The Sizewell C Project

9.110 Sizewell C European Sea Bass Stock Assessment

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Cefas

Sizewell C European sea bass, *Dicentrarchus labrax*, stock assessment

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Executive summary

The proposed Sizewell C (SZC) station would be of a once-through design, abstracting large volumes of seawater for cooling the condenser steam. Fish and other biota may become drawn into the station in the abstracted cooling water. As part of the Development Consent Order (DCO) application for the operation of SZC, the effect of water abstraction on fish populations has been evaluated. The existing assessment of impacts on the sustainability of fish populations applies the Cefas equivalent adult value (EAV) approach, which involves forward projecting the annual losses of predominantly juvenile fish impinged at Sizewell to an annual rate of equivalent adult losses from the spawning population. The EAV approach is a simple risk assessment to determine whether annual rates of losses are likely to pose a risk to the affected populations.

The European sea bass, *Dicentrarchus labrax,* is a long-lived, iteroparous (repeat spawning) species. Sea bass are the 4th most commonly impinged species in monitoring sampling at Sizewell B (SZB). Application of the Cefas EAV approach to sea bass has shown that annual equivalent losses as a proportion of spawning population size are among the higher values recorded for species predicted to be impinged at SZC. While these losses are low in relation to levels of mortality that would pose a risk to the population, stakeholders have raised concerns about the EAV approach and whether it is sufficiently precautionary to evaluate the long-term effects of the station on iteroparous species.

EAV methods do not explicitly estimate the changes in populations that occur if entrapment mortality occurs over the long-term. To address directly the concerns of stakeholders, we therefore apply a stock assessment method for the seabass population to validate the conclusions drawn from EAV-based risk assessment. Stock assessments allow us to assess directly the long-term effects of impingement mortality at SZC. They are developed and applied internationally as a recognised and accepted way of assessing the status of fish populations and the effects of additional mortality.

As a commercially targeted species, sea bass is a data-rich species for which detailed stock assessments are conducted and reviewed by international groups working under the auspices of the International Council for the Exploration of the Sea (ICES). The sea bass population as assessed by ICES, has fluctuated throughout the 35-year assessment period from 1985 to 2020. Environmental factors and fishing pressure have been a major driver on the stock. In the early part of the assessment period SSB declined from over 20,000 tonnes in the mid-1980s to approximately 11,500 tonnes in 1992. The population recovered in the mid-1990s and achieved a period of high biomass up to 2010, driven by above average recruitment. The sea bass stock declined from 2010 onwards due to the increasing level of fishing pressure and low recruitment. Management measures introduced in 2015 and updated thereafter, included the prohibition of pelagic trawls and gillnets during the first six months of the year, bag limits for recreational fishing, and an increase in the minimum conservation reference size (MCRS) to 42cm. Since a low in 2018, the sea bass stock has shown a slight increase in biomass and fishing mortality in 2019 which was below F_{MSY} (maximum sustainable yield), indicating that following management measures the fishing pressure had reduced considerably.

The stock assessment for sea bass can therefore be used as a case-study to demonstrate that the results of the Cefas EAV approach correctly assess the low risk of long-term population level effects on sea bass by incorporating additional impingement mortality into the pre-existing model. Data collected as part of the Comprehensive Impingement Monitoring Programme (CIMP) from 2009-2012 and 2014-2019 at SZB were used to estimate the annual impingement rates and the length distribution of sea bass predicted to be impinged at SZC. Impingement predictions for SZC under a range of different precautionary scenarios were added as an extra source of mortality and included within the existing ICES sea bass stock assessment from 1985 to 2020 to demonstrate the long-term effects had SZC been operational throughout the assessment period. Average impingement rates (mean or upper 95% confidence intervals) were used as the input for the period 1985-2008. Mean and upper 95% confidence interval impingement estimates for SZC were incorporated into historic estimates of sea bass mortality to simulate a scenario with SZC operating for 35

years. The estimated sizes of the spawning populations of sea bass, with the simulated SZC impingement mortality was then compared to the core ICES assessment without SZC.

Impingement predictions included an extreme worst-case scenario of unmitigated impingement mortality applying the upper 95% confidence interval (U95) of impingement rates in every year for the 35-year assessment period. Assessments also considered the effects of fish recovery and return (FRR) system mitigation by assuming mean and U95 impingement predictions. Given the size of the sea bass stock, an additional assessment considered the potential cumulative effects of Hinkley Point C (HPC) and SZC operating from 1985-2020 applying highly precautionary assumptions of impingement losses.

In all scenarios tested, including the extreme worst-case SZC scenario, impingement had no discernible effects on the population trends and only very minor effects on absolute SSB. That is, the size of the spawning population would still increase and decrease at the same times and at an almost identical rates whether or not impingement was occurring (Figure i.). This is particularly evident during the periods of spawning biomass decline in the 1980's, and more recently during the 2010's. During this potentially sensitive period from 2010-2018 of low biomass (coinciding with CIMP) the population trends are barely discernible with or without the addition of SZC impingement mortality.

Commercial and recreational fisheries mortality dominate the mortality on sea bass with the addition of SZC impingement making negligible differences. This is to be expected as the vast majority of sea bass impinged at Sizewell are 0-3-year-old fish and below the MCRS. Whereas fisheries mortality is more intensive and targeted at 4–15-year-old fish.

The application of the ICES stock assessments incorporating precautionary SZC impingement estimates for a duration of 35 years provides powerful evidence that there is no significant impact on the population trends and impingement effects would pose a negligible risk to the viability of the population.

As sea bass is a potentially sensitive species the application of the most robust analytical stock assessments provides the highest degree of confidence available in the assessment that SZC would not pose a risk to the viability of the population.

