creating a better place
for people and wildlife

Environment Agency

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Our Ref: 20026727

Your Ref: EN010012

Date: 23 July 2021

By email only

Dear Ms McKay

Planning Act 2008 – Section 88 and the Infrastructure Planning (Examination Procedure) Rules 2010 – Deadline 5: Post Hearing submission of oral case for Issue Specific Hearing 7 (Biodiversity and Ecology), Part 1 and 2.

Application by NNB Generation Company (SZC) Limited for an Order Granting Development Consent for the Sizewell C Project

For Deadline 5 (23rd July) the Examining Authority (ExA) have requested written submission of the oral case presented at Issue Specific Hearings.

Our comments (Appendix A, B and C) provide a summary and further detail of our oral case presented at ISH7, Biodiversity and Ecology (Part 1 and 2).

We advise that this summary should be read in conjunction with our Written Representation that highlights a number of issues that were not covered within the ISH.

Yours sincerely

[redacted]

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Appendix A: Environment Agency summary of oral case for ISH7 – Part 1: Biodiversity and Ecology

Agenda Item	EA Position
a) Duties under ss.28G and 28I of the Wildlife and Countryside Act 1981 and the effects of s.28P	No Environment Agency comments
b) The Sizewell Marshes SSSI	
i. the SSSI crossing	**SSSI crossing:** The current proposed design of the SSSI crossing would prevent the upstream and downstream migration of numerous polarotactic invertebrate species (which navigate using polarized light reflected from the water's surface) either side of the crossing approximately halfway along the river, and its associated SSSI designated habitat. This will lead to fragmentation of sensitive habitats and the isolation of species populations which could lead to a deterioration under the Water Environment Regulations 2017 (WFD) and would require a regulation 19 exemption under those regulations. It could also prevent the movement of fish along the watercourse. The proposed design optimisation of increasing the soffit height of the crossing to >6m and reducing the width of the crossing to 15m after the construction period, as described by the Applicant in the response to our written representations is welcome. We await submission of the detailed designs and timeframes for each phase of the crossing at deadline 5. We will then determine if the risk of deterioration to invertebrates has been reduced to an acceptable level. The triple span bridge design remains our preferred option as it would further reduce impacts to the ecology of the area including invertebrates, and it would have the minimal land take from the SSSI.

ii. fen meadow replacement, mitigation, monitoring and fallback	No Environment Agency comments
iii. wet woodland and other flora and fauna by reason of which it is of special interest	**Wet woodland:** Wet woodland compensation needs to be of an appropriate size to replace the loss of this habitat from the development, and it needs to be functionally linked to fen and ditch habitats if it is to be successful at compensating for the loss of this habitat for the associated invertebrate species which use it. The additional wet woodland habitat is welcome, but it will not be functionally linked to the area of impact. The reduction of this habitat in close proximity to the Leiston Beck waterbody could contribute to a reduction in the invertebrate species that use it. This has the potential to contribute to a deterioration of invertebrates in this waterbody under the Water Environment Regulations 2017 (WFD).
iv. Water level monitoring	**Water level monitoring:** Changes to water levels from the construction and operation of the project has the potential to impact WFD quality elements in the surface & ground water waterbodies, eel regulation compliance and features for which protected sites have been designated (fen meadow, invertebrates, birds). Effective monitoring of water levels need to be provided alongside effective mitigation measures, should impacts be observed.
c) Minsmere – the marsh harrier, including the proposed HRA Compensatory Measures for the marsh harrier qualifying feature of the	No Environment Agency comments

Minsmere-Walberswick SPA/Ramsar, and discussion of the proposed CM at Upper Abbey Farm (including proposed wetland habitat as detailed in REP2-119 and proposed management and monitoring measures), together with the Westleton compensatory habitat.	
d) HRA	
i. To understand the differences between Interested Parties (IPs) and the Applicant on the Applicant's conclusion of no adverse effects on integrity (as presented in the Shadow HRA Report and addendums) for the following matters: Disturbance/displacement effects on breeding and non-breeding waterbirds using functionally-linked land to Minsmere-Walberswick SPA/Ramsar due to noise and visual disturbance	No Environment Agency comments
ii. To understand the differences between IPs and the Applicant on the effects of recreational pressure on European sites and to discuss the monitoring, mitigation and management proposed to conclude no adverse effects on integrity	No Environment Agency comments
iii. Progress on written agreement to maintain access for the RSPB to the southern side of Minsmere Reserve.	No Environment Agency comments

iv. - ‘collision risk’ -concerns raised by NE re lack of collision risk assessment for new pylons	No Environment Agency comments
v. Position update on air quality effects due to NOx and acid deposition’	No Environment Agency comments
e. Protected species	No additional Environment Agency comments to those of Written Representation.
f. Other designated sites	No Environment Agency comments
g. Ancient woodland, veteran trees and the route of the Two-Village Bypass	No Environment Agency comments
h. The Sizewell Link Road – mitigation for loss of watercourses, mammal and invertebrate surveys	**SLR:** The SLR road will cross 7 watercourses, 2 of which are main rivers, the area covered by each new crossing will effectively be permanently lost to the biodiversity of the area. No information has been provided on the temporary loss of watercourses from construction activities. No mitigation or compensation has been secured to offset either the temporary or permanent losses. We require as a minimum no net loss of watercourses from development. The EA has been present at meetings to develop the design of the watercourse crossings on the SLR. The design details developed during these meetings and the reason why these design developments are needed, as a form of primary mitigation for dispersing otters, has not been adequately captured in the ES for the associated development. We are concerned that if this is not captured as a required form of primary mitigation then it may be seen as an optional design requirement at a later stage.

i. Duties under ss. 40 and 41 Natural Environment and Rural Communities Act 2006	No Environment Agency comments
j. The position in relation to Letters of no impediment and any Environment Agency comfort letters	During the preliminary meeting the ExA asked whether the EA can provide them with a 'letter of comfort' or 'letter of compliance' in relation to any permit applications that are required in addition to the DCO. While this may provide ExA assurance that the non-planning permissions are capable of being obtained, this is not something we provide. It is for the developer to decide on the timing of the submission of their applications to ensure that the Examining Authority has all the information they require to enable full examination of the proposal. There are complex overlapping Habitats Regulations Assessment (HRA) needs that fall across these permit decisions and the DCO decision, especially where there are project-wide in combination impacts on the marine environment. Despite our repeated advice, and that in PINS Advice Note 11 (Annex D), the Applicant has chosen to not submit their applications for these environmental permits well in advance of the DCO Application.

