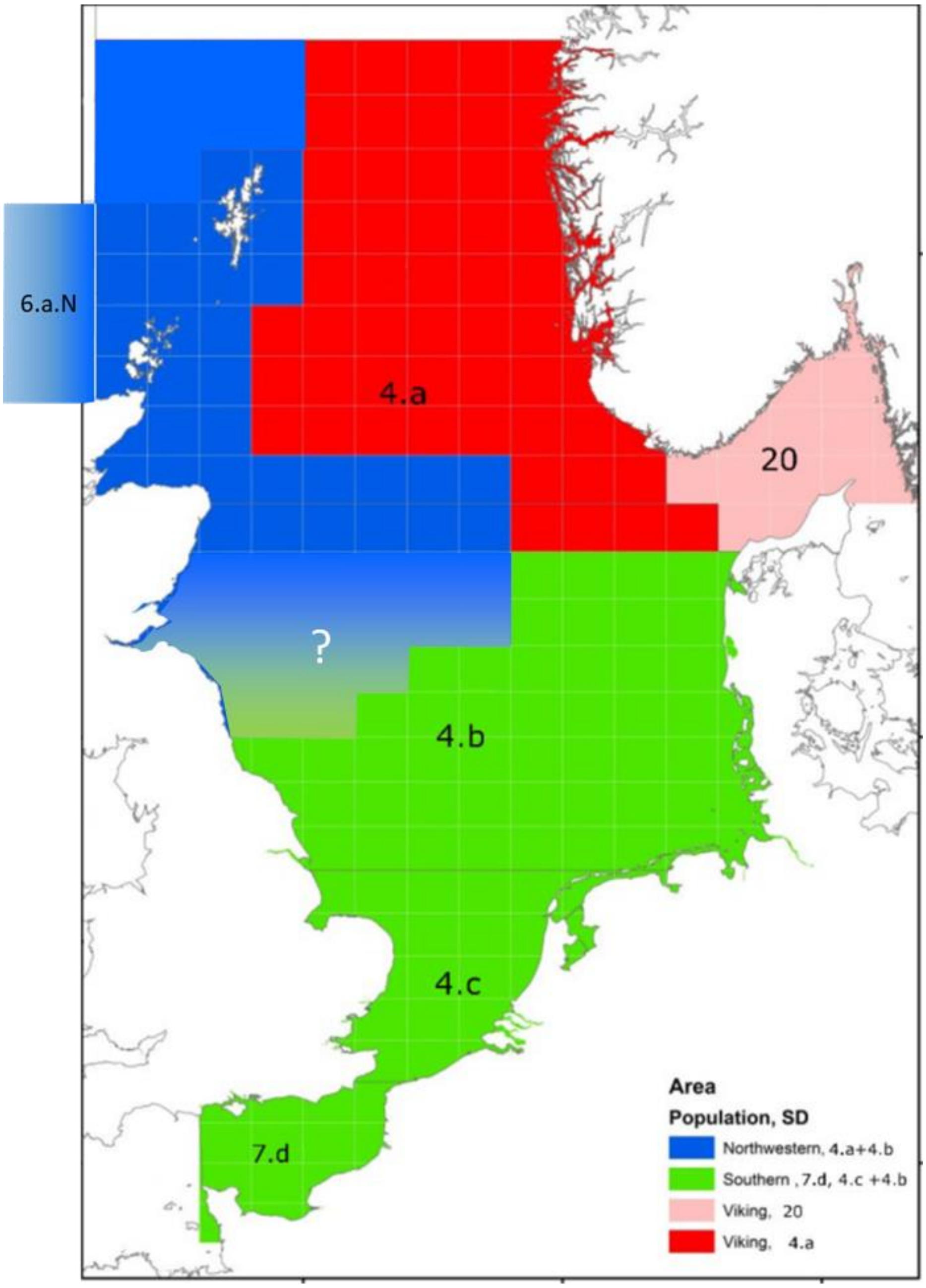

Figure 5. Sub-stock areas for the various sub-stocks of cod: DN = Dogger North (blue), DS = Dogger South (green), V = Viking (red and pink).

Cod impinged at Sizewell would be part of the southern Dogger sub-population. On the basis that ICES is currently addressing the population structure within its assessments of cod, it is appropriate to readdress the comparator for impingement predictions. However, no SSB is currently available for the southern Dogger cod. In the absence of an SSB, landings data have been used by Cefas as a comparison. Landings in 4a would be an unknown mixture of Viking and Dogger cod. Northern Dogger cod are also known to have reduced mixing with southern Dogger cod. As such, the 20,191t per annum of landings from 4a is not considered to be appropriate for the assessment comparator. A precautionary landings comparator of 11,124t per annum has been calculated from landings of southern Dogger cod in 4b-c and 7d (as a rough approximation of catches of this sub-population) between 2009-2017.

Table 2 shows the losses of cod due to impingement from Sizewell C relative to the precautionary landings of southern Dogger cod. Following Natural England's comments, a revised precautionary landings comparator, accounting for the latest developing ICES evidence has been provided. Table 2 shows the effects of the Sizewell C station on cod are negligible at less than 0.15% of landings with no mitigation and 0.08% with FRR mitigation.

Table 2 Annual mean Sizewell C predictions of impingement of cod compared to landings in 4b-c and 7d.

Mitigation	Mean Sizewell C prediction	FRR mortality	EAV number	EAV weight (t)	Mean landings 2009 -2017 (t)	% of landings
Unmitigated	16,505		5,927	15.42	11,124	0.14
FRR mitigation	16,505	9,130	3,279	8.53	11,124	0.08

2.6 Whiting

Response to Natural England Deadline 2 submission [REP2-153]:

SZC Co. responded to **Natural England's** concerns at Deadline 5 (**Appendix K** Doc Ref. 9.54). Information regarding the latest position on whiting is provided in this section.

The ICES stock unit for whiting is the North Sea and Eastern Channel (Subarea 4 and 7.d), impingement assessments are compared against the SSB of this stock (Figure 6).

Whiting is assessed by ICES as a single stock inhabiting the North Sea and eastern English Channel. Genetic studies (Charrier *et al*., 2007) revealed genetic structure within the North Sea, that "may be associated with the complex oceanography of this basin and retention systems reducing larval dispersal". The stock was benchmarked in 2018 and the workshop reached agreement that the stock consists of a northern and a southern component. The boundary between these components is suggested to occur at ~ 50m depth (Holmes et al., 2014). The northern and southern components live at different temperatures and depths and therefore exhibit slightly different life history traits and literature suggests a spatial split in spawning aggregations during the spawning season.

The stock identity was revisited by ICES and it was concluded that the current assessment area of the North Sea and Eastern Channel should remain (ICES 2018c). The two components were further considered by ICES and it was concluded that separate assessment of the northern and southern components is not considered necessary (ICES 2020c) and there is no unambiguous evidence to indicate that the two components are distinct stocks.

On the basis of the latest ICES advice, Cefas considers the North Sea and eastern English Channel stock to be the most appropriate unit for assessment of impacts from the Sizewell C station. Unmitigated losses from the station account for approximately 0.11% of the SSB for whiting, FRR mitigation is predicted to reduce losses to 0.06% of SSB.

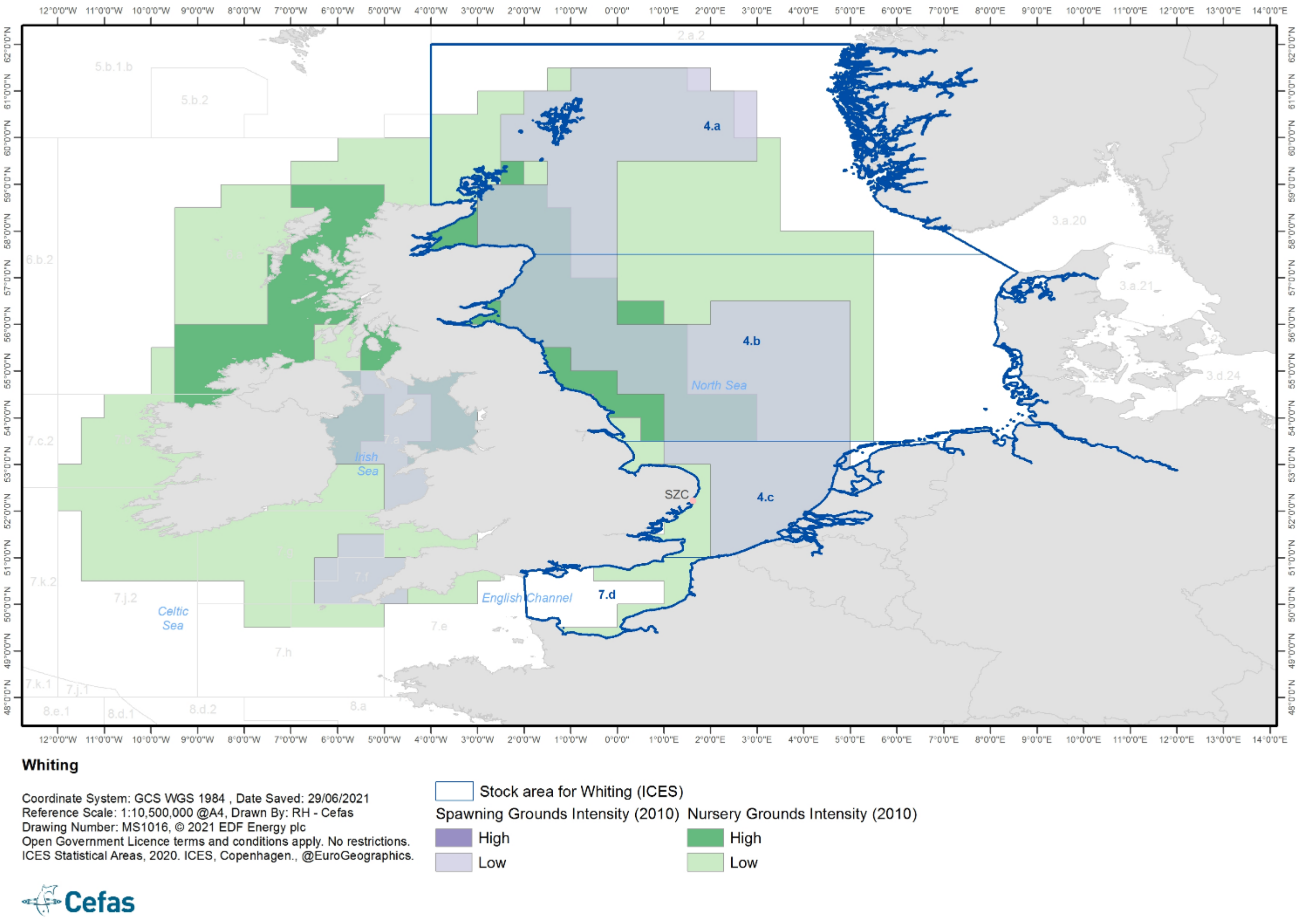

Figure 6. ICES stock area for whiting showing spawning and nursery areas relative to Sizewell C.

2.7 Cucumber smelt

Comment: "*Detail covered in our gap analysis and discussed with EDF on 19th March*".

Response to concerns raised over the status of the Alde-Ore fish status:

The Environment Agency concern pertains to smelt populations within the Alde-Ore Estuary particularly in relation to the potential for a derogation in the Water Framework Directive (WFD) fish status of the Alde & Ore transitional waterbody. **BEEMS Scientific Position Paper SPP108** [AS-238] specifically addresses these concerns. **BEEMS Scientific Position Paper SPP101**[AS-238] provides further information in response to Environment Agency comments pertaining to tidal elevation and temperature on smelt impingement. WFD concerns relating to the Alde & Ore fish classification were discussed with the Environment Agency on 16th March 2021.

The potential for localised effects on smelt is provided in Section 3.6.2.

To determine the sensitivity of the TFCI to smelt abundance, smelt numbers in WFD fish monitoring data were manipulated at a range of levels including complete smelt absence. At the request of the Environment Agency, a further test considered absence of smelt and Twaite shad and 50% reductions in herring and sea bass. The sensitivity of the TFCI was also tested through manipulated removals of thin-lipped mullet and Dover sole, as well as a scenario whereby smelt, thin-lipped mullet and Dover sole were all simultaneously reduced by 50%.

1. The calculated Ecological Quality Ratio (EQR) was insensitive to manipulated reductions in smelt abundance of 25% and 50%.

2. Total absence of smelt reduced the EQR by 11% but 'good' status remained.

3. An extreme case was requested by the Environment Agency including absence of shad (1 individual caught between 2013-2018) and smelt, along with 50% reductions in herring and bass. This reduced the EQR by 10.3%, however, 'good' status remained.

4. Total absence of thin-lipped grey mullet and Dover sole reduced the EQR by less than 4% in each case and 'good' status remained. The status also remained 'good' following the combined 50% reduction of smelt, Dover sole and thin-lipped grey mullet.

Under all of the scenarios tested for fish manipulations, there was no deterioration of 'good' status when the 2019 TFCI was calculated without fyke net data[1] (**BEEMS Scientific Position Paper SPP108** [AS-238]). It is therefore concluded that it is highly unlikely that the proposed development would cause a deterioration in the fish status of the Alde & Ore.

Response to Environment Agency Deadline 2 Written Representation [REP2-135]:

The Environment Agency has raised concerns regarding impingement of smelt and the population estimate. **BEEMS Technical Report TR406.v7** [AS-238] provides two comparators for the smelt population estimate (Table 1), the primary comparator is an Anglian Region estimate of SSB, the second is for further context and is based on the populations estimate from the River Elbe detailed in BEEMS Scientific Position Paper SPP100 [AS-238]. This section provides more context on the primary comparator.

Smelt in the coastal waters around Sizewell and in Suffolk are considered to belong to a population associated with the Norfolk Broads and the estuarine and brackish waters around Great Yarmouth and Lowestoft (Maitland, 2003b). Comparative genomic analyses concluded that smelt from Sizewell and from the River Thames, Waveney, and Great Ouse are genetically homogeneous with no genetic structuring seen within the region (BEEMS Technical Report TR423). It is considered probable, but not yet proven, that the smelt impinged at Sizewell B originate from a southern North Sea population and very large numbers have been observed in the River Elbe in Germany (BEEMS Scientific Position Paper SPP100). For the purposes of assessing impacts on smelt populations, an 'Anglian' smelt population SSB has been estimated based on Environment Agency landings data from the Anglian Region. The Environment Agency manages the licensing of smelt fisheries and a precautionary assumption is made that the regulated landings represent the maximum sustainable harvesting rate for the species of approximately 16% (**BEEMS Technical Report TR406.v7** [AS-238]). Given the restrictive licensing practices this is likely to be highly precautionary and underestimate the SSB. For the years with catch data the mean landings in the Anglian Region between 2009-2017 were 8.63t resulting in an SSB of 53.9t. Losses of the proposed Sizewell C station with no mitigation benefits represent 0.52% as a mean and 0.87% at a 95th percentile. Such losses, relative to a precautionary estimate of SSB, will not have a significant effect on smelt population dynamics.

The potential for immigration between river systems in the Anglian region is considered further in Section 3.6.2.

Despite the small scale of the predicted effects on the regional smelt population, SZC Co. as part of the ongoing Eels Regulations and Water Framework Directive discussions with the Environment Agency, is investigating the potential for installation of measures for eels and further monitoring of smelt (and potential installation of fish passes) in relevant local rivers. The precise details are yet to be confirmed, but this commitment would be secured as a DCO Requirement and funded via the Deed of Obligation.

2.8 Sea Lamprey

Comment: *"Sea lamprey are stated as being widespread throughout the North Sea, but without supporting evidence. There appears to be a serious decline in Humber populations. Significance of sea lamprey entrapment might be more significant if stocks of this species are crashing. Please provide some description of sea lamprey stocks in the North Sea (as has been provided for river lamprey)".*

[1] The TFCI is calculated in the absence of fyke net samples, the appropriateness of this approach was confirmed by the Environment Agency at a meeting on 16/03/2021.

Further comment on version 2: The Environment Agency welcomed the additional context on sea lamprey populations in the North Sea and requested any further quantitative information was available on distribution, population size and at sea behaviour.

Response:

In contrast to most anadromous fish (i.e. those that return from the sea to spawn in rivers where they were born), the sea lamprey (*Petromyzon marinus*) is deprived of homing instinct but rather exhibits regional panmixia during foraging at sea. To complete the life cycle, the species uses a 'suitable river' strategy being attracted to spawning sites by pheromones released by its larvae (Waldman *et al*., 2008). So, after the marine trophic phase, adult sea lampreys re-enter freshwater via the nearest 'suitable' river with already dwelling larvae and migrate upstream where they build nests, spawn and soon die (ICES 2015). Because of this, there is no genetic differentiation between sea lampreys sampled along European shores (Almada *et al*., 2008; Wilson, Veneranta, 2019). Therefore, there are no discrete populations/stocks in the southern North Sea (neither is there a particular Humber population), as the entire European population / stock exhibits a considerable genetic homogeneity over a spatial scale of > 2000 km, from Yorkshire to the South Portugal (Genner *et al*., 2012). Increase or decrease of sea lamprey in a particular river is dictated by water quality and local human activities (e.g. dam building).

Sea lamprey has declined in British freshwaters over the last hundred years mostly due to pollution and engineering barriers, becoming extinct in many rivers (Maitland 2003a). The current International Union for Conservation of Nature (IUCN) status of anadromous sea lamprey in Europe is of "least concern" (IUCN website, Natureserve 2013), however, ICES recently suggested to consider it as "vulnerable" (Wilson, Veneranta, 2019). The UK reported to the EU in the 2007-2012 reporting round that the status of the species in the UK is unknown. There is no ICES sea lamprey stock assessment for the North Sea. At sea numerical estimation is not available as adults cannot be sampled in any reliable manner. Distinct trends of population increase have been registered across the entire distribution range of the species in European waters in recent years though more data are needed to confirm whether this trend actually reflects overall recovery of all stocks (Wilson, Veneranta, 2019).

In the UK, *P. marinus* is reasonably widespread in rivers. In some places it is still common, but it has declined in parts of its range and has become extinct in a number of watersheds. It appears to reach its northern limit of distribution in Scotland and does not occur north of the Great Glen (JNCC website). UK SACs where sea lamprey is a primary reason for site selection are predominantly on the western and southern coasts. The nearest UK SAC to Sizewell where sea lamprey is a qualifying feature, but not a primary reason for site selection, is the Humber Estuary and the associated spawning site of the River Derwent. Sea lamprey SACs are found all along the European coast from the Netherlands to Denmark with specific concentrations in the Scheldt, Hollands Diep, Waddenzee, Ems, Weser, Elbe and Eider and any sea lamprey caught at Sizewell could have originated from any of these systems. In terms of geography the Dutch coast is nearer to Sizewell than the Humber but due to their parasitic feeding lifestyle the distances travelled by the species depend largely upon the dynamics of their prey. As sea lamprey do not home to natal rivers, mortality at Sizewell could not be attributed to any specific site of origin.

A single sea lamprey was recorded in the 2009-2017 CIMP programme in 2015. The expected annual impingement losses of sea lamprey at Sizewell C with the full mitigation is less than 1 fish per annum (BEEMS Technical Report TR406). This is considered negligible for a stock that is widespread throughout the North Sea. There is no reason to consider that the 1 fish caught at Sizewell was from the Humber Estuary and it could have eventually arrived at Sizewell from any North Sea breeding river (or even further afield) dependent on the behaviour of its hosts and would be unlikely to have returned to that river other than by chance, if it had survived to breed.

2.9 Sprat

Comment: *"Sprat are assessed against the North Sea stock but see Section 4.5 of ICES WKSPRAT Report 2013 (attached). There are examples of local populations in the North Sea that have been depleted. It also says 'There are sprats in the Wadden Sea and in the outer Thames estuary, areas that are more closely connected to the main sprat population in the southern North Sea but which may represent populations with distinct dynamics.' This needs to be acknowledged and discussed by the applicant."*

Further comment on version 2: Further information and clarification was requested from the Environment Agency on local populations identified by ICES and the appropriateness of the scale of assessment.

Environment Agency comments on version 3:

- "*We still require confirmation that the scale in table is incorrect as the continued text and underlying WKSPRAT 2018 report suggest it is 4 plus 3a that has been used*

- *WKsprat 2018 can be considered the latest and therefore best advice on the stock from ICES, and we agree it supersedes the 2013 advice for this reason. But it does still leave untouched the original points provided in the 2013 ICES advice which highlights that there are potentially localised stocks of sprat in the outer Thames estuary (WKsprat 2013 Section 4.5) which includes the GSB. Stating in relation to this area that "there are several peripheral areas of the North Sea where there may be populations of sprats that behave as separate stocks from the main North Sea stock. Local depletion of sprats in such areas is an issue of ecological concern". This raised concerns over stocks in ICES expert group over the stock structure given the further action needed on "…, Moray Firth and English channel probably not well resolved, coastal sprat also an issue" (WKsprat 2018). We would highlight that EIA may require a different response to the same evidence than fishery management. A more conservative approach by having a smaller scale of assessment."*

Response:

The Benchmark Workshop on Sprat (WKSPRAT) in 2018 advised that future stock assessments should combine the North Sea, Skagerrak & Kattegat stocks incorporating Subarea 4 and Division 3.a. Sprat of 3.a were data limited and an estimate of SSB was not provided by ICES at the time. Instead, total stock biomass (TSB) was reported. The average TSB between 2009 and 2017 was small at 19.7t. By comparison, the mean SSB in Subarea 4 between 2009 and 2017 was 220,757t (ICES, 2018 a). Therefore, **BEEMS Technical Report TR406.v7** [AS-238] applied the SSB of 220,757t for Subarea 4 only as the comparator for effects.

