The Sizewell C Project

SZC Co.'s Response to the Secretary of State's Request for Further Information dated 25 April 2022: Appendix 2 - Response to Together Against Sizewell C's Submission Relating to Fish.

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APPENDIX 2

SZC CO.'S RESPONSE TO "TOGETHER AGAINST SIZEWELL C" (TASC) CORRESPONDENCE "*POST D10 COMMENTS ON SIZEWELL C DCO SUBMISSIONS IN RELATION TO ADVERSE IMPACTS ON THE MARINE ENVIRONMENT*" IN REPSONSE TO THE LETTER FROM THE SECRETARY OF STATE (BEIS) DATED 18TH MARCH

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1 RESPONSES TO TASC POST D10 COMMENTS

This document contains SZC Co.'s written responses to comments raised by Together Against Sizewell C (TASC) in the submission '*TASC post D10 response FAO Sec of State BEIS Final'* of the 18 March 2022.

This response is structured to address TASC's core comments and conclusions and is supported by further technical information provided in appendices A, B and C.

SZC Co. notes that, throughout their submission, TASC have commented on the role of Cefas (Centre for Environment, Fisheries, and Aquaculture Science) in providing evidence on behalf of SZC Co. SZC Co. would like to explain and to emphasise Cefas' roles in the project. Cefas is an Executive Agency of DEFRA. Evidence and advice developed and presented by Cefas on behalf of SZC Co. has been undertaken in accordance with Cefas' values to work with *"objectivity, honesty, integrity and impartiality*" working within the Civil Service Code[1]. Cefas plays a consultancy role to SZC Co. The pool of Cefas scientists that have been involved in work for the SZC Co. are also drawn upon to undertake science and advice for the UK Government and other bodies, as well as conducting research and development relevant to Cefas' mission.

1.1 Summary and Background

1.1.1 The core concern raised by TASC is the large numbers of fish that would be entrapped by Sizewell C each year. TASC comment on the potential for sampling inefficiencies for small fish leading to underestimates in total entrapment rates (impingement + entrainment). Concern is expressed in relation to species, or life history stages, that are too small to be efficiently retained on the 10mm square mesh of the drum and band filtration screens for recovery by the Fish Recovery and Return (FRR) system and therefore not included in impingement monitoring but are large enough to avoid the pump sampler used during entrainment monitoring (and so, therefore, are not recorded at all). It is suggested that this 'entrainment gap' may lead to underestimates in total entrapment rates. TASC comment that the draft monitoring plans[2] for Sizewell C have not resolved this issue. TASC raise concerns for elongate species such as eel and river lamprey. Section 1.2 provides responses to TASC comments with further technical details provided in Appendix B.

[1] The Civil Service code - GOV.UK (www.gov.uk)

[2] Deadline 10 Submission - 9.89/10.7 Draft Fish Impingement and Entrainment Monitoring Plan - Clean Version [REP10-138].

1.1.2 TASC have also commented on the sea bass stock assessment (*Deadline 8 Submission - 9.110 Sizewell C European Sea Bass Stock Assessment - Revision 1.0 [REP8-131]*). TASC's comments relate to management measures and cumulative effects with other power stations. TASC conclude that the stock assessment is incomplete as it does not account for the entrainment fraction. Following the Secretary of State's Information Request 2, SZC Co. responded to comments from the Environment Agency on the sea bass stock assessment, including the latest management advice[3]. The detailed response can be found here: *Response to SoS request for information of 31 March 2022 - Appendix 7 - Additional technical information to support Question 8.4 in relation to Environment Agency comments on assessment of sea bass*. SZC Co. acknowledges the comments by TASC but considers the sea bass stock assessment to be the most robust application of available evidence. Not including the entrainment fraction is anticipated to have negligible implications for the stock assessment. This is because entrainment losses of early life-history stages from the station are dwarfed by very high rates of natural mortality in this species. Please see Appendix A for detailed responses.

Contextualising losses

1.1.3 Prior to directly addressing specific comments from TASC, this section considers what the assessment of entrapment effects seeks to achieve. Entrapment of fish at Sizewell B varies seasonally and for most species is comprised predominantly of juvenile stages. The majority of these juveniles would never survive to maturity (and reproduce) owing to very high rates of natural mortality. In contrast with the reproductive strategies of mammals and birds, a mature female fish can produce tens of thousands to millions of eggs each year. Because stable populations achieve one for one replacement on average, there are very high rates of mortality between the egg and adult stages. This mortality results from starvation and predation, or both acting in combination. Mortality rates are typically highest (in absolute and proportional terms) during the early life stages and decrease through the juvenile stage and into the adult stage. The high mortality rates in early life stages can mean 100 to 100,000-fold reductions in numbers of fish during the first few months of life. Thus, fish early life-history stages have very high mortality rates and individuals have a very low probability of becoming an adult. This is in direct contrast to the reproductive strategies of birds and mammals that produce rather few eggs or young each year and for which juvenile survival is necessarily higher to achieve one for one replacement of adults on average.

[3] NNB Generation Company (SZC) Limited. Response to SoS request for information of 31 March 2022.

1.1.4 Predicted entrapment results in large estimates of annual losses for some species. Whilst entrapment numbers are large, particularly for early life history stages, this is reflective of high natural abundance in the environment and does not necessarily imply a significant impact to the population. The following paragraphs illustrate this point in relation to the two most commonly impinged species at Sizewell B: sprat and herring, which together account for 69% of impingement numbers.

1.1.5 Mean impingement rates at Sizewell C are predicted to be 6,153,906 sprat per year. In addition, entrainment predictions are an annual loss of approximately 32 million eggs, 45 million larvae and 19 million juvenile sprat[4]. The essential step in the assessment is to determine the significance of such losses to the population in the context of natural mortality. To determine this, the Equivalent Adult Value (EAV) method is applied to convert losses of early-life history stages into equivalent adults. The numbers of equivalent adults that are lost can then be compared with the numbers of fish or weight of fish in the spawning population. Early life stages have dramatically lower probabilities of reaching adulthood. In the case of the sprat entrainment fraction, the ~96 million early life history stages in the entrainment fraction equate to between 45,790 to 199,715 equivalent adults per annum[5]. Conversely, the 6,153,906 sprat in the impingement fraction equate to 4,623,145 million equivalent adults.

1.1.6 This clearly illustrates the greater relative importance of impingement losses of sprat, as these larger life history stages would have had a greater probability of contributing to the spawning population had they not been impinged. Similar estimates can be made demonstrating the relative importance of the impingement and entrainment fractions for herring, where annual impingement equates to losses of approximately 1.6 million equivalent adults relative to approximately 24-thousand equivalent adults estimated in the entrainment fraction.

1.1.7 Even with the conversion to equivalent adults, the projected total entrapment losses (impingement + entrainment) are still in the order of 5 million sprat per year. Such numbers therefore need to be contextualised against the numbers of sprat in the affected population. During the period of impingement monitoring at Sizewell B, the average population numbers for the ICES stocks of sprat relevant to Sizewell were 173 billion fish, with 130 billion young fish joining the population every year. A similar situation occurs for herring where the numbers in the North Sea population averaged 73 billion, with 37 billion young fish joining the population each year. When

[4] 6.3 Volume 2 Main Development Site Chapter 22 Marine Ecology and Fisheries Appendix 22G - Predictions of Entrainment by Sizewell C in Relation to Adjacent Fish and Invertebrate Populations [APP-324].

[5] Uncertainty analyses apply the upper estimate (*Deadline 10 Submission - 9.67 Quantifying Uncertainty in Entrapment Predictions for Sizewell C* [REP10-135]).

the equivalent adult losses are expressed as biomass and compared to the spawning population biomass entrapment losses from Sizewell C they are predicted to equate to 0.03% and 0.01% of the population size for sprat and herring[6], respectively. Losses of this magnitude predicted from Sizewell C would therefore have no discernible effect on the populations of these species.

1.1.8 In acknowledgement that there is the potential for sampling inefficiencies between entrainment and impingement monitoring programmes, an analysis was undertaken to determine the scale of the underestimate and whether this additional detail would have a material bearing on the results. Three species with life history stages subject to the 'entrainment gap' were considered in further detail: sprat, herring and gobies of the genus *Pomatoschistus* spp., as part of the uncertainty analysis[7]. Detailed comments from TASC on the uncertainty analysis are addressed in Section 1.2.

1.1.9 In the case of sprat and herring, the predicted missing fraction of fish with the 'entrainment gap' amounted to an increase in total annual entrapment of equivalent adults of approximately 6% and 1%, respectively. Accounting for the potential entrainment gap in gobies of the genus *Pomatoschistus* spp. resulted in a 17.5% increase in annual entrapment of equivalent adults. TASC have commented on the assumptions of the assessment for gobies and detailed responses are provided in Appendix B. These estimated increases in entrapment rates following allowance for an entrainment gap have no material bearing on the results for the three species tested, which are well below levels that could cause significant effects to the population.

