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Assessment of local effects of HPC on the Hinkley Point fish assemblage

Assessment of local effects of HPC on the Hinkley Point fish assemblage

Brian Robinson

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Executive summary

Consultees on the HPC WDA permit variation need to have evidence that HPC with no Acoustic Fish Deterrent fitted will not cause adverse effects on the SAC/Ramsar fish assemblages nor on the specific fish species that are designated interest features in their own right. A quantitative effects assessment has previously been prepared in BEEMS Technical Report TR456 that assessed the HPC effects on 20 representative fish species (including all of the designated fish qualifying features) as negligible.

After the WDA permit variation was submitted by NNB GenCo (HPC) Ltd, the Environment Agency have issued a series of technical briefs which collectively propose alternative assessment methodologies and provide different results than those provided in TR456. Some of these differences are material. Where possible we have determined why those differences arise, but this process is hampered by a lack of worked examples and an inability to undertake technical discussions on data and methodologies.

In this paper an alternative assessment approach is provided to determine the predicted effects of HPC on the local fish assemblage. The approach is based upon impingement trends which avoids the current difficulties over agreement of the quantitative approach described in TR456 and the associated Environment Agency technical briefs. The approach is based upon information already provided in TR456 but now expanded to cover all assessed species. In particular, the method does not require information on stock areas, SSBs and EAVs and is based upon well proven fish stock assessment science using direct measurements on local populations.

Conclusions

The effects of HPC are assessed assuming the following embedded impingement mitigations:

- Low velocity side entry (LVSE) intake heads;
- A Fish Recovery and Return (FRR) system;

and the additional mitigation of the closure of Hinkley Point B (HPB) before HPC becomes operational.

With the above mitigations in place, it is demonstrated that the impingement pressure from HPC will only increase over the present impingement from HPB for whiting, cod, mullet, bass, thornback ray, blue whiting, salmon, sea trout using Environment Agency estimates of FRR mortality or plus an additional two species (flounder and plaice) if the TR456 FRR mortality rates are used (Table 3, Table 4). In particular, there will be no increase in effects on the HRA or Ramsar designated species of twaite shad, allis shad, eel, marine lamprey and river lamprey.

Using trend analysis from the 37-year HPB impingement record it has been demonstrated that the local fish assemblage is not sensitive to an additional 44 cumecs impingement pressure over and above that from HPB that occurred when Hinkley Point A (HPA) was operational prior to 2000. Taking that lack of sensitivity into account the operation of HPC will not increase impingement pressure to a level that will cause any adverse effects on the fish assemblage with the potential exception, at least in theory, of salmon and sea trout. These species are so rarely impinged at Hinkley Point that it is impossible to draw any sensible conclusions on impingement trends. However, as a quantitative assessment is based upon local stocks, does not involve the use of EAVs and requires no assumptions on the effectiveness of the HPC FRR system, the assessment in TR456 for these two species contains few potential areas for material disagreement with the assessments presented by Environment Agency.

The TR456 impingement prediction for sea trout is derived from 1 fish caught in 37 years. A quantitative assessment against the local stock based upon a highly conservative extrapolation of the fish catch record demonstrates that the predicted HPC effect on the local stock is negligible at approximately 0.45 adult fish per annum or between 0.04% to 0.0054% SSB (TR456).

The impingement record for salmon is based upon 3 adults over 37 years that were caught whilst returning to sea after spawning and in poor condition. Such adults have contributed to the future spawning stock and may never spawn again. The last adult caught at HPB was in 2002. Using a highly conservative data extrapolation it is estimated in TR456 that the annual catch at HPC could be between a negligible 0.8 to 1.4 fish per year or 0.0086% SSB to 0.021% SSB. Given that no catch has occurred at HPB since 2002, it could equally have been claimed that HPC would have no effect on the stock at its current levels.

Based on the results of this alternative assessment, we consider that it has been demonstrated that with the mitigations listed above, that HPC will have no adverse effect on the local fish assemblage nor upon the designated fish qualifying features.

1 Background

Predictions of the effects of HPC cooling water abstraction on fish stocks were provided in BEEMS Technical Report TR456 Edition 2 v10. For most species the fish population at Hinkley Point consists predominantly of juvenile fish; the majority of which naturally do not survive to reproduce due to predation and disease. The sustainability of a fish stock depends upon the number of spawning adults (expressed as the spawning stock biomass or SSB). In order to assess the significance of fish losses the numbers of juvenile fish must be converted into the numbers and then weight of equivalent adult fish. This number is then compared with the appropriate fish stock SSB or with international landings of fish from the stock (the latter is a very conservative proxy for the fish stock as landings are always smaller than the fish stock size). The significance threshold is selected to have no effect on the year to year sustainability of the stock according to well established fisheries science principles.