From 2019 onwards the assessment of sprat stock was carried out by the ICES Herring Assessment Working Group for the Area South of 62° N (HAWG). The SSB for the combined Subarea 4 and Division 3.a area has been estimated by Stochastic Multi Species model (SMS). In 2009-2017 the mean SSB was 192,852t (ICES 2020a), smaller than previously estimated despite the larger assessment area. The SSB of 192,852t will be applied as the comparator for revised impingement assessments.

As noted by the Environment Agency, in 2013 ICES reported concerns over the potential depletion of local stocks, stimulating further research. Local, genetically distinguishable populations have been identified on the periphery of Division 3.a, along the Norwegian coast and likely the Swedish coast. Norwegian populations are not part of the assessment of sprat in the North Sea (ICES Advice on fishing opportunities, catch, and effort Greater North Sea ecoregion (ICES 2020a). Recent genetic studies of sprat in north European waters from the Bay of Biscay to Norway revealed the presence of three homogenous genetic groups: (a) Norwegian fjords; (b) Northeast Atlantic including the North Sea, Kattegat–Skagerrak, English Channel, Celtic Sea, and Bay of Biscay; and (c) Baltic Sea (McKeown *et al.,* 2020; Quintela *et al.,* 2020). Isolated sprat stocks around the Thames Estuary were not evident. These results informed the current ICES advice to combine sprat stocks in Division 3.a and Subarea 4 (Skagerrak, Kattegat, and North Sea) together with Celtic Sea, and Bay of Biscay. The application of 4c as an SSB comparator is therefore appropriate for Sizewell.

2.10 Sea bass

Comment: *"In the latest version of TR406* [version 6] *a personal communication is included from Lisa Readdy. 'Previously, Pawson et al 2007 recommended amended stock units for assessment purposes based upon some UK tagging studies. However, scientific knowledge about bass has advanced since these 2000-2005 studies and ICES continues to recognise the 4b-c, 7a and 7d-h stock unit as the most appropriate for bass stock assessment purposes based upon all of the available scientific evidence.' Citations are not provided for the work which means that Pawson et al 2007 is superseded. The EA review will be helped by informing us of all the literature used to come to our conclusions on the appropriateness of the scale of assessment".*

Further comments on version 2: The Environment Agency noted that *"The extra information is useful but seems to not yet be conclusive as to whether bass in the North Sea should be considered part of a separate sub-population to the Irish Sea (or elsewhere) due to small sample sizes of tagged fish – something the applicant acknowledges, but argues that this as a reason for not splitting the stock. HRA/EIA may require a different response to the same evidence than fishery management. (i.e. fishery management – we can't be sure they are separate stocks so treat as one, HRA – we can't be sure they are separate stocks so treat as separate).*

Natural England commented that: *"It is important to note we fully recognise the expertise of ICES as fisheries managers. We do feel that, when reviewing the best available evidence, the use of evidence for fisheries management purposes differs from the use of evidence for HRA/EIA/impact assessment purposes. In this case for this impact assessment we still query why the scale of assessment remains so large, given the work that CEFAS and Ifremer are currently undertaking to establish to what degree there is finer population structure and mixing of those within the existing stock. In this case it may be prudent, for the purpose of conducting an impact assessment for a project which will not be subject to the same adaptable management as commercial fisheries, to re-evaluate the use of ICES management units to contextualise the local impacts of SZC. While sea bass may currently represent the best example of this overarching point, this query also relates to each species where the use of ICES management units has been flagged as best available evidence, and the reason for overlooking evidence of smaller sub-populations with limited/unknown rates of mixing. Overall this reduces our confidence in the findings of the assessment".*

Environment Agency comments on version 3: "*We asked for more information on how the applicant had decided on the scale of assessment for sea bass and extra information has been provided. The extra information is useful but seems to not yet be conclusive as to whether bass in the North Sea should be considered part of a separate sub-population to the Irish Sea (or elsewhere) due to small sample sizes of tagged fish – something the applicant acknowledges, but argues that this as a reason for not splitting the stock. Splitting the stock into smaller scales of assessment would increase the proportion of fish in that stock impacted by entrapment in the cooling water intake.*

We would highlight that EIA may require a different response to the same evidence than fishery management. A more conservative approach by having a smaller scale of assessment may be required".

Response:

Natural England and the Environment Agency have both indicated a more conservative approach may be required in EIA/HRA than that adopted for fisheries management, incorporating smaller scales of assessment. Cefas' position remains that ICES stock units represent the best available peer reviewed scientific evidence and are the most relevant scale of assessment for contextualising effects and their implications on the stock status of sea bass. However, we acknowledge the potential for localised depletion of fish numbers in the vicinity of power station intakes and in consultation with Sizewell C stakeholders present a framework for determining local effects in Section 3 of this report. The following evidence lends support for the application of ICES stock areas for determining effects of the proposed development on stock status of sea bass.

The ICES stock unit for sea bass is Divisions 4.b-c, 7.a, & 7.d-h (Central & southern North Sea, Irish Sea, English Channel, Bristol Channel & Celtic Sea) (Figure 6). Sea bass is a highly mobile species with a homing instinct in many if not most individuals, and some 55% of tagged bass were recaptured within 16km of their original release position (Pawson et al., 2007). However, it is not clear how the authors dealt with captures of fish within the season (e.g. recaptured the week following tagging).

Summarising the history of previous tagging studies, the ICES Benchmark Workshop on Sea Bass (ICES 2018b) stated:

"*The sea bass inhabiting the Atlantic Ocean show a remarkable homogenous genetic structure although homing based on mark–recapture data suggests some level of population structure. Off the Strait of Gibraltar (9.a) there is evidence of introgression by the Mediterranean group. Sea bass inhabiting the areas Northern (4.b&c, 7.a,d–h) and Biscay (8.a&b)* [see Figure 1] *represent genetically one population unit. The current management in two stocks (Northern and Biscay) can be considered a conservative and correct measure* (ICES 2018b).

DSTs (Data storage tags) have been used to investigate individual behaviour patterns of adult sea bass between the North Sea and English Channel (Quayle et al., 2009) and between the Western Channel and Bay of Biscay. Movements were reconstructed using information about release and recapture locations alongside the temperature and depth of individual fish using hidden Markov models (e.g. Woillez et al., 2016). Five of 11 recaptured bass exhibited migrations of greater than 100 km between the central and southern North Sea and western English Channel, which supports previous studies (Thompson and Harrop, 1987; Pawson et al., 1987; 2007b) and provides evidence of migratory links between the North Sea and English Channel. Ifremer tagged sea bass with DSTs in the Iroise Sea from 2010–2012. Reconstructed tracks confirmed the highly migratory nature of bass, with three behavioural strategies: residency in the Iroise Sea; winter spawning migrations into the Bay of Biscay; and winter spawning migrations into the Western Channel/Celtic Sea. Site fidelity was found not only on summer feeding grounds as previously observed (Pawson et al., 2008), but also and for the first time, on winter spawning grounds. This indicated that sea bass populations may have a much finer spatial structure than supported by the genetics. However, sample sizes are very small, so it is difficult to generate robust estimates of the levels of migration between the current Northern and Biscay stocks."

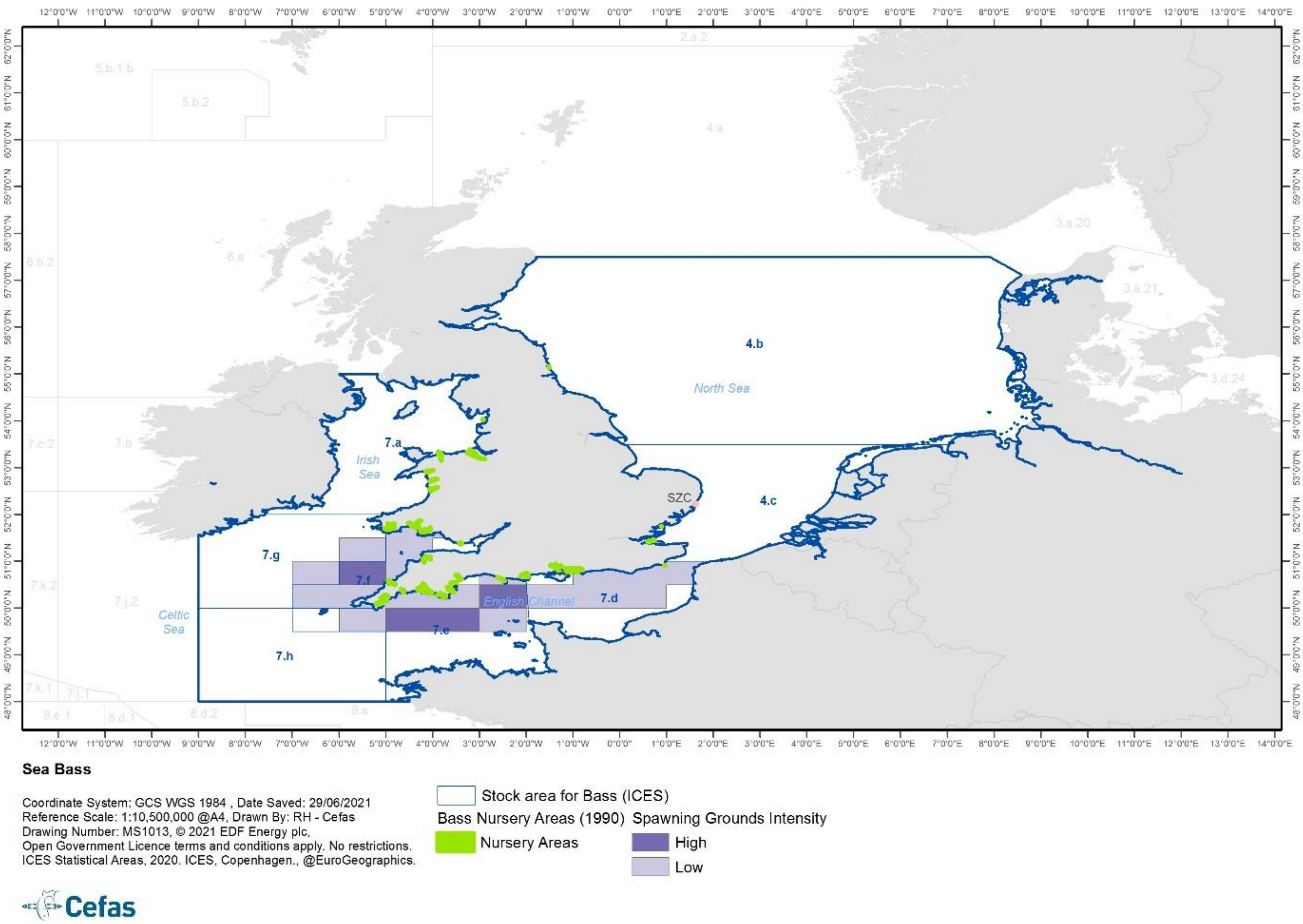

Figure 7. ICES stock area for sea bass showing spawning and nursery areas relative to Sizewell C.

To explore the degree of isolation between Northern and Biscay stocks further, ICES launched two large tagging programmes. The first programme (C-Bass) is being led by the Cefas (CEFAS, 2018) and has tagged almost 200 sea bass with electronic data storage tags (DSTs). The BARGIP study is being led by Ifremer (France) and has released 1,220 fish with DSTs at ten locations in the Channel and Bay of Biscay (ICES 2018b).

Preliminary results of these studies indicated that "*adult bass can undertake very large-scale migrations. Fish tagged in 4.c exhibited two migration patterns: one that remained in the North Sea; and a second that involved long migrations as far as the Irish Sea. Fish that were tagged in May in 4.c were in spawning* *condition, suggesting the presence of spawning ground in the North Sea. Bass tagged in area 7.e appeared to remain in the English Channel, but individuals tagged in the Irish Sea could move between the Northern and Biscay stocks*" (ICES 2018b).

"Sea bass movement between ICES stock units is plausible, as evidenced from some individuals tagged with DSTs, and fidelity to both spawning and feeding grounds may provide evidence of fine population structure that was identified from genetics. However, it is not possible to quantify the proportion of fish migrating between the stocks currently due to the small numbers of fish tracks analysed. As further DSTs are analysed, it may be possible to quantify exchange between stocks [to clarify this is between Northern (4.b&c, 7.a,d–h) and Biscay (8.a&b) stocks]*, so the next benchmark should consider how exchange between stocks should be incorporated into the assessment process*" (ICES 2018b).

In reviewing the available information on the distribution of the stock in the central and southern North Sea, Irish Sea, English Channel, Bristol Channel, and Celtic Sea (bounded by ICES divisions 4.b–c, 7.a, and 7.d–h) ICES benchmark discussions primarily focused on whether the stock area should include bass in a larger area than the one currently adopted. Based on a review of available evidence the benchmark workshop decided to retain the current stock areas which were described as 'conservative'. There are no suggestions of a reduction in the bass stock unit relevant to the Sizewell C assessments.

In response to comments in relation to narrowing the assessment area in an HRA context the latest position of ICES indicates no merit in narrowing the assessment area. Tagging studies are underway to determine both fine scale sub-population structure and wide scale dispersal. However, where sub-populations exist, they still form part of the wider stock (= population), as defined by the MMO (2020).

There is no justification to narrow the stock assessment area from that accepted by ICES when considering the sustainability of the population. However, we note the local level concerns raised by stakeholders in an EIA or HRA context. In an HRA context, sea bass are not an Annex II species, therefore local level HRA concerns pertain to indirect effects and the availability of sea bass as prey items for designated species. Section 3 considers the potential for local effects and has been developed in response to stakeholder requests and feedback.

Response to Natural England Deadline 2 submission [REP2-153]:

SZC Co. responded to **Natural England's** concerns at Deadline 5 (**Appendix K** Doc Ref. 9.54 []). Information regarding the latest position on plaice is provided in this section.

The sea bass stock unit incorporates both Sizewell C and Hinkley Point C developments. Therefore, the evidence provided within the recent Hinkley Point Inquiry including latest tagging data showing wide scale migratory behaviour and mixing at spawning grounds equally applies at Sizewell[2]. Bass is a migratory species. Juvenile fish spend the first 2-3 years of life in estuaries and inshore waters, and upon maturation begin to carry out seasonal migrations between inshore foraging areas in summer and moving offshore to spawn during February to July. During seasonal migrations between spawning and foraging areas bass may travel very long distances. Four selected tracks from the Cefas C-Bass project are provided in Figure 8 showing the distances of migratory movements and mixing of adult sea bass at spawning grounds. Two individuals tagged near Lowestoft on the east coast of the UK in division 4c are shown. One individual migrated from 4c across the English Channel to known spawning areas of the south west coast in divisions 7g and 7f before returning to 4c.

As stated above, the ICES Benchmark Workshop on Sea Bass (ICES 2018) focused on whether the stock unit for sea bass should be increased to incorporate the Biscay stock:

"The sea bass inhabiting the Atlantic Ocean show a remarkable homogenous genetic structure although homing based on mark–recapture data suggests some level of population structure. Off the Strait of Gibraltar (9.a) there is evidence of introgression by the Mediterranean group. Sea bass inhabiting the areas Northern

[2] Proof of Evidence of Dr Simon Jennings Appendix E Biology of Relevant Species https://ea.sharefile.com/share/view/s311eef0a189a4e65b4f5243233691bfa

(4.b&c, 7.a,d–h) and Biscay (8.a&b) [see Figure 1] *represent genetically one population unit. The current management in two stocks (Northern and Biscay) can be considered a conservative and correct measure".*

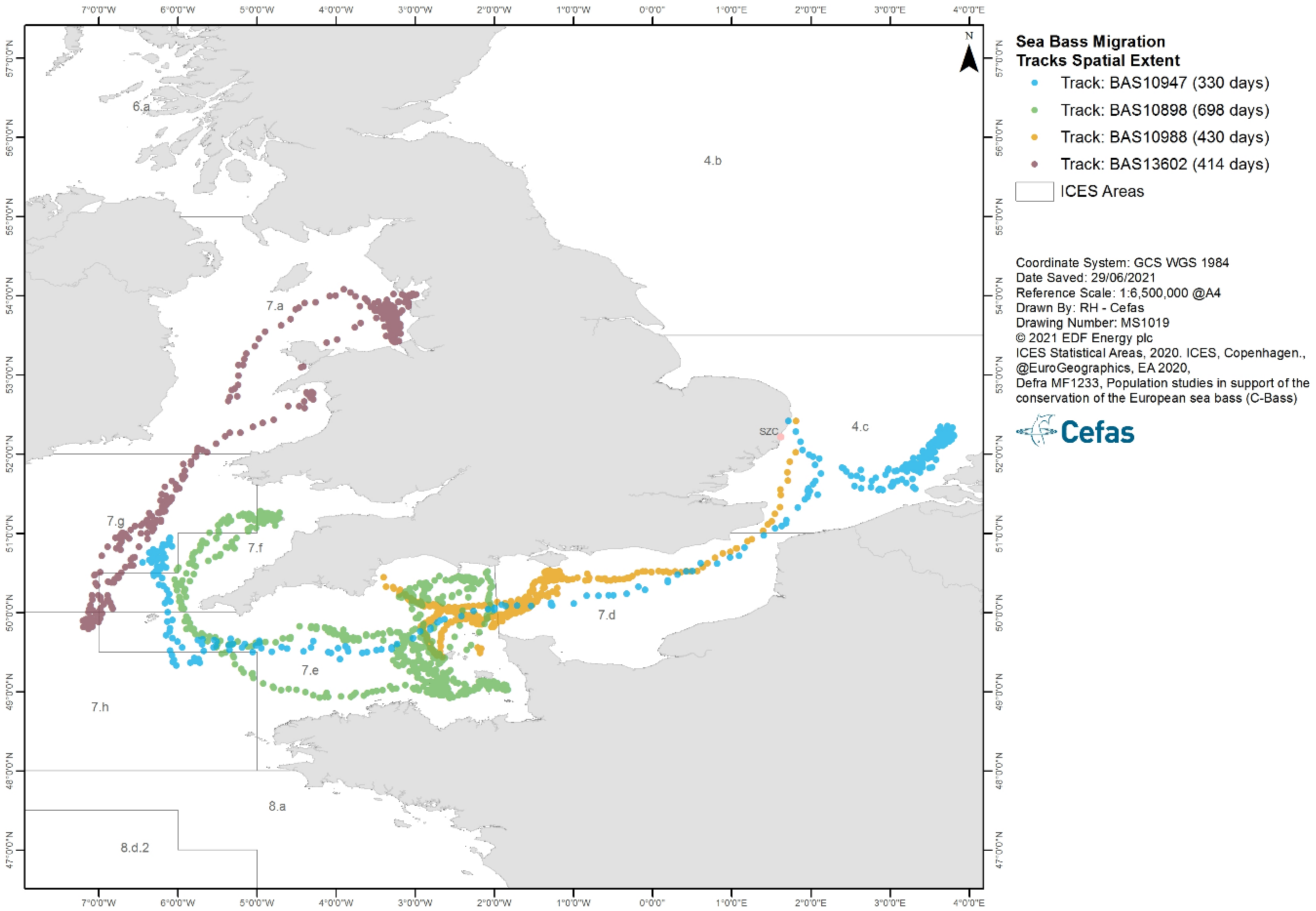

Figure 8. A selection of tracks from four adult sea bass during annual migrations determined from data storage tags employed during the C-Bass project (Ewan Hunter, pers. comm.).

The Cefas is aware of studies showing seasonal site fidelity in some life stages of sea bass. However, in light of the available evidence, the Cefas sees no justification to reduce or deviate from the ICES stock unit, which is described as a "conservative and [the] correct measure".

2.11 Sand Goby

Comment: ***"****The possibility of smaller scale populations of sand goby is not considered. Genetic differentiation has been found between populations in the Schelde estuary and offshore. Refer to Pampoulie et al. (2004) and discuss the potential for final scale population structure in sand goby and how this could be affected by entrainment (and combined) entrapment losses. Pampoulie et al. (2004) Evidence for fine-scale genetic structure and estuarine colonisation in a potential high gene flow marine goby (Pomatoschistus minutus). Heredity 92, 434–445".*

Further comments on version 2: The Environment Agency commented that ***"****Dispersal potential for sand goby is stated as >10km, but the '>' is not quantified (is it 11km, 20km, 100km?). Given that the length of coastline over which the stock estimate has been calculated extends over 250 km of coastline, this large scale of assessment still does not seem appropriate. Can sand goby from the Norfolk coast and Kent both contribute to sand goby numbers in Sizewell Bay?"*

Response:

The sand goby (*Pomatoschistus minutus*) is an egg brooding species with a pelagic stage duration of about one month and larval dispersal potential greater than 10 km (Gysels et al., 2004; Riley, 2007). It should be noted that gobies are a short-lived fast maturing species. Larval dispersal distances of 10 km (each breeding event) along the distribution range would result in widespread genetic mixing. This phenomenon is reflected in genetic studies that have revealed limited genetic differentiation with a weak pattern of isolation-by-distance recorded throughout the entire distributional range of this species in the Atlantic (Gysels et al., 2004). As such the degree of genetic mixing extends well beyond the region from Norfolk to Kent.

Genetic studies of allozymes in fish collected off Belgian shores did not reveal clear differentiation between individual samples between estuarine, coastal and offshore samples (Gysels et al., 2004; Pampouille et al., 2004). However, a separate analysis of microsatellite loci revealed the existence of two spatially separated breeding units "of a complex and dynamic spatiotemporal structure" (estuarine and coastal). These breeding units support their identity by spawning in the different retention zones (estuarine and coastal) but are still connected by a low number of migrants (Pampuoile *et al*., 2004). The authors avoided to use the word "population" to define these breeding units, as "the gene flow appears to be sufficiently large to swamp any potential for large genetic differences". Therefore, both entities represent sub-populations so parts of the same stock.