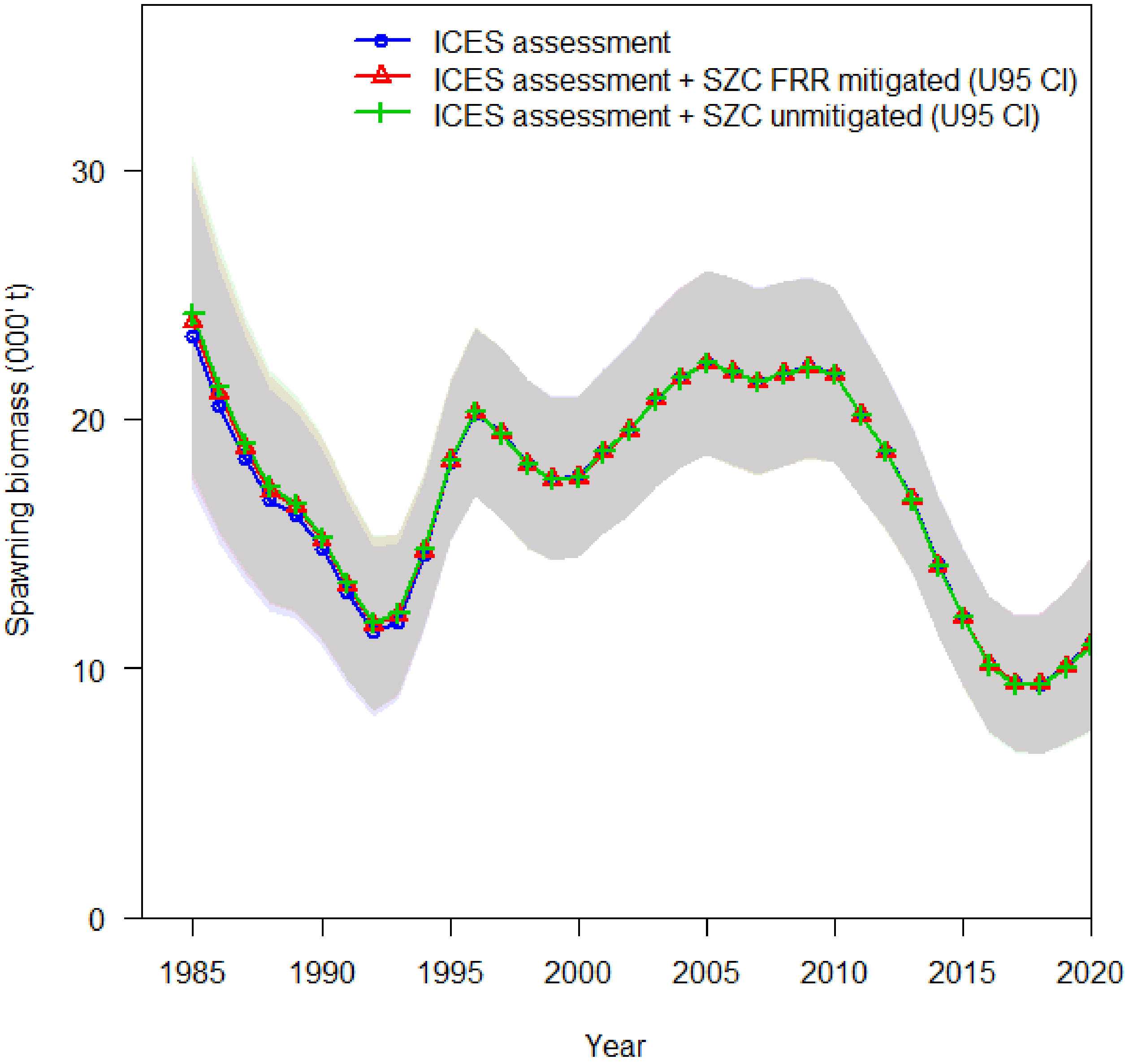

Figure i. Trends in the spawning stock biomass (SSB x1,000 tonnes) for sea bass estimated in the core ICES 2020 assessment (blue line, o symbols) and reruns of that assessment with SZC impingement incorporated as upper 95% confidence interval for impingement predictions both unmitigated (green line, + symbols) and with FRR mitigation (red line, Δ symbols). Estimated 95% confidence intervals of the SSB assessment for all three scenarios are indicated by shading. By applying upper 95% confidence interval for impingement predictions year on year for 35-years this is a highly precautionary assessment. .

1 Background

EDF Energy plans to build a new coastal nuclear power station (Sizewell C, SZC), adjacent to the operational Sizewell B (SZB) and decommissioned Sizewell A (SZA) sites in Suffolk. The station would be of a once-through design, abstracting large volumes of seawater for cooling the condenser steam. Fish and other biota may become drawn into the station in the abstracted cooling water. Biota large enough to be impinged on the fine mesh filtration systems, that are designed to protect the condensers and other essential cooling water systems from blockage, would be returned to the marine environment via the fish recovery and return (FRR) system. Smaller life-history stages including eggs, larvae and juvenile fish of some species may be susceptible to entrainment, whereby they pass through the fine filtrations systems and passage through the stations cooling water system to be discharged at the outfalls.

As part of the Development Consent Order (DCO) application for the operation of SZC, the effects of water abstraction on fish populations have been evaluated. The basis for predictions of impingement by SZC is impingement monitoring data collected at the operational SZB station. The impingement of fish at SZB varies seasonally and for most species is comprised predominantly of juvenile stages. High natural mortality of these fish means that most of the impinged fish would not naturally survive to contribute to the adult spawning population had they not been impinged. On this basis it is widely accepted that the losses of early-life history stages should be converted into equivalent adults to represent the effects of the station in the context of the spawning population.

The Cefas equivalent adult value (EAV) approach is a risk assessment method that involves a forward projection of annual impingement mortalities, accounting for natural mortality, to give an equivalent annual rate of loss of mature fish (the approach is summarised in Technical Note on EAV and Stock Size (Deadline 6 Submission - 9.63 Comments at Deadline 6 on Submission from Earlier Submissions and Subsequent Written Submissions to ISH1-ISH6 - Appendix F, pdf pg. 90 of [REP6-024]). The EAV assessment is a straightforward adjustment to reflect the likelihood of entrapped fish reaching maturity and contributing to the spawning population. Estimates of annual equivalent adult losses are expressed as a percentage of the annual spawning population size e.g., spawning stock biomass (SSB) or other relevant comparator such as annual landings.

The Cefas EAV assessment assumes on a precautionary basis that losses of 1% or so of annual SSB pose negligible risks to the population, as is well established from decades of research into the effects of additional mortality. Further details on the evidence for effect thresholds are provided in BEEMS Technical Report TR406.v7, Section 5 report pg. 55 [AS-238].

In the case that the Cefas EAV assessments suggest a risk to the population then additional assessments may be required to quantify risk and potential consequences of impingement. Stock assessments provide a powerful method for assessing fish population dynamics when sufficient data are available. The usual purpose of a stock assessment is to estimate the status of a fish population, the effects of fishing and the intensity of fishing that is acceptable given benchmarks for sustainability. Stock assessments also provide information on how future rates of fishing mortality affect population size and catches. Impingement can be included in a stock assessment as an additional source of mortality.

In this report, we apply a well-established stock assessment to determine the potential for SZC to affect the population trends and population size of the European sea bass, *Dicentrarchus labrax.*

1.1 European sea bass, *Dicentrarchus labrax*

European sea bass is the 4th most impinged species at SZB. A large proportion of sea bass recorded in impingement samples are juvenile 0-, 1-, 2- or 3-year-old fish with some 4-year-old and mature adults. The juveniles are overwhelmingly caught in the period November to March. Less than 1% of seabass impinged at Sizewell are above the minimum conservation reference size (MCRS) for fisheries of 42cm.

The installation of the fish recovery and return (FRR) systems at SZC is predicted to allow approximately 45% of impinged sea bass to survive impingement (efficiency factor of 0.551).

Accounting for the FRR efficiency, annual equivalent losses to impingement as a proportion of spawning population size were predicted to be 0.87% (Deadline 2 Submission - 9.11 Responses to the Examining Authority's First Written Questions (ExQ1) - Volume 3 - Appendices Part 3 of 7 Table 5 of Appendix 7L pdf pg. 104 of [REP2-110]). A full uncertainty analysis was completed in BEEMS Scientific Position Paper SPP116 [REP6-028] which incorporated the confidence intervals in impingement predictions, entrainment mortality[1], the uncertainty in the FRR performance and variance in the baseline population estimate (SSB). The uncertainty analysis calculated mean effects of annual equivalent losses as a proportion of spawning population size to be 0.99% of SSB with 1.87% as an upper 95% confidence interval (Table 7 of BEEMS Scientific Position Paper SPP116 [REP6-028]).

These losses do not account for the distribution of sea bass within the Greater Sizewell Bay[2] and are therefore likely to be an overestimates. They are not considered to pose risks to the population. However, this full stock assessment provides the greatest degree of confidence available in the assessment of the population level effects of the proposed development.

To Note: a complementary but independent assessment of the potential for localised depletion in fish abundance has been assessed and is presented in BEEMS Scientific Position Paper SPP103 Rev.5 [REP6-016].