Appendix B: Environment Agency summary of oral case for ISH7 – Part 2: Marine Ecology

Agenda Item	EA Position
a. HRA, European and other designated sites	Natural England is the Statutory Nature Conservation Body for DCO advice. The Environment Agency is a competent authority for the purposes of the Habitats Regulations when determining applications for permits, consents and licences for which it is the regulatory authority. A number of permits will be required for construction and operation. Three Environmental Permit applications for the operation of the power station have been submitted to the Environment Agency: • a Water Discharge Activity permit - required for the proposed discharges of cooling water and liquid process effluents into the marine environment, during operation of the power station • a Combustion Activity permit - required for the proposed operation of diesel generators, to be used to provide back-up electrical supply at the site, and • a Radioactive Substances Regulations permit - required for the proposed disposal of operational radioactive waste emissions to air, and water, and by transfer. There are complex overlapping Habitats Regulations Assessment (HRA) needs that fall across these permit decisions and the DCO decision, especially where there are project-wide in combination impacts on the marine environment. Despite our repeated advice, and that in PINS Advice Note 11 (Annex D), NNBGenCo (SzC) Ltd has chosen to not submit their applications for these environmental permits well in advance of the DCO application. We are a competent authority and must undertake an HRA as part of our determination process. It is currently our projection that our permit decisions - and associated HRA conclusions - are unlikely to be available by the close of the Examination, due to the submission strategy

	adopted by NNBGenCo (SzC) Ltd. We consider that our permit determination HRA conclusion would have assisted with the within project in combination HRA for the DCO application.
i. Marine Mammals	No Environment Agency comments
ii. Fish, including migratory fish	No Environment Agency comments in HRA context – other fish issues captured in agenda item e.
iii. Birds - Disturbance/displacement of the red-throated diver qualifying feature of the Outer Thames Estuary SPA due to vessel movements/traffic	No Environment Agency comments
iv. Birds – collision risk	No Environment Agency comments

b. Cooling water system, acoustic fish deterrents,	**Hinkley Point C – Water Discharge Activity Permit Appeal** The Environment Agency note that within the hearing NNBGenCo (SzC) Ltd highlighted that, when available, they would submit the decision for the Hinkley Point C Water Discharge Activity Permit Appeal. We wish to highlight that the appropriateness of direct cooling water system will vary depending on the site and the receiving environment. This is a developing field and thus new methods/ designs are being developed and will need to be incorporated in assessments. **Summary of cooling water design issues** There are a number of environmental issues associated with direct cooling water systems arising from water abstraction. These include fish and invertebrate impingement and entrainment. The use of fish deterrent devices has the potential to substantially reduce the numbers of fish impinged. The Environment Agency considers that NNBGenCo (SzC) Ltd has insufficiently evaluated the potential for the use of fish deterrent devices (such as Acoustic Fish Deterrents) and have not provided suitably detailed evidence to support their case that the deployment of such devices at Sizewell C is precluded. In considering the environmental impacts of water abstraction there are planning policies to ensure that best practice in planning, design, mitigation and compensation are followed. **Planning Policy Context** **Overarching National Policy Statement for Energy (EN-1)** Relevant part of the Energy NPS states that: 5.3.18 “(The applicant should demonstrate that)

	* during construction and operation best practice will be followed to ensure that risk of disturbance or damage to species or habitats is minimised, including as a consequence of transport access arrangements" **National Policy Statement for Nuclear Power Generation** **The Nuclear National Policy Statement (NNPS) EN-6.** Relevant parts of the NNPS state that: 3.7.5 "(The IPC should liaise closely with) the EA who will consider issues of water quality (including any water abstraction and discharge) as part of the environmental permitting process". 3.7.6 "There should also be specific measures to minimise impact to fish and aquatic biota by entrainment or by excessive heat or biocidal chemicals from discharges to receiving waters". 3.7.7 "Discharges into water sources will be controlled in accordance with permits issued by the EA. Applicants will be expected to demonstrate Best Available Techniques to minimise the impacts of cooling water discharges". **Evidence Documents** Evidence documents such as the Environment Agency report on cooling water options for new nuclear build (2010) https://www.gov.uk/government/publications/cooling-water-options-for-the-new-generation-of-nuclear-power-stations-in-the-uk indicates that direct cooling can be used for estuarine and coastal sites, provided that (a) best practice in planning, design, mitigation and compensation is followed and (b) any residual impacts are not deemed to be unacceptable. **Planning – Best Practice / Good Design** Given the highlighted planning policy and evidence documents the Environment Agency considers there is a need to consider whether the proposals are best practice. On this basis,

	proposals will need to consider the impingement and entrainment of biota. These impacts will need to be considered from a wider conservation value, with the rejection of mitigation measures and the preferred design option being fully justified.
c. The securing mechanisms to control impacts on marine water quality;	**Fish Monitoring Plan - Deemed Marine Licence Condition 50** There is uncertainty as to what monitoring can be undertaken and whether any adaptive measures can be undertaken on site or through optimisation of the cooling water system. Should offsite mitigation or compensation be required then securing mechanisms (such as a S106 TCPA 1990 agreement) that fall outside of the powers of this condition in the DML may be required. The Environment Agency understand that NNBGenCo (SzC) Ltd are preparing further information to provide confidence as to what monitoring can be provided. In addition, the Environment Agency understand that NNBGenCo (SzC) Ltd are preparing further proposals to identify appropriate securing mechanisms to provide mitigation/compensation for marine ecology impacts.
d. Progress update on status of the Water Industry National Environment Programme (WINEP) study being undertaken by Essex and Suffolk Water	The Environment Agency have been consulted by ESW on the Broadland Interim Report (received 09 July) which considers water supply matters that may need to be considered in a SZC Water Supply Strategy.
e. Fisheries, fish stocks, equivalent adult values, sabellaria spinosa;	EA no comments comment on *Sabellaria spinosa* – further detail on fish issues below

Sampling Data Issues, Comprehensive Impingement Monitoring Programme (CIMP) Data	**CIMP bulk overflow** The estimated numbers of fish impinged at Sizewell B (SZB) is one component used to help calculate the likely impingement at SZC. The CIMP undertaken at SZB had frequent overflowing of the bulk overnight sample. On these occasions an incomplete bulk sample was collected, providing a 'greater than' result, or the bulk sample was abandoned and no result obtained. This means that more fish may have been collected than recorded in the sampling. Results from overflowing bulk samples have been excluded from the data set, and impingement for surveys affected extrapolated from day-time hourly samples. Presently, the true impingement rate at SZB is uncertain, as based on the CIMP data presented. The consequence of this is that the predicted impingement at SZC may have been underestimated and the impacts to species of relevance for the DCO application under the Environmental Impact Assessment Regulations 2017 and The Water Environment Regulations 2017 may prove to be unacceptable. We consider that the Applicant should produce a precautionary correction factor for use in the DCO to account for this issue.
Low Velocity Side Entry (LVSE) intakes and issues related to intercept area of the proposed design	**LVSE mitigation** The LVSE intake is proposed as a mitigation measure to reduce the impingement of fish. We consider that there is significant doubt on the degree of mitigation that is offered by the LVSE. No evidence has been provided that the low velocities will reduce the impingement of fish in poor visibility conditions at the intake head, in the absence of a behavioural deterrent such as an Acoustic Fish Deterrent (AFD). The consequence of this is that the predicted impingement at SZC may have been underestimated and the impacts to species of relevance under the Environment Impact Assessment regulations 2019 (EIA) and the Water Environment Regulations 2017 (WFD) may be found to be unacceptable. In the absence of any evidence to support the reduction factor applied by the Applicant we must assume it offers no mitigation as it is untested. We consider that the Applicant should remove this reduction calculation from the impingement figures.