In the next paper published in the same journal (Gysels et al., 2004), the authors noted that the Schelde (Scheldt in English) estuary (first breeding unit) is heavily polluted while the level of pollution decreases towards the offshore areas (where the second breeding unit was defined) and "a number of studies have revealed differential mortality of distinct genotypes when exposed to heavy metals". Therefore, there is some possibility that such a genetic differentiation between two breeding sites might be a result of the different survival of spawners with different genetic loads (low- and high fitness genotypes) after larval settlement. An analogy is Darwin's description of peppered moth evolution with higher survival of black morph in polluted areas with blackened trees, and pale morph faring better in clean areas with normal trees because of selective predation by birds. Such a problem of environmentally-induced selective mortality of particular phenotypes (so genotypes), is more likely to appear in a resident benthic species, where juveniles and adults do not carry out long-distant migrations and remain in more or less the same habitat the entire life. All connections between different parts of population/stock range occur mostly through larval transport ensuring genetic connectivity and distribution of recruits over this entire range.

Therefore, the fine-scale genetic structure revealed in this species is likely to be an artefact caused by differential survival in the different habitats, but even if it is not, the genetic flow due to larval transport (Gysels et al., 2004) and migrations (Pampuoille et al., 2004) is so intensive, that for assessment and management reasons such closely connected entities should be considered as parts of a single population.

In the open coastal waters of Sizewell such fine-scale genetic structuring and the presence of sub-populations is not expected.

3 Local effects assessment

3.1 Background

Sizewell C stakeholders have indicated that in principle they agree with the population level assessment methodology for determining effects on fish at the stock level but questioned the application of ICES stock units for assessing potential effects of a coastal power station on local populations. The concern pertains to the geographical scale of ICES stock units resulting in impacts from the station having small perceived effects on SSB and an inability to determine local level effects should they occur.

Cefas' position remains that ICES stock units are the most relevant scale of assessment for contextualising effects and their implications for stock status. The Cefas position is also consistent with that of the Marine Management Organisation (MMO). The MMO defines a stock as:

"*A fish stock refers to a fish population that is isolated from other stocks of the same species.*"

(MMO, 2020).

The MMO in their Deadline 2 Submission to the Planning Inspectorate determined at paragraph 2.4.7 [REP2-140]; *"The MMO conclude that the use of ICES stock areas for commercial fish species represents the current best scientific evidence available. There is currently no robust information that would support use of more local stock areas in the assessment".*

There are no isolated fish populations at Sizewell, fish live and move in an open coastal environment with most species undertaking wide spatial migrations throughout the year and over wider geographical areas on longer timescales in the course of their full life history. As such, ICES stock units, which take into account the full life history of the fish, represent the best available evidence for assessing the impacts of the proposed development in relation to stock sustainability. A Topic Note on **Equivalent Adult Values (EAVs) and Stock Sizes** has been prepared for Deadline 6 (Doc Ref. 9.63) outlining the position of SZC Co. However, to investigate stakeholders concerns as to whether there may be effects on the abundance of fish at smaller spatial scales due to localised depletion, further complementary analysis has been undertaken.

The potential for localised effects is pertinent in an HRA context where impacts leading to direct or indirect likely significant effects (LSE) need to be considered. For example, the effects on any fish species listed under Annex II of the Habitats Directive must be considered in relation to the Special Area of Conservation (SAC) they are a designated feature of. There are no Annex II fish species designated in the SACs adjacent to the proposed development. Assessments do consider the SAC from which wide-ranging or migratory Annex II species impinged at Sizewell are most likely to originate from (e.g. allis shad in Section 0). The most pertinent HRA consideration of local effects of the proposed development is that of indirect effects on fish as prey items for designated species. Prey species of designated SPA, Ramsar and SAC species of relevance to the proposed development are detailed in BEEMS Technical Report TR431 and include the pelagic species sprat, herring and anchovy, epi-benthic species such as plaice, Dover sole, flounder and gobies and demersal species whiting and juvenile sea bass.

In addition to HRA considerations, the Environment Agency has raised concerns regarding the potential for the proposed development, acting in-combination with Sizewell B, to cause a deterioration in the WFD Transitional Fish Classification Index (TFCI) of the Alde & Ore water body. The concern is primarily in relation to smelt but the Environment Agency also identified the potential for changes in the abundance of herring, sea bass, Dover Sole, thin-lipped grey mullet and twaite shad to influence the status of the fish classification in the water body. **BEEMS Scientific Position Paper SPP108** [AS-238] specifically addresses these concerns and shows that the proposed station is highly unlikely to cause a decline in status of the Alde-Ore waterbody fish status. However, Section 3.6.2 this report considers the potential for the proposed Sizewell C station to reduce the population of smelt in the Alde and Ore Estuary.

Version 3 of this report, submitted as part of the **Supplementary Fish Pack in January 2021** [AS-238] presented a simple local effects assessment to contextualise the magnitude of local depletion focusing on prey items and species of importance for the WFD. The aim of the approach was to provide an additional tool in the evidence toolbox that is independent but complementary to the assessments of the effects of Sizewell C on the sustainability of fish populations presented in **BEEMS Technical Report TR406.v7** [AS-238]. Consultation meetings were held with the Environment Agency and Natural England on the 12 March 2021 to present the model and gauge further feedback. In response to comments received prior to Deadline 2 Written Representations, SZC Co. provided and updated version of this report (version 4 released April 2021). The updated version was based on comments during consultation meetings and written responses provided prior to Deadline 2. Version 4 was provided to the Environment Agency, Natural England the Eastern IFCA and MMO and included:

- Sizewell B full (worst-case) operational abstraction (from $51.5m^3s^{-1}$ to $56.7m^3s^{-1}$);
- More information and sensitivity testing of the underlying assumptions and limitations of the conceptual model;
- A simple refinement to the assumption of homogenous distribution in the water column for epibenthic and demersal species.

In addition, a copy of the spreadsheet calculation used to determine local effects was provided to the stakeholders and titled 'SPP103.v4 Local Depletion Spreadsheet Model (version 1)'.

Stakeholders including in their Deadline 2 Written Representations welcomed the addition of the local assessment. However, a number of additional comments have been raised. Specific comments have been responded to formally in SZC Co. responses to Written Representations. This report aims to increase the confidence in the assessments of local depletion and provide the evidence base for formal responses.

3.1.1 Deadline 2 stakeholder comments addressed in version 5 of this report

The MMO in their Deadline 2 Submission to the Planning Inspectorate determined at paragraph 2.4.7 [REP2-140], emphasis added;

"***MMO advises that further sensitivity analysis should be undertaken and provided within Report SPP103 [AS-238], to examine the effectiveness of the LVSE design and FRR system.*** *The MMO supports the evidence that the Applicant has put forward in Report SPP103 [AS-238] in relation to the appropriate scale of assessment area for the 12 fish species. The MMO broadly supports the findings of the local impact assessment which reinforces the findings of previous assessments of the potential local impacts on fish populations."*

A further comment was raised by the **Environment Agency** [REP2-135], that raised concerns over the degree of mitigation afforded by the LVSE intakes which would have implications for the local depletion assessment in an EIA and WFD context. The suggested solution was *"A precautionary LVSE factor should be applied for the Local Area Effect model."*

In response to these comments, version 5 of this report, assumes no benefit from the LVSE for all species in terms of a LVSE intercept area or the reduced velocities at face, only the capped head factor is applied for pelagic species (Section 3.3.5). In response to comments on the effectiveness of the FRR mitigation, the model applies both the predicted FRR efficiency factor applied in the **Marine Ecology and Fisheries Environmental Statement (ES)** [APP-317] (detailed in **BEEMS Technical Report TR406.v7** [AS-238]) and an uncertainty range of FRR effectiveness for each species produced by the Environment Agency as part of the Hinkley Point Inquiry (Section 3.3.5.3).

The **RSPB/SWT** [REP2-505] and **Natural England** [REP2-153] have commented about relating the scale of local depletion to natural variability, pointing to evidence that reductions in prey availability can have implications on breeding success. The **RSPB/SWT** [REP2-505] noted that little tern feed their chicks with small prey that could be susceptible to entrainment. Prey items include early life-history stages of fish and crustaceans. In response to this comment, an assessment of local depletion of larval fish and early juvenile stages has been completed. If should be noted that as part of the **ES** [APP-317], para. 22.6.220 onwards] an assessment of localised depletion of zooplankton due to entrainment was completed (further details are provided in **BEEMS Technical Report TR318** [APP-324]). The effects on entrainment on zooplankton was considered to be minor. In a similar vein, the **RSPB/SWT** [REP2-505] raised concerns that indirect effects on birds due to changes in prey availability may not be fully considered when losses of juvenile fish are converted to equivalent adult vales (EAV). The local effects assessment here is independent of the population level effects and does not apply EAVs. Therefore the local depletion assessment of small prey items subject to entrainment in version 5 of this report, along with assessments made in the **ES** [APP-317], are provided to address these concerns.

Comments from **RSPB/SWT** [REP2-505] and **Natural England** [REP2-153] also pertained to the potential for contamination of fish returned from the FRR to result in contamination of prey for opportunistic seabirds including gulls. These comments have been addressed in formal responses, however, the FRR wash water would not be chlorinated, therefore, impinged biota would not be subjected to TRO exposure.

Additional specific comments are addressed within the relevant sections of this report.

3.2 Scale of local effects assessment

In an open coastal environment, the first question to address is the appropriate scale at which to consider localised depletion and how to delineate the system.

Sizewell B cooling water infrastructure is located inshore of the Sizewell-Dunwich Bank within the Greater Sizewell Bay (GSB). Sizewell C intakes and outfalls would be located approximately 3km offshore, seaward of the Sizewell-Dunwich Bank in deeper water.

The smallest scale of assessment is the Greater Sizewell Bay from which Sizewell B abstracts water, and the tidal excursion beyond the Sizewell-Dunwich Bank from where Sizewell C would abstract water.

Water from the GSB and tidal excursion exchanges with the wider area, first in ICES Statistical Rectangle 33F1 and, at a wider scale in ICES Statistical Area 4c (Figure 9). ICES rectangle 33F1 extends from Lowestoft to the north of Sizewell to just above Felixstowe to the south (Figure 10).

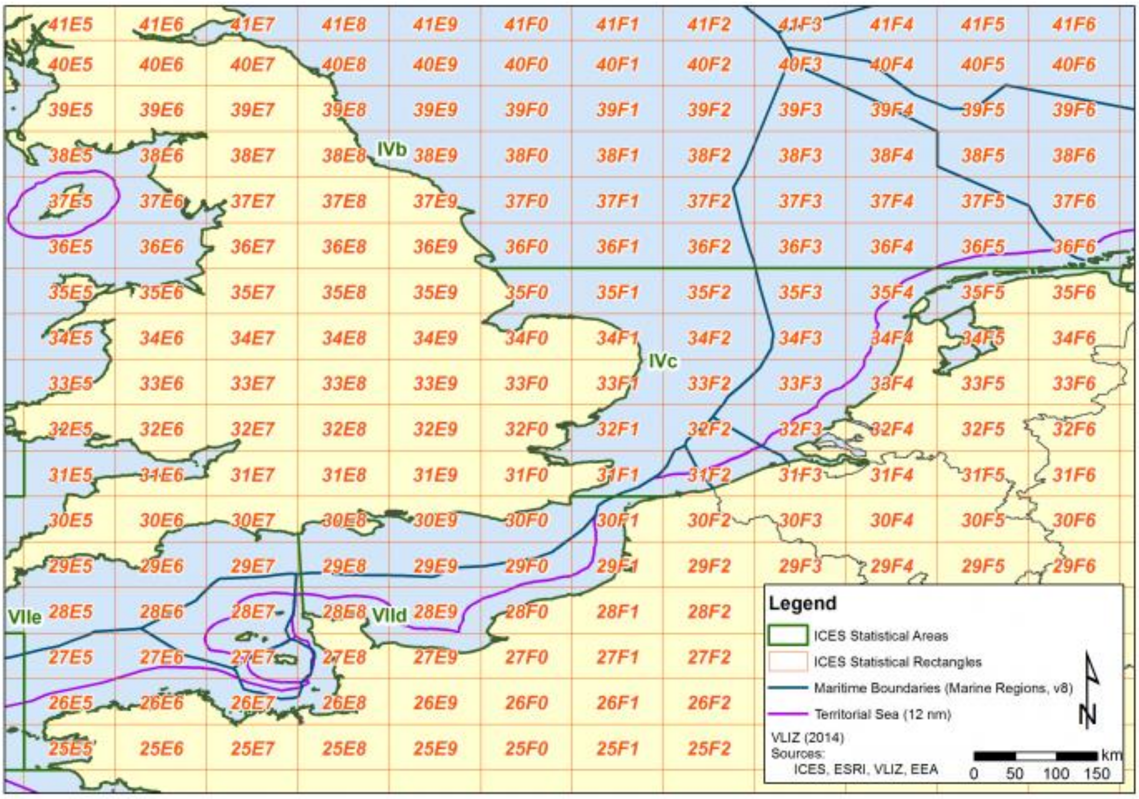

Figure 9 ICES statistical areas.

To determine the effects of entrainment on phytoplankton populations, from Sizewell B and C, BEEMS Technical Report TR385, determined the approximate volume of water within the influence of the power station during a tidal cycle. Based upon a current meter (S2) deployed near the proposed Sizewell C intake locations, a progressive vector diagram (PVD) method indicated that the north – south tidal excursion is approximately 15.9 km in each direction, and 1.4km east – west during spring tides. The trajectory of the tide flows both north and south, thus the tidal volume represents a body of water 31.8 km long and approximately 2.8km wide. For comparison, a harmonic analysis was conducted on the same current meter data (BEEMS Technical Report TR233) and provided similar results to the PVD method. The surface area, average depth and estimated volume of the assessment cells is provided in Table 3.

Sizewell B forms part of the baseline against which effects on fish from the proposed Sizewell C are assessed (and against which the current WFD fish status is established). The assessment of local effects considers both stations acting in isolation and cumulatively thereby providing the most precautionary and transparent assessment of the impacts of Sizewell B and Sizewell C acting alone and in-combination. The potential for localised depletion of fish is considered here at the scale of the GSB and tidal excursion, 33F1 and 4c.

Focus on the local effects assessment is on the smallest scale of assessment, the GSB and tidal excursion where the model is less susceptible to the assumptions.

Table 3. Spatial area, average depth, and approximated volume of the assessment cells for local effects.

Assessment cells	Effect assessment	Surface area (ha)	Average depth (m)	Volume (x10^8 m^3)
GSB	SZB	4,120	8.8	3.64
Outer tidal excursion	SZC	7,081	13.9	9.85
GSB + tidal excursion	SZB + SZC	9,670	12.5	12.1
ICES 33F1	SZB+ SZC	140,595*	23.2	326.8
ICES 4c	SZB + SZC	6,421,433	24.6	15,816

*33F1 is truncated as it intersects the east coast, a full ICES rectangle is approximately 380,000 ha.

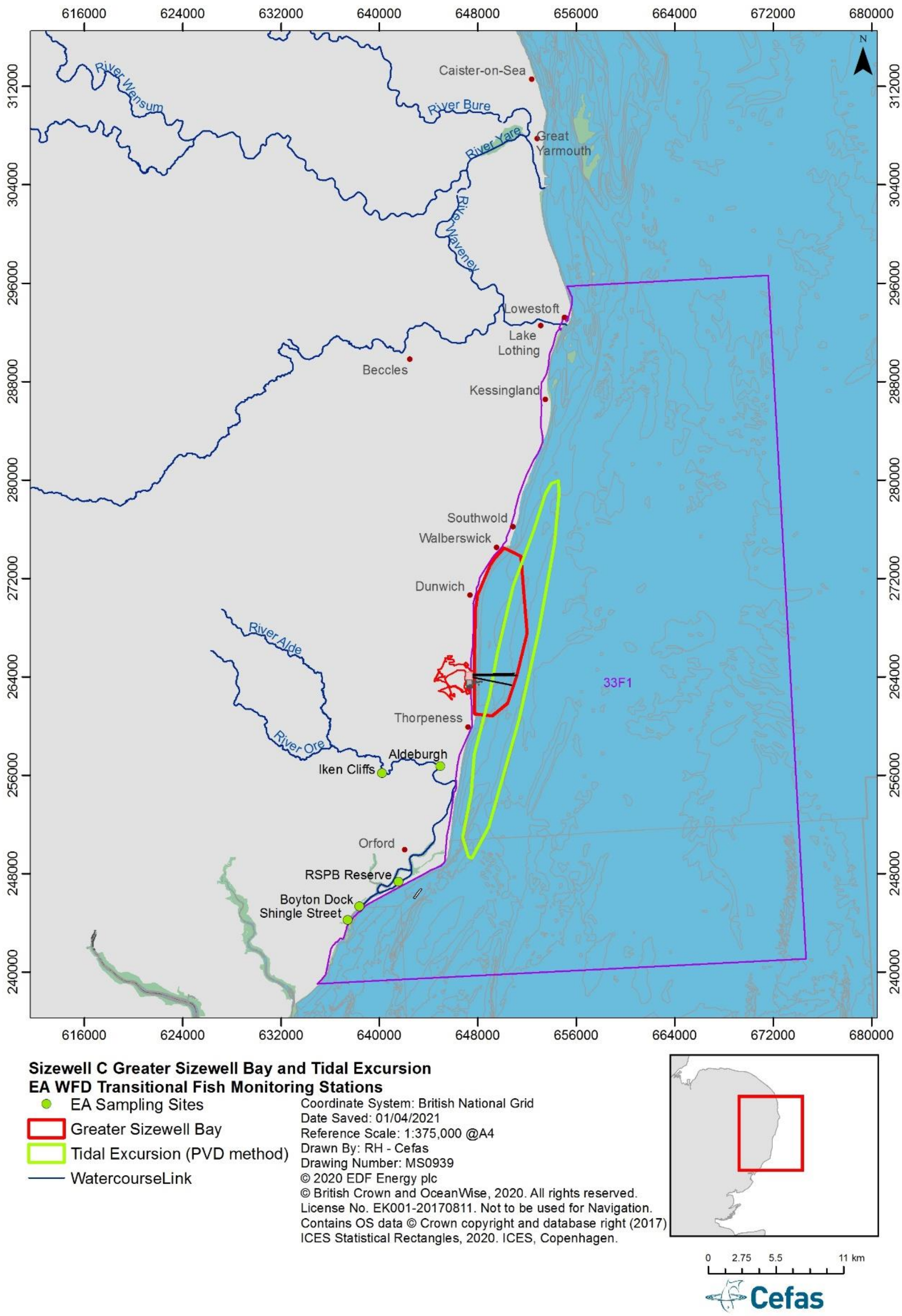

Figure 10. Scales of assessment for localised effects showing the GSB (red), the outer tidal excursion (green) and ICES Statistical Rectangle 33F1. ICES Statistical Area 4c extends beyond 33F1. The location of the Environment Agency TFCI monitoring stations in the Alde & Ore waterbody are also indicated.

3.3 Parameterising local effects

Having defined the assessment cells, the next step is to attempt to parameterise a conceptual model for assessing local effects of the Sizewell C development on fish.

It is not feasible to parameterise a model in an open coastal environment with the complexities of fish dynamics and behaviour, resulting in diurnal, seasonal and life-history changes in distribution and abundance, for each individual species. Therefore, the conceptual model makes the following assumptions:

- Fish are evenly distributed horizontally throughout the domain. The model makes precautionary assumptions to account for the vertical distribution of different species groups relative to the intake infrastructure.
- Fish density (in the absence of abstraction) remains constant through the assessment period i.e. no mortality, recruitment, or migration into/out of the domain.
- Fish behaviour is only considered in a limited capacity; vertical distribution in the water column (Section 3.3.4), in relation to the abstractions risk factor from the intakes (Section 3.3.5).
- Fish immigration and emigration rates between assessment cells are proportional to conservative rates of daily tidal exchange.
- ICES statistical Area 4c is considered a hard boundary i.e. there is no exchange/ replenishment of fish beyond this area.
- Assessment cells are not overlapping, i.e. the effects of impingement are concentrated at the local level with effects on the wider area a result of net losses due to exchange across the boundaries.

The results must therefore be interpreted within the above established assumptions and recognising the limitations of the approach. The purpose of the approach is not to quantify a precise local depletion figure for a given species, rather to contextualise the predicted magnitude of depletion. The magnitude of depletion can then be considered in relation to prey availability in an HRA context or against WFD concerns to determine the potential for significant effects. In terms of the WFD TFCI, losses at the population level are an important consideration.

The validity of the underlying assumptions and the sensitivity of the results to re-parameterising the underlying assumptions is considered in Appendix B.

3.3.1 Volumetric assessment

In this simplified model, local effects are based on volumetric assessments of abstraction relative to processes of fish replenishment (immigration/emigration). In the absence of modelling specific behaviour in open coastal waters, fish immigration and emigration from the assessment cells is assumed to be approximately proportional to the rate of tidal exchange. Tidal exchange is therefore a key parameter in the assessment.

A typical value for exchange rate coefficients in partially mixed estuaries is 5% volume exchange on each tide (Dyer, 1979) i.e., 10% per day. As a general rule, the exchange volume at coastal sites on the east coast is approximately 10% over a 12-hour tidal period (i.e., ~20% per day) (Environment Agency, 2011). Assessments of effects on zooplankton (**BEEMS Technical Report TR318** [APP-324]) and phytoplankton (**BEEMS Technical Report TR385** [APP-325]) at Sizewell have incorporated a conservative 10% daily volumetric exchange rate. (The smaller the volumetric replenishment the more conservative the assessment).

A 10% daily exchange of fish has been incorporated as the starting point for assessments between the GSB and tidal excursion and 33F1, and between 33F1 and 4c. The sensitivity of the results to changes in exchange rate is provided in Section 4.6.1.