1.1.1 Why has sea bass been selected for stock assessment?

As described, sea bass is the 4th most commonly impinged species at SZB and, with the exception of sand gobies, impingement of bass by SZC is predicted to have the highest population level effects.

Sea bass is a long-lived, repeat spawning species. As a commercially targeted species, sea bass is a data-rich species with information on the full life-history, migratory behaviour, population genetics and stock dynamics available. Well-established, internationally reviewed and accepted stock models are also available for assessing sea bass stock dynamics (Section 1.2).

The selection of sea bass for stock assessment was welcomed by Natural England (Deadline 7 Submission - Comments on submissions from earlier deadlines and subsequent written submissions to ISH1 to ISH6 and appendices [REP7-143]);

> *"We agree seabass is a good example as, in addition to the reasons already given, it is a long-lived fish which is slow to mature, with juveniles being heavily reliant on estuarine and coastal nursery habitats. These characteristics mean that the population is relatively more vulnerable to entrapment impacts".*

On this basis, sea bass provides a model species to determine the potential long-term effects of SZC on fish population sustainability.

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[1] Entrainment of early life history stages of sea bass is predicted to be negligible at the population level (BEEMS Technical Report TR318, Table 12, report pg. 42 [APP-324]).

[2] Sea bass are not uniformly distributed within the Greater Sizewell Bay. Survey data identified low catches in offshore otter trawl surveys with 95% of sea bass caught in-shore of the Sizewell-Dunwich Bank. This suggests that impingement predictions scaled-up from SZB may overestimate sea bass impingement at the offshore SZC intakes (see BEEMS Technical Report TR406.v7, Section 4.1.1.1. report pg. 30 of [AS-238]).

1.2 Stock assessment approaches for predicting effects on fish populations

The Cefas EAV approach can be applied to a wide range of species and is less data demanding than stock assessments. However, where indicative thresholds for equivalent annual rates of loss as a proportion of spawning population size are exceeded or where further confidence in the assessment is required, stock assessments or population modelling provide the most powerful assessment tool currently available.

Stock assessment takes account of recruitment, growth and the different sources of mortality affecting a fish population throughout its geographical range and over the full course of its life history. In the case of data-rich species, they are a powerful analytical tool for determining population dynamics. Additional sources of mortality, such as losses resulting from impingement, can be introduced to stock assessments to assess their effects. Stock assessment can comprehensively consider the long-term effects of annual impingement mortality on annual spawning stock biomass (SSB) and hence future reproductive potential.

Stock assessments are rarely used to assess impingement effects. This is because stock assessments are analytically demanding, and the scale of impingement mortality is typically orders of magnitude lower than fisheries losses. Furthermore, because stock assessments have high data requirements it would not be possible to complete stock assessments for all the key species assessed at SZC (which is an advantage of the Cefas EAV approach).

1.2.1 Sea bass stock assessment

The International Council for Exploration of the Sea (ICES) is an intergovernmental marine science organisation with the remit of meeting societal needs for impartial evidence for the sustainable use of the seas and oceans. Stock assessments conducted by ICES represent the consensus of experts, working within an international process. There are high levels of quality control and international review, and the assessments are regularly benchmarked.

The ICES sea bass stock assessment results are used to describe trends in the size of sea bass spawning populations over 35 years (1985-2020). The sea bass stock assessment was used to provide fisheries management advice in 2020 (ICES, 2020a,b). The ICES assessment includes survey data, commercial landings and discards and recreational mortality as well as changes in management measures. The setup of the ICES sea bass stock assessment followed the protocols detailed within the ICES 2018 benchmark, stock assessment working group and advice drafting group (ICES, 2018, 2020b).

The core ICES assessment demonstrates how the sea bass population has fluctuated throughout the 35-year assessment period from 1985 to 2020 (see ICES, 2021[3]) with environmental factors being a major driver for sea bass production and distribution (Pawson, 1992). In the early part of the assessment period SSB declined from over 20,000 tonnes to approximately 11,500 tonnes in 1992 (Appendix A.1; Table 3). The population recovered in the mid-1990s and achieved a period of high biomass between the mid-1990s and 2010 driven by above average recruitment. During this period the stock was above B_{pa}[4] and MSY $B_{trigger}$[5] (ICES, 2021).

[3] ICES Advice 2021: https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2021/2021/bss.27.4bc7ad-h.pdf (Accessed 21/09/2021)

[4] B_{pa} represents a precautionary safety margin incorporating the uncertainty in ICES stock estimates, which is a biomass reference point designed to have a low probability of being below B_{lim}. When the spawning–stock size is estimated to be above B_{pa}, the probability of impaired recruitment is expected to be low.

[5] MSY $B_{trigger}$ is the lower bound of spawning–stock biomass fluctuation when fished at F_{MSY} and is used in ICES advice rule to trigger a cautious response. In cases where the spawning–stock falls below MSY $B_{trigger}$, fishing mortality is reduced to allow a stock to rebuild to levels capable of producing MSY. The reduction in fishing mortality is proportional to the ratio between the size of the spawning–stock and MSY $B_{trigger}$ (ICES, 2018).

The sea bass stock declined from 2010 onwards due to the increasing level of fishing pressure (Appendix A.1; Table 3) and low recruitment and the stock fell below B_{lim} (the biomass limit reference point, below which there is a high risk that recruitment will be impaired). The European Commission developed a package of management measures to promote recovery from 2015. Management measures introduced in 2015 and updated thereafter, included the prohibition of pelagic trawls and gillnets during the first six months of the year, bag limits for recreational fishing, and an increasing in the MCRS to 42cm (just above size of first maturity; 40.65cm L_{50}).

Since 2018, the sea bass stock has shown a slight increase in biomass and in 2019 the SSB was estimated to be above B_{lim}, at 10,061 tonnes, with 95% confidence intervals of 6,999 tonnes and 13,123 tonnes (ICES, 2020b). The ICES Working Group for the Celtic Seas Ecoregion reported commercial landings from the sea bass stock as 972 tonnes in 2019. In addition, commercial discards of 464 tonnes and recreational removals of 273 tonnes were estimated (ICES, 2020b). Fishing mortality in 2019 was below F_{MSY} (maximum sustainable yield), indicating that following management measures the fishing pressure had reduced considerably. In their advice for 2020 (ICES, 2020a), ICES advised that total removals from the sea bass stock should be between 1,680 and 2,000 tonnes in 2021. In the most recent advice, ICES continues to note that fishing pressure remains below F_{MSY} and that SSB is above $B_{lim.}$ Reflecting the slight increase in SSB, total removals for 2022 were advised to be limited to 2,216 tonnes (ICES, 2021).

In this report, the ICES stock assessment has been used to determine if the predicted effects of additional SZC impingement would have led to differences in the population size, population trajectory and the timing of increases or decreases in the population.

1.2.2 SZC sea bass stock assessment methodology

Predictions of the numbers and sizes of fish impinged at SZC are derived from data collected at SZB during the Comprehensive Impingement Monitoring Programme (CIMP). This can be used to generate a time-series of estimates of SZC impingement mortality by year assuming SZC was operational for the 35-year ICES assessment period (1985-2020).

The CIMP data set used to inform predictions of impingement impacts was based on 205 daily sample visits stratified into 28 to 40 samples per year from February 2009 to March 2013 (128 samples) and a further 77 samples collected between April 2014 and December 2017. The dataset was used to provide an annual estimate of the numbers and lengths of fish impinged at the SZB station for the 9-year period. The SZB data have been 'scaled up' relative to the increased abstraction rate to predict SZC impingement rates, as described in (BEEMS Technical Report TR406.v7 [AS-238]). The stock assessment utilises preliminary data from February 2018 to December 2019 collected as part of the ongoing CIMP at SZB. The preliminary data were applied because the alternative would be to use average data from the period 2009-2017, the influence on the input parameters is minor.