The stocks identified for each fish species assessed in TR456 are those defined by the International Council for the Exploration of the Sea (ICES) which is an international scientific body that advises the EU commission and individual governments on the status of fish stocks and their sustainable exploitation. ICES has been established for more than 100 years and is the scientific authority for assessment of fish stocks in Europe. Fish stock identities are decided after a critical review of all the scientific evidence and are subject to regular peer review when new evidence becomes available. By a considerable margin (orders of magnitude) fishing is by far the largest contributor to anthropogenic fish mortality for most marine fish species and the assessment methods developed by ICES scientists are both evidence based and at the forefront of fisheries science.

TR456 was produced to provide part of the evidence base for the proposed permit variation for HPC to remove the Acoustic Fish Deterrent system. TR456 has been discussed at length with consultees and has been revised in successive releases in response to consultee comments. After submission of the WDA permit variation for HPC, the Environment Agency have issued a series of technical briefs which collectively propose alternative assessment methodologies and provide different results than those provided in TR456. In a few cases NNB GenCo (HPC) Ltd has received sufficient information to reproduce the Environment Agency calculations and this has led to either revisions to some TR456 calculations or to issues with the Environment Agency methodologies being identified. Some major differences in results exist which include:

a. Calculation of Equivalent Adult Values for some species (used to convert the number of juveniles into the number of equivalent adults)
b. Stock definitions to compare predicted fish losses against.

1.1 Example difference in the results produced by the two methodologies for cod.

An extreme example of the differences between the Environment Agency and TR456 calculations for cod is shown in Table 1. This example was selected as cod has the highest predicted impingement as a percentage of the estimated SSB in Environment Agency Technical Brief TB020.

Table 1 Differences in the predictions of the effects of HPC impingement between TR456 and the Environment Agency results from technical Brief TB020

Source of prediction	Predicted effect on Cod
TR456 Ed 2 v10	0.054% of the internationally agreed ICES SSB in ICES area 7e-k
EA TB020	22% of Environment Agency calculated local SSB (SSB from TB011)

The difference in predicted effect in this case is a factor of 407. Losses of 0.054% of the ICES stock would have negligible effect based upon well-established fisheries science principles (in comparison commercial landings represented 65% of the SSB in the assessment year).

Using the Environment Agency's definition of stock area (contained in TB011), a loss of 22% of the SSB from HPC in addition to the Environment Agency's calculated 65% predicted losses from commercial fishing would cause the stock to collapse if the TB011 definition represents a self-contained stock and if the Environment Agency's HPC catch estimate is correct.

The source of this discrepancy is discussed below but simple reasonableness tests can be conducted on the numbers.

1.1.1 Reasonableness test 1: The existing Hinkley Point B (HPB) catch

In TR456 the estimated HPB impingement losses of cod were 5.3t or 0.1% of the 7e-k SSB of 5092 t which would have had no effect on the stock sustainability. Using the Environment Agency results, it is estimated that the HPB cod catch would be approximately 80t (after correcting for the increased EAV and vertical audit of input data from Table 2) from an Environment Agency estimated cod stock of 1118t and landings of 723t (64.7% SSB) (TB011). HPB losses would represent 7.1% of SSB and the combined fishing and HPB catch would represent approximately 72% SSB. This additional estimated mortality on top of the already high fishing mortality rate would have been likely to have pushed the stock into collapse leading to a reduction in impingement numbers at Hinkley Point B. Whereas in practice this is the exact opposite of what has happened and the HPB impingement numbers have shown a significant positive trend over the period when HPB has been operational (TR456). On the basis of this test neither the HPB catch (calculated via the Environment Agency methodology) nor the revised stock area are reasonable and by implication the HPC estimated loss of 22% of the 'SSB' from TB020 is not credible.

1.1.2 Reasonableness test 2: Comparison with the commercial fleet catch data

An alternative way of looking at the HPC forecast is to compare it with data for the commercial fleet operating in ICES area 7e-k (data from ICES WGCSE 2019). The combined Irish, French and UK fleet landed 3263 t in 2009 with an estimated trawling effort of 1.09M hours or landings per unit of effort equal to approximately 3kg/h. The HPC predicted catch of 245t from TB020 would have been caught in 8760 hours (hours in 1 year) or 28kg/h. This translates to HPC being equivalent to 9.3 trawlers operating 24h a day for every day of the year. In practice the fishing fleet exploits cod when and where it is most abundant, whereas there is no evidence that HPC is optimally sited to catch cod. Most trawling in ICES area 7e-k is done with otter trawls (>75% of the fishing effort from ICES WGCSE). The door spread of a commercial otter trawl is typically 100m. Headline heights (the vertical opening of the nets) are typically up to 2.5m but can be as low as 1m in nets designed to reduce bycatch of haddock and whiting i.e. the intercept area of a typical otter trawl is 100m^2 to 250m^2. Cod are mainly found within 1m of the sea bed (evidence from catches with different trawl headline heights). The HPC intake surfaces start at 1.5m off bottom i.e. they will be inefficient at catching cod, whereas the HPB intakes from which the HPC estimates are derived catch fish to the seabed and are, therefore, more efficient at catching cod. The calculated intercept area of the HPC LVSE intakes is approximately 31m^2 (BEEMS Scientific Position Paper SPP105) i.e. the intercept area of each trawler is 3 to 8 times that of HPC. Neglecting the sub optimal height of the HPC intakes and the fact that trawling is focussed when cod density is highest, it would be expected that the HPC cod catch would be at least 0.3 to 0.13 of that of a trawler operating continuously.