Equivalent Adult Values (EAVs)	EAVs are a means by which the losses of fish of all ages can be represented as an equivalent number of adults as it is recognised that not all fish entrapped would survive to maturity in the wild and therefore reproduce. The method used by the Applicant calculates, for a particular species, how many of the individuals impinged at SZB in one year would have gone on to become mature fish, counting an adult as a fish which has reached maturity and has spawned for the first time. However, individuals of many species of fish survive to spawn again in years subsequent to the one in which they first matured. These are referred to as repeat spawners. They also produce more eggs in subsequent years as they increase in size and some species select more successful breeding locations in subsequent years. The method used by the Applicant does not take 'repeat spawning' into account and is therefore likely to underestimate the impact SZC has on some fish species. The spawning population will include fish that have reached maturity and that reproduce for a number of years. The method used by the Applicant does not account for the number of repeat spawners that would also have been present in the spawning population in a given year, had they not previously been impinged and so is underestimating the impact by counting some, but not all, of the fish that would otherwise have been present in the spawning population in a given year. We consider that the Applicant should provide an updated impingement assessment which includes repeat spawning in the EAV calculations. We also consider that the underlying parameters used by the Applicant in the SZC EAV calculations should be checked to ensure they are suitable precautionary and have been calculated using the latest available information.
Scale of assessment and appropriateness of stock areas used	The stock units used for the assessment of impacts to fish species use very large areas that include the Southern North Sea and large areas of European seas (ICES spawning stock biomass figures and/or international fisheries landings). We recognise that this is an accepted way to assess the impact of a mobile and international commercial fishing impact on an area covered by that mobile fleet. It should be noted that fishing effort can be controlled and reduced where required to safeguard stocks if population decline is observed. This has been the case in recent years for cod and bass. We do not think that the use of such large stock areas offer a meaningful ecological assessment of the losses to fish populations within the

	waters around SZC. The cooling water intakes for SZC will be a fixed and constant fishing instrument, which cannot be adapted or switched off if population declines are observed for a period exceeding 60 years. In addition the impact from the operation of SZC will not form part of the overall total allowable catch (TAC) for any stock. Smaller sub-populations of some species are known to exist in this area and the impact to these populations has not been adequately assessed. Species of relevance highlighted below

Species of Relevance

Species	EIA	WFD	Repeat Spawner (iteroparous)	Agreement on stock comparator
River lamprey	Yes	No	No	Yes
Twaite shad	Yes	Yes	Yes	No
European eel	Yes	Yes	No	Yes
Five beard rockling	No	Yes	No data	No data
Herring	No	Yes	Yes	No
Bass	No	Yes	Yes	No
Thin lipped grey mullet	No	Yes	No data	No
European smelt	Yes	Yes	Yes	No
Plaice	No	Yes	Yes	No data
Sand goby	No	Yes	Yes	No
Dover sole	No	Yes	Yes	No
European sprat	No	Yes	Yes	No

Table 1: Species of relevance under the EIA and WFD assessments with outstanding impingement prediction concerns.

The Applicant has produced a local effects assessment in BEEMS SPP103 v3 which attempts to quantify impacts using local replenishment rates from a given area. This is helpful in indicating the relative scales of impact at a more meaningful scale for some key species. However, the model has to make a number of assumptions e.g. that fish behave as inert particles with no behavioural responses. In addition, the use of different parameters within the model, such as the LVSE factor, would affect the results of this model. It may be possible using

	agreed, precautionary parameters that this local effects model may be appropriate for assessing the impact to some species of concern, but it will not be an appropriate method for some species due to the assumptions needed within it.

WFD Ore & Alde TFCI deterioration risk	The Environment Agency is concerned that as a result of entrapment losses to some fish species from the operation of SZC that a reduction in the number of fish entering the Ore & Alde and Blyth waterbodies has the potential to lead to a deterioration of this element under the Water Environment Regulations 2017 (WFD). The Blyth is not currently monitored for fish under the WFD programme and assessment will be undertaken on the Ore & Alde and applied to the Blyth by proxy. NNBGenCo (SzC) Ltd at the request of the Environment Agency have run some potential fish reduction scenarios for the Ore & Alde Transitional Fish Classification Index (TFCI) looking at a targeted number of species of greatest importance in this waterbody. A within class deterioration is observed in all scenarios which brings the Ecological Quality Ratio (EQR) score close to the good/moderate boundary (0.58) and reduces the confidence in the classification to uncertain or no confidence. A greater number of scenarios have been run by the Environment Agency using a greater number of species that feature in the Ore/& Alde TFCI in the 6 year reporting cycle (2013-2018), these additional scenarios resulted in a class deterioration from good to moderate potential for fish in this waterbody. Due to the uncertainty which remains as to what the final predicted and actual entrapment loss figures will be from the operation of SZC, we are currently unable to conclude that a risk of deterioration for fish within this waterbody and by proxy the Blyth waterbody does not exist. In order for us to maintain WFD compliance we recommend requirements are included in the DCO to address this potential impact. These requirements would secure robust monitoring and provide mitigation and compensation to undertake improvements which would benefit fish in the affected waterbodies should a deterioration occur.

Eel Regulations 2009 compliance	The proposed operation of SZC nuclear power station will not be compliant with the Eel Regulations 2009 as NNBGenCo (SzC) Ltd cannot use a screen on the four cooling water intakes that will prevent the entrainment of glass eels. The Environment Agency has outstanding concerns over what the total entrapment losses of eel will be from the operation of SZC and what impact this could have on the Anglian River Basin District (RBD) eel stock. Our concerns are predominantly in relation to the uncertainty that exists of what entrainment losses will be to glass eels and the effectiveness of some of the mitigation that is proposed to reduce impacts to impinged eels. Through our review of predicted glass eel entrainment survival we have seen a reduction in predicted survival from 100% in BEEMS TR318 v3 to 82.8% in BEEMS TR273. The latest assessment does not account for mortality at the band screens. Mean survival of entrainment through the drum and band screens is expected to be 75.35%, L95 survival is 68.42%. Numerous other variables could influence this result further and this is not considered a precautionary assessment. We consider that the glass eel specific sampling undertaken at the location of the SZC intakes is too limited to predict glass eel entrainment figures from. Sampling also missed the peak migration period for the year it was undertaken and sampling only took place in daylight, evidence indicates that glass eels are more likely to be moving at night. The Applicant produced a worst case glass eel entrainment paper (BEEMS SPP104) which used speculative calculations built from assumptions. It was not possible to conclude what the level of entrainment would be from this report and we requested that the Applicant should monitor glass eel entrainment once SZC becomes operational to determine impacts from. The Applicant indicated at a recent meeting that it would not be possible to monitor glass eel entrainment at SZC due to constraints with station design and available space for monitoring equipment. Without entrainment monitoring conducted at a sufficient intensity it will not be possible to confirm the actual impacts to eels and the Anglian RBD eel stock once the station becomes operational. The Applicant has committed to provide additional mitigation to help offset impacts to eels from the operation of SZC. This could be achieved by improving fish passage in the waterbodies adjacent to SZC (Ore & Alde and Blyth) for migratory species.