For the period 2009-2019, except for 2013, impingement predictions and length distribution data were included in the core ICES stock model. The ICES sea bass assessment runs from 1985 to 2020, so the average impingement predictions were used for years prior to 2009. Mean impingement for 2012 and 2014 was used as the input for 2013. Impingement predictions used both the mean and U95 confidence intervals with and without FRR mitigation (Table 1).

SZC impingement mortality was introduced to the ICES stock assessment as another source of 'catch' being similar to 'landings' or a commercial 'fleet'. SZC length data were included in the assessment to estimate the size selectivity of the 'fleet'. The length distributions have been classified into 2cm length classes which is a requirement of the sea bass stock assessment model.

Table 1 Annual impingement losses (mean and upper 95% confidence intervals) of sea bass applied to the ICES stock assessment. SZC impingement predictions based on CIMP data provided as part of the DCO application runs from 2009-2012 and 2014-2017. Preliminary data from 2018 and 2019 is also provided.

Year	SZC Unmitigated		SZC with FRR mitigation (0.551)	
	Mean	U95	Mean	U95
2009	1,044,096	1,719,346	574,843	946,613
2010	1,940,622	2,442,129	1,068,439	1,344,551
2011	429,990	664,260	236,737	365,718
2012	459,095	778,606	252,762	428,674
2014	475,073	713,513	261,559	392,836
2015	184,264	408,054	101,449	224,660
2016	333,638	544,171	183,690	299,602
2017	269,616	574,325	148,441	316,204
2018	*218,533*	*332,803*	*120,317*	*183,230*
2019	*402,051*	*644,516*	*221,355*	*354,848*

Results from the core ICES 2020 assessment can then be compared to the ICES 2020 assessment with the additional inclusion of estimated SZC impingement mortality, to determine how SZC impingement would have affected the sea bass population if it had been operational for 35 years since 1985.

The model may over-estimate impingement losses in the 1980's and 1990's when very few sea bass were present in the Greater Sizewell Bay (BEEMS Technical Report TR406.v7, Section 11.1. report pg. 118 [AS-238]) and under-represent impingement in the early 2000's when sea bass were more abundant in the southern North Sea. However, selectivity is based on the entire time-series and the impingement losses are accurate for the reference period from 2009-2017 and beyond to 2018-2019.

1.2.3 Stock assessment scenarios

Four scenarios were adopted:

i. ICES 2020 assessment alone

ii. ICES 2020 assessment with SZC impingement:

   a. **Extreme worst case:** Applies upper 95% confidence intervals of unmitigated impingement losses for the 35-year time series. Upper 95% confidence intervals of impingement represent 1 in 40-year events. This assessment is an extreme worst case because it assumes no mitigation and 1 in 40-year impingement events occurring every year, for 35 years. Assumes no FRR benefits.

   b. **Mean FRR mitigated scenario:** Applies mean FRR mitigated SZC impingement mortality. This assessment is the most realistic scenario

c. **Upper FRR mitigated scenario:** Applies upper 95% confidence intervals of FRR mitigated SZC impingement mortality (i.e., FRR mitigation factor of 0.551 applied to U95 impingement estimates). This assessment represents a highly precautionary scenario of U95 mortality rates occurring for 35 years consecutively.

All assessment scenarios are run without accounting for the distribution of sea bass, which are not uniformly distributed in the Greater Sizewell Bay. Survey data demonstrated low catch rates offshore and 95% of sea bass were caught in-shore of the Sizewell-Dunwich Bank suggesting that impingement predictions scaled-up from SZB may overestimate sea bass impingement at SZC. Thus, the SZC impingement losses used in the model can be treated as precautionary. The distribution of juvenile sea bass within the Greater Sizewell Bay, and in relation to the thermal plumes from SZB, and the future SZC plumes is discussed in further detail in BEEMS Technical Report TR406.v7, Section 4.1.1.1. report pg. 30 and Section 7.2.4 report pg. 97 of [AS-238].

In the case of scenarios applying the U95 data for each year of the assessment effects are extremely precautionary. The U95 is on average 1.67-fold greater than the mean (range 1.26 – 2.21; see Table 1) and the probability of the U95 impingement rates occurring year-on-year for just the period 2009-2019 is 0.025^{11}.

Sea bass is a wide-ranging species, and the same population will be affected by impingement mortality at Hinkley Point C (HPC) in the Bristol Channel as well as SZC. Consistent with the approach of assessing impacts across the population range and across all life-history stages, the risks of abstraction posed by the operation of both power stations was assessed cumulatively (Appendix B.1). The cumulative assessment scenario was run using the HPC sea bass stock assessment evidence provided within the recent Hinkley Point C Water Discharge Activity (WDA) Appeal Inquiry[6].

[6] Proof of Evidence of Dr Simon Jennings CD 12.g Appendix F Application of Stock Assessment https://ea.sharefile.com/share/view/sfb86ac1978a14420862086325f233f9f/fo0eb3c3-a748-4816-be7c-c98a687d4955

2 Sizewell C stock assessment

2.1 Overview

The ICES sea bass stock assessment has been used to estimate changes in spawning population size and trends in the population, by assuming that SZC had been operating throughout the existing stock assessment period. The sea bass stock assessment directly estimates the expected consequences of year-on-year impingement mortality on the seabass population, by allowing a direct comparison of spawning population size (as SSB) and trends with and without SZC impingement mortality.

2.2 Extreme worst-case scenario

Results from both the worst-case unmitigated and the FRR mitigated scenarios show that SZC impingement throughout the 1985-2020 assessment period would not have had a significant effect on trends in SSB (Figure 1). The absolute spawning biomass varies year on year with the effects of the station resulting in minor reductions in SSB (Table 2). Differences in the timing of increases and decreases in SSB, as well as the rates of change in SSB with and without the addition of SZC impingement, are minor. This is particularly evident during the periods of spawning biomass decline in the 1980's, and more recently the 2010's when the stock fell below $B_{lim.}$ During this potentially sensitive period of low biomass the population trends are barely discernible with or without the addition of SZC impingement mortality. This provides powerful evidence that even in the situation where extreme (beyond) worst-case impingement effects from SZC are applied there is no significant impact on the population trends and no impingement effect on SSB that would pose a risk to the viability of the population.

There are negligible differences in fishing mortality when the SZC impingement mortality is included along with catches (Appendix A.1; Table 3). Commercial and recreational fisheries dominate fishing mortality as would be expected as the vast majority of sea bass impinged at Sizewell are 0–3 year-old fish and below the minimum conservation reference size (MCRS), currently set at 42cm. Fishing mortality in the ICES stock assessment is estimated for 4-15 year old fish.