1.1.10 It is acknowledged that the results of any monitoring programme or sampling campaign are bounded by the limitations and assumptions of sampling. However, it is important to recognise residual uncertainty relative to the inbuilt precaution in the assessment and predicted magnitude of the effect. In the case of gobies of the genus *Pomatoschistus* spp. for example, the assessment of entrapment losses makes three conservative assumptions:

1. When calculating EAVs for juvenile gobies in the entrainment fraction, individuals are assumed to be 30mm Total Length (TL). Most juvenile gobies in the entrainment fraction are likely to be smaller than 30mm TL so the EAV is therefore expected to be overestimated. Estimated losses

[6] The potential for impacts of the station on the Blackwater herring stock was considered in ES Addendum Appendix 2.17.A Rev 2 (see Section 6.6.5 of TR406 Rev [AS-238]). The latest position on herring is presented in response to recent comments from Natural England in Section 2.3 of BEEMS Scientific Position Paper SPP103 Rev.5 [REP6-016].

[7] Deadline 10 Submission - 9.67 Quantifying Uncertainty in Entrapment Predictions for Sizewell C [REP10-135].

of gobies in the size range of the ‘entrainment gap’ have been added to these numbers based on size specific EAV calculations (Appendix B).

2. The assessment assumes 100% mortality of larval and juvenile stage fish entrained[8]. Gobies are a robust species and previous studies have observed high entrainment survival of larval gobies at other power plants[9]. The assessment, therefore, overestimates entrainment mortality of gobies.

3. All gobies in the impingement fraction are assigned an EAV of 1. This assumes all gobies impinged are mature adults that would have contributed to the spawning population. Given the size distribution of individuals impinged and the high natural mortality rates, this is a conservative assumption.

1.1.11 Gobies of the genus *Pomatoschistus* spp., are ubiquitous in European coastal waters and are short lived, fast maturing with relatively high fecundity and showing high natural variability in abundance. These characteristics, and no directed fishery, mean they have high resilience to the predicted impacts from Sizewell C[10]. Estimates of impacts on gobies are considered appropriately precautionary and robust to residual uncertainty.

1.2 Entrainment Gap

1.2.1 This section considers the following conclusions from TASC:

- *“(i) The Applicant/CEFAS have conceded that their estimates of the number of fish killed were too low because the 10 mm mesh does not retain small fish.*
- *(ii) The Applicant/CEFAS have undertaken some revised calculations for a few species. They need to revise the estimates for all species so that a proper impact assessment can be made. Some small thin fish have been seriously under-sampled, and this must be addressed.*
- *(iii) In particular, the Applicant/CEFAS need to produce revised estimates for long, thin species of conservation concern, eels and lamprey. This is an essential legal requirement.*

[8] Glass eels stages of the European eel are the exception, 80% survival rates have been applied in assessments based on the results of Entrainment Mimic Unit (EMU) experiments. Table 2 of 6.3 Volume 2 Main Development Site Chapter 22 Marine Ecology and Fisheries Appendix 22G - Predictions of Entrainment by Sizewell C in Relation to Adjacent Fish and Invertebrate Populations. [APP-324].

[9] 88-98% entrainment survival of larval gobies at Calvert Cliffs nuclear power station in the U.S.A. Mayhew, D.A., Jensen, L.D., Hanson, D.F., Muessig P.H. 2000. A comparative review of entrainment survival studies at power plants in estuarine environments. Environmental Science & Policy. 3 (1), 295-301.

[10] Deadline 10 Submission - 9.67 Quantifying Uncertainty in Entrapment Predictions for Sizewell C [REP10-135].

– *(iv) The Applicant/CEFAS have tried to minimise the missing entrainment numbers caught, by assuming that the pump sampler efficiently catches small fish. This is incorrect, as the pump sampler is highly inefficient for this purpose. CEFAS know this to be the case, which is why they do not use pump samplers for their regular small fish surveys. This is a major defect, and the Applicant will need to undertake appropriate entrainment sampling to rectify the issue.*

– *(v) The Applicant/CEFAS have also tried to question DrH's observations on mesh penetration through a 10 mm mesh by pointing out that sprat of a size DrH claims will go through the mesh have a head depth greater than 10 mm. As explained in Annex A, this is because it is the diagonal distance across the square mesh, which is the critical dimension for mesh penetration, a distance of just over 14 mm. TASC are surprised that the scientists at CEFAS would make such a schoolboy error".*

1.2.2 The entrainment gap is bounded at the lower end by the minimum size a typical larval/juvenile fish may be able to actively avoid the pump sampler. TASC are correct that in Young Fish Surveys (YFS) Cefas deploys trawls and plankton nets from a research vessel to sample fish. Such approaches are not feasible within the forebay of an operational nuclear power station. The Expert Panel for BEEMS Scientific Advisory Report SAR005[11] on the 'Methodology for the measurement of entrainment' advise that *"On balance, therefore, the pump-sampler or pumping methods are most suitable for offshore intake types".* Entrainment sampling was undertaken by Pisces Conservation Limited and involved taking pumped water samples from the Sizewell B forebay for 24 hours on 40 occasions over a 12-month period between May 2010 and May 2011[12]. The pump sampler used during entrainment monitoring at Sizewell B was consistent with the recommendations of SAR005. In the forebay the pump sampler is assumed to be effective at sampling larval fish with limited ability to avoid the intake flow. Furthermore, data from the entrainment monitoring at Sizewell B was used to estimate that 19.5 million juvenile fish are entrained each year, of which gobies and sprat were most common accounting for nearly 80% of the numbers. The optimal sample point for entrainment sampling at Sizewell C is being confirmed, and would utilise an inline sampling point if feasible *(Deadline 10 Submission - 9.89/10.7 Draft Fish Impingement and Entrainment Monitoring Plan - Clean Version [REP10-138]).*

1.2.3 The residual uncertainty in quantifying absolute numbers of early life history stages due to limitations in the available sampling techniques is

[11] BEEMS Expert Panel. Science Advisory Report No 005. 2011. Methodology for the measurement of entrainment. Edition 2.
[12] 6.3 Volume 2 Main Development Site Chapter 22 Marine Ecology and Fisheries Appendix 22G - Predictions of Entrainment by Sizewell C in Relation to Adjacent Fish and Invertebrate Populations. [APP-324].

acknowledged. However, entrapment of large numbers of early life stages is reflective of the reproductive biology of these fish as these stages are highly abundant in the environment. Equally, high rates of natural mortality mean these early life stages have a low probability of reaching maturity.

1.2.4 The upper bound of the size range of fish subject to the entrainment gap is determined by the size of fish that can penetrate the 10mm square mesh screens. TASC contest that the assessments in the uncertainty analysis *(Deadline 10 Submission - 9.67 Quantifying Uncertainty in Entrapment Predictions for Sizewell C [REP10-135])* have not accounted for the diagonal measurement of the mesh and that it is this value of 14mm that is the critical upper dimension for mesh penetration. This is an oversimplification.

1.2.5 Penetration through the mesh is species and body shape specific. Laterally and dorsoventrally compressed species with a height or width in excess of 10mm may indeed pass through the mesh on the diagonal. Species with an approximate round profile are not appreciably thinner on the diagonal. Applying 14mm as the critical dimension assumes that fish are either very thin in the opposing dimension or able to flex.

1.2.6 Turnpenny (1981)[13] provides a formula for the mesh size required for total exclusion. However, as noted in the Environment Agency (2005)[14] guidance, the *"formula ensures that the calculated aperture size is small enough to exclude a fish by the bony part of the head, i.e. it is not the size at which a fish would just penetrate the mesh."* Many species are wider beyond the bony part of the head meaning there is a distinction between the theoretical absolute mesh size that the bony part of the head is not able to penetrate and the size at which high retention rates in the filtration system would be achieved. Debris, weed and other biological clogging material such as ctenophores increase the retention of the mesh.

1.2.7 It should be noted that the assessment of the entrainment gap for sprat and herring applied a critical body length for full retention where the corresponding body height exceeds 14mm (Appendix B). Thus, the upper bound applied was greater than the diagonal distance of the mesh. The assessment can, therefore, be considered appropriate as fish below this size would be fully retained.

Eel and Lamprey

1.2.8 In their concluding remarks, TASC raised concerns over the quantification of losses of eel and lamprey. Further TASC state "*eel and river lamprey*

[13] Turnpenny, W.H. 1981. An analysis of mesh sizes required for screening fishes at water intakes. Estuaries 4, 363-368.
[14] Environment Agency. 2005. Screening for Intake and Outfalls: a best practice guide. Science Report SC030231.

have certainly been underestimated as a wide size range occur in the sea and even quite long individuals can wriggle through a 10 mm mesh" and *"yellow eels with a body height of 14mm will pass through a 10mm square mesh on the diagonal".*

1.2.9 Species with an approximate round profile, such as yellow eels and lampreys, are not thinner on the diagonal. An eel with a 14mm body diameter has a circumference of more than the perimeter of the rigid 10mm square mesh and would not pass. The smallest yellow eels recorded in the impingement record were 225mm. There is no step change above 225mm[15] and should eels be present in appreciable numbers below this size in the waters off Sizewell they would have been observed in the eight-year impingement record. The potential entrainment gap for yellow eels is not considered to result in significant underestimates of the numbers of this life stage. Furthermore, the assessment of effects has taken the precautionary measure of applying the maximum theoretical EAV of 1 for a semelparous (spawn once then die) species. As such, predicted effects resulting from impingement losses of yellow eels are not considered to be underestimated.