It should be noted that the greater the exchange rate the lower the local effects due to dilution. However, as greater exchange rates maintain the local density, total impingement also increases with higher exchange rates. Conversely, very low replenishment rates between the assessment cells would result in the model predicting high local depletion. This is because within assessment cells the model assumes homogenous horizontal distribution of fish. In the case of fish demonstrating spatially restricted movements, minimising replenishment between the local assessment cell of the GSB and the wider 33F1, it is highly unrealistic to simultaneously assume equal distribution within the assessment cell i.e., equal change of impingement at each subsequent time step. For species with highly restricted movements, it is feasible that increased rates of depletion could occur at highly localised areas near the head with an inverse density gradient radiating from the intakes. This point is considered further in relation to comments made regarding smelt replenishment rates by the **Environment Agency** [REP2-135] in Section 3.6.2.

3.3.2 Abstraction

Sizewell B operating at full capacity abstracts 56.7m^3 s^{-1} (cumecs) from the GSB (BEEMS Scientific Position Paper SPP111). Sizewell C operating at full capacity would abstract 131.86 cumecs from the tidal excursion. The combined daily abstraction volume is 188.56 cumecs from the GSB + tidal excursion. Daily abstraction as a percentage of the assessment cell volumes (Table 3) and tidal exchange volume is provided in Table 4.

Local effects are considered within each assessment cell under different operating scenarios (see Table 5). The effects of abstraction are concentrated in the smallest spatial scale, whereas wider effects are the result of reduced net exchange of fish between cells due to impingement losses. Effects in 33F1 are considered as the area beyond the GSB and tidal excursion (i.e., the volume of 33F1 – the volume of GSB and tidal excursion), likewise the effects on 4c subtract the area of overlap with 33F1. This approach allows the dilution of effects away from the impact to be observed.

ICES 4a has been set as the final delineation, with no wider exchange. Therefore, all effects are concentrated within this area. For many species, this is conservative as they have wider ranges (Table 1). The Environment Agency commented about the potential for more localised sprat sub-populations [REP2-135], and this is addressed in Section 2.9.

The assessment illustrates localised depletion at a fine spatial scale. However, it should be noted that depletion is expressed as an average within each assessment cell. Depletion would be tidally dynamic and equivalent to an inverse density gradient, reducing with distance from the intakes.

Table 4. Daily abstraction volumes as a percentage of the assessment cell and daily volumetric exchange, assuming a conservative 10% exchange rate, under different operating scenarios.

Station	GSB		Tidal excursion		GSB + tidal excursion	
	% of cell	% of exchange	% of cell	% of exchange	% of cell	% of exchange
SZB	1.35	13.5				
SZC			1.16	11.6		
SZB + SZC					1.35	13.5

3.3.3 Fish density and distribution assumptions

The initial density of fish is set at 0.001 ind. m^3, however, the depletion assessment is expressed as a percentage change and is, therefore, independent of the starting density. This is an important distinction as the % depletion is consistent irrespective of abundance.

The calculation assumes homogenous density throughout the domain (horizontal density). The assumption of homogenous density becomes increasingly invalid as the scale of the assessment increases. Therefore, the local depletion assessment is most appropriately applied for the smallest assessment cells; the GSB and/or tidal excursion. For some species such as sea bass, the assumption of homogenous distribution within the GSB and tidal excursion has been shown to be incorrect with greater abundance of juvenile sea bass located within the Sizewell-Dunwich Bank. Therefore, at the localised scale of the GSB and tidal excursion, the existing Sizewell B would have a greater effect on depleting sea bass numbers than the proposed Sizewell C station (this is discussed further in Section 3.5).

In version 5 of this report the assumption of vertical distribution of fish within the water column has been refined (Section 3.3.4).

3.3.4 Fish vertical distribution relative to intake infrastructure

In the initial volumetric assessment (version 3 of this report submitted to PINS as part of the supplementary fish pack in January 2021 [AS-238]), fish were assumed to be homogenously distributed throughout the water column and all species groups had equal probability of abstraction. The assumption of homogenous distribution has been considered further in version 4 and herein.

The vertical distribution of fish in the water column relative to the intake infrastructure influences the abstraction risk. A simple correction factor has been applied to better represent the vertical distribution of different pelagic, demersal and epi-benthic species groups relative to the intakes.

At Sizewell B the intakes are situated in 9m of water. The vertically capped intake apertures are 3m high and extend from 1.5m - to 4.5m off the seabed. The abstraction risk zone represents 1/3 of the water column from near the bed to mid-water.

At Sizewell C the intakes would be in approximately 13m water depth. The intake apertures would be vertically capped and 2m high, extending from approximately 1.5m to 3.5m off the seabed. The abstraction risk zone therefore represents 15.4% of the water column.

3.3.4.1 Distribution of pelagic species

Pelagic species are known to change their vertical distribution within the water column throughout the day. For example, schools of predominantly sprat (the species impinged in the greatest numbers at Sizewell B) have been shown to be present at the surface in the morning then descend to midwater, returning to the surface in the evening before dispersing at night (Whitton *et al.,* 2020).

As an average position throughout the day, pelagic species are assumed to be equally distributed throughout the water column. Therefore, pelagic species have an equal probability of being impinged i.e. the proportion of fish within the abstraction risk horizon is equal to the proportion of the water column the intake apertures occupy. An ‘abstraction risk factor’ of 1.0 has therefore been applied (Table 5).

Acoustic surveys off Minsmere, Sizewell and Thorpeness from the coast to 20m water depths during daylight hours indicate the assumption of even vertical distribution is likely to be precautionary with a higher proportion of pelagic species in the surface layers. In winter, 56% (2015) and 36% (2016) of pelagic species were observed in the top 2-5m water depth, whilst in summer 44% (2015) and 27% (2016) of pelagic fish were in the top 2-5m of water (BEEMS Technical Reports TR359 and TR381).

3.3.4.2 Distribution of larvae and juveniles

The offshore location of the Sizewell C cooling water intakes in deeper water is in part designed to reduce the entrapment of juvenile and larval fish stages. A number of studies point to subsurface peaks in abundance of larval stages. For example, Maes *et al.,* (1999) showed that juvenile herring and sprat were 2 to 3 times more abundant in the top 4m of surface waters than at the bottom layers in the Zeeschedlde Estuary during both day and night. This is consistent with the acoustic surveys of pelagic fish during the day off Sizewell as described above.

To account for the greater abundance in the surface layers, the calculation makes an assumption that two-thirds of the density of larval and juvenile fish are in the top half of the water column and one-third is in the bottom half where the intakes of Sizewell B and Sizewell C are situated. This results in an abstraction risk factor of 0.67 (Table 5).

To note unlike the adult stages, no benefit of the capped head is assumed (Section 3.3.5.1). This is considered appropriate for the early juvenile stages, but becomes increasingly precautionary as the length and swimming capabilities of the juvenile fish increases.

3.3.4.3 Distribution of demersal species

Demersal and epi-benthic species have an affinity for the seabed and deeper depth horizons. Therefore, the assumption of homogenous vertical distribution in the simple volumetric assessment may lead to an underestimate of their risk of impingement.

Cod tagged in the southern North Sea demonstrate seasonal variability in vertical position in the water column. From November to March, cod spend 25% of the time high in the water column or referencing the seabed, whereas from May to September, 95% of the time is spent very close to the seabed. Across the North Sea, tagged cod spent over 55% of their time within 5m of the seabed (Hobson *et al.* 2007). Data on the vertical distribution of cod provides the most detailed information available for the southern North Sea and has been used as a proxy for depth strata utilisation in gadoid and epi-benthic species. The vertical distribution of cod was rescaled from the seabed to the depth of water at the intakes at Sizewell B (9m) and Sizewell C (13m) based on data provided in 2.5m bins in Hobson *et al*., (2007) assuming equal distribution within each 2.5m depth bin (Figure 11).

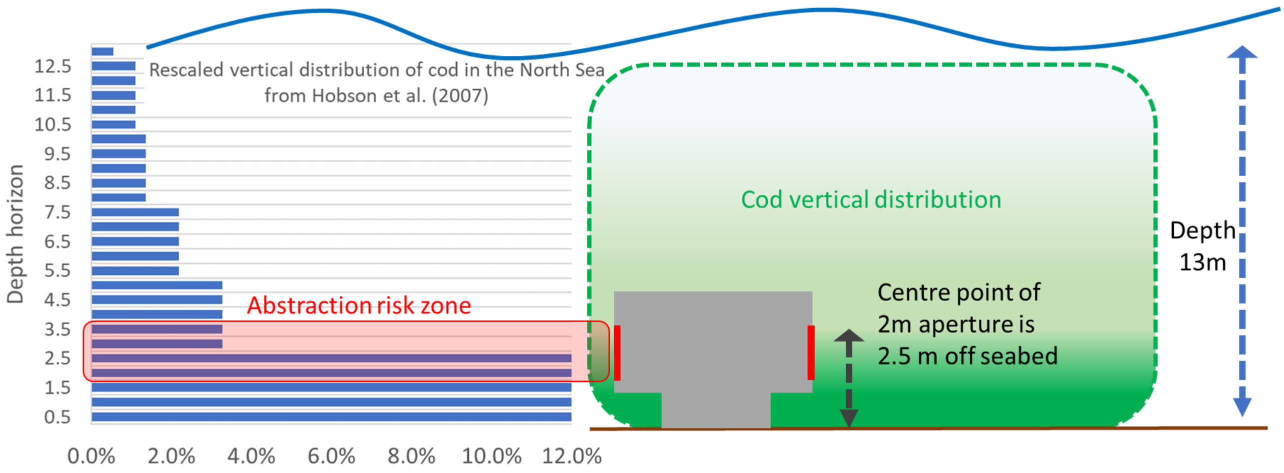

Figure 11. Schematic of the approximate vertical distribution of cod at 0.5m depth horizons at the location of the Sizewell C intakes demonstrating the abstraction risk zone.

At Sizewell C, approximately 30.5% of cod would be expected to be within the depth horizon of the intake apertures. The apertures represent 15.4% of the water column, therefore an abstraction risk factor of 1.98 has been applied (Table 5). This abstraction risk factor effectively doubles the likelihood of impingement in the simple volumetric model.

At Sizewell B, approximately 48.6% of cod would be expected to be within the depth horizon on the intake apertures. The apertures represent 33.3% of the water column, therefore an abstraction risk factor of 1.46 has been applied (Table 5). This abstraction risk factor is considered appropriately precautionary for cod, and possibly other gadoids such as whiting. It has not been applied for all demersal species as it may be overly precautionary especially given the assumptions relating to the vertical capped head mitigation offering no benefit to demersal species (Section 3.3.5.1), and the assumed mitigation from the low abstraction velocities achieved by the intake heads (Section 3.3.5.2).

Sea bass normally remain at the surface during the night and swim deeper in the water column during the day (Schurman *et al.,* 1998; Pontual *et al.,* 2019). Adults using offshore areas are known to spend the day in deeper water and ascend at night, but the behaviour is not so pronounced or consistent inshore and in the summer months (Quayle *et al.,* 2009; de Pontual *et al.,* 2019). Experimental (tank) studies have indicated that sea bass occupy the surface layer at night and swam deeper in the water column during the day (Schurmann *et al.,* 1989). An abstraction risk factor of 1 has been applied, and is discussed further in Section 3.3.5.

3.3.4.4 Distribution of epibenthic species

In the southern North Sea, plaice use selective tidal stream transport to migrate between spawning and foraging areas. During migrations in December and January, plaice may spend between 1/4 to 1/3 of the day in midwater. Post spawning migration, plaice rarely leave the seabed (Hunter *et al.,* 2004).

The same abstraction risk factor has been applied for epi-benthic species as that for cod and gadoids. For many epibenthic species with a strong association with the seabed the abstraction risk factor applied is considered to be precautionary. It should also be noted that during periods when epibenthic species utilise selective tidal stream transport to migrate and are therefore active within the water column and at greater risk of impingement, replenishment rates would be higher (i.e., they are actively migrating).

Table 5. Abstraction risk factor for different species groups in the volumetric assessment of impingement effects.

Abstraction risk factor	SZB	SZC	SZB + SZC
Pelagic species	1	1	1
Pelagic larvae and juveniles	0.67	0.67	0.67
Gadoids (cod and whiting)	1.46	1.98	1.83
Sea bass	1	1	1
Epi-benthic species	1.46	1.98	1.83

3.3.5 Mitigation

The simple volumetric calculation does not incorporate fish behaviour beyond their vertical distribution in the water column and relative abstraction risk (Section 3.3.4). Consequently, any form of mitigation requires the application of a correction factor.

The assessment considers the proposed, and active mitigation measures for each site. For example, Sizewell B is fitted with capped intake heads and a fish recovery and return (FRR) system; whereas Sizewell C intakes would also be capped and adopt a low velocity side entry (LVSE) design and incorporate an advanced FRR system.

It is acknowledged that common ground has not been achieved on all mitigation efficiencies for various mitigation options.

3.3.5.1 Capped heads

As part of the Hinkley Point C project the Environment Agency recommended that capped intakes would reduce the abstraction of pelagic fish by a factor of 0.23 (Environment Agency Technical Brief TB007), with an uncertainty range of 0.18 to 0.28. The Environment Agency questioned the application of vertical capped heads in a purely volumetric assessment, which is indeed correct. However, the vertical distribution of pelagic species has been taken into account and a precautionary assumption of homogenous distribution has been applied. Pelagic species are known to undertake diurnal migrations throughout the water column (Section 3.3.4.1) and the Environment Agency guidance indicates that capped heads afford mitigation to these species. Accordingly, to parameterise the model as close as possible to reality, the capped head mitigation factor is applied for pelagic species only.

The application of a 0.23 factor for pelagic species only is considered precautionary. A review of the evidence for head designs undertaken by the Environment Agency (Environment Agency, 2020) concluded that capped heads afford a *"higher level of protection for pelagic species than for benthic and prioximo-benthic species".* The literature cited therein includes a review by the New York State Department of Environmental Conservation that suggests capped heads reduce catches of all species by around 76% (+/- 14.7%) and benthic-dominated catches by 57%. Whilst the Environment Agency (2020) report states flaws in some of the studies considered in the New York State Department of Environmental Conservation review, it is clear that applying no mitigation factor for demersal and epibenthic species is precautionary.

3.3.5.2 Intake heads

The LVSE intakes are designed to minimise impingement[3] by:

a. Reducing vertical velocities which fish are ill equipped to resist by means of velocity caps on the intakes (Section 3.3.5.1).

b. Limiting the intercept area of the intake surfaces to the tidal stream and in so doing reduce the risk of impingement for fish swimming with the tidal stream. i.e. to reduce the cross-sectional area of the intake to the prevailing tidal directions by mounting the head orthogonally to the tidal flow.

c. Reducing intake velocities into the head to a target velocity of 0.3m/s over as much of the length of the intake surface which will maximise the possibility of most fish avoiding abstraction.

Statutory consultees have questioned the effectiveness of the LVSE in the absence of an AFD. In their response to **Examining Authority question Bio.1.245** [REP2-140] the MMO state that

> *"It is recognised that the LVSE design has been put forward by the Environment Agency as a mitigation measure for cooling water abstractions (in its good practice guidance), although this tends to be accompanied by Acoustic Fish Deterrent (AFD) systems (which are not currently proposed for Sizewell C). While it is feasible that the LVSE design, on its own, will provide some benefit in terms of reductions in fish impingement, even if the benefit was zero, the MMO does not believe this would not materially change the conclusions of the overall fish entrapment assessment."*

In acknowledgement of the uncertainty in the current assessment of the effectiveness of the LVSE heads, the local depletion assessment assumes no benefit of the LVSE, beyond the capped head mitigation which is common ground for pelagic species as presented by the Environment Agency through the Hinkley Point Inquiry (Section 3.3.5.1).

Impingement per cumec is therefore assumed to be no different than the current Sizewell B head. A value of 1.0 has been applied in the sensitivity assessment (Table 6).

3.3.5.3 Fish recovery and return (FRR) system

The fish recovery and return (FRR) system is designed to return robust species (particularly flatfish, eels, lampreys and crustacea and to a lesser extent demersal species such as bass, cod and whiting) that are impinged onto the station drum and band screens safely back to sea. Both Sizewell B and Sizewell C have FRR mitigation. The FRR mortality in version 4 of this report applied Environment Agency (2005) guidance adjusted for the Sizewell C specific FRR design. Survival rates for demersal species were based on the estimated 45% survival of sea bass through the trash racks, drum screens and band screens at Sizewell C; whereas epi-benthic species were assumed to have 20% mortality with a precautionary 100% mortality for pelagic species.

Following requests from statutory stakeholders to consider mitigation efficiency in the local depletion assessments, uncertainty in the FRR efficiency has been included in the assessment.

For the UKEPR, an FRR system has been designed and, following intensive design scrutiny, has been received regulatory approval for Hinkley Point C. The values of FRR efficiency applied in the impingement assessments at DCO were based on Environment Agency (2005) guidance for species specific survival through FRR systems, modified for the Sizewell C specific trash racks, band screens and drum screens. A description of the approach is provided in **BEEMS Technical Report TR406.v7** [AS-238]. Table 6 shows the predicted FRR mortality for each of the key species.

[3] Small life-history stages subject typically entrained are not predicted to benefit significantly from the head design due to reduce swimming capabilities.

As part of the Hinkley Point Inquiry, the Environment Agency provided an evidence report (Technical Brief: TB008 Fish Recovery and Return System Mortality Rates);

> "*The Technical Brief recommends a method to set a FRR mortality rate for each species and a range around the FRR mortality rate for each species. The range set accounts for the uncertainty in the underlying evidence used to set the FRR mortality rate, and in the efficiency of the bespoke FRR system proposed for Hinkley Point C (HPC).*"

The Sizewell C project will replicate the design of Hinkley Point C as much as possible. However, the reduced tidal range at Sizewell compared with Hinkley allows several design changes that are improvements over the Hinkley Point C design:

a. The reduced tidal range means that the drum screens can be smaller – the diameter will be 4m less than at Hinkley Point C which means that the rotation time (and time that fish and biota will be in the bucket will be shorter than Hinkley Point C);

b. Due to the reduced tidal range, and the elevations of buildings on the power station platform, the debris recovery building is at a suitable elevation to drain back to sea under gravity directly from its floor. At Hinkley Point C due to the large tidal range the material needs to be elevated to platform level at Hinkley Point by use of an Archimedes screw – which involves an additional element of "fish handling" (i.e., manipulation) within the FRR. An Archimedes screw is not required at Sizewell.

c. The reduced tidal range and lack of the need for an Archimedes screw, allows each UKEPR unit to have its own, dedicated FRR tunnel to return fish to sea from the debris recovery building which is more direct and therefore reduces transit time for fish through the system.

The FRR system at Sizewell C is predicted to have greater efficiency than that at Hinkley Point C. Therefore, it is considered appropriately precautionary to apply the Environment Agency (TB008) Hinkley Point C FRR uncertainty ranges for the local depletion assessment for Sizewell C (Table 6).

Sizewell B FRR mortality will continue to apply the same values as presented in **BEEMS Technical Report TR406.v7** [AS-238]. This is due to the fact that FRR survival studies at Sizewell B, in part informed the Environment Agency (2005) guidance for FRR efficiency.

The Environment Agency best case and worst-case values have been used in the sensitivity analysis for local depletion. Where Environment Agency worst-case ranges in TB008 are lower than the FRR efficiency applied by Cefas in **BEEMS Technical Report TR406.v7** [AS-238], the higher values are used.

Table 6. Mitigation parameters applied in uncertainty analyses. Where the predicted FRR efficiency is greater than the Environment Agency worst case, the FRR efficiency value from TR406 is applied as the worst-case. Sensitivity analyses apply the FRR efficiency (impingement assessment) and TB008 best and worst-case range (entrapment assessment).

Common name	LVSE	FRR efficiency (TR406.v7 [AS-238])	FRR mitigation range applied in uncertainty analysis based on Environment Agency HPC values (TB008)		
			TB008 predicted	Realistic best case	Realistic worst case
Sprat	1.000	1.000	1.000	0.950	1.000
Herring	1.000	1.000	1.000	0.900	1.000
Whiting	1.000	0.551	0.552	0.410	1.000
European sea bass	1.000	0.551	0.608	0.300	0.950
Sand gobies	1.000	0.206	0.200	NA	NA
Dover sole	1.000	0.206	0.200	0.050	0.206+
European anchovy	1.000	1.000	NA*	*0.900*	*1.000*
Dab	1.000	0.535	NA*	*0.206*	*0.535*
Thin-lipped grey mullet	1.000	0.551	NA	NA	NA
Flounder	1.000	0.231	0.200	0.050	0.231

Common name	LVSE	FRR efficiency (TR406.v7 [AS-238])	FRR mitigation range applied in uncertainty analysis based on Environment Agency HPC values (TB008)		
			TB008 predicted	Realistic best case	Realistic worst case
Smelt (cucumber)	1.000	1.000	NA*	*0.900*	*1.000*
European plaice	1.000	0.206	0.200	0.020	0.206+
Atlantic cod	1.000	0.553	0.563	0.180	0.560
Thornback ray	1.000	0.206	0.545	*0.206‡*	0.550
Twaite shad	1.000	1.000	1.000	0.960	1.000
River lamprey	1.000	0.206	0.200	0.110	0.206+
European eel	1.000	0.206	0.200	0.110	0.206+
Horse-mackerel	1.000	1.000	NA*	*0.900*	*1.000*
Mackerel	1.000	1.000	NA*	*0.900*	*1.000*
Tope	1.000	0.206	NA	NA	NA
Sea Trout	1.000	1.000	1.000	NA	NA
Sea lamprey	1.000	0.206	0.407	NA	NA
Allis shad	1.000	1.000	1.000	NA	NA

* Where there is no FRR information of the species from the Environment Agency TB008 report a range has been applied for similar species groups, ranges are shown in italics. + Where the TB008 values are lower than those predicted in TR406 Rev 7, the TR406 values are applied. ‡The lower value for best case FRR efficiency applies the predicted value rather than the Environment Agency TB008 reported value of 0.41, this is a result of the larger trash rack spacing between HPC (50mm) and SZC (75mm).