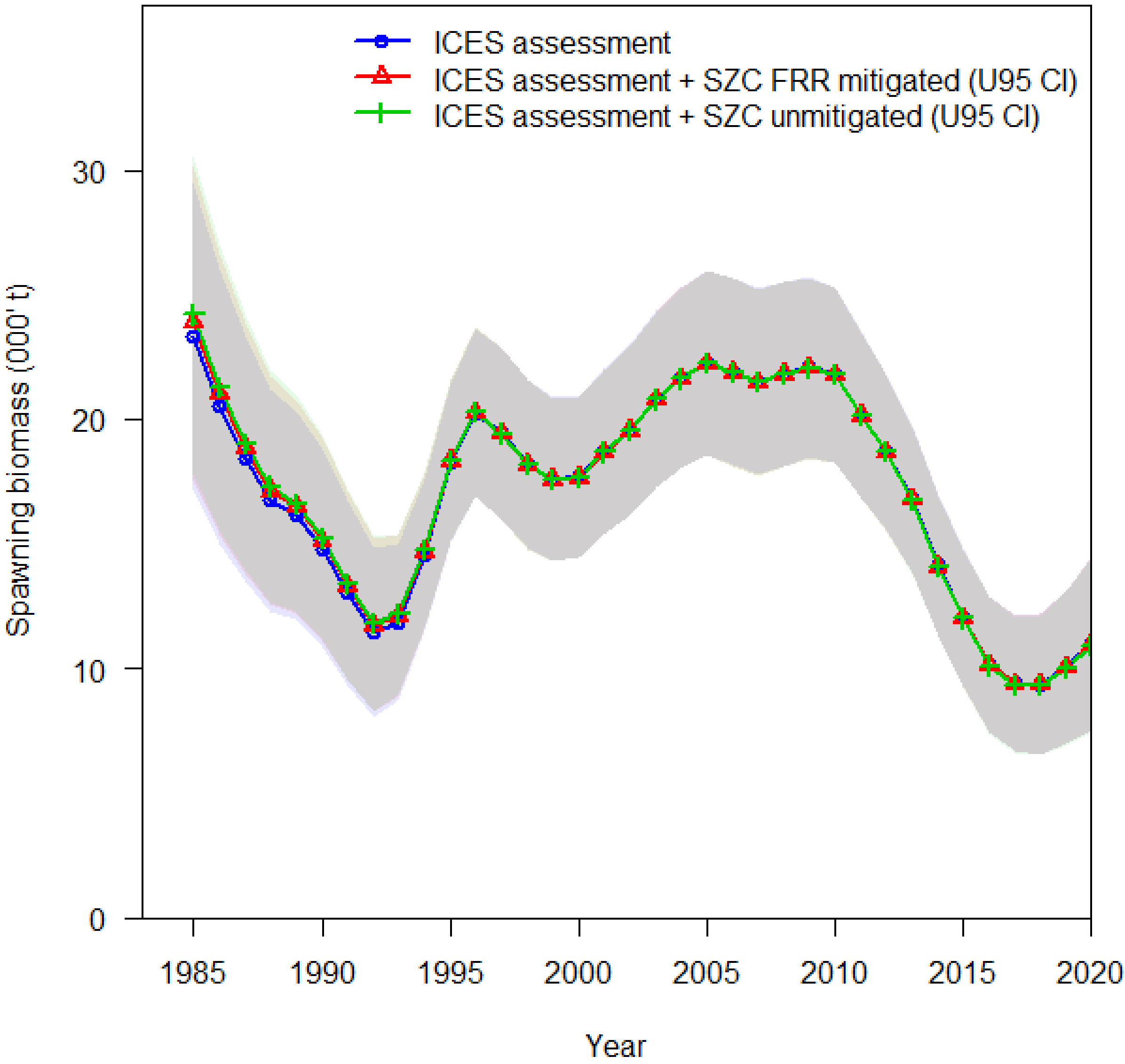

Figure 1 Trends in the spawning stock biomass (SSB x1,000 tonnes) for sea bass in the core ICES 2020 assessment compared to the extreme worst-case scenarios with SZC operating. Blue line (o symbols) represents the core ICES assessment. The upper 95% confidence interval for unmitigated impingement from SZC is shown in green (+ symbols) and with FRR mitigation represented by the red line (Δ symbols). Estimated 95% confidence intervals of the SSB assessment for all three scenarios are indicated by shading.

Table 2 Comparison between spawning stock biomass (SSB) as estimated in the ICES 2020 stock assessment, the 'mean FRR mitigation scenario' and the 'extreme worst-case' scenario.

Year	SSB, ICES 2020 (t)	**Mean FRR mitigated:** Reduction in SSB (t), assuming mean annual impingement with FRR mitigation.	Difference in SSB (%) relative to ICES 2020.	**Extreme worst-case scenario:** Reduction in SSB (t), assuming U95 CI unmitigated rate of impingement.	Difference in SSB (%) relative to ICES 2020
2009	22,076	2	0.01%	20	0.09%
2010	21,780	-9	-0.04%	0	0.00%
2011	20,161	1	0.00%	8	0.04%
2012	18,707	14	0.07%	23	0.12%
2014	14,147	34	0.24%	63	0.45%
2015	12,085	23	0.19%	60	0.50%
2016	10,173	0	0.00%	41	0.40%
2017	9,395	-19	-0.20%	27	0.29%

2.3 Mitigated Scenario

Results from the sea bass assessment that assumes mean annual FRR mortality, and is therefore the most realistic scenario, shows that impingement throughout the 1985-2020 assessment period would have had an insignificant effect on trends in SSB and a very small effect on the absolute spawning biomass each year (Figure 2).

Differences in the timing of increases and decreases in SSB, as well as the rates of change in SSB with and without the addition of SZC impingement, are very minor. Results show that SZC impingement mortality would not have long-term effects on the dynamics of the adult sea bass population and environmental variation and fishing will remain the overriding drivers of population dynamics. In other words, there is no risk to the viability of the population and SSB would still have increased and decreased at the same times and at an almost identical rate whether or not SZC were operating. There are only small relative differences in SSB with and without the inclusion of mean FRR mitigated SZC impingement (Table 2).