Impacts to smelt populations of relevance to Sizewell.	The Environment Agency has a statutory duty to maintain, improve and develop smelt fisheries and conserve their aquatic environment under the Environment Act 1995. Smelt are listed as a biodiversity action plan (BAP) species and are a key indicator species under The Water Environment Regulations 2017 (WFD). Smelt have been described as vulnerable, rare and very sensitive to anthropogenic environmental changes. Status of Rare Fish. A Literature Review of Freshwater Fish in the UK, Winfield et al (1994). Smelt populations have historically been impacted to a point causing the collapse and loss of discrete populations of the species from some water bodies on the east coast, from which their recovery has taken a long time. Some water bodies have not recovered from this historical collapse. The closest known breeding population of smelt to the Sizewell area is located in the Ore and Alde waterbody to the south of the development. The Applicant has hypothesised that smelt impinged in the Sizewell Bay are from a wider Southern North Sea stock, the Applicant has applied large stock assessment units which include large smelt populations from estuaries in Germany and Belgium. They have also compared impacts against a UK stock that spans the east coast of England. The methods used to derive the European population figures in BEEMS SPP100 are not acceptable. Genetic studies have demonstrated a level of homogeneity in a wider stock that spans the coast from the Thames to the Broads. This would indicate that the population in the Ore & Alde experience some immigration from this wider stock. The geographical extent and level of immigration effecting the Ore & Alde population is not known. The EA's monitoring programme undertaken for the WFD does not support the hypotheses that large numbers of smelt are migrating into the Sizewell area from a wider stock. If we compare the Orwell, Stour and Ore/Alde waterbodies, all located along the Suffolk coast, we can see a significant difference in smelt abundance between 3 waterbodies. All 3 waterbodies are sampled consistently for the WFD. Catch Per Unit Effort (CPUE) is a measurement of how many individuals of a given species are recorded per sampling occasion in a given waterbody.

Waterbody	No of smelt caught	Size range mm	Years of sampling	CPUE (TraC only)
Ore & Alde	278 (406 incl freshwater)	49-247	10	**1.66**
Stour	11	28-216	12	0.03
Orwell	9	62-222	15	0.03

Table 2. Smelt abundance in the Stour, Orwell and Ore & Alde waterbodies (EA data).

Due to the uncertainty over the level of immigration into this area it is not possible to confirm that immigration from a wider stock would exceed the predicted exploitation from SZC and SZB. This predicted exploitation could lead to the sustainability of the Ore & Alde population being compromised.

The Applicant has committed to provide additional mitigation to help offset impacts to smelt from the operation of SZC. This could be achieved by improving fish passage in the waterbodies adjacent to SZC (Ore & Alde and Blyth) for migratory species.

Fish Monitoring Plan - Deemed Marine Licence Condition 50	There is uncertainty as to what monitoring can be undertaken and whether any adaptive measures can be undertaken on site or through optimisation of the cooling water system. Should offsite mitigation or compensation be required then securing mechanisms that fall outside of the powers of this condition in the DML may be required. The Environment Agency understand that NNBGenCo (SzC) Ltd are preparing further information to provide confidence as to what monitoring can be provided. In addition, The Environment Agency understand that NNBGenCo (SzC) Ltd are preparing further proposals to identify appropriate secure securing mechanisms to provide mitigation/compensation for marine ecology impacts.

Appendix C: Equivalent Adult Values - a summary of the principal difference in position between the Applicant and the Environment Agency

1. Introduction

Power station abstractions typically result in the entrapment (impingement and entrainment) of large numbers of juvenile and young fish. However, mortality of a particular number of juveniles will not have the same effect on a population as the removal of the same number of adults. This is because many fishes produce large numbers of young, with few of these young naturally surviving to adulthood.

It is therefore easier to visualise the potential impact of entrapment at SZC by converting entrapment losses across all ages to losses of an equivalent number of adults. For example, if only one out of 100 juvenile fish entrapped would have otherwise reached adulthood, then the effect on the spawning population of the loss of 100 juveniles would be equivalent to the effect of the loss of one adult. The calculation of Equivalent Adult Values (EAVs) is a means by which numbers of entrapped fish of all ages can be contextualised as an equivalent number of adult fish. Entrapment losses, expressed as equivalent adults, can then be compared to measures of the adult fish population to predict the impact of the abstraction on the population.

There is more than one method of calculating an EAV. Methods differ in the biological data they make use of, and the way in which they define an adult fish. The number of equivalent adults predicted to be lost to entrapment by one method, can therefore differ to the number of equivalent adults predicted to be lost by a different method. It is therefore important to ensure that the EAV method selected, and the corresponding definition of adult fish, are appropriate for the task in hand.

There is a disagreement between the Environment Agency and the Applicant over the method used to convert multi-age entrapment data to numbers of equivalent adults. This centres on whether there is a need to account for the effect of repeat spawning within the population – the ability of individuals within many fish species to spawn over a number of years. Repeat spawning species include fishes predicted to comprise a large proportion of those entrapped at SZC, including prey species for seabirds (European sprat, Atlantic herring), European seabass, twaite shad and smelt. The EAV calculation is therefore of relevance to WFD, EIA and HRA considerations. The Applicant's consultants have developed and used a method for calculating EAVs in their application which the Environment Agency (EA) views as underestimating impacts. The EA has developed an extension to the Applicant's method to address this perceived underestimation. In a reflection of the EA's view of the Applicant's method, the Applicant perceives the EA's extension to be overestimating impacts.

This appendix sets out the EA's main arguments and provides examples to aid understanding.

In addition to the disagreement over how repeat spawning should be accounted for in the calculations, the Examining Authority will also need to bear in mind a number of other issues associated with EAV methodology. These include ensuring the biological parameters underlying the calculations are geographically appropriate and represent the best available information. The biological parameters to consider include factors such as mortality rates at particular lengths/ages and the proportion of fish that are mature in each age group. The Examining Authority may also need to consider whether to include the effect of fishing mortality in the calculation of EAVs (and the most appropriate way in which this could be done). However, regardless of what parameters are used in the calculation, or whether the effect of fishing mortality is accounted for or not, for repeat spawning fish, the Applicant's method will always predict lower impacts on the population than will the EA's extension. This is therefore a key difference for the Examining Authority to understand, and the choice of biological parameters and the effect of fishing mortality will not be discussed further in this paper.