3.3.6 Model duration

The local effects assessment was calculated for 365 days, however, in almost all cases tested the system reaches equilibria within 50 days as immigration from the wider area balances losses through emigration and abstraction.

The relevant duration for species specific simulations is based on seasonal impingement rates for key species based on data in **BEEMS Technical Report TR345** [APP-321] and **TR339** [AS-238].

3.4 Estimated local depletion

The potential for impingement to cause localised depletion of pelagic, demersal and epibenthic species groups was considered in the case of Sizewell B and Sizewell C individually and in-combination at the scale of the GSB and tidal excursion, ICES Statistical Rectangle 33F1 and Statistical Area 4c. Localised depletion was computed for the course of a year and depletion values were selected based on the period of time the species of interest is most abundant at Sizewell, based on the Sizewell B impingement record (**BEEMS Technical Report TR339** [AS-238]). Exchange rates between the GSB and 33F1, and 33F1 and 4c were both set at 10%, with the exception of larvae where a range of values are applied with mitigation applied as described in Table 6.

3.4.1 Pelagic species

The two most dominant species impinged at Sizewell B are herring and sprat, together contributing 70% of annual impingement by numbers. Both species are seasonally abundant at Sizewell with approximately 95% of herring and 79% of sprat impinged in the period from Q4 to Q1 (BEEMS Technical Report TR339).

With the stations acting in isolation, Sizewell B abstracts less than half the volume of the proposed Sizewell C station. However, Sizewell B intakes are inshore of the Sizewell-Dunwich Bank acting on a smaller volume of water. Impingement by Sizewell B results in depletion of approximately 2.8% of sprat within the GSB in the period December to March when they are most abundant, whereas herring would reduce by a similar margin in the period February to April.

Sizewell C operating in isolation, is predicted to result in depletion of sprat and herring in the outer tidal excursion by approximately 2.8%.

Acting in combination, Sizewell B and Sizewell C may result in reductions of 2.9% of pelagic species within the GSB + tidal excursion. Figure 12 shows that with both stations operating together, a plateau occurs after approximately 40 days by which point >95% of annual depletion is achieved. After 40 days, abstraction losses and emigration are balanced by immigration into the cell. Depletion continues to rise at the scale of 33F1 and, to a lesser extent within ICES 4c, as the wider area dilutes impingement losses. The highest abundance period for sprat at Sizewell lasts for approximately 121 days during which time 0.13% depletion of pelagic species in 33F1 beyond the GSB and tidal excursion is predicted with 0.02% depletion in 4c beyond 33F1 (Table 7; Figure 12). Figure 13 provides a spatial illustration of the areas of depletion for sprat and dilution of effects in the wider area. The colour systems in the following graphs are intended to mirror the assessment cells in Figure 13.

The FRR system is not predicted to be effective for delicate pelagic species. The best-case FRR efficiency my result in localised depletion reducing by a factor of 4% for sprat and 10% for herring (Table 6). In the case of herring localised depletion from both stations may reduce from 2.9% as a worst-case to 2.6% if the FRR allows 10% survival.

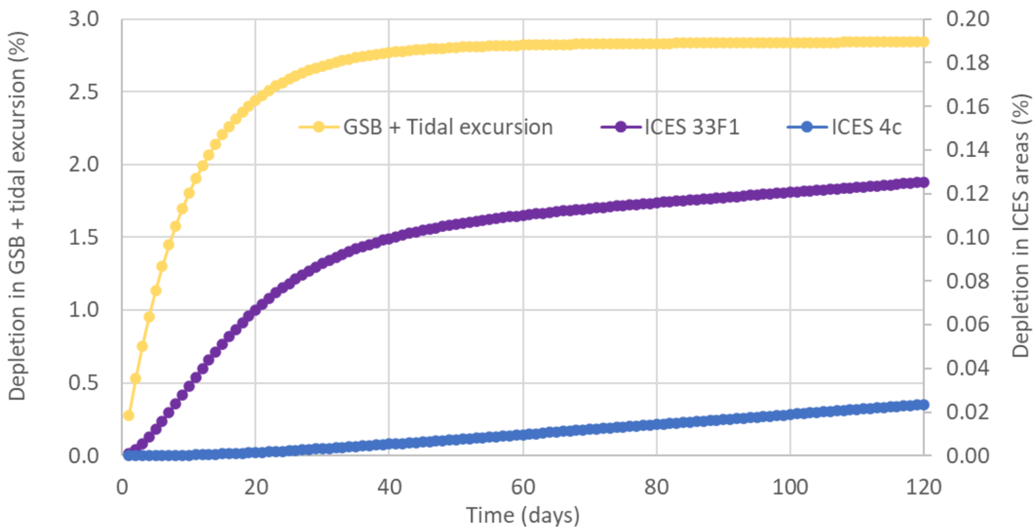

Figure 12 Localised depletion of pelagic fish due to impingement from Sizewell B and Sizewell C with full mitigation. The in-combination effects of Sizewell B and C at the scale of the GSB + tidal excursion (yellow), and the wider effects on ICES Statistical Rectangle 33F1 (purple) and Statistical Area 4c (blue).

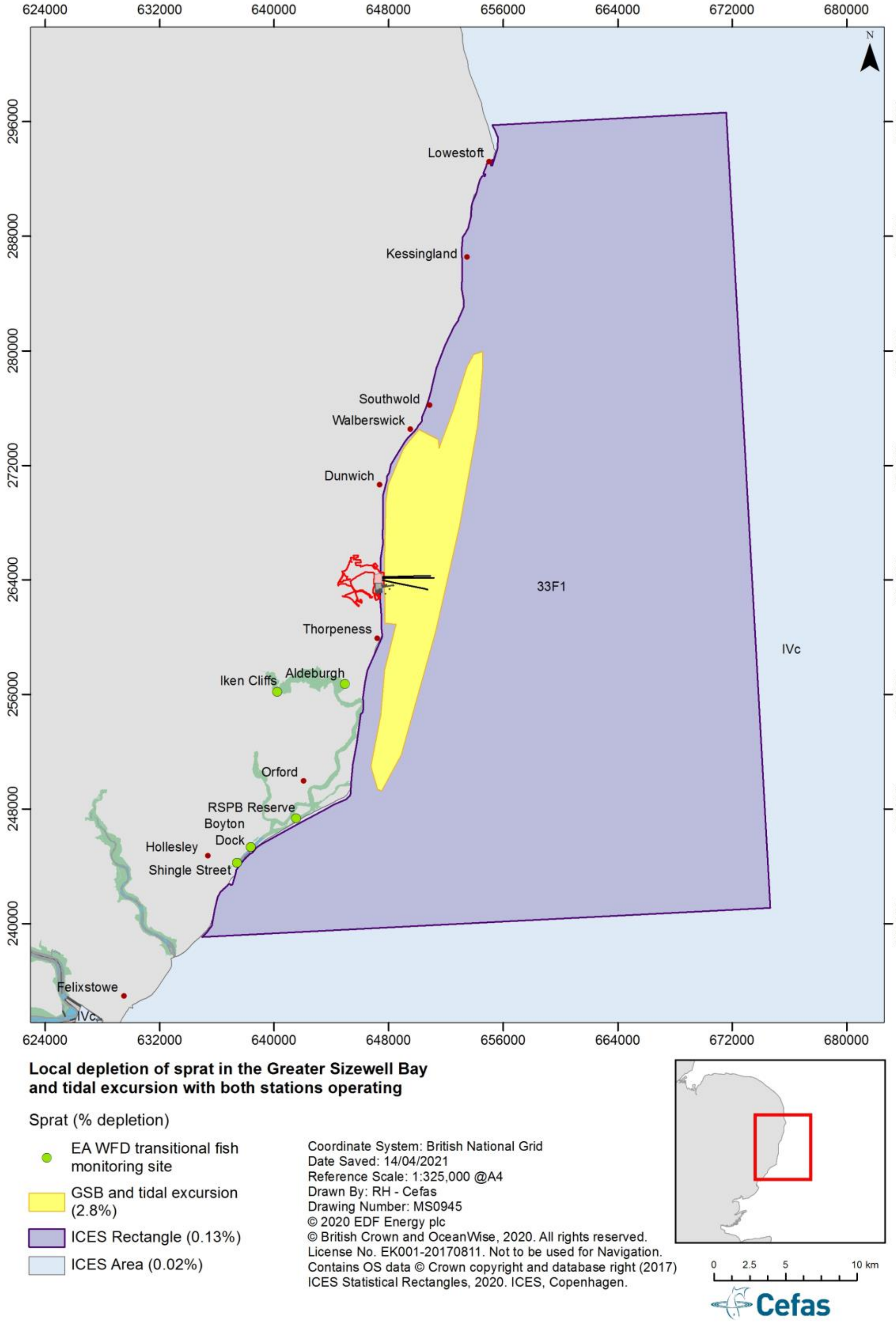

Figure 13 Areas of localised depletion for sprat assessed with both stations acting in-combination during the period December to March. The GSB + tidal excursion (yellow), ICES statistical rectangle 33F1 (purple) and part of ICES Statistical Area 4c (blue) are shown. Depletion in each assessment cell is depicted by shading relative to epi-benthic and demersal species.

3.4.1.1 Larvae and juveniles

Young-of-the-year clupeids have been shown to be important prey resources for little terns (Perrow *et al.,* 2011). Therefore, the potential effects of entrainment of these small prey items has been assessed in the context of local depletion.

Clupeid larvae are the most abundant at Sizewell during the summer months and are precautionarily assumed to incur 100% mortality during entrainment passage. A conservative abstraction risk factor of 0.67 has been applied to reflect their vertical distribution of larvae and juveniles relative to the intakes (Section 3.3.4). Larvae and early juvenile stages have limited swimming capabilities and are largely transported by tidal flows. As such, the replenishment rate will be dependent on exchange rates. Two scenarios are tested one with the precautionary 10% daily exchange rates applied and a second assuming 20% tidal exchange corresponding to typical east coast daily exchange rates (Environment Agency, 2011).

With the stations act in isolation, Sizewell B abstracts less than half the volume of the proposed Sizewell C station, however, Sizewell B intakes are inshore of the Sizewell-Dunwich Bank acting on a smaller volume of water. Impingement by Sizewell B results in depletion of approximately 3.5% of larvae/juveniles at a 20% daily exchange rate and 7.6% of larvae/juveniles assuming a 10% daily exchange of water in the GSB.

In comparison, Sizewell C acting in isolation, would result in depletion of 3.2% of larvae/juveniles at a 20% daily exchange rate and 6.8% of larvae/juveniles assuming a 10% daily exchange of water in the offshore tidal excursion.

Acting in combination Sizewell B and C would cause 8.0% depletion of larvae and early juvenile stages in the GSB with a tidal excursion assumed to be a conservative 10% daily exchange rate. Assuming 20% daily exchange rates Sizewell B and C would cause 3.9% depletion of larvae and early juvenile stages with the GSB tidal excursion (Figure 14).

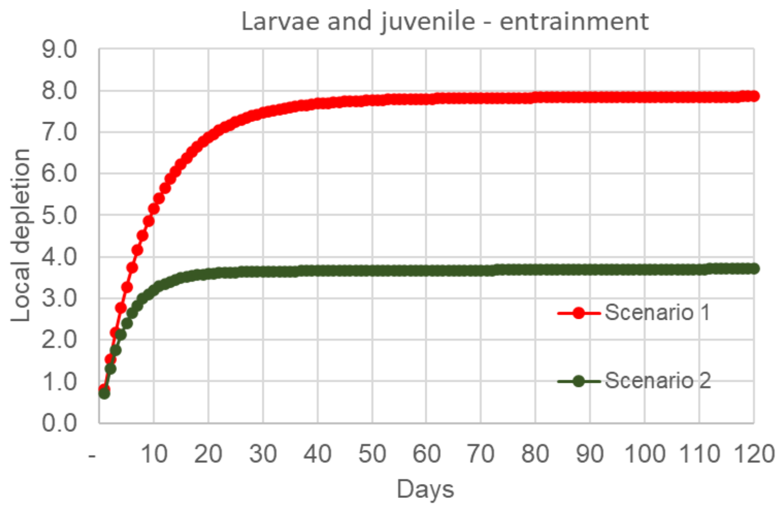

Figure 14 Localised depletion in the larvae and juvenile stages of pelagic fish abundant at Sizewell. Scenario 1 in red represents a hypothetical worst case with 10% exchange rates and 100% entrainment mortality. Scenario 2 in green represents a case with 20% exchange rates and 100% entrainment mortality. In both cases the vertical distribution of larval and early juvenile stages is considered and no benefits from the head design are assumed.

3.4.2 Demersal species

Whiting and sea bass are the third and fourth most frequently impinged species at Sizewell B, respectively, together account for 18% of total annual impingement numbers. Sea bass are highly seasonal with >99% impinged in Q4 and Q1 equally, whereas 78% of whiting are impinged in the winter period. Cod are the 13th most frequently impinged species and are also most frequently impinged at Sizewell B in winter between December and March (BEEMS Technical Report TR339).

3.4.2.1 Sea bass

Sea bass are a demersal species that are more active throughout the water column (Section 3.3.4). The potential local depletion of sea bass was calculated based on the mitigation parameters in Table 6 and assuming 10% replenishment rates.

When the predicted FRR mitigation values in **BEEMS Technical Report TR406.v7** [AS-238] are applied, local depletion due to Sizewell B alone is predicted to be approximately 6.4% over the 120-day winter period for sea bass in the GSB.

Sizewell C operating alone is predicted to cause approximately 5.6% depletion of sea bass in the larger offshore tidal excursion.

Acting in-combination, Sizewell B and C, result in approximately 6.6% local reductions in sea bass within the GSB tidal excursion. Exchange with the wider area results in approximately 0.3% of sea bass in the ICES area 33F1 beyond the GSB tidal excursion after 121 days, and 0.05% depletion in ICES 4c beyond 33F1 (Table 7).

The sensitivity of the local depletion assessment to the uncertainty in the operational efficiency of the Sizewell C FFR was tested by applying the Environment Agency (TB008) best-case and worst-case scenarios which range from 70% survival to 5% survival of sea bass (Table 6). Sizewell B FRR rates remain constant in the assessment.

In the worst-case scenario, Sizewell C is in effect operating as an unmitigated station and represents a highly precautionary assessment. In the best case[4] of 70% sea bass survival through the FRRs Sizewell B and C in-combination result in approximately 4.6% local reductions in sea bass the GSB + tidal excursion whereas the worst-case 9.6% local depletion is predicted (Figure 15).

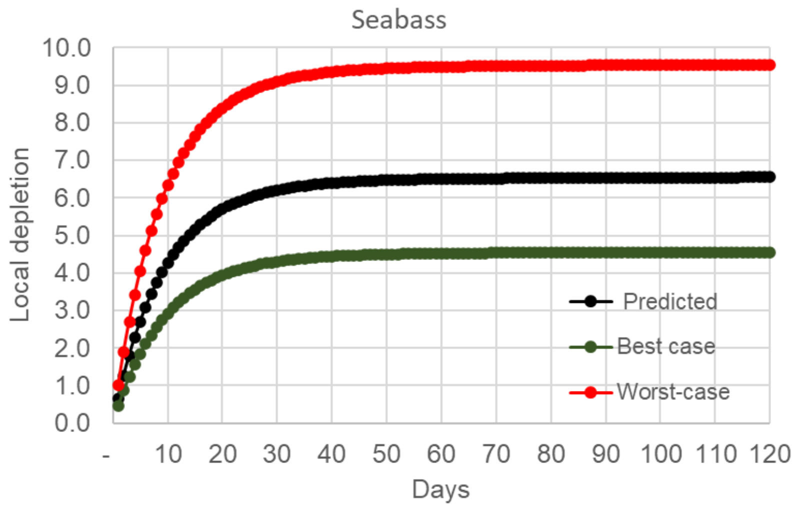

Figure 15 Sensitivity of the localised depletion assessment of sea bass in the GSB + tidal excursion to uncertainty in the operational efficiency of the Sizewell C FRR, depletion shows Sizewell B and Sizewell C operating in combination. Black lines represent the predicted FRR efficiency at Sizewell C **BEEMS Technical Report TR406.v7** [AS-238], the red line represents the worst-case FRR scenario, and the green line represents the best case FRR scenario. No other mitigation is included.

3.4.2.2 Gadoids

In the case of cod and whiting, a highly precautionary assessment is made whereby an abstraction risk factor is applied such that the vertical distribution of the fish is adjusted to remain largely within the horizon of the intakes, however, no benefit from the LVSE at Sizewell C (Section 3.3.5.2) or the capped head design

[4] Note: this assumes no benefit from the capped head at either station or the LVSE at Sizewell C.

employed by both stations (Section 3.3.5.1) is assumed. Accordingly, results are likely to overestimate the depletion of these species.

When the predicted FRR mitigation values in **BEEMS Technical Report TR406.v7** [AS-238] (Table 6) are applied, Sizewell B alone is predicted to result in approximately 9% local depletion in cod and whiting over the 120-day winter period.

Sizewell C operating alone is predicted to cause approximately 10.6% depletion in the larger tidal excursion.

Acting in-combination, Sizewell B and C, result in approximately 11.4% local reductions in the gadoid species such as cod and whiting within the GSB + tidal excursion. Exchange with the wider area results in approximately 0.5% of cod in the ICES area 33F1 beyond the GSB and tidal excursion after 121 days, and 0.1% depletion in ICES 4c beyond 33F1 (Table 7).

The sensitivity of the local depletion assessment to the uncertainty in the operational efficiency of the Sizewell C FFR was tested by applying the Environment Agency (TB008) best-case and worst-case scenarios which range from 0% survival to 59% survival for whiting, and 82% survival to 46% survival for cod. Sizewell B FRR rates remain constant in the calculation.

In the worst-case scenario, Sizewell C is assessed as operating as an unmitigated station for whiting representing a highly precautionary assessment. In the best case for cod and whiting, Sizewell B and C operating in-combination would result in approximately 4% and 9.5% local reductions in the GSB + tidal excursion, respectively. In the worst-case local reductions for cod equate to 9.6% whereas whiting, in an entirely unmitigated scenario, result in 16.8% local depletion (Figure 16).

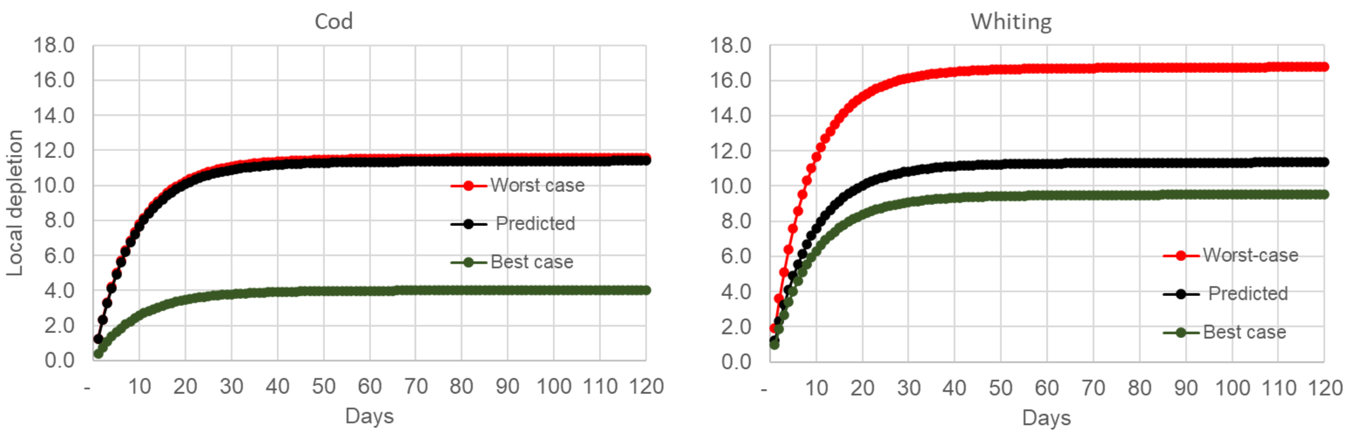

Figure 16 Sensitivity of the localised depletion assessment of cod (left panel) and whiting (right panel) in the GSB + tidal excursion to uncertainty in the operational efficiency of the Sizewell C FRR, depletion shows Sizewell B and Sizewell C operating in combination. Black lines represent the predicted FRR efficiency at Sizewell C **BEEMS Technical Report TR406.v7** [AS-238], the red line represents the worst-case FRR scenario, and the green line represents the best case FRR scenario. No other mitigation is included.

The reported 16.8% reduction for whiting can be considered a very worst-case scenario in that it assumes:

- No FRR mitigation from Sizewell C.
- No capped head mitigation from either Sizewell B or Sizewell C.
- No benefit from the LVSE intake heads.
- Whiting vertical distribution in the water column is assumed to be concentrated at the height of the intakes increasing the abstraction risk factor.

Environment Agency (2005) guidance, review a study by Turnpenny and Taylor (2000) that showed that the design and location of Sizewell B in comparison to Sizewell A reduced whiting impingement by 21% whilst the FRR system reduced mortality of impinge fish by 48%. The net result was Sizewell B causing approximately 41% of the mortality of whiting per cumec abstracted as the older Sizewell A station.

Whilst impingement data is not directly comparable to the theoretical modelling, the data from the operational Sizewell B and former Sizewell A station illustrate the highly precautionary assumptions of assuming no mitigation benefits for whiting. Based on the Sizewell A to Sizewell B comparison, the worst-case results would overestimate the local scale effects on whiting by a factor of 2 or more.