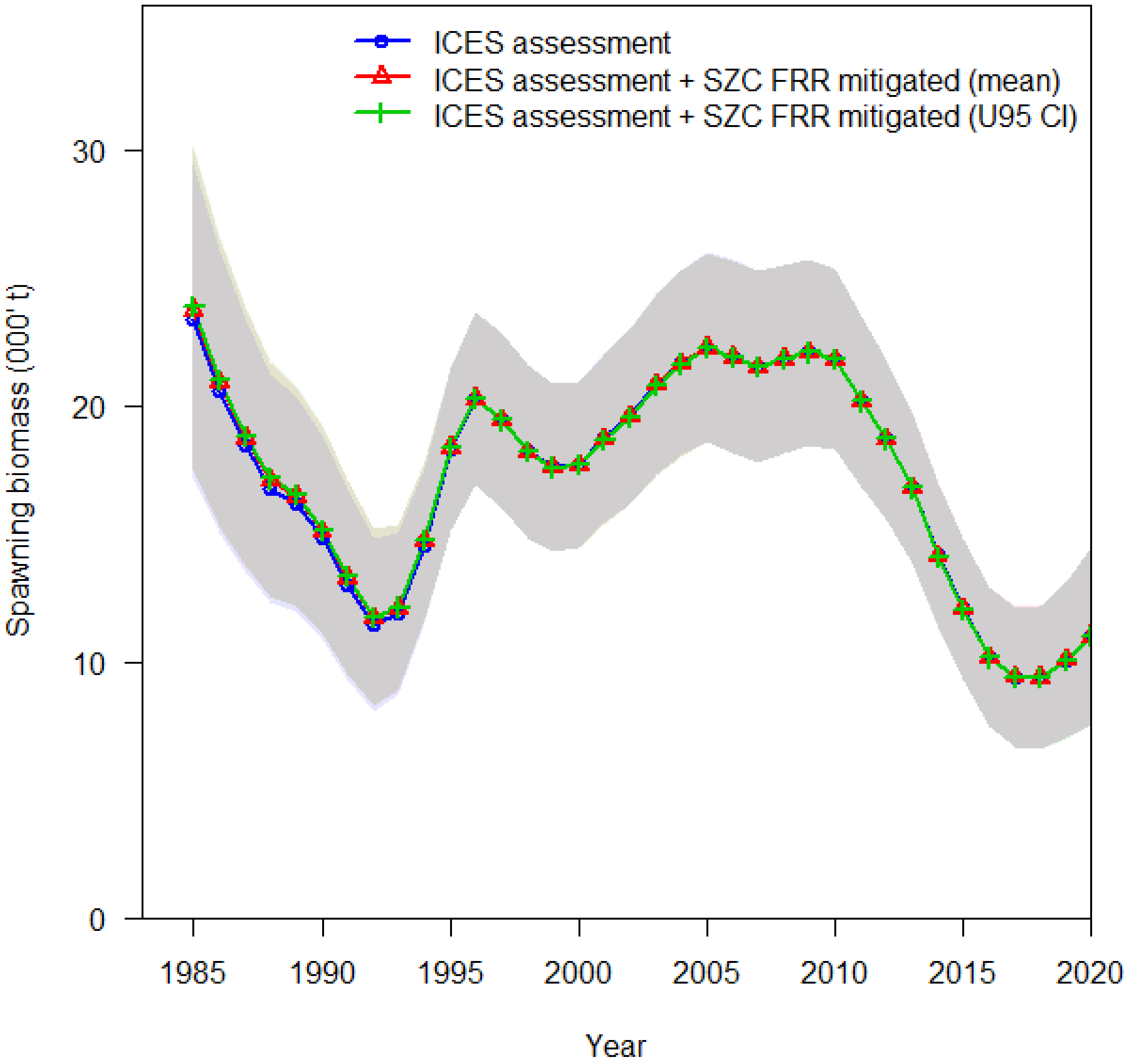

Figure 2 Trends in the spawning stock biomass (SSB x1,000 tonnes) for sea bass in the core ICES 2020 assessment compared to the FRR mitigated scenarios with SZC operating. Blue line (o symbols) represents the core ICES assessment. The upper 95% confidence interval for FRR mitigated impingement from SZC (as Figure 1) is shown in green (+ symbols) and the mean FRR mitigation is represented by the red line (Δ symbols). Estimated 95% confidence intervals of the SSB assessment for all three scenarios are indicated by shading.

When SZC impingement mortality is considered relative to catches, there are negligible effects of impingement (Appendix A). Commercial and recreational fisheries mortality far exceed the impacts of the impingement which primarily affects the juvenile stages that are not targeted commercially. Catch trends remain the same regardless of the addition of the SZC impingement losses (Appendix A.1; Table 3).

3 Conclusions

The European sea bass, *Dicentrarchus labrax,* has been selected as a model species for the application of ICES stock assessments on the basis that it is a long-lived, iteroparous species that is commonly impinged at Sizewell.

Consistent with the results of the Cefas EAV-based risk assessment, the stock assessments also demonstrate that SZC impingement does not pose a risk to the sea bass population. In other words, SZC impingement mortality would not have long-term effects on the dynamics of the adult sea bass population and environmental variation and fishing would have remained the overriding drivers of population dynamics. Results show that SSB would still have increased and decreased at the same times and at an almost identical rate whether or not SZC were operating. This is particularly evident during the periods of spawning biomass decline in the 1980's, and more recently the 2010's. During this potentially sensitive period from 2010-2018 of low biomass (coinciding with CIMP) the population trends are barely discernible with or without the addition of SZC impingement mortality.

The analyses were conservative because even when the assessments included worst-case assumptions about impingement rates the results were consistent. Further, the analyses did not account for the distribution of bass within the Greater Sizewell Bay, which are likely to mean that estimates of SZC impingement, as derived from SZB data, are already conservative.

The application of the ICES stock assessments incorporating precautionary SZC impingement estimates for a duration of 35 years provides powerful evidence that there would be no significant impact on the population trends or absolute biomass of sea bass. As sea bass are a potentially sensitive species, the application of the most robust analytical stock assessments should provide the highest degree of confidence available in the assessment of no population-level effects.

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Appendix A SSB and Fishing mortality

A.1 Spawning stock biomass (SSB) and fishing mortality (F) of the 2020 ICES assessment scenarios with and without SZC impingement

Table 3 Comparison of annual spawning stock biomass (SSB) and fishing mortality (F) of the 2020 ICES assessment and the SZC impingement scenarios. CIMP years assessed within the DCO application are indicated in bold.

Year	SSB (t)				Fishing mortality (ages 4-15)			
	ICES	ICES + SZC mean FRR mitigated	ICES + SZC U95 FRR mitigated	ICES + SZC U95 unmitigated	ICES	ICES + SZC mean FRR mitigated	ICES + SZC U95 FRR mitigated	ICES + SZC U95 unmitigated
1985	23331	23736	23872	24189	0.101	0.100	0.100	0.100
1986	20549	20908	21022	21285	0.120	0.119	0.118	0.118
1987	18398	18727	18820	19036	0.158	0.156	0.155	0.154
1988	16759	17069	17141	17310	0.126	0.125	0.125	0.124
1989	16136	16435	16489	16618	0.127	0.125	0.125	0.125
1990	14813	15102	15144	15247	0.129	0.127	0.127	0.127
1991	13011	13290	13323	13406	0.148	0.146	0.146	0.146
1992	11448	11718	11743	11807	0.150	0.148	0.148	0.148
1993	11865	12114	12133	12182	0.143	0.142	0.142	0.142
1994	14531	14713	14724	14755	0.128	0.128	0.128	0.129
1995	18259	18346	18348	18361	0.141	0.141	0.142	0.142
1996	20242	20266	20266	20277	0.194	0.195	0.195	0.196
1997	19430	19419	19418	19426	0.181	0.182	0.182	0.183
1998	18204	18181	18180	18187	0.176	0.177	0.177	0.178
1999	17600	17577	17577	17586	0.190	0.191	0.191	0.192
2000	17700	17675	17672	17676	0.174	0.175	0.176	0.176
2001	18699	18674	18670	18673	0.174	0.175	0.176	0.177
2002	19576	19553	19548	19548	0.172	0.173	0.173	0.174
2003	20829	20802	20795	20793	0.201	0.202	0.202	0.203
2004	21654	21628	21621	21618	0.206	0.207	0.208	0.208
2005	22279	22251	22242	22236	0.234	0.234	0.235	0.236
2006	21910	21886	21878	21874	0.235	0.236	0.236	0.237