2. The Cefas EAV and the SPF extension

The calculation of EAVs and their application to population data relies upon a number of assumptions. These include an assumption that there will be no change in the numbers, lengths and ages of fish from year to year, as well as an assumption that the adult population remains constant from year to year. Calculations of EAV form a 'first approximation' of potential impacts (described as a 'risk assessment' by the Applicant) and take place in an 'EAV bubble' where losses in one year do not feed through to affect populations or impingement numbers in future years.

The Applicant's consultants, Cefas, have developed a method of calculating EAVs to examine entrapment impacts on fish populations at SZC. Defra group bodies often refer to this as the 'Cefas method', and it has particularly been applied to impingement data. For each species, the Cefas method first calculates the number of fish that would have been mature when impinged and then calculates the number of immature impinged fish that which would otherwise have survived to maturity.

The Cefas method was used in EDF's application to vary their Water Discharge Activity permit at Hinkley Point C. The EA reviewed the method and considered that the Cefas method systematically underestimated the impact of impingement on the population. Whilst the number of first time spawners that would be missing from the population in any given year as a result of impingement in previous years was calculated, the number of repeat spawners that would have been present was not. In any given year, in addition to the number of maturing fish (first time spawners) that would otherwise have been present in the adult population, there would also have been a number of fish that would have matured in a previous year but would have spawned again in the given year, had they not previously been lost to impingement.

The EA (together with its consultants, APEM Ltd) developed an extension to the Cefas method to account for repeat spawning. This extension used the same parameters and assumptions as the Cefas method – the only difference being that the Cefas method calculates survival of fish up to the point where they mature whereas the extension completes the calculation, continuing the process on to calculate the numbers of fish surviving and spawning again in years subsequent to the one in which they first spawned. The extension calculates the total number of fish, both first time and repeat spawners, that would have otherwise been present in the population in any given year, had they not previously lost due to impingement. The extension works by calculating the total number of spawning events that the lost fish would have otherwise participated in, and so is known as the Spawning Production Foregone (SPF) extension, often shortened to 'the extended method'. The theory underpinning the use of the Cefas method and the SPF extension is described in greater detail in the following sections and in the examples below.

The Applicant does not dispute that the SPF extension is a valid calculation, rather they disagree with the way in which the EA recommends it is applied. The Applicant argues that the Cefas method produces an annual rate, which can be compared to annual rates of loss to the population, but that the extended method does not. The Applicant argues that as the extension considers fish survival over many years, it counts fish more than once, and therefore does not produce an annual rate. The EA disputes this (Example 1) and proposes that the extended method calculates an annual rate too, but that this annual rate is the total number of fish that would otherwise have been present in the spawning population in any given year, whereas the Cefas method counts only the first time spawners (Example 2).

Simply put, in the EA's view, the Cefas method underestimates the true impact of abstraction mortality, because it does not count all the fish that would otherwise have been contributing to the spawning population in any given year.

Another of the areas of dispute between the Applicant and the EA is that the Applicant believes that the EA's EAV factor also needs to be applied to the population measure in order to predict impact. The EA does not agree that there is a need to 'multiply up' the population measure (Example 3).

The difference between the results of the Cefas EAV and the SPF extension can be considerable. At Hinkley Point C, for repeat spawning species, numbers of equivalent adults impinged calculated using the Cefas method (fish that were mature when impinged and first time spawners) could range from 60% down to 20% of the number of equivalent adults calculated using the SPF extension (fish that were mature when impinged, first time spawners and repeat spawners).

The Applicant has provided an example for SZC in Cefas BEEMS Scientific Position Paper SPP102[1] wherein they calculate the Cefas method EAV factor for seabass (0.224) and a corresponding SPF extension EAV factor (1.05). In other words, using the Cefas method, an annual impingement of 1,000 seabass at SZC would result in 224 adult fish failing to enter the spawning population each year. Using the SPF extension, an annual impingement of 1,000 seabass at SZC would result in 1,050 adult fish (first time and repeat spawners) being absent from the spawning population each year.

[1] Cefas BEEMS Scientific Position Paper SPP102 Use of Spawning Production Foregone EAVs for impingement assessment

3. The calculation of the Cefas method EAV and its SPF Extension

Predictions of potential impact of entrapment losses at SZC are based on entrapment estimates from SZB. The calculation process for the Cefas method and its SPF extension are summarised in Table 1.

Once calculated, the number/biomass of equivalent adults predicted to be lost through entrapment at a new abstraction can be compared to a measure of the fish population to give the predicted impact of the entrapment (Equation 1).

$$\frac{Number/biomass\ of\ equivalent\ adults\ lost\ through\ entrapment}{Population\ size\ (number\ or\ biomass)} \times 100 = predicted\ impact\ (\%)$$

Equation 1. Formula to predict the impact of the entrapment

The calculation of the SPF extension follows the same method and relies on the same assumptions as the Applicant's, except that repeat spawners are included in the EA's calculation (Table 1). By including repeat spawners, the EA necessarily arrives at a higher EAV factor than the Applicant, and therefore a higher predicted impact.

It is important to recognise how the EAV method and the scale of assessment (i.e. fish population size) may interact to affect predicted impacts for marine fish species. There are some differences in opinion between the Applicant and the EA on fish population sizes being used by the application. Briefly, if an underestimated number of adult equivalents were compared to an overestimated population size, entrapment impacts would be underestimated – the EA is concerned this may be the case for some species. Similarly, if an overestimated number of adult equivalents were compared to an underestimated population size, entrapment impacts would be overestimated – the Applicant is concerned this may occur if the SPF extension is used, and population sizes reduced.

Table 1. The steps involved in the calculation of potential impact of impingement from SZC on the spawning population using the Cefas method and the SPF extension.

Step	Cefas method	SPF extension
1	For a particular species of fish, an annual impingement estimate is calculated for SZB by multiplying up from fish recorded during impingement monitoring.	As for Cefas method
2	The SZB annual impingement estimate is converted to a number of equivalent adults, this being the number of fish mature when impinged plus the number that would have survived to maturity had they not been impinged. Survival to maturity is forecast using growth rates, maximum size, natural mortality rates, and length-at-age data.	As for Cefas method, but survival calculations are carried on beyond maturity, so the total number of spawning events that would have resulted from the lost fish is calculated.
3	The number of equivalent adults is divided by the number of individuals of the species, of all ages, that were actually impinged. This gives a number called the EAV factor, which is the proportion of the impinged fish that would have been/become adults.	The total number of spawning events that would have resulted from the lost fish is divided by the number of individuals of the species, of all ages, that were actually impinged. This gives the SPF EAV factor, which is the total number of spawning events expressed as a proportion of the number of impinged fish.
4	The annual impingement estimate for SZB fish (unadjusted multi-age data, not the EAV number) was then scaled up to provide a predicted impingement for SZC.	As for Cefas method
5	The total number of fish predicted to be lost at SZC is then multiplied by the EAV factor, to express the predicted loss in terms of a number of equivalent adults.	As for Cefas method, except the SPF EAV factor is used.
6	The number of equivalent adults is subsequently adjusted to account for mortality of fish passing through the FRR system.	As for Cefas method
7	This number of equivalent adults lost is then compared to a measure of the population to give a predicted impact (%). Spawning populations of commercially fished species are often expressed as weight, this being the **Spawning Stock Biomass** (t) (SSB). To compare to SSB, the number of equivalent adults is multiplied by the average weight of an adult fish, derived from fishery catch data.	As for Cefas method.