3.4.3 Epi-benthic species

Dab, Dover Sole and sand gobies all contribute towards the top 95% of species impinged at Sizewell B. Sand gobies are predominantly impinged in Q3 and Q4, however, Dover sole and dab are impinged for longer periods throughout the year (BEEMS Technical Report TR339). Impingement assessments were run for 365 days. Equilibria within the GSB + tidal excursion was achieved within 40 days (95% of annual depletion achieved) after which effects increase in the wider area. The FRR efficiency ranges for most epi-benthic species suggests high survival rates and therefore assessments using the predicted values would be precautionary (Table 6).

Sizewell B operating alone is predicted to result in approximately 3.6% local depletion of epibenthic species in the GSB. Sizewell C operating alone is predicted to cause approximately 4.6% depletion assuming a larger tidal excursion.

Acting in-combination, Sizewell B and C, is predicted to result in a 4.7% reduction in epi-benthic species in the GSB + tidal excursion. In the annual assessment (e.g. dab which is present year round), exchange with the wider area results in 0.3% depletion of fish in the area of 33F1 beyond the GSB and tidal excursion, and 0.13% in ICES 4c beyond 33F1 (Table 7; Figure 17).

The increase in depletion estimates for epibenthic species reported here, in comparison to version 3 of this report, is a result of the refinements to the assumption of homogenous vertical distribution in the water column and the inclusion of an abstraction risk factor accounting for the greater abundance at the depth of the intakes (Section 3.3.4).

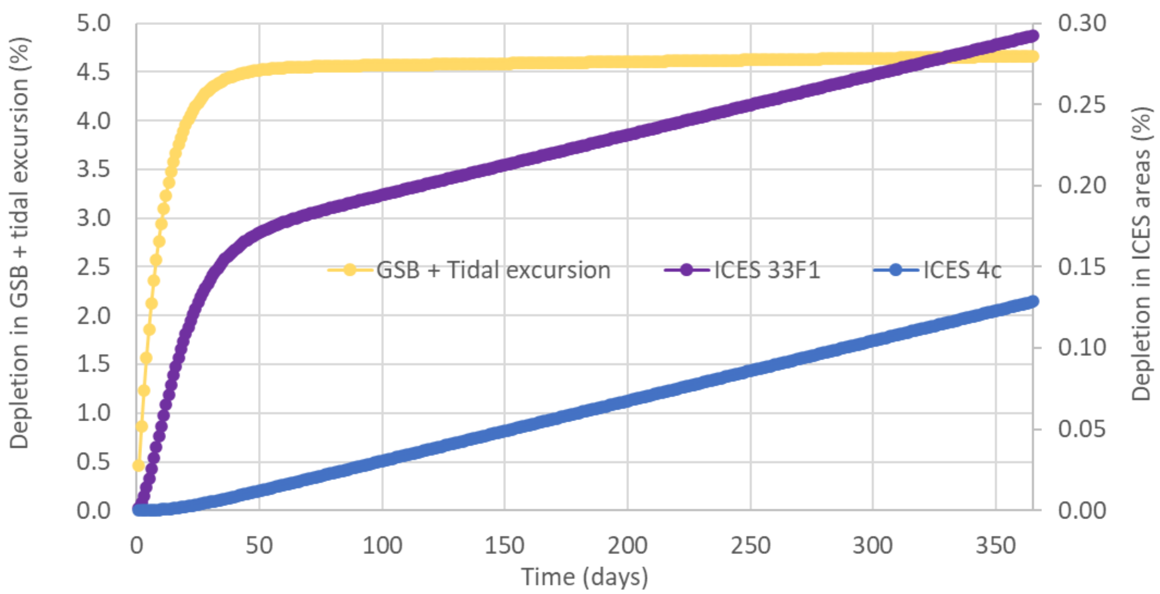

Figure 17 Localised depletion of epi-benthic fish due to impingement from Sizewell B and Sizewell C with full mitigation. The in-combination effects of Sizewell B and C at the scale of the GSB + tidal excursion (yellow), and the wider effects on ICES Statistical Rectangle 33F1 (purple) and Statistical Area 4c (blue).

The sensitivity of the local depletion assessment to uncertainty in the FRR efficiency was tested for plaice and Dover sole. The FRR efficiency applied by the Applicant in the DCO assessments (**BEEMS Technical Report TR406.v7** [AS-238]) is equivalent to the worst-case scenario in the Environment Agency (TB008) FRR efficiency range. Therefore, incorporating the FRR uncertainty range (Table 6) reduces depletion from a maximum of 4.6% with the operation of Sizewell B and C operating together to a best case of 2.2% for Dover sole and 1.8% for plaice (Figure 18). It is noteworthy that this level of local depletion does not include potential benefits from the capped head or the LVSE heads.

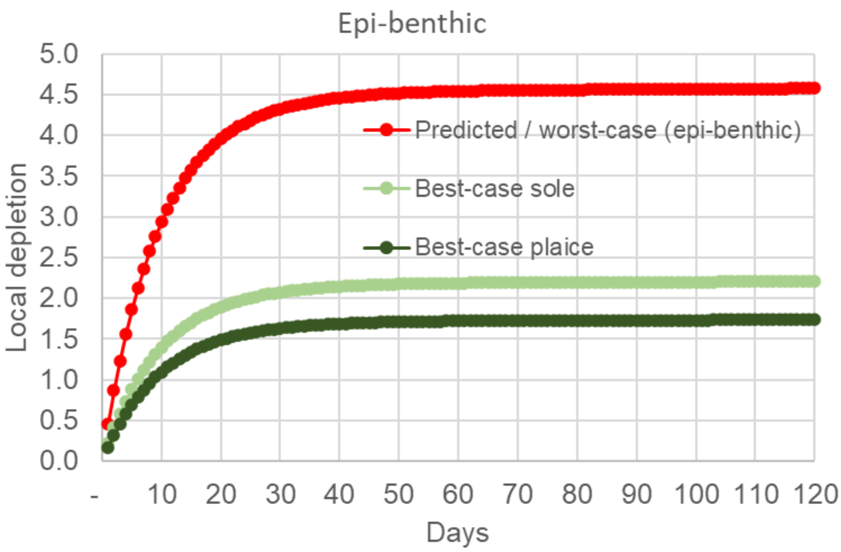

Figure 18 Sensitivity of the localised depletion assessment of epi-benthic species in the GSB + tidal excursion to uncertainty in the operational efficiency of the Sizewell C FRR, depletion shows Sizewell B and Sizewell C operating in combination. The red line represents the predicted/worst-case FRR efficiency at Sizewell C, the light green line represents the best-case FRR scenario for Dover sole, and the green line represents the best-case FRR scenario for plaice.

Table 7 Predicted depletion of selected key species during periods of maximum abundance, focusing on the GSB with tidal excursion. Values provided show local effects of Sizewell B and Sizewell C operating in-combination and are based on a precautionary 10% exchange rate. Green shaded species have been identified as potential prey items for HRA designated species at Sizewell. Underlined species have been identified by the Environment Agency as important for the Alde & Ore WFD fish classification. The table shows the sensitivity of the local depletion assessment to uncertainty in the FRR operational efficiency at Sizewell C. The capped head design is incorporated into the assessment of pelagic species, but conservatively assumed to offer no mitigation for other species. The potential benefit of the LVSE intercept area is also not included. Depletion accounts for the abstraction risk factors for different species groups.

Species Group	Species	Period that the species is occurs in greatest numbers at Sizewell (days)	FRR mitigation range applied in uncertainty analysis based on Environment Agency HPC values (TB008)		Predicted % depletion in each area due to Sizewell B + Sizewell C. Applicants FRR efficiency (TR406.v7 [AS-238])		
			Realistic best case	Realistic worst case	GSB + tidal excursion	*33F1*	*4c*
Pelagic	Sprat	Dec. – March (121)	**2.8**	**2.8**	**2.8**	*0.13*	*0.02*
	Herring	Feb. – April (89)	**2.6**	**2.8**	**2.8**	*0.12*	*0.02*
	Smelt	April – Nov. (253)	**2.7**	**2.9**	**2.9**	*0.16*	*0.05*
	Twaite shad*	March – Aug. (184)	**2.8**	**2.9**	**2.9**	*0.14*	*0.04*
	Anchovy	June (30)	**2.5**	**2.7**	**2.7**	*0.09*	*0.00*
Demersal	Sea bass	Dec. – March (121)	**4.6**	**9.6**	**6.6**	*0.29*	*0.05*
	Whiting	Oct. – April (221)	**9.6**	**16.9**	**11.5**	*0.60*	*0.19*
	Cod	Dec. – March (121)	**6.4**	**11.5**	**11.4**	*0.50*	*0.10*
Epibenthic	Sand goby	Aug. – Dec. (162)	**NA**	**NA**	**4.6**	*0.22*	*0.05*
	Dover sole	March – Oct. (245)	**1.8**	**4.6**	**4.6**	*0.25*	*0.08*
	Dab	Throughout (365)	**4.7**	**9.4**	**9.4**	*0.59*	*0.26*
	Flounder	Oct. – June (282)	**2.2**	**4.6**	**4.6**	*0.26*	*0.10*
	Plaice	Throughout (365)	**2.2**	**4.7**	**4.7**	*0.29*	*0.13*

* Note: A single twaite shad has been recorded in TFCI sampling (BEEMS Technical Report SPP108 [AS-238])
Seasonal source data BEEMS Technical Report TR345 and TR339.
Key prey species for HRA designated Annex II species are detailed in BEEMS Technical Report TR431.

3.5 Interpretation of depletion results in an ecological context

The local depletion results presented in Section 3.4 provide a framework for contextualising the relative magnitude of depletion based on the simple assumptions of the model. As stated by the Environment Agency [REP2-135];

> *"The model is noted to require a number of assumptions and there is inherent uncertainty in the outputs, but it is helpful as a broad relative indication of local impacts to use alongside other evidence."*

Local depletion is subject to the complexities of fish behaviour at a range of spatial and temporal scales and at different life stages. Therefore, it is necessary to make a series of assumptions to try and encapsulate these uncertainties and derive meaningful predictions. Version 5 of this report has considered stakeholder comments and through a series of precautionary measures attempted to refine the input parameters. As requested by the MMO and Environment Agency the sensitivity of the local depletion assessment to uncertainty in mitigation efficiency has been tested by assuming no benefit of the LVSE and applying a range of FRR efficiency parameters. The sensitivity of the model to the assumptions of replenishment rates and density has been considered in previous versions of this report but is also included in Appendix A, Section 4.6.

This section considers the results of the local depletion assessment and their significance in an ecological context.

The Sizewell B intakes are located approximately 600m offshore whilst Sizewell C intakes are situated 3km offshore beyond the Sizewell-Dunwich Bank. The offshore location means the dynamic volume of water within the tidal excursion that the intakes interact with is substantially larger. Despite having over twice the abstraction volume, Sizewell C has a similar local depletion for most species assessed as Sizewell B. Operating in-combination, the two stations act on a partially shared body of water (Figure 10). The results indicate that the effects of both stations operating together would be comparable to the current Sizewell B station but over a larger spatial area. It should be noted that fish behaviour means the GSB and tidal excursion are by no means independent. However, there is a spatial element to consider when applying the results of local depletion in fish due to the two stations in terms of prey availability and foraging areas.

Local depletion is presented as an average value over the relevant assessment cells, for example the GSB and tidal excursion. In reality, localised depletion would be concentrated downstream of the intakes and would be tidally dynamic. In effect, notwithstanding fish behaviour, there would be an inverse density gradient with lower densities downstream of the intakes. Processes of mixing and fish behaviour would reduce depletion, as distances from the intakes increases. Overall, the results clearly show how the effects of impingement are rapidly diluted at larger scales i.e., from the tidal excursion to 33F1.

The average depletion is based on the assumption of uniform density across the domain. This is clearly an oversimplification of the conceptual model. Many species exhibit seasonal migrations and shoaling behaviour. Shoaling species result in highly variable impingement rates, as such local depletion would equally be highly variable. Should a shoal pass directly within the abstraction zone of influence for the intakes, the local depletion would be temporally far higher than predicted. Equally, should a large shoal within the GSB or tidal excursion not encounter the spatially limited abstraction zone of influence around the intakes, there would be negligible depletion.

The assumption of uniform distribution is most marked in sea bass. Sea bass are not uniformly distributed across the site with evidence suggesting juvenile sea bass are more abundant inshore and may be attracted to the warm water effluents of Sizewell B in winter when the vast majority are impinged at Sizewell B. Sea bass distribution surveys were completed off Sizewell in February 2016. Low catch rates were observed at all offshore survey stations with 95% of sea bass caught inshore of the Sizewell-Dunwich Bank suggesting the inshore distribution of juvenile sea bass is a wider phenomenon on the Suffolk coast and not just related to the immediate area of the plume. This corresponds to the established behaviour of juvenile bass utilising inshore coastal waters, where other factors such as food availability and predation threat are likely to drive distribution (further details are provided in **BEEMS Technical Report TR406.v7** [AS-238]). The model is independent of density, as such the percentage depletion remains valid, however, the far greater local effects on losses of juvenile sea bass would be from the existing Sizewell B station.

3.5.1 Local depletion in relation to natural variability

One of the primary concerns leading to the development of this fine scale local depletion assessment is the implication of depletion of fish on predator-prey relationships particularly the implications of food availability on central place foraging seabirds during the breeding season. It is therefore important to contextualise the predicted levels of depletion relative to natural variability.

3.5.1.1 Natural variability in pelagic species

Pelagic species form an important component of the diets of foraging seabirds. The natural variability in the distribution of these species at the scale of the GSB and the seasonal and interannual variability is illustrative of the baseline variability in food-availability. A series of acoustic surveys were completed in winter and summer 2015 and 2016 off Minsmere to Thorpeness extending from the coast up to 4 nautical miles offshore with the aim of mapping and quantifying the small pelagic fish community in the area as a food resource for designated seabirds. A high degree of spatial and temporal variability occurred both between seasons and between years. Biomass was considerably higher in winter. The fish were widely distributed in the survey area but biomass was heterogeneous across the survey area. In 2015 higher biomass was reported in the Minsmere sector during winter (Figure 19), whilst in 2016 all areas had high winter biomass (Figure 20). Noting the logarithmic scale of the biomass plots, it is clear to see the large degree of spatial and temporal variability in these shoaling species and reiterates the point made above that average depletion across the GSB is an approximation for shoaling species which would vary depending on the probability, or not, of a shoal encountering the intakes.

Whilst it was not an aim of the survey, there was no evidence of localised depletion in the vicinity of the Sizewell B intakes nor in the Sizewell sector in general (BEEMS Technical Reports TR359 and TR381). This is to be expected as the scale of depletion due to Sizewell B is predicted to be below 3% (Section 3.3.4.1), orders of magnitude below the spatial variability. Such an effect would be indiscernible for any predator with foraging ranges in the order of kilometres or more.

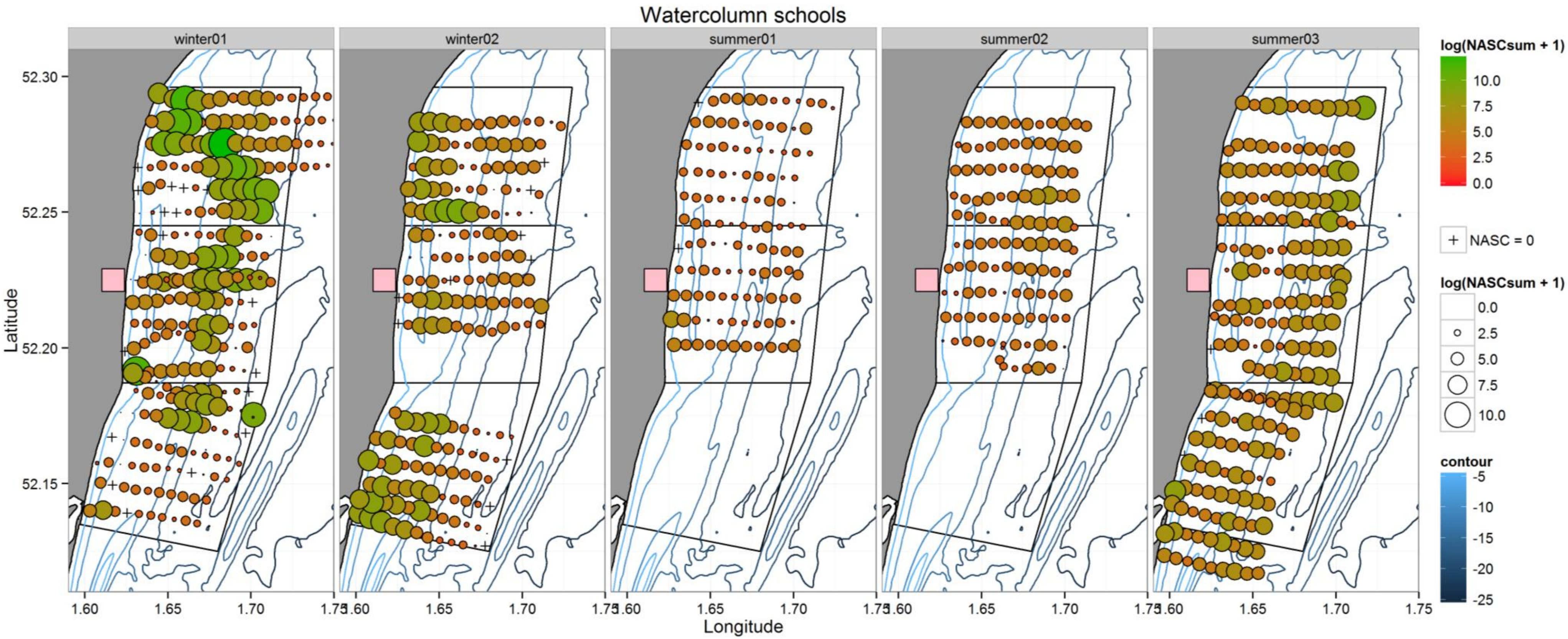

Figure 19: Log-transformed acoustically derived pelagic fish density distribution (NASC) per 500 m interval as collected during the 5 surveys in 2015. Bubble size and colour represent density. Blue lines represent bathymetry (contour). Stratum 1 (top) represents Minsmere; stratum 2 Sizewell (centre) and 3 Thorpeness (bottom). Approximate position of proposed Sizewell C site indicated by pink box. See BEEMS Technical Report TR359 for full details.

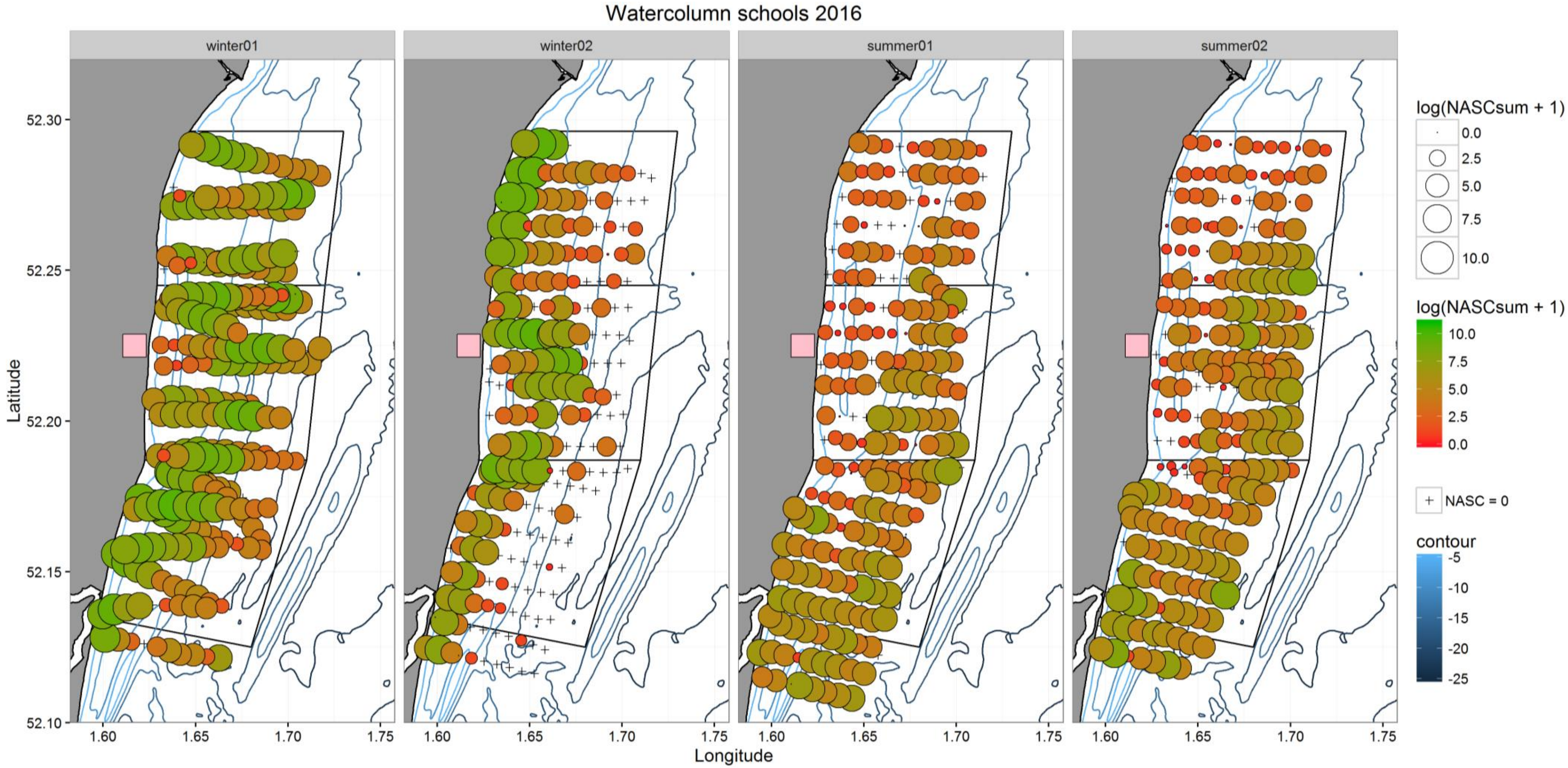

Figure 20: Log-transformed acoustically derived pelagic fish density distribution (NASC) per 500 m interval as collected during the 4 surveys in 2016. Bubble size and colour represent density. Blue lines represent bathymetry (contour). Stratum 1 (top) represents Minsmere; stratum 2 Sizewell (centre) and 3 Thorpeness (bottom). The position of the power station is indicated by the pink square (not to scale). See BEEMS Technical Report TR381 for full details.