1.2.10 It is accepted that the entrainment effects on glass eels cannot be quantified with a high degree of certainty. Whilst the risk of the station to glass eels is considered to be very low due to the low abundance of glass eels in the coastal waters around Sizewell, the offshore sampling effort required to provide a high level of certainty would be disproportionate. Through consultation with the Environment Agency in relation to the Eels Regulations and Water Framework Directive, SZC Co. has committed to funding the installation of fish passes to enhance upstream migration of eels and other diadromous species such as smelt within the Deed of Obligation[16]. It should also be noted that glass eel survival during entrainment is predicted to be high (80%) anyway.

1.2.11 TASC stated that "*Lamprey, for example, can penetrate a 10 millimetre mesh even when they're approximately 200 millimetres long*". River lamprey metamorphose into adults at a length of 90-120mm in fresh waters and at around 130mm they migrate to the sea. Therefore, low numbers of fish of this size might be expected to be found at Sizewell. It has previously been acknowledged that there is the potential for sampling inefficiencies of fish between 130-200mm, and fish in this size class may be underrepresented. However, 64% of river lamprey that are impinged at Sizewell B are larger than 300mm TL, well above the size range where

[15] The size distribution of eels is provided on pdf pg. 60 of Additional Submission in relation to the Applicant's request for changes to the application and Additional Information - 6.14 Environmental Statement Addendum Volume 3: Environmental Statement Addendum Appendices Chapter 2 Main Development Site Appendices 2.17.A Marine Ecology [AS-238].

[16] Deadline 10 Submission - 8.17/10.4 Deed of Obligation Engrossment Version - Front End of Plans [REP10-075].

entrainment would occur. Only 18% of lamprey impinged are between 200mm and 300mm when sampling inefficiencies are anticipated to be minor. This suggests the majority of adult river lamprey in the waters at Sizewell would be effectively sampled. Sampling of parasitic lamprey in surveys at sea is challenging and primarily related to capture of the host. Of 421 river lamprey sampled using a range of survey gears in European marine waters, the majority of fish were >200mm TL, with a mean of 300mm and a size range of 140mm to 420mm[17].

1.2.12 Impingement of river lamprey is low, and unmitigated impingement is predicted to be 2,607 fish per annum (95% confidence intervals; 1,430 – 4,393). The uncertainty analysis considered the range of predicted mortality of lamprey through the FRR system and determined mean losses of 468 fish per annum (95% confidence intervals; 254 – 765). Despite the occurrence of some juvenile stages, all lamprey impinged have been allocated a maximum theoretical EAV of 1. Whilst sampling limitations may result in minor underestimates of fish below 200mm, these additional losses are not predicted to be material. Total losses associated with Sizewell C have been assessed against the river lamprey qualifying feature of the Humber Estuary SAC. The numbers of losses predicted would not cause an adverse effect on integrity of the SAC. This is consistent with the position of Natural England in their responses to the Secretary of State's Information Request[18]: "*The predicted annual impingement rates for river lamprey are a minute proportion of the estimated run size in the Humber Estuary SAC, even with the smallest run estimate of 335,000*."

Representative taxa

1.2.13 TASC have commented that additional analyses should be undertaken to account for sampling uncertainties for all the species of fish impinged or entrained at Sizewell. Entrainment and impingement estimates have been made for all species identified. Key taxa, representative of the fish community have been selected for the purpose of assessing effects of impingement and entrainment by Sizewell C at the population level. Twenty-four key finfish taxa were selected based on three criteria; socio-economic value, conservation importance, and/or ecological importance. The process is described in the Environmental Statement at para. 22.8.56 (*6.3 Volume 2 Main Development Site Chapter 22 Marine Ecology and Fisheries* [APP-317]) and in more detail within the Fish Characterisation Report (*6.3 Volume 2 Main Development Site Chapter 22 Marine Ecology and Fisheries Appendix 22D - Sizewell Characterisation Report – Fish* [APP-321]). Taxa selected on the criterion of ecological importance were

[17] Elliott, S.A.M., Deleye, N., Rivot, E., Acou, A., Reveillac, E., Beaulaton, L. 2021. Shedding light on the river and sea lamprey in western European marine waters. Endangered Species Research, 44: 409–419

[18] Natural England. Response to SoS request for information of 31 March 2022

common and abundant in at least one of the data series used to characterise the fish community of the Greater Sizewell Bay. The characterisation data included demersal trawls (2m beam trawls and otter trawls), a glass eel survey using a Methot Isaacs-Kidd net and impingement monitoring at Sizewell B.

1.2.14 Over 80 finfish taxa have been identified in the impingement record at Sizewell B; of these, 40 species have been recorded in less than 5% of the samples. Eight species account for over 95% of impingement by numbers, these include sprat, herring, whiting, sea bass, sand gobies, Dover sole, anchovy, and dab. The population level effects of entrapment of these species have been assessed in detail. The potential for entrainment gap effects was investigated for sprat, sand gobies and herring. These species were selected as they spawn in waters adjacent to Sizewell, are the three most abundant species in entrainment monitoring sampling and contribute to the top 95% of individuals in the impingement record. In the case of sprat, all life stages (including eggs, larvae, juvenile and adults) are identified in ichthyoplankton surveys, entrainment and impingement monitoring. The analyses showed that accounting for the entrainment gap in these species did not have a material bearing on the results. It would not be proportionate to complete additional analyses for all the species encountered. Furthermore, in the case of many of the species, the biological information to complete the analyses, including calculation of equivalent adults and/or the population comparator is not available. Therefore, representative taxa have been selected based on ecological, socio-economic or conservation importance to determine the effects of Sizewell C on fish.

1.2.15 Further comments on specific species are considered in Appendix B.

1.3 Sea bass stock assessment

1.3.1 TASC comments on the sea bass stock assessment are considered in further detail in Appendix A.

1.4 Discharge of biota

1.4.1 This section considers the following conclusions by TASC:

- *"(vii) As fish mortality is substantially underestimated, then the adverse impact of all the dead/dying biota that will be discharged at the outfall point will be underassessed. TASC note that the RSPB recognise this issue in para 1.1.10 of their D10 submission REP10-204.*

- *(viii) The more biota in the outfall, the more birds and mammals attracted to the area where the chemical plume exists, therefore increasing the risks of contaminants poisoning birds, mammals, fish and other marine creatures. TASC say this as an area where the Habitat Regulation Assessment is inadequate in terms of the impacts on European sites, SPA species such as the little tern, as well as wildlife generally.*
- *(ix) The greater the amount of biota in the outfall, the greater will be the attraction of unnatural numbers of predator and scavenger species upsetting the balance of nature in the vicinity of the outfall.*
- *(x) As fish mortality is substantially underestimated, the impact on protected fish, those of conservation concern and the species that prey on them has been understated."*

1.4.2 Dead or moribund biota in the main cooling water flow would consist of organisms subject to entrainment which would be discharged 3km offshore. The high cooling water flow rate coupled with tidal mixing would dissipate any food items in the discharge and not attract significant numbers of fish or marine mammals. Furthermore, the SZC Co shadow Habitats Regulations Assessment (sHRA) considered the potential for impact of direct toxic effects from the cooling water discharge plume concluding there was no evidence to suggest such an effect (see REP3-042, Section 11.27; and REP7-073, Section 1.8). Given this, the number of individuals within any zone of influence has no bearing on the conclusion of the sHRA.

1.4.3 In terms of biomass, discharges from the FRR system represent a potential impact. The water quality and food web effects of FRR discharges have been assessed within the DCO assessments and no significant effects were identified. Equally, as part of the draft Water Framework Directive compliance assessment for the Water Discharge Activity environmental permit, the Environment Agency applied a different assessment approach with additional precautionary steps and concluded that there is minimal risk of these activities on compliance with Water Environment Regulations[19]. The FRR discharge is 2km inshore of the SZC cooling water discharge and geographically separate from the plume.