EXAMPLE 1. Why the SPF extension is not 'double counting' fish

From the simple description in Table 1 (Steps 2 and 3), it appears that in the SPF extension, entrapped fish are counted more than once, with each fish potentially being counted as a first-time spawners, and then counted again at each subsequent spawning event. This is central to the Applicant's argument that the SPF extension does not count an annual rate. However, in fact, by counting the total number of spawning events that fish would otherwise have participated in, the SPF extension in fact represents the number of spawning fish that would be missing from the spawning population in any given year. This is due to calculations taking place in the 'EAV bubble'.

One of the assumptions of the 'EAV bubble' that underlies both the Cefas method and its SPF extension is that the number and age structure of impinged fish will be the same every year. For our example, let's consider three fish, Fish A, Fish B and Fish C (Figure 1).

Fish A (Figure 1) was impinged in 2009. Had it not been impinged, Fish A would have been immature throughout 2009, would have matured and become a first-time spawner in 2010, and would have survived to spawn again (as a repeat spawner) in 2011. Because the number and age structure of fish is assumed to be the same every year (the 'EAV bubble'), then in 2008 there would have been a similar fish, Fish B, which, had it not been impinged, would have matured in 2009, and spawned for its second and final time in 2010. Fish B would have been counted as part of the spawning population in 2009 (and 2010) but is now 'missing' because it was impinged the previous year. A further fish, Fish C, would have been immature when impinged in 2007, would have become a first-time spawner in 2008, and a repeat spawner in 2009.

Only Fish A is actually impinged in 2009. The Cefas EAV for Fish A has a value of 1 (Fish A would have otherwise matured and become a first time spawner in 2010). The SPF extension for Fish A is 2 (Fish A would have otherwise matured and become a first time spawner in 2010, and would have then spawned again in 2011). Whilst it appears that the SPF extension counts Fish A twice, in fact what it is doing is representing the mature fish that are 'missing' from the population in 2009, having been impinged in previous years. Fish A's maturation in 2010 represents Fish B, which would have been a first time spawner in 2009. Fish A's subsequent spawning in 2011 represents Fish C, which would have been a repeat spawner in 2009.

The SPF extension represents all the adult fish that would have been present in the population had they not been impinged in previous years (Fish B and Fish C in Figure 1). The Applicant's method only represents some of them (Fish B in Figure 1), ignoring fish that have spawned in previous years but that would have still been alive and part of the adult population (Fish C in Figure 1).

The only difference between the Applicant's method and the SPF extension is that the SPF extension counts all the mature fish that would otherwise have been present in the spawning population whereas the Cefas method does not consider repeat spawners. All of the assumptions underlying the SPF extension are the same as those underlying the Cefas method, these being that the number of fish impinged, the age composition of impinged fish, and the population size do not change from year to year.

Year	2007	2008	2009	2010	2011
Fish A			Immature when impinged	First-time spawner (if not for impingement)	Repeat spawner (if not for impingement)
Fish B		Immature when impinged	First-time spawner (if not for impingement)	Repeat spawner (if not for impingement)	
Fish C	Immature when impinged	First-time spawner (if not for impingement)	Repeat spawner (if not for impingement)		

Figure 1. *EAV illustration showing how under the assumption of constant impingement number and unchanging age structure from year to year, Fish A, Fish B and Fish C would all have been present in 2009, had Fish B and Fish C not been impinged in previous years. By counting the full future spawning potential of Fish A, impinged in 2009, and giving it an EAV of two, the SPF extension represents Fish B and Fish C which would have both been part of the spawning population in 2009, had they not previously been impinged.*

EXAMPLE 2. The Cefas method and the SPF extensions both return 'annual rates'.

The SPF extension is derived from the Cefas method, and relies upon the same assumptions. Both the Cefas method and its extension function by calculating how many of the fish lost through impingement in any year would have otherwise survived in subsequent years – the only difference being that the SPF extension carries on the calculation beyond the age fish mature to calculate the number of repeat spawning events that could occur. Including these repeat spawning events does not 'double count' fish, but in fact represents fish that would have survived beyond first spawning to be present in the spawning population in any given year (Example 1).

Figure 1 illustrates an example from an ongoing abstraction. However, in order to consider the Applicant's position that the SPF extension does not return an annual rate, it is useful to look at how the impact of impingement mortality builds up over time from the first year abstraction begins. Using the Cefas method, this proceeds as follows:

- In the first year of operation of a new abstraction (Year One), the fish lost to the spawning population in Year One will be those that were mature when impinged, plus those that were immature when killed but that would have otherwise matured (becoming first time spawners) that year.

- In the second year of operation (Year Two), the fish lost to the spawning population will consist of fish that were mature when impinged in Year Two, fish that were immature in Year Two but that would have otherwise matured (and become first time spawners) in Year Two <u>plus</u> immature fish that were killed in Year One that would have otherwise matured (and become first time spawners) in Year Two.

This pattern builds, year on year, until an equilibrium level is reached (when a sufficient number of years have passed such that all of the immature fish killed in Year One would have otherwise matured). The equilibrium level is referred to by the Applicant's as an annual rate.

The Cefas method calculates the loss of maturing fish (first time spawners) to the spawning population in each year. This 'annual rate' consists of fish which would have matured in any given year – but these will in fact have been impinged across a number of preceding years. This is because fish impinged in any one year will be made up of a number of ages and sizes, and fish do not all necessarily mature at the same age. Some of the immature individuals may have otherwise matured in the year they were impinged, some may have otherwise matured the following year, or the year after that, with the number of successive years over which fish may have become mature being determined by the life-history of the fish.

Similarly, in the SPF extension, the impact of impingement mortality also builds up over time, as follows:

- In the first year of operation of a new abstraction (Year One), the fish lost to the spawning population in Year One will be those that were mature when impinged, plus those that were immature when killed but that would have otherwise matured in Year One. This is exactly the same as for the Cefas method.

- In the second year of operation (Year Two), the fish lost to the spawning population will consist of those counted by the Cefas method (namely, fish that were mature when impinged in Year Two, fish that were immature in Year Two but that would have matured that year had they not been killed plus immature fish that were killed in Year One that would have otherwise matured in Year Two). In addition though, the SPF extension will also count any of the fish that were mature when impinged that would otherwise have survived to spawn again in Year Two and the number of immature fish that matured in Year One that would have survived to spawn again in Year Two.