Notwithstanding the sporadic nature of impingement of shoaling species, the average local depletion can also be contextualised relative to the interannual variability in impingement rates as a proxy for natural abundance (Table 8). Local depletion of pelagic species is predicted to be below 3% within the GSB + tidal extent with both stations operating. This can be contrasted with mean interannual variability which is a factor of 1.72 for sprat (172% change year to year) with maximum between year variation a factor of 4.54 (454% change from year to year). In the case of anchovy interannual variability is on average orders of magnitude greater at 4.04 (>400%).

During the Issue Specific Hearing 7 part 2 on the 16th July 2021, Natural England made reference to a paper by Jennings *et al*., (2012) as evidence that depletion of sprat could directly lead to reductions in tern breeding success. This paper assessed the breeding success of common tern in the Firth of Forth relative to the status of the sprat fishery in ICES statistical rectangles 41E6 and 41E7 (Figure 9) from 1966 to 2010. The period was split into “harvest period” of high sprat landings, “initial no-take period”, “recent periods” and “collapse” of the fishery. Jennings *et al*., (2012) showed that the collapse of the fishery due to sprat stock collapse in the region resulted in significantly lower numbers of common tern breeding pairs. Whilst Jennings *et al*., (2012) has important messages for fisheries management, the scale of impact is incomparable to the context at Sizewell.

Table 8 Year to year variations in annual predicted Sizewell B impingement numbers (2009-2017) for selected species.

Species	The year-year changes in annual numbers from the Sizewell B CIMP dataset 2009-2017[1] (shown as the ratio of predicted impingement numbers in adjacent years).	
	Mean interannual variability (2009-2017)	Maximum interannual variability between any two adjacent years
Sprat	1.72	4.54
Herring	1.33	1.53
Whiting	1.50	2.08
Sea bass	2.01	4.46
Sand goby	4.27	15.32
Sole	1.42	2.41
Dab	2.44	8.22
Anchovy	4.04	4.87
Flounder	1.39	1.86
Plaice	1.78	3.03

[1] Data from the year 2013 is not available, therefore interannual variability details changes from 2012 to 2014.

3.5.1.2 Natural variability in larvae

The RSPB and SWT in their Written Representations [REP2-505] noted that little tern feed their chicks with small prey items that could be susceptible to entrainment. During the breeding season, little terns feed their chicks on a range of prey items including fish and crustaceans and young-of-the-year clupeids have been shown to be important prey resources for little terns regionally (Perrow *et al.,* 2011). The prey items for young chicks can be as small as 25mm (Pavia *et al.,* 2006; Bogliani *et al.,* 1994). Accordingly, an assessment was made on the local depletion of larval fish and early juvenile stages.

BEEMS Technical Report TR315 [APP-319] reports the mean numbers of fish larvae sampled each month at Sizewell, between 2008 and 2012 for a range of species. Larval recruitment is driven by meteorological, oceanographic and ecological processes. Variability in these factors mean the locations and numbers of young fish reaching coastal areas varies year to year. Over the summer breeding season large within year variation and between year variation can be observed with mean abundances per m^3 changing several fold.

Monthly ichthyoplankton samples were also collected from 2014-2017 at the location of the Sizewell B intakes and outfalls and at the offshore location of the Sizewell C cooling water infrastructure (BEEMS Technical Report TR454). The results showed high degrees of spatiotemporal variation across the site and between years. When the scale of predicted local depletion is considered relative to a background of high variability in recruitment and high natural mortality rates, the effects of the station are an order of magnitude lower.

3.6 Local depletion in an HRA and WFD context

3.6.1 Food webs

Designated breeding bird species at Sizewell with central place foraging from nesting sites include lesser black-backed gulls, sandwich terns, common terns, and little terns. The foraging ranges of sandwich terns, lesser black-backed gulls, and common terns during the breeding season extends beyond the GSB and tidal excursion allowing these species to access prey resources from a wide area (BEEMS Technical Report TR431). Marine mammals and overwintering red throated diver have greater foraging ranges still without the restriction of having to return to local breeding colonies near Sizewell.

The FRR system is designed to return robust species that are impinged onto the station drum and band screens safely back to sea. However, the FRR system would also return dead and moribund species retaining biomass within the system. As the FRR is not chlorinated the returned biomass is retained within the system resulting in potential bottom-up effects stimulating secondary production and, in some cases, affording opportunistic feeding opportunities for seabirds. Whilst the majority of FRR discards sink and would therefore not be accessible to surface feeding seabirds, floating discards would represent a potential foraging opportunity to scavenging seabirds (BEEMS Technical Report TR501).

Common terns and sandwich terns are known to extensively exploit fisheries discards in the Mediterranean and lesser and greater black backed gulls and herring gull are known to extensively exploit fisheries discards in the Northeast Atlantic, whilst black-headed gull and common gull exploit fisheries discards less frequently (Bicknell *et al*., 2013). Studies have shown seabirds can take up to 71% of discarded roundfish (the predominant fish impinged at Sizewell B), 8% of discarded flatfish, 12% of discarded elasmobranchs and 4% of discarded invertebrates in the southern North Sea (Garthe *et al.,* 1996). Wide foraging ranges coupled with the low levels of depletion relative to natural variability and the potential to exploit opportunistic foraging opportunities from the FRR suggests no significant adverse food-web effects due to fish impingement for these species.

Little terns have the most area restricted foraging ranges and during the breeding season forage close to their colonies out to a maximum distance of approximately 2.4km offshore (BEEMS Technical Report TR431). Furthermore, little tern are not expected to benefit from FRR discharges as they do not follow trawlers to exploit discards (Oro and Ruiz, 1997). Given this, little terns have therefore been the focus of this study. Breeding SPA little tern from colonies at Minsmere, Dingle Marshes (both within the Minsmere-Walberswick SPA) and Slaughden (within the Alde-Ore Estuary SPA) would forage to a large extent within the GSB and tidal extent. However, based upon the expected breeding season foraging ranges of the birds from these colonies, foraging would primarily be within the Sizewell-Dunwich Bank and therefore more likely be subject to the immediate effects of Sizewell B (see the predicted little tern foraging ranges shown in **Plate 8.7** in the **Shadow HRA Report** [APP-145]) rather than the Sizewell C as the intakes are located 3km offshore.

The prey of little terns may be subject to both impingement and entrainment. Impingement of pelagic fish by both stations is predicted to result in depletion at the scale of the GSB and tidal excursion of less than 3%. In the case of larval and early-stage juvenile fish, entrainment assuming 100% mortality would be in the range of 4 - 8% in comparison to a baseline with neither station operating. The contemporary Sizewell B station is predicted to cause local depletion in the smaller GSB area by 3.5 – 7.6% (Section 3.4.1.1). Such predicted values of local depletion in prey resources are orders of magnitude lower than natural variability. The within year spatial, and temporal variability in pelagic prey resources is demonstrated on a logarithmic scale in Figure 19 and Figure 20. Impingement records show mean interannual variability as a factor of 1.72 (172% change year to year) for sprat and 4.04 (>400%) for anchovy (Table 8). Therefore, scale of depletion as predicted by this local assessment is likely to be indiscernible against this highly variable background for little terns with foraging ranges in the order of several kilometres from breeding colonies.

Shrimps form part of the diet of little tern (Pavia *et al.,* 2006; Bogliani *et al.,* 1994) and are a commonly impinged and entrained group of invertebrates. The most common shrimp at Sizewell is the brown shrimp *Crangon crangon* which attains maximum lengths of approximately 89mm. *Crangon crangon* is widely distributed at Sizewell with high degrees of seasonal and spatial variability in distribution. Benthic sampling off Sizewell provides no evidence of local depletion in the inshore waters near Sizewell B where high abundance and high variability has been recorded (BEEMS Technical Report TR348 [APP-320]).

The scale of local depletion of prey resources is therefore well within the bounds of natural variability to which predator-prey relationships are adapted. As such, no significant reductions in the prey availability of designated HRA species are anticipated.

3.6.2 WFD fish status and impacts on smelt

The Environment Agency has raised concerns pertaining to smelt and the status of the Alde & Ore water body Transitional Fish Classification Index (TFCI) under the WFD, and for smelt as a species of importance under the Natural Environment and Rural Communities Act 2006. Specific comments in relation to the WFD were addressed in **BEEMS Scientific Position Paper SPP108** [AS-238]. A summary of the results is provided in Section 2.7.

The mouth of the Alde-Ore Estuary is 25km to the south of Sizewell C (near Shingle Street in Figure 10). The **Environment Agency** [REP2-135] indicate that the smelt in the Alde and Ore is common with a breeding population belonging to the Deben, Orwell and Stour. The mouth of the Deben is located 33km to the south of Sizewell C whilst the Orwell and Stour estuary mouth is some 42km south of Sizewell C.

The mouth of the Alde-Ore Estuary is well beyond the GSB and tidal excursion and would therefore be subject to lower levels of depletion than predicted in the local assessment off Sizewell. Given the TFCI is insensitive to 25 and 50% reductions in smelt abundance, even with the most robust fish manipulations tested, and are also far beyond the predicted losses due to the proposed development as determined by the local depletion modelling, it is highly unlikely that the proposed development would cause a deterioration in the fish status of the Alde & Ore.

3.6.2.1 Impingement effects on smelt

In commenting on version 3 of this report the Environment Agency noted that without the ability to quantify immigration rates of smelt to replenish losses due to impingement from stocks outside of the area, limited immigration must be assumed. The Environment Agency [REP2-135] indicate that *"this is supported by the fact that smelt populations have previously been exploited to a point causing the collapse and loss of the species from some waterbodies on the east coast, recovery from this collapse has taken a long time and has still not happened in some water bodies".*

The mouth of the Alde-Ore Estuary for which the Environment Agency have concerns regarding the smelt population is located 25km to the south of Sizewell C (near Shingle Street in Figure 10). The Environment Agency [REP2-135] indicate that the smelt in the Alde and Ore are common with a breeding population belonging to the Deben, Orwell and Stour. The mouth of the Deben is located 33km to the south of Sizewell C whilst the Orwell and Stour are some 42km south of Sizewell C. Equidistant, north are the Rivers Yare, Bure, Wensum and Waveney each with spawning populations (Figure 10). Tagging studies of adult smelt captured on the River Waveney (over 30km north of Sizewell) show upriver migration of adults in the Waveney and Yare in March with likely spawning sites at Beccles (15.7km upstream) and Oulton Dyke (Moore *et al.,* 2015). After spawning, the majority of fish move back to sea to feed (A. Moore pers. comms.). Smelt in the coastal waters around Sizewell and in Suffolk are considered to belong to a population associated with the Norfolk Broads and the estuarine and brackish waters around Great Yarmouth and Lowestoft (Maitland, 2003b). Comparative genomic analyses concluded that smelt from Sizewell and from the River Thames, Waveney, and Great Ouse are genetically homogeneous with no genetic structuring seen within the region (BEEMS Technical Report TR423). The population genetics is indicative of a degree of mixing across the region. This is supported by the recovery of smelt following the extinction in the Thames (Wheeler 1979), with subsequent recovery considered most likely to have come from the Medway, demonstrating elasticity of the species in its inshore coastal and outer estuarine behaviour (S. Coates pers. comms, reported in **SPP108** [AS-238]). Recovery of smelt populations in some waterbodies is not only dependent on immigration but also on reversal of the pressures that lead to the initial collapse. Furthermore, it is considered probable, but not yet proven, that the smelt impinged at Sizewell B originate from a southern North Sea stock and very large numbers have been observed in the River Elbe in Belgium (**BEEMS**

Scientific Position Paper SPP100 [AS-238]). The population estimate for smelt has been precautionary assessed based on landings in the Anglian Region as detailed in Section 2.7.

Impingement monitoring at Sizewell B shows that the majority of smelt impinged are juvenile fish during the summer months when they feed at sea (**BEEMS Scientific Position Paper SPP101** [AS-238]). There is limited knowledge of the at sea behaviour of smelt and it is not feasible to quantify the replenishment rates of smelt in an open coastal system such as Sizewell. Smelt are a pelagic shoaling species, that feed in the coastal environment. There is no suggestion that juvenile smelt from a given waterbody aggregate at Sizewell during the summer months and impinged fish are likely to originate from a number of river systems in the region. Movements of shoaling smelt along the East Anglian coast are likely to be driven by tidal processes and prey availability.

To account for the uncertainty in replenishment rates, localised depletion of smelt has been considered at replenishment rates from 1% to 25% of fish per day in the case of Sizewell B and Sizewell C operating together on both the GSB and tidal excursion and ICES 33F1 (Figure 22). Local depletion at replenishment rates of 5% per day is 5.8% in the GSB and tidal excursion and 0.26% in ICES 33F1. Assuming the lowest replenishment rate of 1% of fish per day, local depletion in the GSB and tidal excursion reaches 23% and 0.71% in ICES 33F1. However, as noted in Section 3.3.1 caution needs to be exercised when forcing extreme values into the simple conceptual model. This is due to the relationship between exchange rates and the assumption of equal horizontal density across the GSB and tidal excursion. As greater exchange rates maintain the local density, total impingement also increases with higher exchange rates. Conversely, very low replenishment rates between the assessment cells would result in the model predicting high local depletion. This is because within assessment cells, the model assumes homogenous horizontal distribution of fish. It is highly unrealistic to simultaneously assume very low replenishment rates whilst maintaining equal distribution within the assessment cell i.e., equal change of impingement at each subsequent time step. Immigration/emigration rates for pelagic species such as smelt of 1% are unlikely in the tidally dominated environment at Sizewell when east coast daily tidal exchange rates of approximately 20% are anticipated (Environment Agency, 2011).

It is likely that the juvenile fish impinged at Sizewell B during the summer months come from a number of river systems in the East Anglian Region and possibly beyond. It is therefore unlikely that impingement by Sizewell C alone or in-combination with Sizewell B would have an significant effect on smelt in the nearest river systems of the Alde & Ore, Deben, Orwell and Stour 25-42km to the south or the Rivers Yare, Bure, Wensum and Waveney some 30-40km to the north (Figure 10). Furthermore, impingement records from Sizewell B show no significant changes in smelt abundance during the impingement monitoring period (**BEEMS Scientific Position Paper SPP108** [AS-238]). Uncertainty analysis completed as part of the Deadline 6 submissions (**BEEMS Scientific Position Paper SPP116** (Doc Ref. 9.67) determined that the station is anticipated to result in losses of 0.51% of the estimated Anglian Region SSB with an upper 95% percentile estimate of 0.82%. Such losses would not be significant relative to the conservatively estimated Anglian Region SSB.

The population dynamics and abundance of smelt in Alde-Ore is likely to vary proportionally to the wider spawning population size and in response to factors other than the effects of the station. For example, the water body typology and variations in freshwater inputs may influence smelt numbers in the Alde-Ore. The Alde & Ore is classed as a Type 4 transitional water body characterised as a fully mixed, polyhaline or euhaline, and mesotidal. Smelt favour macrotidal systems with large freshwater inputs providing a signal to spawn. Anthropogenic pressures of drought conditions could limit smelt occurrence in the water body (S. Coates pers. comm. Reported in **BEEMS Scientific Position Paper SPP108** [AS-238]).

Despite the small scale of the predicted effects on the regional smelt population, SZC Co. as part of the ongoing Eels Regulations and Water Framework Directive discussions with the Environment Agency, are investigating the potential for further monitoring of smelt and installation of fish passes in relevant local rivers. The precise details are yet to be confirmed, but this commitment would be secured as a DCO Requirement and funded via the Deed of Obligation.

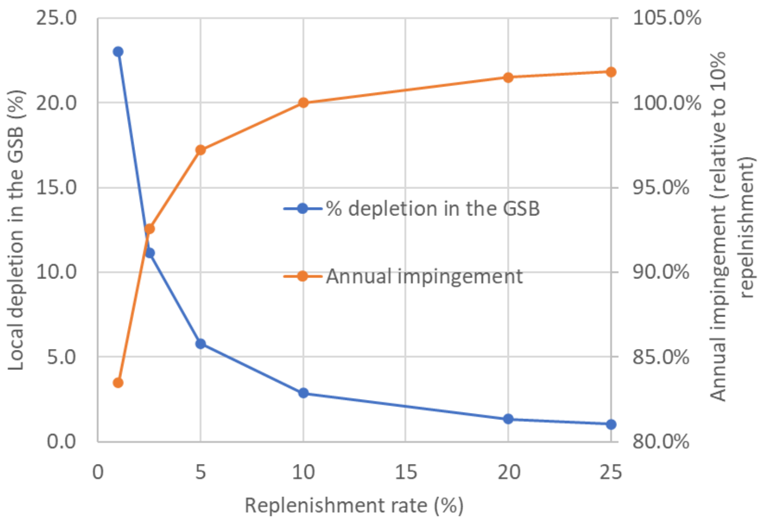

Figure 21. The influence of the replenishment rate on local depletion of smelt in the GSB + tidal excursion and ICES 33F1 from the operation of Sizewell B and Sizewell C.

3.7 Local depletion conclusions

Local level depletion of fish has been considered by applying a simple conceptual model of impingement relative to tidal replenishment. Whilst the model necessitates making assumptions relating to fish distribution and behaviour, it is possible to approximate the likely size of effects at local scales. The main conclusions are:

1. With both stations operating together, local depletion reaches a plateau after approximately 30-50 days, after which point abstraction losses and emigration are balanced by immigration into the local area.
2. Replenishment rates of 10% per day of fish within the GSB + tidal excursion result in minor reductions in pelagic species such as sprat and herring of less than 3% during periods of seasonal abundance with both Sizewell C and Sizewell B operating assuming no benefit from the LVSE or FRR.
3. Depending on the range of tidal replenishment rates larval and early juvenile stages may incur local depletion in the order of 4-8% at the scale of the GSB and tidal excursion due to entrainment with both stations operating assuming 100% entrainment mortality and no benefits from the design of the capped headworks or LVSE.
4. Local depletion of demersal species such as sea bass is anticipated to be approximately 6.6% with an FRR uncertainty range of 4.6% to 9.6% at the scale of the GSB and tidal excursion with no benefit from the design of the capped headworks or LVSE. Adjusting for the vertical distribution of cod in the water column which could increase the risk of abstraction, local depletion was predicted to be in the range of 6.4% to 11.5% again assuming no benefits from the headworks.
5. Epibenthic depletion at the scale of the GSB + tidal excursion is typically predicted to be approximately 4.7% with both stations operating (minimum best-case range from 1.8% for Dover sole to maximum worst-case of 9.4% for dab). These estimates include approximate corrections to the distribution of fish in the water column relative to intake infrastructure and no benefits from the headworks.
6. Predicted local depletion due to impingement is orders of magnitude below natural variability in abundance to which predator-prey relationships are adapted to. Therefore, impingement from Sizewell B and Sizewell C is not anticipated to have any adverse food-web effects on designated features of HRA sites.

7. Local effects are not predicted to cause a deterioration in the WFD fish status of the Alde & Ore water body as local depletion is well below the sensitivity of the TFCI metric.

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Appendix A – Population information for additional species

The following species information was provided in previous versions of this report. The Environment Agency in their Deadline 2 Written Representation did not raise any further concerns relating to these species. Accordingly the information has been retain within this report but moved to the Appendix allowing Section 2 to have greater focus on the species where agreement is still being sought.

4.1 Allis Shad

Stakeholder comment: "*There are closer populations than the Garonne population, which make us question the validity of using the Garonne fish as the reference population. Can further evidence be provided".*

Further comment on version 2: The Environment Agency and Natural England acknowledged that impingement predictions amount to a single fish per annum. However, emphasised the necessity to follow the HRA processes and assign fish to specific SACs including the Tamar Estuary where Environment Agency monitoring detected 419 fish in 2015.

Environment Agency comments on version 3: "*The applicant proposes that the Garonne stock is the likeliest source for the occasional fish that are caught in summer feeding grounds that are present in the North Sea, although they acknowledge that there are smaller populations nearby. No evidence is presented as to why the North Sea fish would come from a more distant, larger, population as opposed to a closer, smaller, population. Predicted annual impingement of allis shad is small (mean = 2, L95 = 0, U95 = 13) and if shad come from a mixture of populations, then the chance of an impact on any one population is correspondingly reduced. However, comparing losses to the largest European population is potentially misleading. No population estimates are provided for rivers other than the Garonne. Self-sustaining populations in Brittany and Normandy are mentioned but no references/population estimates cited. Within EIA, consideration should be given to potential impacts on populations other than that of the Garonne".*

Response:

A single fish was impinged at Sizewell B on the 28 May 2009. The specimen was 50 cm in length, at the top end of the expected length at maturity that typically varies between 30 and 50 cm (Froese, Pauly, 2019).