1.4.4 Young of year clupeids (e.g., sprat and herring) are important prey items for designated seabirds. Equally, highly abundant sand gobies are ecologically important prey resources. Uncertainty analysis undertaken[20], applying conservative assumptions (Section 1.1), have demonstrated that sampling inefficiencies for these three key taxa do not materially alter the

[19] Environment Agency. Response to SoS request for information of 18 March 2022.
[20] Deadline 10 Submission - 9.67 Quantifying Uncertainty in Entrapment Predictions for Sizewell C [REP10-135].

conclusions of the assessments. The potential for depletion in prey availability has been considered for both the entrainment and impingement size fraction using a conceptual approach that is independent of impingement and entrainment predictions. Depletion is predicted to be well within the bounds of natural variability in fish abundance at the site and significant changes in prey availability linked to the extraction and discharge of cooling water are not predicted *(Deadline 6 Submission - 6.14 Environmental Statement Addendum - Volume 3: Environmental Statement Addendum Appendices - Chapter 2 - Main Development Site - Appendix 2.17.A - Marine Ecology and Fisheries - Revision 2.0 [REP6-016]).*

1.4.5 TASC challenge the statement that "*Sandeels are an important part of diet of little terns in other regions of the North Sea, but off East Anglia they represent only a small proportion (<8%) of the diet of these birds (Green, 2017)*" and stated that "*TASC believe that the Applicant needs to consider that sandeels may only form a smaller part of the East Anglia little terns' diet due to the numbers killed by the SZB CWS, so their availability is not as great*." The data on little tern diet were collected from North Denes and Winterton, some 60-70km north of Sizewell. Significant depletion associated to the Sizewell B station at this scale is not realistic. The diet of the little tern varies with the regional abundance of sandeels. Sandeel abundance is relatively low in the southern North Sea in comparison to the central North Sea and off the northeast coast of the UK[21] where they represent ~ 45% of tern diet during the reproductive period[22].

1.5 Station Design

1.5.1 This section considers the following conclusions by TASC:

- *"(xi) As fish mortality is substantially underassessed, then the benefits for the inclusion of mitigation in the form of acoustic fish deterrents will likely be incorrectly assessed (for further TASC comments regarding the acoustic fish deterrent see REP6-077), and*
- *(xii) As fish mortality is substantially underassessed, then the consideration of, and comparison with, alternative cooling systems eg cooling towers, will be incomplete".*

1.5.2 SZC Co.'s position in relation to the feasibility of installing an acoustic fish deterrent (AFD) as part of the suite of mitigation measures was outlined in Deadline 5 Submission - 9.57 Acoustic Fish Deterrent Report - Revision 1

[21] Ellis, J.R., Milligan, S.P., Readdy, L., Taylor, N. and Brown, M.J., 2012. Spawning and nursery grounds of selected fish species in UK waters. Sci. Ser. Tech. Rep., Cefas Lowestoft, 147. 56 pp.

[22] Wanless, S., Harris, M. P., and Greenstreet, S. P. R. 1998. Summer sandeel consumption by seabirds breeding in the Firth of Forth, south-east Scotland. – ICES Journal of Marine Science, 55: 1141–1151.

[REP5-123]. An AFD does not form part of the mitigation measures proposed for Sizewell C and entrainment assessments have been undertaken in the absence of an AFD. To allow full transparency and to determine the predicted effectiveness of mitigation measures, entrapment assessments within the Environmental Statement have been undertaken sequentially with no mitigation and with fish recovery and return (FRR) system mitigation. As part of the uncertainty analysis, the sensitivity of entrapment predictions was tested relative to the range of FRR efficiency values *(Deadline 10 Submission - 9.67 Quantifying Uncertainty in Entrapment Predictions for Sizewell C [REP10-135])*. TASC's comment in relation to assessing the benefit of an AFD due to underestimates of fish mortality is not valid. If it were technically viable to install an AFD, the species that would benefit the greatest are hearing specialists, such as sprat and herring. Assessments on the potential entrainment gap for sprat and herring showed minor increases in numbers impinged and had no material bearing on the conclusion that the station would not have a significant effect on the populations of these species (Section 1.1).

1.5.3 A consideration of alternative cooling options for Sizewell C is provided in **Volume 2, Chapter 6** of the **Environmental Statement** (Main Development Site Chapter 6 Alternatives and Design Evolution [APP-190]). Direct (or 'once-through') Cooling is the preferred choice for nuclear power stations in the UK for several reasons if Environment Agency criteria relating to design and environmental impacts are satisfied (see Section 6.6.21 to 6.6.27 of APP-190). All criteria are met for Sizewell C and so use of alternative cooling options (which themselves are not suitable for Sizewell C) is neither necessary nor desirable.

2 APPENDIX A

2.1 Sea Bass Assessment REP8-131: '9.110 Revision: 1.0 Sizewell C European Sea Bass Stock Assessment'

2.1.1 This section includes responses to TASC comments pertaining to the sea bass stock assessment (*Deadline 8 Submission - 9.110 Sizewell C European Sea Bass Stock Assessment - Revision 1.0 [REP8-131]*). Comments included the cumulative effects of Sizewell C operating with other nuclear power stations, consideration of management measures including Bass Nursery Areas (BNAs) and the sea bass stock assessment not incorporating entrainment data. Each point is considered further below.

Entrainment

2.1.2 TASC concluded that "*(vi) As the sea bass assessment has not considered entrainment, it is incomplete".* Not including the entrainment fraction is anticipated to have negligible effects on the abundance of mature sea bass. This is because entrainment losses of early life-history stages are a very small proportion of natural mortality in this species and juvenile sea bass are predominantly impinged.

2.1.3 The vast majority of sea bass impinged at Sizewell B are juveniles in the age groups 0-3 years old. The most common size of sea bass observed in impingement records is 175-179mm Total Length (TL). At this length, sea bass have an approximate body depth of 34.3-35.1mm (mean body depth is 19.6% TL[23]). Impingement of the smallest year 0 age class is primarily between 65mm and 109mm TL (approximate body depth 12.7-21.3mm), peaking at 80-89mm (15.7-17.4mm). At this length, the majority of fish would be retained by the 10mm square mesh. Indeed, applying the equations of Turnpenny (1981) shows that the bony part of the head would not penetrate the mesh for sea bass of 77mm TL (64mm SL), thus resulting in complete exclusion. The smallest sea bass recorded in impingement monitoring at Sizewell B was 45-49mm TL (8.8-9.6mm body depth). If small sea bass were common off Sizewell, they would regularly be observed in impingement monitoring as is the case for other fish species with small life stages (e.g., sprat and gobies). Due to the very high natural mortality of early life stages of sea bass, the relative population effects of any feasible underestimates of losses of these stages is minor.

2.1.4 The sea bass stock assessment is precautionary. It included an extreme worst-case assessment that applied upper 95% confidence intervals (U95)

[21] Ellis, J.R., Milligan, S.P., Readdy, L., Taylor, N., Brown, M.J. 2012. Spawning and nursery grounds of selected fish species in UK waters. Cefas, Lowestoft, 60 pp.

of unmitigated (no FRR) impingement for the 35-year simulation. Such a scenario is very precautionary and thus provides a high degree of confidence that the results are conservative. In addition, the stock assessment did not consider the distribution of sea bass within the Greater Sizewell Bay. Offshore surveys have shown significantly higher abundance inshore of the Sizewell-Dunwich Bank[24] where the Sizewell B intakes are located. As such, scaling up impingement rates from Sizewell B to Sizewell C, seaward of the Sizewell-Dunwich Bank, is likely to lead to overestimates of impacts on the population.

Cumulative effects

2.1.5 In commenting on the cumulative effects assessment scenario TASC state that: *"In preparing REP8-131, CEFAS are putting a veneer of careful scientific arguments that hide sweeping assumptions which cannot be justified. By far the most important one, in TASC's opinion, is the in-combination impact when CEFAS combine Hinkley Point C (HPC) and SZC. However, EDF operate a large number of once-through cooled power stations along the Northern coast of France that also kill large numbers of bass. So, any true in-combination calculation would include impingement/entrainment mortality from Graveline, Flamanville etc. As mentioned above, there are also stations in Belgium, Netherlands etc which also kill bass."* The statement by TASC is misleading and misinterprets the treatment of data in the stock assessment and the purpose of the cumulative effects scenario.

2.1.6 The observed size and age structure of the sea bass stock, the absolute or relative abundance of sea bass caught in surveys, and the size of catches that can potentially be taken from the stock, are a consequence of the reproductive success, growth and mortality of sea bass. The stock assessment seeks to determine sea bass stock size and age structure, and rates of fishing mortality. The estimates of stock size and age structure will be indicative of the status of the stock after the effects of mortality on the early life stages. Therefore, the relative effects of entrapment mortality of early life stages at the existing operational stations are indirectly included in the estimated trend in spawning stock biomass through time. This trend was used as the baseline for assessing the additional effects of Sizewell C and Hinkley Point C.

2.1.7 The purpose of the cumulative effects sea bass assessment was to determine the potential for the additional impingement associated with the new stations of Sizewell C and Hinkley Point C to significantly affect the existing dynamic baseline. This approach is consistent with the National

[24] Please see Deadline 8 Submission - 9.110 Sizewell C European Sea Bass Stock Assessment - Revision 1.0 [REP8-131].

Infrastructure Planning Advice Note Seventeen: Cumulative effects assessment relevant to nationally significant infrastructure projects[25]. The stock assessment distinguishes between existing power stations (that form part of the dynamic baseline) and those included in the assessment; Sizewell C and Hinkley Point C.