As with the Cefas method, in the SPF extension the pattern builds, year on year, until an equilibrium level is reached. The equilibrium level reached by the SPF extension will necessarily be higher than the equilibrium reached using the Cefas method (Figure 2). The equilibrium reached in the Cefas method is described by the Applicant as an annual rate – it is the number of first time spawners that would otherwise enter the population each year. The equilibrium reached in the SPF extension then must also be an annual rate, but in this case it is the number of first time and repeat spawners that would have otherwise been present in the population in any given year. It is worth remembering though that in both methods, the annual mortality actually occurs at the time when fish are impinged.

In determining the impact of the abstraction on the population, the impact will consist of the total number of 'missing' fish in any one year i.e. the total number of adults that would have been spawning that year had they not been impinged in previous years. This value is given by the SPF extension, not by the Cefas method which only counts a fraction of the 'missing' fish (the fish that were mature when impinged and the first time spawners).

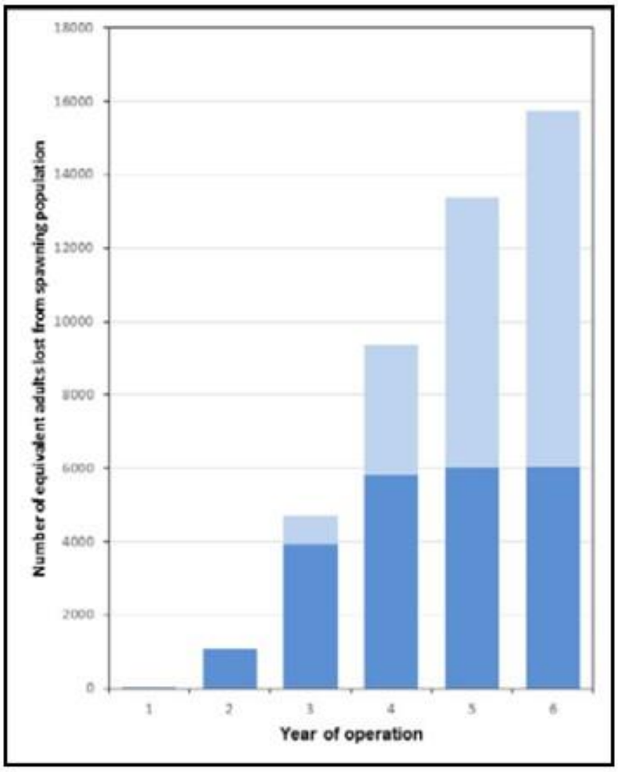

Figure 2. *An example of how the impact of abstraction builds up to an equilibrium level from the first year of operation of an abstraction for both the Cefas method and its SPF extension. The graph shows the number of Atlantic cod mature on impingement each year together with the number of first time spawners that would otherwise have been present had they not been impinged in previous years (, as well as the number of repeat spawners that would otherwise have been present ( ) (based on Hinkley Point data). The dark blue bars show the equilibrium point reached by the Cefas method, the light blue bars show the equilibrium point reached by the SPF extension.*

EXAMPLE 3. Demonstrating why there is no need to multiply the population by its own SPF factor before comparing it with SZC impingement predictions.

Example 1 demonstrated a situation in the middle of an ongoing abstraction – impingement was constant from year to year (one of the assumptions of EAV calculations). Example 2 considered how the impact of an abstraction increases annually from the first year of operation, until an equilibrium point is reached. Example 3 again considers the effect of an abstraction as it builds up from the first year of operation in order to demonstrate why the SPF extension can be compared to the adult population, without the need to multiply the population figure by its own SPF value.

In this example, Fish A, B and C form a stable population of the species ‘letterfish’. All letterfish live for three years. They are all immature in their first year of life (Age 0), all mature in their second year of life (Age 1) and all survive to spawn again in their third year of life (Age 2). In the year that abstraction begins (Year One), one immature fish has been produced (Fish A). The spawning population consists of two mature fish, Fish B and Fish C. Fish B is a first-time spawner, having been immature one year ago. Fish C is a repeat spawner, having entered maturity last year and been produced two years ago (Figure 3).

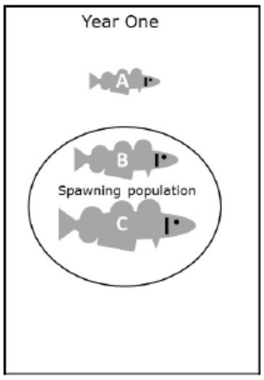

Figure 3. *The letterfish population in Year One. Fish size indicates age with Fish A being age 0 and immature, Fish B being age 1 and a first-time spawner and Fish C being age 2 and a repeat spawner.*

In the absence of impingement mortality, Fish C would die after spawning in Year One, Fish B would become a repeat spawner in Year Two and Fish A would become a first time spawner in Year Two. Because this is a stable population (one of the assumptions of 'EAV bubble'), one new immature fish (Fish D) would be produced in Year Two. The spawning population would consist of two mature fish, Fish A and Fish B (Figure 4).

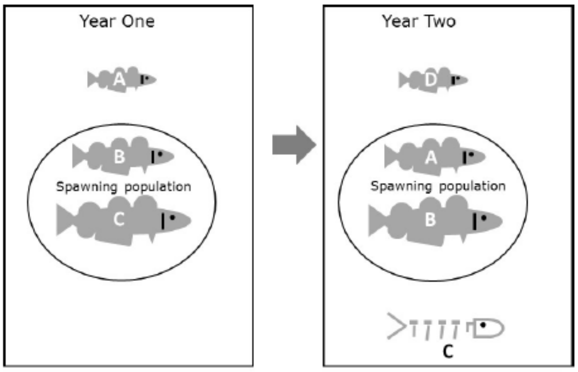

Figure 4. *The letterfish population in Year One and Year Two in the absence of impingement. In Year Two, Fish A becomes a first-time spawner, Fish B becomes a repeat spawner and Fish C has died. Fish D is produced.*

Similarly, in Year Three, Fish B would no longer be present, and the spawning population would consist of Fish A, which would be a repeat spawner, and Fish D, which would be a first time spawner. A new fish would be produced (Fish E). The spawning population would consist of Fish A and Fish D (Figure 5).