Year	SSB (t)				Fishing mortality (ages 4-15)			
	ICES	ICES + SZC mean FRR mitigated	ICES + SZC U95 FRR mitigated	ICES + SZC U95 unmitigated	ICES	ICES + SZC mean FRR mitigated	ICES + SZC U95 FRR mitigated	ICES + SZC U95 unmitigated
2007	21519	21501	21492	21486	0.220	0.221	0.222	0.223
2008	21821	21810	21800	21789	0.219	0.220	0.220	0.221
2009	**22076**	**22074**	**22066**	**22056**	**0.212**	**0.212**	**0.213**	**0.214**
2010	**21780**	**21789**	**21781**	**21780**	**0.247**	**0.249**	**0.249**	**0.251**
2011	**20161**	**20160**	**20154**	**20153**	**0.230**	**0.230**	**0.231**	**0.231**
2012	**18707**	**18693**	**18687**	**18684**	**0.250**	**0.251**	**0.252**	**0.253**
2013	**16811**	**16783**	**16774**	**16763**	**0.287**	**0.288**	**0.289**	**0.290**
2014	14147	14113	14102	14084	0.231	0.232	0.232	0.233
2015	**12085**	**12062**	**12048**	**12025**	**0.211**	**0.211**	**0.212**	**0.212**
2016	**10173**	**10173**	**10158**	**10132**	**0.131**	**0.132**	**0.132**	**0.133**
2017	**9395**	**9414**	**9397**	**9368**	**0.109**	**0.109**	**0.109**	**0.110**
2018	9372	9393	9375	9342	0.097	0.097	0.097	0.098
2019	10061	10066	10046	10011	0.097	0.098	0.098	0.099
2020	11007	11009	10985	10948				

Appendix B Cumulative effects

B.1 Cumulative effects assessment: SZC and HPC

The sea bass population, as recognised by ICES, moves, migrates and mixes over large areas within ICES Divisions 4.b–c, 7.a, and 7.d–h in the course of its life cycle (Figure 3)[7]. Consequently, the same population will be subject to impingement mortality at Hinkley Point C (HPC) as well as at SZC once both stations are operational. For this reason, an assessment of the cumulative effects of HPC and SZC impingement was conducted. This enabled an assessment of the extent to which cumulative impacts would pose risks that were not identified in the assessments for the individual power stations.

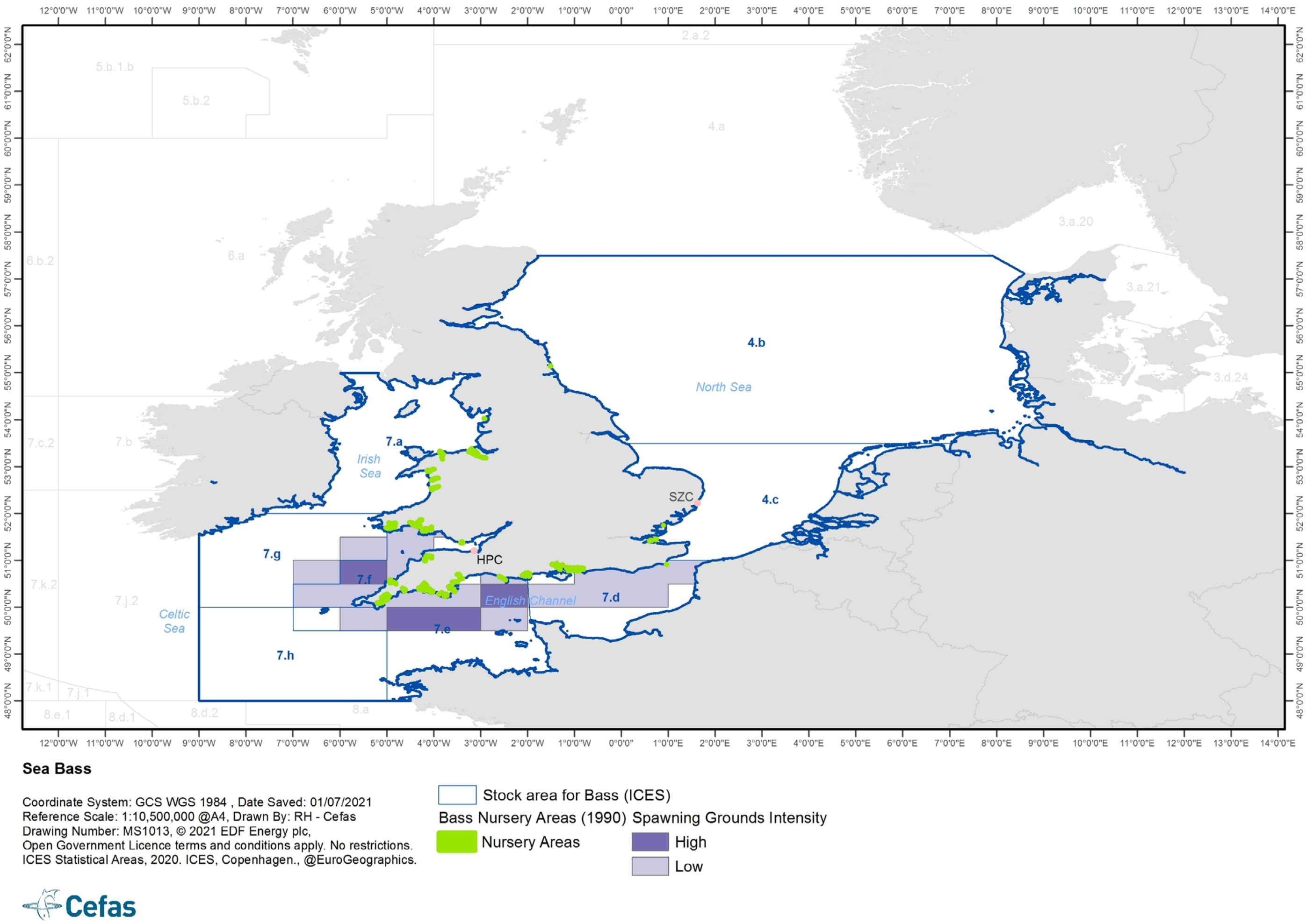

Figure 3. ICES stock area for sea bass showing spawning and nursery areas relative to Sizewell C (SZC) and Hinkley Point C (HPC).

Hinkley Point B Routine Impingement Monitoring Programme (RIMP) data from 1981 were used to support the HPC stock assessment. These data were adjusted and raised to predicted HPC impingement rates

[7] Further information of the stock area of sea bass is provided in Section 2.10 (pdf pg. 37) of BEEMS Scientific Position Paper SPP103 Rev.5 [REP6-016].

based on the scaling up of the abstraction flow. As the ICES assessment starts in 1985, the timeseries of mortality at HPC was truncated to start in 1985. The RIMP timeseries ceased in 2017, therefore the average of the last 5 years (2013-2017) was used as 'landings' input for 2018-2019 to complete the length of timeseries needed. Length data were available for 1992-1999 and 2007-2017 and these were apportioned into 2 cm length classes as required by the model. The impingement estimates for unmitigated HPC were input to the stock assessments in addition to the upper 95% confidence interval for FRR mitigated SZC impingement. In reality, HPC will be fitted with an FRR system which is predicted by the Environment Agency (Environment Agency, 2020; TB008) to result in 39% of impinged sea bass surviving impingement (uncertainty range 5-70% survival).

During some periods of the 35-year assessment period, Sizewell A (SZA), SZB, Hinkley Point A (HPA) and HPB were all in operation and contributing to impingement. Their effects on the sea bass population will already be included in the ICES 2020 assessment treated as a baseline. In total, therefore, the 35-year assessment as modelled includes the contribution of impingement losses from the operation of;

- Sizewell A (SZA)from 1985 until decommissioning in 2006;
- SZB from 1995 until the end of the assessment period;
- SZC for the full 35 years from 1985 until the end of the assessment period;
- Hinkley Point A (HPA) from 1985 until decommissioning in 2000;
- HPB for the full 35 years from 1985 until the end of the assessment period; and,
- HPC for the full 35 years from 1985 until the end of the assessment period.