2.1.8 Through time, new stations are commissioned, and existing stations decommissioned. It is acknowledged that Flamanville 3 on the Normandy coast may become operational in 2023 resulting in additional entrapment of sea bass the influence of which is not currently included in survey and fisheries data for the current stock assessment (and no impingement estimates are available). However, Hinkley Point B is effectively included in the baseline derived from the current stock assessment and is due to cease operating in 2022; so, while Flamanville 3 will introduce one source of mortality, the impacts from Hinkley Point B will stop. Furthermore, the cumulative effects stock assessment is based on highly precautionary assumptions and will thus overestimate the most plausible relative impingement effects of both Hinkley Point C and Sizewell C. In the case of Hinkley Point C, the annual impingement rates are based on U95 confidence intervals for unmitigated losses. Hinkley Point C will be fitted with an FRR system which is predicted, by the Environment Agency[26], to result in 39% of impinged sea bass surviving impingement (uncertainty range 5-70% survival).

2.1.9 The cumulative effects assessment is consistent with established methods and the approach undertaken is considered to be suitably precautionary and robust. Adding existing stations to the stock assessment would result in double counting as the mortality is effectively incorporated within the dynamic baseline.

Management advice for sea bass

2.1.10 Throughout their submission, TASC have commented on the perceived mismatch between Cefas fisheries advice (including the identification of potential bass nursery areas) and the assessment of effects from Sizewell C. There is no such mismatch and Cefas' role is described in Section 0.

2.1.11 SZC Co. considered the latest management advice in relation to the sea bass stock in its response to the Secretary of State's second letter on comments from the Environment Agency on the sea bass stock

[25] Advice Note Seventeen: Cumulative effects assessment relevant to nationally significant infrastructure projects | National Infrastructure Planning (planninginspectorate.gov.uk).

[26] Environmental Agency 2020. CD 8.6 Technical Brief: TB008 Fish Recovery and Return System Mortality Rates. Draft-04. 15 pp. Available at: https://ea.sharefile.com/share/view/s61339f123dad4ed794643b4b4f6932b9.

assessment[27]. This section is in response to comments from TASC in relation to the inshore waters off Sizewell being identified as a potential Bass Nursery Area (BNA); *"TASC find it hard to understand how CEFAS can consider Sizewell as a BNA but then support the slaughter of bass through the SZC CWS."*

2.1.12 BNAs are Statutory Instruments[28] that have been created to protect aggregations of juvenile sea bass from fishing in areas where catches below the Minimum Conservation Reference Size predominate. Thermal uplifts created by direct cooled power stations result in aggregations of juvenile sea bass and BNAs have been created at the former Bradwell, Blythe, Fawley and Kingsnorth power stations. A review of the presence of sea bass in potential inshore nursery areas indicated there was sufficient evidence to support further consideration of the inshore area around Sizewell B as a potential new BNA (Hyder *et al.,* 2018[29]). In total 48 amendments were proposed to existing BNAs in England and Wales including 39 new BNAs, and the proposed removal of the BNAs that no longer benefit from warm water outflows due to the decommissioning of power stations. Twelve new BNAs were considered in the area managed by the Eastern IFCA, including at Sizewell. At the time of writing there has been no change in status of the UK BNAs. The degree of protection afforded by BNAs to sea bass populations depends on the level of recruitment from each area to the population. The report identified areas where available data has indicated the presence of juvenile sea bass, but it was not possible to assess the impact of BNAs on the stock. Further work was needed to better understand the relative contribution of individual nursery areas to the population in the context of other management measures to judge the benefit of BNAs in conservation of the stock (Hyder *et al.,* 2018).

2.1.13 The assessment of effects of the proposed Sizewell C is based on scaling up impingement rates from Sizewell B. The abundance and size distribution of juvenile sea bass impinged at Sizewell B is therefore incorporated. However, the Sizewell C intakes would be situated 3km offshore, seaward of the Sizewell Dunwich Bank whilst the Sizewell B intakes and outfalls are inshore of the Sizewell Dunwich Bank in shallower water. Sea bass distribution surveys off Sizewell have showed low catch rates at all offshore survey stations with 95% of sea bass caught inshore of the Sizewell-Dunwich Bank. This corresponds to the established behaviour

[27] NNB Generation Company (SZC) Limited. Response to SoS request for information of 31 March 2022 - Appendix 7 - Additional technical information to support Question 8.4 in relation to Environment Agency comments on assessment of sea bass.

[28] The Bass (Specified Areas) (Prohibition of Fishing) (Variation) Order 1999 (legislation.gov.uk).

[29] Hyder *et al.,* 2018. Presence of European sea bass (*Dicentrarchus labrax*) and other species in proposed bass nursery areas. Cefas. 27 April 2018. Available here: Presence of European sea bass and other species in proposed bass nursery areas - GOV.UK (www.gov.uk).

of juvenile sea bass utilising inshore coastal waters, where other factors such as food availability and predation threat are likely to drive distribution[30]. Therefore, the assessment of effects on the sea bass population from scaling up Sizewell B impingement is likely to lead to overestimates.

TASC impingement estimates

2.1.14 In Annex B of their submission, TASC provide estimates of annual impingement numbers which includes a predicted impingement of 2.1 million sea bass per annum from Sizewell C. The data originate from the SZC Co. Environmental Statement (Volume 2 Chapter 22, Appendix D: the Fish Characterisation report[31]) and is a sub-set of the impingement record from 2009-2013. A scaling approach was applied to establish annual means for each year. The report was not the formal impingement assessment and what was not clear in the report is that the values presented were the highest annual mean for each species from the period 2009-2013. As such the values were reasonable for considering the worst-case annual losses for a given species during that period. Predicted annual impingement rates with confidence intervals are provided for the key taxa in the uncertainty analysis *(Deadline 10 Submission - 9.67 Quantifying Uncertainty in Entrapment Predictions for Sizewell C [REP10-135])*.

2.1.15 The highest impingement rates for sea bass at Sizewell B occurred in 2010. The stock assessment inputs data for each year of the impingement record and the 2010 values are very similar to the number produced by TASC and include an unmitigated mean of 1.94 million fish and a U95 value of 2.44 million[32]. However, 2010 was an exceptional impingement year for sea bass. Over the full period of the impingement monitoring (2009-2017), mean annual impingement predictions for Sizewell C are 641,398. The majority of these fish are juveniles.

2.1.16 Impingement predictions for all species at Sizewell C are provided in Appendix C.

[30] The implications for thermal uplifts on sea bass impingement rates in relation to the cooling water infrastructure associated with Sizewell C is considered in Section 7.2.4 'Juvenile bass attraction to thermal discharges', pdf pg. 163 of *Additional Submission in relation to the Applicant's request for changes to the application and Additional Information - 6.14 Environmental Statement Addendum Volume 3: Environmental Statement Addendum Appendices Chapter 2 Main Development Site Appendices 2.17.A Marine Ecology [AS-238].*

[31] 6.3 Volume 2 Main Development Site Chapter 22 Marine Ecology and Fisheries Appendix 22D - Sizewell Characterisation Report – Fish [APP-321].

[32] Table 1 of Deadline 8 Submission - 9.110 Sizewell C European Sea Bass Stock Assessment - Revision 1.0 [REP8-131].

3 APPENDIX B

3.1 Responses to specific comments on quantifying the entrainment gap in the Uncertainty analysis [REP10-135].

Sprat and herring

3.1.1 TASC have challenged both the upper and lower bound for estimation of the entrainment gap for sprat and herring. The lower size bound selected was 35-39mm Total Length (TL)[33] (30mm Standard Length (SL)[34]). This size range was selected on the basis that metamorphosis of sprat larvae into juveniles occurs between 32mm and 41mm TL, therefore sprat below this size would be larvae only, and at 35-39mm TL - a mix of latest larvae and earliest juveniles. In the forebay it is considered this size range would be less well equipped to avoid the pump samples, and as stated in Section 1.1, entrainment sampling recorded both larval and juvenile sprat in appreciable numbers. Furthermore, it is consistent with the position of TASC that *"sprat > 30 mm SL will be inefficiently caught by the entrainment pump sampler"*[35]. SZC Co. is confident that the lower bound applied does not significantly underestimate entrainment of fish of this size class. Equally, any underestimation of these small size classes would have minor effect on the results, as demonstrated in Section 1.1 due to the low relative EAV.

3.1.2 TASC claim that in setting the upper bound *"CEFAS have failed to understand that the critical dimension for mesh penetration is not the 10mm length of each side of the mesh but the diagonal distance across the mesh. For a 10 mm mesh this is the square root of 200 = 14.14 mm."* The assessment assumed the TASC position that *"on a 10 mm mesh as used at Sizewell B sprat need to be > 70 mm SL before they are always retained on the 10 mm filter screens"*[32] and applied an upper bound of 70-74mm SL. At this length sprat would have a typical body depth of 14.7 – 15.6mm, based on a fineness ration of 4.75[36]. This is consistent with other studies that show the body depth to length relationship in sprat at this size range is ~20-22%[37] implying a 72mm SL fish would have a body depth of 14.4-15.8mm. This exceeds even the diagonal dimension of the mesh and confirms the upper bound has been conservatively applied as total

[33] Total length - The greatest length of the whole body between the most anterior point of the body and the most posterior point, in a straight line

[34] Standard length: The measurement from the most anterior tip of the body to the to the posterior end of the vertebral column

[35] Together Against Sizewell C (TASC) Deadline 2 Submission - Written Representation (WR) - Ecological Impacts [REP2-481h].