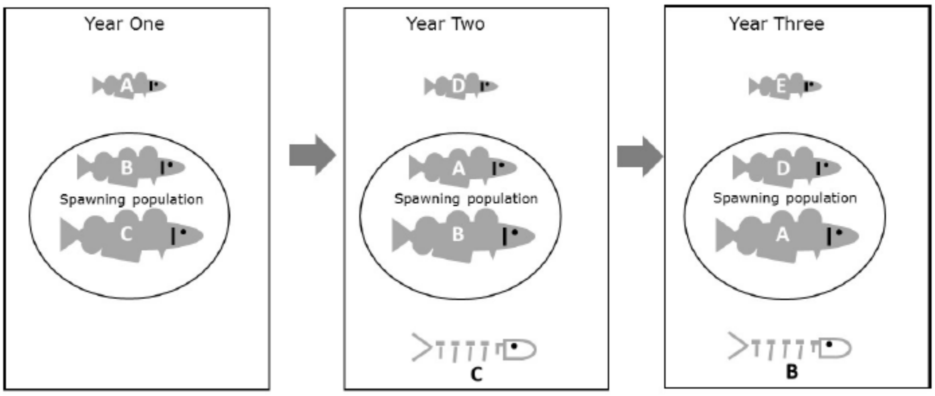

Figure 5. *The letterfish population in Year One, Year Two and Year Three in the absence of impingement. In Year Three, Fish D becomes a first-time spawner, Fish A becomes a repeat spawner and Fish B has died. Fish E is produced.*

Let us now suppose that an abstraction commences in Year One, which has the effect of entrapping and killing one immature fish per year. Fish A is impinged and lost. Fish A would have otherwise matured in Year Two and so it is equivalent to one adult, using the Cefas method. Fish A would have survived to spawn again in Year Three, and so Fish A is equivalent to two adults, using the SPF extension (Figure 5).

In Cefas BEEMS SPP102, the Applicant describes the predicted impact (compared to fisheries landings) as 'impingement effect = impingement number × impingement EAV factor / landings' (this is equivalent to Equation 1). In this example, we will use the spawning population in the place of landings and so, predicted impact = impingement number × impingement EAV factor / spawning population. The impingement EAV factor is the number of adults that would have otherwise have resulted from the impinged fish, divided by the number originally impinged (the fraction of adults impinged that would otherwise have become adults/spawners)(Step 3 in Table 1). The impingement EAV factor is 1/1 = 1 for the Cefas method, and 2/1 = 2 for its SPF extension.

Predicted impact using the Cefas EAV is impingement number (1) × impingement EAV factor (1) / spawning population (2) = 0.5 (50%).

Predicted impact using the SPF extension is impingement number (1) × impingement EAV factor (2) / spawning population (2) = 1.0 (100%).

The Applicant's argument is that in order to make a valid comparison, in addition to multiplying the impinged fish (which they call 'the impact') by the SPF EAV factor, the population (which they refer to as 'the baseline') must also be multiplied by its own SPF EAV factor. In Year One, Fish B and Fish C were the spawning population. Fish B was equivalent to two spawners (spawning in Year One and Year Two), Fish C was the equivalent of one spawner (with no future spawning potential as it would not survive to Year Two). The Applicant's SPF EAV factor for the population then is the number of spawners that would result from the fish in the population (3) divided by the number of spawners in the population (2), 3/2 = 1.5. The predicted impact, as calculated in SPP102 would be impingement number (1) × impingement EAV (2) / [spawning population EAV (1.5) × spawning population (2)]. Predicted impact is 2/3 = 0.6 (66%).

We can see in Figure 6 that with a constant impingement rate of one immature fish per year, in Year Two, one spawning fish would be absent from the population due to impingement in Year One. In Year Three, two spawning fish would be absent from the population due to impingement in Year One and Year Two. This is as represented by Fish A having an SPF EAV of 2. Indeed, there would be no spawning fish in Year 3. The impact on the letterfish population would be 100%, as in the predicted impact calculation using the SPF EAV.

The Cefas EAV predicts an impact of 50% and yet in Year Three, there are no letterfish. Multiplying the spawning population ('the baseline') by its SPF EAV, impact is predicted to be 66%, and yet in Year Three, there are no letterfish. The impact is 100%, as predicted using the SPF extension on the impinged fish ('the impact') alone.

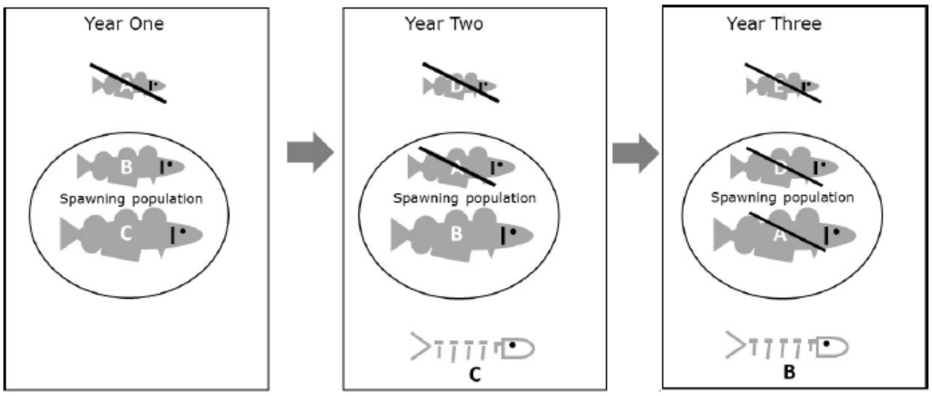

Figure 6. *The letterfish population in Year One, Year Two and Year Three showing the effect of entrapment mortality of one juvenile each year. Fish A is lost in Year One. In Year Two, Fish D is lost but as Fish A has previously been impinged, Fish B is the only mature fish. In Year Three, Fish E is lost and there are no spawning fish, with both Fish A and Fish D having been impinged in previous years. Fish C and Fish B die at the end of their natural lifespans.*

While the Cefas EAV tells us how many fish would have otherwise matured, this is not the most useful figure to compare to the population. Applying the SPF extension to 'the impact' represents all the fish that would have been present in the spawning population had they not been impinged in previous years, and makes for a more useful comparison with the population.

Whereas applying the SPF EAV to 'the impact' represents fish that would have been present had they not been impinged, the future spawning potential of 'the baseline' just represents the fact that in a stable population, in any given year, in addition to the first time spawner (Fish B in Year One), there would also be a repeat spawner present (Fish C in Year One). Multiplying 'the baseline' by its SPF EAV factor does not represent the 'reality' of the model. The spawning population is two fish, and it is against that spawning population of two fish that the impact needs to be measured. Furthermore, unless you count all the spawning fish that would have been present had they not previously been impinged (SPF EAV of 'the impact'), the predicted impact is underestimated.

The 'baseline' (SSB) does not need to be multiplied up in order to compare the SPF EAV number to it. In fact, to compare the Cefas method to the SSB, the SSB needs to be scaled down so as to count only the number of fish maturing and entering the spawning stock for the first time. This can be seen in the model above. If we scale the spawning population of letterfish down to count only the number of fish maturing and entering the spawning stock for the first time, then we would count only Fish B in the spawning stock, not the repeat spawner (Fish C). Predicted impact then becomes number impinged (1) × Applicant's EAV factor (1) / number of first time spawners (1) = 1.0 (100%). The impact is 100%, as this refinement predicts. In Year Three, there are no letterfish.