Allis shad are known to migrate very large distances and have higher dispersal capacities at sea than twaite shad (Taillebois *et al.,* 2020). The Gironde-Garonne-Dordogne stock is typically used as a reference in population dynamics (Wilson, Veneranta, 2019) though it is not the closest river with a breeding population to Sizewell. The Gironde-Garonne-Dordogne stock is by far the largest in Europe and likely to provide the source for the occasional fish that are caught in the summer feeding grounds in the Celtic Sea, the English Channel and southern North Sea. Fish from the Gironde-Garonne-Dordogne stock have high site fidelity and forage near natal rivers; however, the species exhibits moderate but nevertheless sufficient straying to uniformise the Allis shad population genetic structure along French shores. The furthest recorded distance between natal and spawning river was > 700 km (Martin *et al*., 2015), which is roughly similar to the distance between Sizewell and the mouth of Loire in Brittany. For example, fish that were born in France were caught on their spawning migration in Portugal, and fish born in northwest France (Bay of Biscay) were caught in northern France, English Channel (Wilson and Veneranta, 2019).

Populations of *Alosa alosa* exist along the north-eastern Atlantic coasts in some large rivers of France (Loire, Gironde–Garonne–Dordogne, and Adour) and Portugal (Minho and Lima) (BEEMS Scientific Position Paper SPP071/s). A single allis shad in spawning condition was found dead on 26 April 2020, 200km up the river Scheldt in Belgium after an organic pollution event in early April 2020 more than 100km upstream in France. The shad was an exceptionally large specimen of 57cm length and confirmed as an allis shad by gill raker count; according to the Instituut Natuur-En Bosonderoek (INBO) this is the first record in 100 years of allis shad in the upper Scheldt (INBO 2020). The fish would have entered the Scheldt from the sea in early to mid-April and INBO hypothesise that it may have originated from one of a number of recent reintroduction programmes in the Oosterschelde (Eastern Scheldt). The Scheldt and the Rhine are the nearest European rivers to Sizewell (approximately 150km to the east) with records of allis shad but there is no convincing evidence of self-sustaining populations, particularly in the Scheldt. INBO have previously caught a 27cm immature fish off the coast in 2012 and this was also attributed to the reintroduction programme. Allis shad have recently been reintroduced into the Rhine, which is the nearest reproduction area, but the number of recruits is still small.

As noted by the Environment Agency, the single fish impinged at Sizewell may have originated from a number of river systems: from the reintroductions in the Scheldt or the Rhine, or from other self-sustaining populations in Brittany and Normandy or from the largest population in the Garonne. Seven SACs along the northern French coast with recorded breeding populations of allis shad have been scoped into the shadow HRA screening assessment for LSE (EDF Energy, 2021). These SACs range from 400km to 865km from Sizewell and include:

- Rivière Laïta, Pointe du Talud, étangs du Loc'h et de Lannenec SAC.
- Estuaire de la Rance SAC.
- Rivière Elle SAC.
- Rivière Elorn SAC.
- Marais du Cotentin et du Bessin - Baie des Veys SAC.
- Rivière Leguer, forêts de Beffou, Coat an Noz et Coat an Hay SAC.
- Tregor Goëlo SAC.

To our best knowledge, there are no assessments of shad populations sizes for each of these rivers.

In the UK, two locations have been identified where individuals in breeding condition have been recorded: the river Tamar in SW England and the Solway Firth on the border between England and Scotland (Jolly *et al*., 2012). Individual immature adults are occasionally found in the Bristol Channel, the English Channel and the UK east coast. The Tamar Estuary forms part of the Plymouth Sound and Estuaries SAC situated approximately 700 km from Sizewell. Although it is unlikely the shad impinged at Sizewell originated from the Tamar, the Plymouth Sound and Estuaries SAC is screened into the shadow HRA. Allis shad are a qualifying feature of the Plymouth SAC, but not a primary reason for site selection. Allis shad are also qualifying features for SACs in Wales such as Pembrokeshire Marine SAC, however, these sites are further afield (>1000km by sea) and do not have confirmed self-sustaining populations.

Adult allis shad gather in rivers in May for spawning having migrated from the sea typically in early to mid-April, the large Sizewell B specimen, impinged at the end of May, was likely to have been a mature fish which lost its homing instinct. The specimen would not have reproduced that year had it not been impinged and would have had to survive to the following year for the opportunity to reproduce. The single impingement record of allis shad at Sizewell would not make any material difference to whichever population it was from. No self-sustaining population could be dependent upon such low numbers of fish.

4.2 Dab

Comment: *“The paper cited in TR406 seems to indicate a smaller scale of assessment than actually used”.*

Further comments on version 2: Further comments from the Environment Agency *“Although area division 3.a is now excluded, justification for the use of landings data from all of subarea iv is weak*.”

“Rijnsdorp et al. (1992), which is cited in TR406 and suggests a still smaller assessment area would be appropriate (perhaps iv.b and iv.c). This has not been answered by the applicant.”

“The original version of TR318 concluded that dab were part of a population limited to the southern North Sea and compared entrainment to landings data from IVc only and we have previously asked for the change from this position to be explained to us. It still hasn’t been.”

Response:

The ICES report of working Group on the Assessments of Demersal Stocks in the North Sea and Skagerrak (WGNSSK) (ICES 2020c) states: *"The several spawning grounds and the wide distribution of dab indicate the presence of more than one stock. Meristic data (Lozán, 1988) corroborate the hypothesis of several stocks for dab, distinguishing significantly between populations from western British waters, the North Sea and the Baltic Sea".*

Therefore, we agree that including landings in Division 3.a overestimates landings from the relevant population for contextualising losses at Sizewell. The appropriate scale for impingement losses at Sizewell should only apply annual landings from the North Sea Subarea 4 as the comparator. Mean landings data for dab in Subarea 4 for the period 2009 to 2017 was 5,188t (ICES, 2020e).

The change in landings data comparator has no bearing on the outcome of the assessment. Furthermore, it should be noted that using landings as a comparator is not equivalent to the larger (undefined) SSB for the species, so the assessment is highly precautionary, especially when the very high level of discarding of the species (mean of 766% of landings in the period 2009-2017), which are not captured in the landings data, is considered (BEEMS Technical Report TR406). Stocks of dab are in sufficiently good status that in 2017, ICES advised that "*the risk of having no catch limits for the dab … was considered to be low and not inconsistent with the objectives of the Common Fisheries Policy... Dab and flounder are no longer managed under a TAC*" (ICES, 2020c). This effectively means dab is unmanaged because of no concerns over sustainability leading ICES to state that… "*this advice was valid as long as dab and flounder remained largely bycatch species, with the main fleets catching dab and flounder continuing to fish the target species (plaice and sole) sustainably … If this situation changes, or dab is no longer within safe biological limits, this advice would need to be reconsidered*." (ICES, 2020c).

4.3 Flounder

Comment: "*The change in the scale of assessment was significant but not explained".*

Further comments on version 2: Further comments from the Environment Agency *"The applicant has not understood the questions we have over the flounder assessment and has instead provided an explanation of ICES methodology. We asked why flounder losses were compared to local landings of 12 tonnes in the original TR406 (2016)* [the first edition of TR406 was in 2019] *but are now compared to the whole North Sea (3,365 tonnes)."*

Response:

The first version of BEEMS Technical Report TR406 was released in 2019. A preliminary impingement assessment was provided in 2016 to allow consultation and an iterative development of the methodology. The preliminary report was not based on as complete an evidence base as BEEMS Technical Report TR406. The Environment Agency has been informed that the preliminary report has been superseded by BEEMS Technical Report TR406 and is no longer relevant. BEEMS Technical Report TR406 is based on the most contemporary evidence, where evidence gaps are identified, or evidence changes the report has been updated accordingly.

The scale of assessment adopted in BEEMS Technical Report TR406 is based on fisheries landings from Subarea 4 & 3.a (North Sea & Skagerrak and Kattegat). Updated information on landings in the different sub-divisions of the North Sea, Kattegat and Skagerrak) are provided in Table 9. The updated mean landings from 2009-2017 are 2,313t opposed to 2,309t applied in **BEEMS Technical Report TR406.v7** [AS-238].

Table 9. Total landings of flounder in the North Sea in tonnes (table 6.5 in ICES 2020e).

Year	Division 3.a (Kattegat and Skagerrak)	Subarea 27.4. (North Sea)	Total
2009	273	2,815	3,088
2010	205	3,160	3,365

Year	Division 3.a (Kattegat and Skagerrak)	Subarea 27.4. (North Sea)	Total
2011	145	3,048	3,193
2012	118	2,192	2,310
2013	173	1,703	1,876
2014	194	1,873	2,067
2015	77	1,836	1,913
2016	109	1,630	1,739
2017	159	1,103	1,262
Average	161	2,151	**2,313**

Flounder was last benchmarked by ICES in 2018 and the SPiCT model was successfully used for assessment of this stock. However, updating the SPiCT with new data led to increased uncertainties and in 2019 the model was abandoned. The stock status was assessed using length-based indicators, as had been the case prior to the incorporation of the SPiCT model, with survey indices taken into account. This change in methods of assessment has limited implications for stock management and no effect on the assessment of the proposed development which is contextualised against landings.

The current stock of flounder in the North Sea are sufficiently high leading to ICES stating that flounder is no longer needed to be managed under a TAC and this advice was valid as long as dab and flounder remained largely bycatch species, with the main fleets catching dab and flounder continuing to fish the target species (plaice and sole) sustainably (ICES, 2020c).

Flounder is a bycatch species with a high discard rate (some 12.1 - 49.4% of landings in the North Sea) in the period 2002-2019 (ICES, 2020c), and discard survival in the North Sea and English Channel is of 42-64% in otter trawls and ~37% in beam trawls (Catchpole *et al.,* 2015). The stock is estimated to be in the safe limits to the extent that ICES was not requested to provide advice on fishing opportunities for this stock in 2019 because the risk of having no catch limits for flounder was considered to be low and not inconsistent with the objectives of the Common Fisheries Policy (ICES 2020c).

4.4 Thornback ray

Comment: *"There is some evidence of more localised population in the North Sea that should be considered".*

Response: The population structure of thornback ray has been explored in UK waters using a reliable tool of microsatellite loci, which demonstrated absence of genetic differentiation even between distant locations. Immature rays might travel to winter foraging areas and intermix there, whereas spring and summer foraging grounds are relatively isolated due to partial philopatry (Hunter *et al*., 2006; Chevolot *et al*., 2006). However, some immature rays are believed to migrate into the different areas thus making genetic structure uniform all around the U.K., and defining population limits becomes challenging (Chevolot *et al*., 2006). Therefore, the respective definition of stock units becomes to some extent subjective and driven by expert judgement.

Based on the latest ICES advice the assessment area previously applied in BEEMS Technical Report TR406.v6 of Subarea 4 & Divisions 3.a & 7.d (North Sea, Skagerrak, Kattegat & eastern English Channel) was accepted to be too extensive as rays from the Eastern Channel were assigned to be a different management unit with a separate allocation of TAC. An alternative, more precautionary approach was applied based on the assessment/TAC-allocation of Subarea 4 and Division 2a (North Sea and Norway) as defined by ICES (ICES 2019). During the period 2010-2017 landings of thornback ray in the Division 2a were negligible (< 1 t. per annum), whereas landings in the North Sea (Subarea 4) were of 491-905t, mean 677t (ICES, 2020e). As such Division 2a has little bearing on the landings comparator. The stock size indicator demonstrated a strong increase in ray abundance from around 2012 onwards and the agreed TAC (798-1,404t) was not taken by fishermen (ICES, 2019).

Using landings as a comparator is not equivalent to the larger (undefined) SSB for the species, therefore this coupled with the fact that the TAC has not been achieved means the assessment is highly precautionary. The change in landings data comparator has no bearing on the outcome of the assessment.

4.5 Sand eel

Comment: *"A prey species for relevant bird and mammal features (TR431) which needs suitable consideration".*

Response:

Sand eel are present in the waters off Sizewell but in low biomass (BEEMS Technical Report TR345) Common sand eel are impinged at Sizewell B at very low numbers with annual estimates from the CIMP predicted to be 3,175 individuals of the common sand eel (*Ammodytes tobianus*) and 570 greater sand eel (*Hyperoplus lanceolatus*) over the period 2014-2017 (BEEMS Technical Report TR339). Entrainment estimates are negligible, predicted to be 0.00010% of SSB (BEEMS Technical Report TR318). As stated in BEEMS Technical Report TR431, sand eel form a part of the diet of many piscivorous seabirds and marine mammal including designated SPA and SAC species of relevance to Sizewell. However, many seabirds and marine mammals are opportunistic foragers and display plasticity in their diet depending on prey availability. For example, ICES benchmark workshop on sand eel (WKSand) analysed the importance of the species in the diet of the different seabirds and their respective vulnerability. Among seabirds occurring in Suffolk, the Sandwich tern was found to be highly vulnerable to change in the diet, but the species is seemingly more specialised on clupeids (ICES 2017).

The following is an extract from BEEMS Technical Report TR431 (revision 2):

"The most important fish families taken by breeding piscivorous seabirds in the North Sea are sand eels and clupeids with diets varying geographically and seasonally depending on the site-specific food availability (Tasker and Furness, 1996). The scientific literature frequently indicates that sand eels form a major part of the diet of terns (Common, Sandwich and Little Tern) and lesser black backed gulls in the North Sea. For example, Furness and Tasker (2000) estimate that sand eels form 40%, 60% and 20% respectively of the diet of the above three tern species in the southern and south-eastern North Sea. For seabirds in the north-western North Sea (such as Shetland and Orkney), there are no food-fish other than sand eels or adult herring and adult mackerel Scomber scombrus*. These adult fish are too big for most seabirds to eat, and so most seabirds in this region feed predominantly on sand eels.*

However, in the southern and eastern North Sea, the fact that sand eels form only a small part of the diet of many seabirds and that clupeids are predominant in many diets, suggests that clupeid abundance may be more important in determining breeding success than sand eel abundance in these areas. This is supported by detailed studies of Common Tern breeding success in the southeastern North Sea, where it has been found that chick growth rate and fledging success are closely correlated with abundance of young herring (Greenstreet et al., 1999).

The weight of evidence from BEEMS fishing, plankton, impingement and entrainment sampling is that sand eels are present at Sizewell but in small numbers (BEEMS Technical Report TR345). Sand eels spend most of their time buried in the sediment and are only found in the water column for a proportion of daylight hours. Due to their morphology they can pass through coarse mesh nets. For example, the 10mm drum screen mesh at Sizewell B would retain some sand eels with a variable proportion being entrained dependent upon the size of the fish. Impingement sampling data with a 10 mm mesh therefore provides a relative index of sand eel abundance not an absolute measure. In the BEEMS entrainment sampling (using pumped sampling from the Sizewell B forebay with 500 and 270 µm mesh nets) sand eel larvae only represented 2% [revised numbers <1%[5]] *of the number of fish entrained compared with 31% for clupeids (BEEMS Technical Report TR318).*

The dominant fish species at Sizewell are sprat and herring which represent 64% of the total annual impingement numbers. The evidence from surveys is that only two of the five North Sea sand eel species are present at Sizewell:

- *Lesser sand eel (Ammodytes tobianus). This is a small, common inshore species which reaches a maximum length of 20 cm, and is found along sandy shores from the mid-tide level to 30 m water depth. The species spawns from late March to early April throughout its range, depositing its eggs on the sandy substrate. This species represented 0.03% (See Table 5) of the annual Sizewell impingement numbers with 79% being caught in the December- January period.*

- *Greater sand eel (Hyperoplus lanceolatus) attains a length of approximately 32 cm. It is found in sand from the inter-tidal to 150 m depth. The species spawns in April and May at depths of 20-100 m. This species represented 0.026% (see Table 5) of the annual Sizewell impingement numbers with 71% being caught in the June -September period.*

To put the relative abundances in context, the total annual sand eel impingement catch at Sizewell was 0.1% of the sprat catch and in the seabird breeding season of May to August sand eel only represented 0.5% of the sprat catch (indicative results from an interim analysis of BEEMS impingement surveys from 2009-2013). In the BEEMS pelagic fishing surveys in April and May 2015 (with 2mm mesh nets) at three sites along Sizewell Bay, the near surface catch composition was 81-98% sprat and herring with sand eel never exceeding 1% of catch (BEEMS Technical Report TR356). From the available evidence it is concluded that sand eel form a negligible part of the fish assemblage at Sizewell and are, therefore, not an important component of SPA/SAC protected species in the region of the site".

As a result of the very low predicted losses of sand eel, and the small relative contribution to the diets of marine mammals and seabirds locally to Sizewell, sand eel have not been described further in BEEMS Technical Report TR406. However, impingement rates are contextualised against SSB and landings in BEEMS Technical Report TR318.

[5] The values quoted from TR431.v2 are based on previous versions of BEEMS Technical Reports TR318 and TR406. These reports have subsequently been modified in response to regulatory comments. As such, the exact figures are subject to minor changes, however, the scale of assessment and conclusions remain valid.

Appendix B – Sensitivity to local depletion parameters

4.6 Sensitivity to parameters

The results presented herein, are subject to the validity of the assumptions described in Section 3.3. Two key assumptions are considered in further detail 1) the replenishment rate, and 2) the assumption of equal density.

4.6.1 Sensitivity to replenishment rates

The underlying factor determining the potential for local depletion is the rate at which impinged fish are replenished from the wider area by immigration in relation to abstraction losses. Quantifying immigration and emigration rates for a range of species in an open coastal site is simply not feasible. This point was reflected in the Relevant Representations from the MMO that stated, *"it is the MMO's view that in the absence of information on the rate at which fish may migrate into the GSB area (the replenishment rate), it is difficult to quantitatively assess localised impacts on abundance".* This report attempts to put depletion in a local context by applying conservative tidal exchange rates as a proxy for fish replenishment.

Within the local depletion assessment there are effectively two boundaries; 1) the boundary of the GSB and tidal excursion with 33F1, and 2) the boundary between 33F1 and 4c. Replenishment rates (daily fish immigration/emigration) have been tested across a range of levels from 1% to 25% of fish per day. Immigration/emigration rates of 1% are likely to be rare for most species in the tidally dominated waters at Sizewell where estimated daily tidal exchange rates of approximately 20% have been estimated on the east coast of the UK (Environment Agency, 2011).

In the case of mobile pelagic species, a 10% per day replenishment rate applied in the original assessment appears suitably precautionary for most species. The greater the exchange rate the lower the local effects due to dilution. Local depletion is minimal at replenishment rates of 5% per day at 5.8%. At 10% replenishment depletion falls to just 2.9% and 1.3% depletion at 20% daily replenishment. Assuming the lowest replenishment rate of 1% of fish per day, local depletion in the GSB is 23.0% (Figure 22). However, the local depletion model assumes homogenous horizontal distribution of fish in the assessment cell. Therefore, it is highly unrealistic to assume the mobility of fish at the boundary of the GSB and tidal excursions is sufficiently small to limit replenishment to just 1% for example, whilst simultaneously assuming equal distribution within the assessment cell.

As greater exchange rates maintain the local density, total impingement increases with increasing replenishment rates. This point is illustrated in Figure 22, which shows the relationship between local depletion of pelagic group species in the GSB and tidal excursion and impingement from Sizewell B and Sizewell C operating. By fixing impingement numbers based on 10% daily exchange it is apparent that annual impingement has low sensitivity to variations in replenishment rates between 5 and 25%, with total impingement numbers changing less than ±3%. However, annual impingement drops by 16.5% as exchange rates fall to 1% (Figure 22).

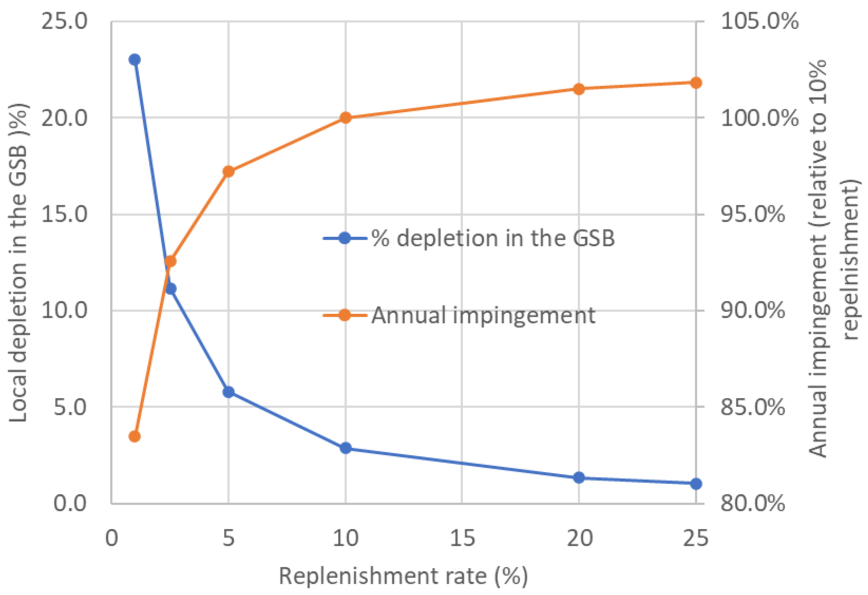

Figure 22. The relationship between local depletion and impingement of pelagic species within the GSB with Sizewell B operating. Impingement rate percentages are calculated based on annual impingement using 10% daily exchange.

4.6.2 Sensitivity to density assumptions

The assumption of uniform density across the domain is a simplification of the conceptual model. Many species exhibit seasonal migrations and shoaling behaviour. Shoaling species result in highly variable impingement rates, as such local depletion would equally be variable. Should a shoal pass directly within the small abstraction zone for the intakes, the local depletion would be temporally far higher than predicted. Equally, should a large shoal within the GSB or tidal excursion not encounter the intakes, there would be negligible depletion.

As the scale of the assessment increases the assumption of uniform density is increasingly violated and focus should be on the smallest spatial scales (i.e. the GSB and tidal excursion). For example, juvenile herring and sprat utilise inshore nursery grounds overwinter and after adult sprat spawn inshore they move further offshore post-spawning to forage mostly in the southern and western North Sea (BEEM Technical Report TR406). Both 33F1 and 4c extend to the coast and impingement numbers are small relative to the stock allowing replenishment of fish.