[36] Turnpenny, W.H. 1981. An analysis of mesh sizes required for screening fishes at water intakes. Estuaries 4, 363-368.

[37] Gűnther C.C., Temming, A., Baumann, H., Huwer, B Mollmann, H., Clemmesen, C., Herrmann, J-P. 2012. A novel length back-calculation approach accounting for ontogenetic changes in the fish length – otolith size relationship during the early life of sprat (Sprattus sprattus). Canadian Journal of Fisheries and Aquatic Sciences, 69: 1214-1229.

exclusion of this size range would occur. Fish close to this size range would only be able to pass through the mesh if they were oriented on the diagonal. As stated in the uncertainty analysis, emphasis added; *"If the **body depth of a fish appreciably exceeds 10mm**, it is unlikely to be squeezed through the stainless steel mesh, but rather would be turned by the water flow to lie flat on the mesh surface and so be impinged".*

3.1.3 Therefore, we consider the upper and lower bounds of the assessment to be robust and show only minor increases in total equivalent adult losses of 6% for sprat and 1% for herring.

Gobies: *Pomatoschistus*

3.1.4 Gobies of the genus *Pomatoschistus* are ubiquitous in shallow waters along European shores and are abundant in the Sizewell area. These gobies brood their eggs in nests, therefore, eggs are not prone to abstraction. Larvae, juveniles and adult stages are susceptible to cooling water abstraction. To determine the potential for sampling inefficiencies to result in underestimates of gobies, SZC Co. undertook a series of additional analyses. TASC have questioned the assumptions of these analyses based on five points, each of which are discussed below and found not to materially change the results.

3.1.5 TASC claimed that *"First, there is the error of not using the diagonal dimension of the mesh when considering mesh penetration".* Gobies of the genus *Pomatoschistus,* and gobies in general, have a rounded body morphology, slightly wider than high (Figure 1). TASC contend that exclusion of gobies occurs at a SL of 87mm based on the formula of Turnpenny (1981). However, as previously stated the formula for exclusion of fish is based on measurements at the bony part of the head at the rear of the orbit behind the eye. The body width of *Pomatoschistus* is greater than at the head. This means the formula for total exclusion predicts a size well above that of high retention rates. This point is well illustrated in previous TASC submissions; Figure 6 of TASC Deadline 2 Submission - Written Representation (WR) - Ecological Impacts [REP2-481h] fits a predictive regression curve to estimate the proportion of sand gobies retained on a 10mm square mesh and shows nearly full retention rates above 60mm SL (approximately >95%).

3.1.6 The size of effective impingement of 70-74mm TL as suggested by SZC Co. should be considered as a reasonable position as it corresponds to 62-65mm SL. At this length, gobies have a body height of approximately 9.2-9.7mm and a body width of 10.9-11.4mm. A size at which it is anticipated the majority of individuals would be efficiently impinged.

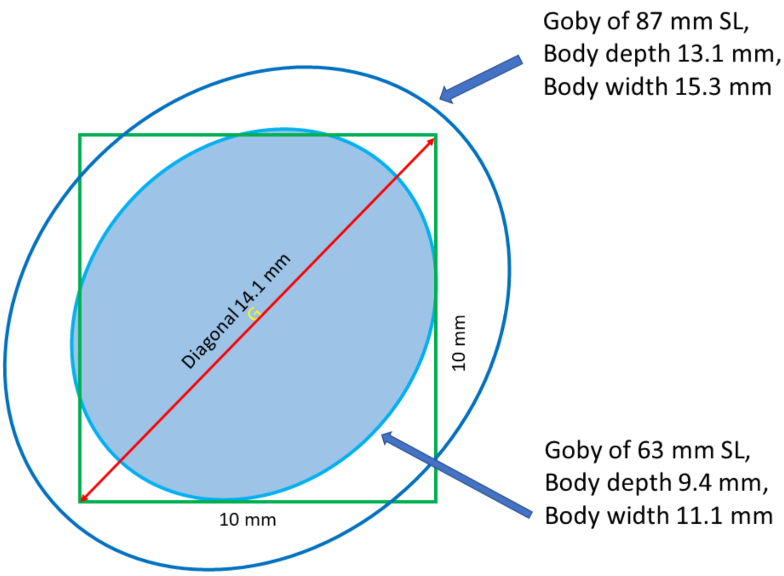

Figure 1 Profiles of *Pomatoschistus minutus* of 63mm SL and 87mm SL oriented on the diagonal relative to a 10mm square mesh. Body depth is taken as 13.1% TL[38], body width estimated from fineness ratio (Turnpenny, 1981)

3.1.7 The second comment by TASC challenged the assumption that the pump sampler is effective up to a length of 35-39mm TL; "*This is untrue as small gobies about 18mm SL are fully formed fish and will avoid capture in a pump sampler."* The third (linked) claim of TASC was that "*CEFAS assume the smallest juveniles are 20-24 mm TL. Gobies enter the water column at a length of about 9 mm and well-formed juveniles > 16 mm are observed in high numbers. No explanation of the 20-24 mm TL cut off length is presented*". The SZC Co. does not contest the statement about juvenile gobies being well formed below 35-39mm, however the comment does not have a bearing on the assessment of the entrainment gap. *Pomatoschistus minutus* eggs hatch and larvae of ca. 2.5mm soon after enter the water column. Metamorphosis from larvae to juvenile stages occurs across a range of sizes, from as early as ~10mm TL but on average at 17mm TL. From 17-18mm *Pomatoschistus* descend to the bottom[39]. Therefore, we assume that by 20-24mm TL all fish are juveniles living near the seabed like the adult life stages.

[38] Froese, R. and D. Pauly. Editors. 2022. FishBase. World Wide Web electronic publication. www.fishbase.org, version (02/2022).

[39] Gonçalves, R., Teodosio, M.A., Cruz, J., Ben-Hamadou, R., Correia, A.D., Chicaro, L. 2017. Preliminary Insight into winter native fish assemblages in Guadiana Estuary Salt Marshes coping with environmental variability and non-indigenous fish introduction. Fishes, 2(4), 19.

3.1.8 These small juvenile gobies have been recorded in entrainment monitoring and therefore sampled by the pump sampler. Entrainment estimates for Sizewell C, based on monitoring at Sizewell B, estimate 19.5 million juveniles will be entrained per annum in comparison to 133 million entrained larvae (*6.3 Volume 2 Main Development Site Chapter 22 Marine Ecology and Fisheries Appendix 22G - Predictions of Entrainment by Sizewell C in Relation to Adjacent Fish and Invertebrate Populations* [APP-324]). The number of entrained juveniles equated to 14.6% of entrained larvae. Assuming larvae are effectively sampled and applying established growth rates we can determine the level of natural mortality that would account for this percentage entrainment of juvenile gobies. It takes ~45 days from hatching for larvae to grow to 18mm SL (20.6mm TL)[40]. Therefore, for every 133 million larvae (the number entrained) 19.5 million juveniles would be entrained if larval daily mortality is M = 0.04-0.05. This mortality rate is in the range of typical values for pelagic fish larvae occurring in the area e.g., plaice, sprat, herring that are of M=0.02-0.09[41]. Therefore, the number of juveniles identified in entrainment sampling falls within expected bounds and implies that juveniles must be relatively well selected by entrainment sampling. A tentative back-calculation of the entrainment gap in gobies to 20mm TL (17.5mm SL) was also undertaken in the uncertainty analysis. This resulted in 17.9 million juveniles being entrained and is consistent with the estimate from entrainment sampling (19.5 million). Therefore, irrespective of the size at which gobies become fully formed juveniles, there is not predicted to be a significant underestimate of entrainment rates in this size class. Moreover, the calculation of equivalent adults from entrainment losses assumed all juvenile gobies are of 30mm TL. This is precautionary, and, as suggested by TASC, most would be expected to be much smaller. As a result, the EAV factor for juveniles is conservative.

3.1.9 The fourth TASC comment was “*The maximum age of maturity of sand goby at Sizewell is not 2.7 years and is much closer to 1 year. They quote data for P. minutus and avoid data for P. lozanoi which is smaller and lives for only about 1 year. Further the maximum longevity of 2.7 years is not for southern North Sea.”* The age of 2.7 years is the maximum age a mature fish may attain and does not have a bearing on the EAV calculation. The life span of *P. minutus* is 2 years across the Atlantic species range (less in the Mediterranean) and during each season three age classes might be observed: 0+, 1+ and 2+ years old (y.o.). In Atlantic temperate water populations, the age-at-maturity (50% mature) is 1 y.o.; the late maturing group is composed of individuals aged from 20 to 24 months and represents

[41] Mc Gurk, M.D. 1986. Natural mortality of marine pelagic fish eggs and larvae: role of spatial patchiness. Marine Ecology Progress Series. 34: 227-242.
Pepin, P. 1991. Effect of temperature and size on development, mortality, and survival rates of the pelagic early life history stages of marine fish. Canadian Journal of Fisheries and Aquatic Science 48: 503-518.