All six stations contribute to losses from 1995 until 2000 when HPA was decommissioned, and five until 2006 when SZA was decommissioned. Post 2006 the remaining four operational stations in the modelled scenario (HPB, HPC, SZB and SZC) contributed to impingement removals. In practice, HPB will have stopped operating before HPC begins to operate. By the time SZC becomes active only SZB and HPC would be operational. The assessment is therefore highly precautionary, as impingement losses from the existing stations already form part of the baseline.

In the cumulative assessment, the ICES 2020 assessment was compared with an assessment that included the upper confidence interval for both the FRR mitigated SZC impingement and the unmitigated HPC impingement mortalities. This provides an extremely precautionary assessment.

Results of the cumulative effects assessment showed that the additive effects of impingement at SZC and HPC would not have posed a risk to the sea bass population, with SSB having increased and decreased at the same times and at an almost identical rate whether or not SZC and HPC were operating (Figure 4). Environmental variation and fishing would have remained the overriding drivers of population dynamics, with extreme impingement predictions leading to small relative reductions in SSB. The contribution of impingement relative to "fishing" mortality would have been minor (Table 4).

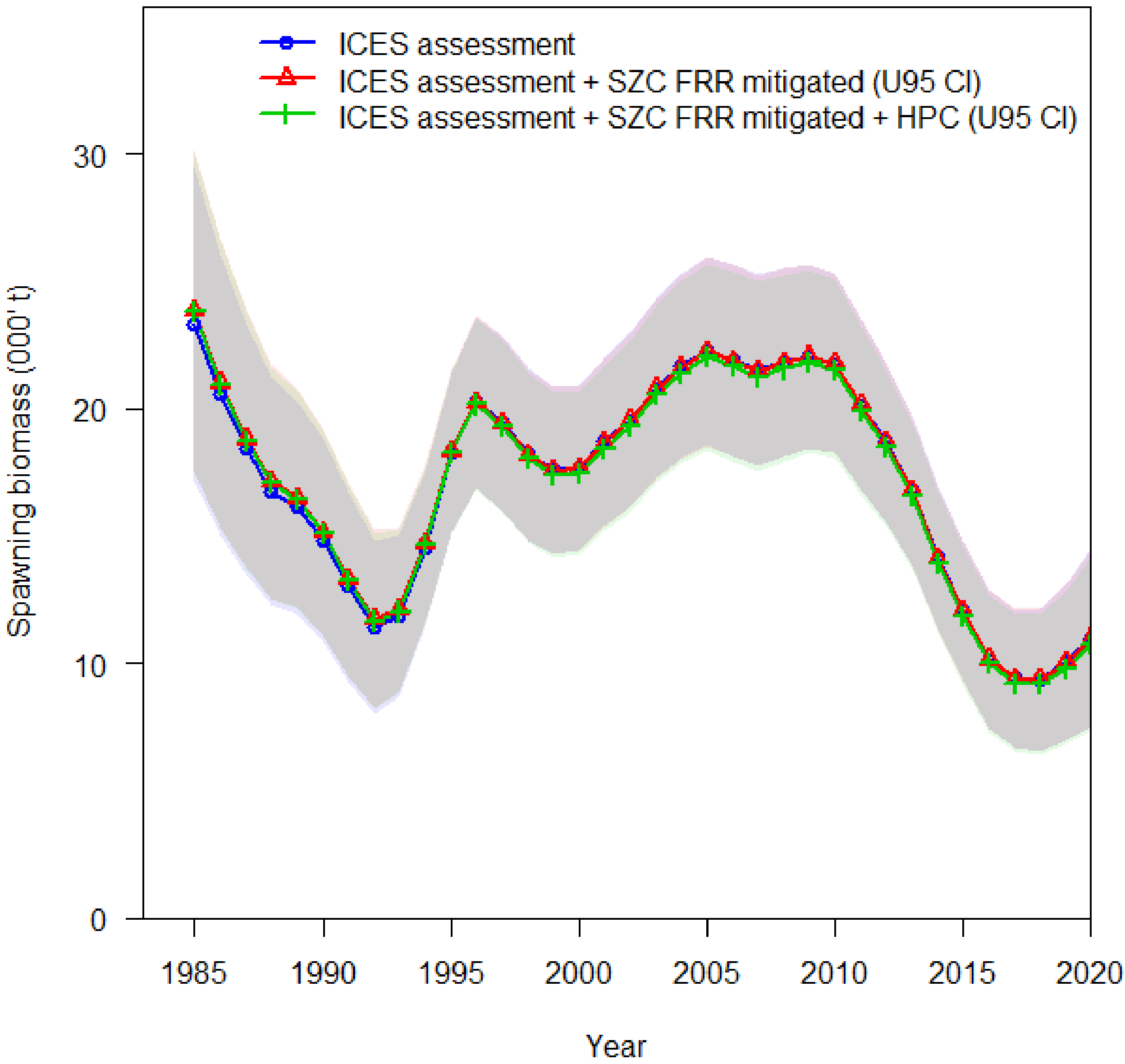

Figure 4 Trends in the spawning stock biomass (SSB x1,000 tonnes) for sea bass estimated in the core ICES 2020 assessment compared to the cumulative effects scenario with both SZC and HPC operating. Blue line (o symbols) represents the core ICES assessment. The upper 95% confidence interval for FRR mitigated impingement from SZC (as Figure 1) is shown in red (Δ symbols). Green line (+ symbols) shows the cumulative scenario of SZC impingement incorporated as upper 95% confidence interval FRR mitigated losses + HPC unmitigated upper 95% confidence interval impingement predictions. This represents an extremely precautionary scenario. Estimated 95% confidence intervals of the SSB assessment for all three scenarios are indicated by shading.

Table 4 Comparison of annual spawning stock biomass (SSB) and fishing mortality (F) of the 2020 ICES assessment and the cumulative HPC + SZC impingement scenarios.

Year	SSB (t)		Fishing mortality (ages 4-15)	
	ICES	ICES + Cumulative SZC & HPC	ICES	ICES + Cumulative SZC & HPC
1985	23331	23823	0.101	0.100
1986	20549	20967	0.120	0.119
1987	18398	18753	0.158	0.156
1988	16759	17074	0.126	0.125
1989	16136	16426	0.127	0.126
1990	14813	15081	0.129	0.127
1991	13011	13255	0.148	0.147
1992	11448	11674	0.150	0.149
1993	11865	12041	0.143	0.143
1994	14531	14637	0.128	0.129
1995	18259	18273	0.141	0.142
1996	20242	20174	0.194	0.196
1997	19430	19315	0.181	0.183
1998	18204	18066	0.176	0.179
1999	17600	17428	0.190	0.193
2000	17700	17489	0.174	0.178
2001	18699	18445	0.174	0.178
2002	19576	19310	0.172	0.176
2003	20829	20555	0.201	0.205
2004	21654	21394	0.206	0.210
2005	22279	22029	0.234	0.238
2006	21910	21661	0.235	0.239
2007	21519	21266	0.220	0.224
2008	21821	21572	0.219	0.223
2009	22076	21843	0.212	0.215
2010	21780	21560	0.247	0.252
2011	20161	19931	0.230	0.233
2012	18707	18476	0.250	0.254
2013	16811	16588	0.287	0.292
2014	14147	13933	0.231	0.235
2015	12085	11885	0.211	0.215
2016	10173	10000	0.131	0.134
2017	9395	9228	0.109	0.112
2018	9372	9172	0.097	0.100
2019	10061	9821	0.097	0.100
2020	11007	10759		