5 to 8% of the population, spawning at the start of the breeding season before dying[42]. Therefore, we assume that the age of 100% maturity is 1.5 years as numbers of fish maturing ~2 y.o. is very low, and that all gobies would be mature before the second year. It should be noted that the application of biological parameters from *P. minutus* to generate EAVs for the entrainment fraction has no bearing on the impingement estimates that precautionarily assume all impinged fish are mature adults contributing to the spawning population with an EAV=1. This is a precautionary approach as the size distribution in the impingement record indicates many of the individuals impinged are immature.

3.1.10 Finally, TASC stated that *"CEFAS argue that the entrapment death rate is insufficient to affect the sand goby population. The problem here is that there is not a sand goby species, there are 3 species. CEFAS treats it as a single species which is incorrect. The P. minutus species complex in North Atlantic waters comprise 3 species P. minutus, P. lozanoi and P. norvegicus."* Gobies of the genus *Pomatoschistus* were common and abundant in beam trawl surveys in the Greater Sizewell Bay[43] and accounted for 87% of all individual gobies from the different genera impinged at Sizewell B[44]. Gobies of the genus *Pomatoschistus* have, therefore, been assessed as a key taxa. The assessments do not treat sand gobies as a single species, it is recognised that there is a species complex, which locally may comprise of *P. lozanoi* and *P. minutus* and possibly *P. norvegicus* (though the latter species is more common further offshore). Some less common species in the genus include *P. pictus* and *P. microps*. The biological characteristics of the best studied species in the complex, the sand goby *P. minutus,* have been applied to generate EAVs. However, the EAV value is only relevant to the entrainment fraction as all impinged gobies are assumed to be mature (EAV = 1). The estimated entrapment losses of the *Pomatoschistus* spp. species complex have been compared against the estimated numbers in Region 2 (Winterton and North Foreland) from the Cefas Young Fish Surveys. The population estimate is of the same species complex. As such, conclusions about the potential significance of effects of Sizewell C on this group of gobies can be derived.

3.1.11 The comments raised by TASC have been considered in detail and it is acknowledged that there are residual uncertainties in establishing the absolute number of gobies of the genus *Pomatoschistus* spp. entrapped. However, the assessment undertaken by SZC Co. is inherently precautionary based on three conservative assumptions outlined in Section

[42] Bouchereau J-L., Guelorget, O. 1998. Comparison of three Gobiidae (Teleostei) life history strategies over their geographical range. Oceanologica Acta, 21: 503-517.
[43] 6.3 Volume 2 Main Development Site Chapter 22 Marine Ecology and Fisheries Appendix 22D - Sizewell Characterisation Report – Fish [APP-321].
[44] 6.3 Volume 2 Main Development Site Chapter 22 Marine Ecology and Fisheries Appendix 22G - Predictions of Entrainment by Sizewell C in Relation to Adjacent Fish and Invertebrate Populations [APP-324].

1.1, notably the assumption of 100% entrainment mortality and conservative assumptions applied when determining EAV values for entrained and impinged gobies. The population level effects on the species complex, are well below levels that would affect sustainability and the assessment is robust to the residual sampling uncertainties.

Smelt

3.1.12 TASC stated that *"As in the case of sprat, they assert, incorrectly, that it is 10 mm body depth which is the maximum size for penetration when in actual fact it is closer to 14 mm."* Smelt body morphology is approximately round, therefore, if the body depth appreciably exceeds 10mm, retention rates would be expected to be high. Smelt spawn in upper estuaries and freshwaters. Most of the juvenile fish descend to the lower estuary by the early autumn[45] at which point their length is ~60mm TL[46]. At this body length, smelt have an approximate body depth of 10mm[47]. In the lower Thames Estuary at Canvey Island autumn smelt are generally >80mm TL[43], with a body depth of >13.3mm.

3.1.13 This corresponds to the impingement record in the coastal waters at Sizewell B. The first smelt in the impingement record appear at 55-70mm TL although in very low numbers (2.8% of impingement record) as would be expected as fish of this size are just leaving the estuaries. Smelt of 55-85mm have a body depth of approximately 9-14mm, with a high proportion likely retained by the mesh. Fish of this size-range account for 9.6% of impingement numbers; the mean length being 72.6 mm (body depth 12.1mm). In the whole impingement record the mean length is 114mm (body depth 18.9mm). Whilst a proportion of smelt within the size range from 55-85mm may not be retained by the mesh and subject to underestimates, any additional losses of individuals in this infrequently occurring smaller size range are not anticipated to have a significant bearing on the results.

Other species

3.1.14 TASC stated that "*Another class of fish which has been greatly underestimated are those with a long, thin body form that can penetrate the mesh as adults or late-stage juveniles. These include the abundant Nilsson's, greater and snake pipefishes. Nilsson's pipefish is particularly*

[45] Colclough, S., Coates, S. 2013. A Review of the status of Smelt *Osmerus eperlanus* (L.) in England and Wales. Environment Agency, 60 pp. Veckenstedt.

[46] Scholle, J., Schuchardt, b., Schultze, S. 2007. Situation of the smelt (*Osmerus eperlanus*) in the Ems estuary with regard to the aspects of spawning grounds and recruitment. RWS – Rijksinstituut voor Kust en Zee (RWS – RIKZ), Netherlands. 101 pp.

[47] Froese, R. and D. Pauly. Editors. 2022. FishBase. World Wide Web electronic publication. www.fishbase.org, version (02/2022).

abundant at Sizewell and is regularly recorded in impingement samples. The vast majority of pipefish will penetrate the screens, so the number recorded in the impingement samples is probably a tiny fraction of the total that are killed." Larval and juvenile pipefish are recorded during entrainment monitoring. Pipefish have low mobility, fully formed fish are recorded in the entrainment monitoring and annual estimates are 8-fold higher than in the impingement record. Entrainment losses assume all non-larval pipefish have an EAV of 1 and incur 100% entrainment mortality. High natural mortality of juvenile pipefish means in reality, few juveniles would survive to maturity. The precautionary assumptions applied to derive the number of equivalent adults lost as part of the entrainment assessment are expected to counter the effects of any sampling inefficiencies that may have occurred.

3.1.15 Pipefish are common in inshore coastal waters. Multiannual Young Fish Surveys have been undertaken in inshore waters around the British Isles to determine the abundance of juvenile fish[48]. From 1981 to 2010 over 10,000 hauls were completed in the area from Margate to the east Norfolk coast. Pipefish were recorded throughout the region with the greatest densities in the Thames Estuary. Nilsson's pipefish were the most common species accounting for 74% of the catch numbers. Off the coast of Suffolk, pipefish are present but at lower abundance than in other parts of the region. At Sizewell B, Nilsson's pipefish are the most commonly impinged pipefish species. Maximum abundance of Nilsson's pipefish occur in estuarine environments with salinities of 15-20 parts per thousand (ppt) followed by decline in densities at >20ppt. The seawater off Sizewell has a relatively narrow annual range of salinity (typically 32.5 – 34.5ppt). In the estuarine environment at West Thurrock Power Station, where intakes also have a screen mesh size of 10mm, Nilsson's pipefish occurred in 81.4% of all impingement samples and accounted for 1.46% of all impinged marine fish sampled[49]. At Sizewell B, Nilsson's pipefish account for less than 0.3% of fish impinged. Observations on West Thurrock power plant demonstrated that despite losses from the station, the long-term trend of the species abundance during the power plant activity was increasing and fluctuating depending on the different environmental parameters e.g., temperature. Pipefish are predicted to be entrapped relative to their abundance at Sizewell. The species is sampled in both entrainment and impingement monitoring and significant effects from the station are not anticipated.

3.1.16 TASC stated that "*Another group which needs to be properly quantified are the flatfish*." Dab, plaice, Dover sole and flounder are key taxa at Sizewell and are routinely impinged during impingement monitoring. Flatfish larvae

[48] Cefas Young Fish Survey: YFS https://www.cefas.co.uk/data-and-publications/dois/young-fish-survey-data-1981-to-2010/

[49] Power, M., Attrill, M.J. 2003. Long-term trends in the estuarine abundance of Nilsson's pipefish (*Syngnathus rostellatus* Nilsson). Estuarine, Coastal and Shelf Science 57; 325–333.

of Dover sole, flounder, solenette, soles and unidentified flatfish have been recorded in the entrainment monitoring[50]. Flatfish are highly fecund and have multiple spawning seasons[51]. Very high natural mortality of these early life stages means the equivalent adult losses are predicted to be low but upper estimates of larval entrainment losses have been incorporated into the uncertainty analyses[52]. The uncertainty analyses show that entrapment losses of Dover sole, dab, flounder, and plaice are all well below 0.05% of the respective population comparators as both a mean and upper confidence interval. Whilst it is likely that limitations in impingement and entrainment sampling result in a proportion of small individuals being subject to the entrainment gap leading to underestimates in absolute numbers, the assessment is not sensitive to the residual uncertainty. The station is therefore not predicted to have significant effects on the populations of the key flatfish species.

[50] 6.3 Volume 2 Main Development Site Chapter 22 Marine Ecology and Fisheries Appendix 22G - Predictions of Entrainment by Sizewell C in Relation to Adjacent Fish and Invertebrate Populations [APP-324].

[51] Froese, R. and D. Pauly. Editors. 2022. FishBase. World Wide Web electronic publication. www.fishbase.org, version (02/2022).

[52] Deadline 10 Submission - 9.67 Quantifying Uncertainty in Entrapment Predictions for Sizewell C [REP10-135].

4 APPENDIX C

4.1 Annual impingement predictions for Sizewell C

4.1.1 In Annex B of their submission, TASC provide estimates of annual impingement numbers based on a sub-set of the impingement record (see Appendix A for more details). Following comments from the Environment Agency during consultation on the WDA Environmental Permit, relating to treatment of invalid bulk samples and raising factors, revised impingement estimates for Sizewell B and Sizewell C were provided and used in subsequent assessments. Table 1 provides the raw annual impingement predictions for Sizewell C for each of the species in the impingement record. The numbers are not converted to equivalent adult values (EAVs). Mean values represent the bootstrapped annual mean scaled-up to Sizewell C based on data collected from Sizewell B from 2009-2017. Upper and lower values represent 95% confidence intervals of the annual mean. The raw data used to determine impingement predictions were submitted to the Environment Agency as a supporting report for the WDA Environmental Permit (BEEMS Scientific Position Paper SPP111.v2). The modified results for the key species were provided to the Examining Authority in response to Examining Authority Questions BIO.1.242 and BIO.1.243 (SZC Co. Responses to Examining Authority's Written Questions. Appendix 7L Detailed response to questions ExA Ref. Bio 1.242 and 1.243 [REP2-110]) and have been applied in subsequent analyses submitted within the Examination. The impingement predictions in Table 1 were used to determine population effects within the uncertainty analysis *(Deadline 10 Submission - 9.67 Quantifying Uncertainty in Entrapment Predictions for Sizewell C [REP10-135]).*

Table 1 Annual unmitigated Sizewell C impingement predictions at full operational capacity. Numbers are mean values with confidence intervals (2009-2017) and are not converted to EAVs. Key taxa are shaded in blue.

Common name	Scientific name	SZC - prediction		
		Mean	Lower	Upper
Sprat	*Sprattus sprattus*	6,153,906	3,173,989	10,415,898
Herring	*Clupea harengus*	2,211,750	1,310,172	3,352,700
Whiting	*Merlangius merlangus*	1,495,192	1,095,717	1,954,416
European seabass	*Dicentrarchus labrax*	641,398	296,862	1,113,750
Gobies of the genus *Pomatoschistus spp.*	*Pomatoschistus spp.*	483,487	205,548	916,287
Dover sole	*Solea solea*	211,083	146,474	290,806
European anchovy	*Engraulis encrasicolus*	148,332	43,495	356,894
Dab	*Limanda limanda*	128,476	76,309	214,481

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Common name	Scientific name	SZC - prediction		
		Mean	Lower	Upper
Thin-lipped grey mullet	*Liza ramada*	107,602	33,386	207,685
Transparent goby	*Aphia minuta*	90,917	38,118	189,673
Bib	*Trisopterus luscus*	72,620	33,838	123,305
Lesser weever fish	*Echiichthys (trachinus) vipera*	48,307	31,008	71,023
Nilsson's pipefish	*Syngnathus rostellatus*	32,547	5,883	67,028
Flounder	*Platichthys flesus*	32,149	24,367	42,211
Pogge (hooknose)	*Agonus cataphractus*	23,136	16,531	31,312
Cucumber smelt	*Osmerus eperlanus*	22,165	13,867	32,370
European plaice	*Pleuronectes platessa*	21,956	14,135	32,723
Five-bearded rockling	*Ciliata mustela*	20,359	12,642	31,610
Atlantic cod	*Gadus morhua*	16,505	5,716	30,807
Lesser spotted dogfish	*Scyliorhinus canicula*	11,973	5,871	20,648
Great pipefish	*Syngnathus acus*	10,522	4,868	17,031
Common sea snail	*Liparis liparis*	8,795	3,885	16,230
Grey mullets	*Mugilidae*	8,655	0	37,594
Thornback ray	*Raja clavata*	6,700	4,172	9,833
Tub gurnard	*Trigla lucerna*	4,957	2,950	7,755
Unidentified herrings	*Clupeidae*	3,940	0	17,234
Pilchard	*Sardina pilchardus*	3,870	873	10,784
Starry smooth-hound	*Mustelus asterias*	3,634	1,694	6,003
Poor cod	*Trisopterus minutus*	3,352	697	7,208
Common dragonet	*Callionymus lyra*	3,345	1,457	6,207
Twaite shad	*Alosa fallax*	2,693	1,340	4,691
Black goby	*Gobius niger*	2,688	205	8,933
River lamprey	*Lampetra fluviatilis*	2,607	1,430	4,393
European eel	*Anguilla anguilla*	2,463	1,530	3,628
Three-spined stickleback	*Gasterosteus aculeatus*	2,360	594	6,809
Common sandeel	*Ammodytes tobianus*	2,185	892	4,481
Bullrout	*Myoxocephalus scorpius*	2,001	896	3,601
Scald fish	*Arnoglossus laterna*	1,816	912	3,006
Witch	*Glyptocephalus cynoglossus*	1,740	14	5,020
Great sandeel	*Hyperoplus lanceolatus*	1,609	515	3,111
Horse-mackerel	*Trachurus trachurus*	1,560	488	3,756
Brill	*Scophthalmus rhombus*	1,303	379	2,802
Rock goby	*Gobius paganellus*	1,106	26	4,670
Snake pipefish	*Entelurus aequoreus*	792	10	3,508
Lemon sole	*Microstomus kitt*	774	266	1,516
Solenette	*Buglossidium luteum*	656	188	1,398
Montague's seasnail	*Liparis montagui*	605	25	1,869
Sand Smelt	*Atherina boyeri*	394	14	978
Butter fish	*Pholis gunnellus*	344	110	664
Red mullet	*Mullus surmuletus*	312	88	666
Mackerel	*Scomber scombrus*	277	14	916
Tompot blenny	*Parablennius gattorugine*	263	36	712
Sandeels	*Ammodytidae*	220	0	688
Grey gurnard	*Eutrigla gurnardus*	220	35	538
Sea scorpion	*Taurulus bubalis*	203	18	496
Eelpout (Viviparous blenny)	*Zoarces viviparus*	203	0	575
Jeffrey's goby	*Buenia jeffreysii*	199	0	1,057
Garfish	*Belone belone*	177	24	423

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Common name	Scientific name	SZC - prediction		
		Mean	Lower	Upper
Baillons wrasse	*Symphodus balloni*	176	0	549
Sand smelt	*Atherina presbyter*	148	0	618
Corkwing wrasse	*Crenilabrus melops*	137	0	434
Lesser forkbeard (tadpolefish)	*Raniceps raninus*	129	0	388
Frie's goby	*Lesueurigobius friesii*	128	0	391
Turbot	*Scophthalmus maximus*	114	8	311
Northern rockling	*Ciliata septentrionalis*	103	0	315
John dory	*Zeus faber*	76	0	211
Norway bullhead	*Micrenophrys lilljeborgii*	68	0	382
Sandeel	*Ammodytes marinus*	61	0	255
Tope	*Galeorhinus galeus*	55	0	207
Four-bearded rockling	*Enchelyopus cimbrius*	53	0	137
Ballan wrasse	*Labrus bergylta*	48	0	184
Spotted ray	*Raja montagui*	47	0	154
Lumpsucker	*Cyclopterus lumpus*	38	0	113
Crystal goby	*Crystallogobius linearis*	35	0	193
Thick-lipped grey mullet	*Crenimugil labrosus*	33	0	193
Black seabream	*Spondyliosoma cantharus*	21	0	89
Cuckoo wrasse	*Labrus mixtus*	19	0	106
Snake blenny	*Lumpenus lampretaeformis*	18	0	107
Goldsinny	*Ctenolabrus rupestris*	18	0	107
Pollack	*Pollachius pollachius*	15	0	92
Deep-snouted pipefish	*Syngnathus typhle*	11	0	65
Bigeye rockling	*Antonogadus macropthalmus*	10	0	37
Shore rockling	*Gaidropsarus mediterraneus*	9	0	44
Norway pout	*Trisopterus esmarkii*	9	0	55
Sea Trout	*Salmo trutta*	8	0	48
Red gurnard	*Aspitrigla cuculus*	6	0	35
Sea lamprey	*Petromyzon marinus*	4	0	26
Spotted dragonet	*Callionymus maculatus*	4	0	24
Allis shad*	*Alosa alosa*	0	0	0
Saithe	*Pollachius virens*	0	0	0
Sand sole	*Pegusa lascaris*	0	0	0

* A single allis shad was impinged on 28 May 2009 in an invalid bulk sample, meaning impingement predictions are not available for the species. However, impact assessments continue to consider the species as present and acknowledge its occurrence in the impingement record.