Compared with the calculated 9.3 trawlers from the TB020 the estimated catch of 245t is therefore not credible. Based upon a reasonableness test HPC should be catching much less per hour than the hypothetical trawler operating continuously, not much more. Using the TR456 estimates the cod catch from HPC in 2009 is 8.2t (0.161% of an SSB 5092t) which translates to being equivalent to 0.3 trawlers which appears reasonable on physical grounds, if somewhat large. As stated in TR456, the assessment underlying that report is not a full fisheries assessment as this would not have been proportional to the predicted effects of HPC. One of the key differences in a full stock assessment is accounting for the time mismatch in the analysis. The cod catch at Hinkley Point is mostly of juveniles. In 2009 an exceptionally high cod recruitment event occurred (the largest in the 37-year HPB time series). These fish in their first year of life would not have fully entered the commercial fishery until 2012 i.e. the correct comparator for the 2009 HPC catch is not the 2009 SSB but the 2012 SSB of 13,628t (ICES WGCSE 2019). Recalculating using ICES data for catch and effort from 2012, the HPC catch in 2009 would be equivalent to 0.1 trawlers in 2012 i.e. Depending on how the numbers are interpreted, the HPC effect calculated via the TR456 methods is equivalent to 0.1 to 0.3 of the catch of a single trawler from ICES area 7e-k working continuously. This shows good agreement with what would be expected on physical grounds whereas the TB020 figure is not credible.

The expected reasons for the TB020 overestimates are described in the next section but the inappropriate EAV used to derive the TB020 cod effect is at the heart of the problem.

1.2 How could such a large difference have arisen for cod?

The main contributors to this difference for cod are shown in Table 2.

Table 2 Factors that contribute to the differences in the TR456 and Environment Agency cod effects calculation

Factor	Increase produced by Environment Agency calculations for cod
Difference in the EAV calculations TB010	14.62
Difference in stock size TB011	4.54
Correction factor for the fact that 2009 was an exceptional year for cod recruitment (the largest in 37 years) taken from the TR456 interannual variability analysis. The exceptional recruitment in 2009 over estimated the mean HPC effect in the period 2007-2016 by a factor of 3. This factor has not taken into account in the Environment Agency calculations). Another way of looking at this is to consider the time mismatch in the analysis described in the previous section which would imply a correction factor of 2.7 for the 2009 result.	3
Intercept area of LVSE heads TB006	2.16
Audit of input numbers TB001	1.03
Fish Recovery and return system mortality TB008	1.01

The total calculated difference from these factors is 448.The reason that this is not the factor of 407 reported above is that the differences in each component have been shown in Table 2 but the mean HPC effect estimate is calculated by a statistical bootstrapping process which, because it uses a random number generator to undertake joint probability calculations, produces a different answer every time the programme is run within the uncertainty limits of the data. Exact agreement between the final effect estimate and estimates derived by considering each component of the calculation would therefore never occur except by remote chance.

The two biggest differences are in the cod EAV calculation and the cod stock definition (and associated SSB).

1.2.1 Cod EAV

The TR456 cod EAV = 0.0117

The TB010 cod EAV =0.171 (calculated with different input parameters and a different methodology - Spawning Production Foregone, SPF)

From what it is possible to determine from the Environment Agency documentation, the difference in the EAVs is accounted for by 3 factors:

i. Incorrect interpretation of how ICES uses values for natural mortality (M) in stock assessments in TB010 results in an EAV more than 5 times too large. In the absence of the detailed calculation to check, we assume that the authors have misunderstood the evidence in ICES working group reports and that provided in TR456. A simple reasonableness test demonstrates that the values of M used in TB010 for 0 group fish would imply an M value that is far too low at age 3 and above that is not supported by measurements, ICES analyses or ICES modelling. The selection of M values for cod is explained in detail in Appendix F of TR456.The key point to take from that text is that for stock assessment purposes estimates of M are only required for the <u>exploitable part</u> of the population when the population is either mature or partially mature. I.e. ICES single species stock assessments have no interest in M for the small fish that make up the largest part of the impingement at Hinkley Point and indeed for most species ICES use a single M value for adult fish (for cod the earliest age of interest to the stock assessment is age 1 but even that forms a relatively small part of the biomass in the stock assessment analyses). However, it is known from multiple measurements and theoretical considerations that M is size related and changes most rapidly with size for young fish (the relationship is L shaped but at adult size the variation in M with size is normally small and unimportant to stock assessment). To compute EAVs it is necessary to use empirical relationships between M and fish size suitably corrected to represent field measurements (This is the approach followed in Appendix F TR456). The use of numbers quoted in ICES single species stock assessments to calculate the EAV is not appropriate and will give incorrect effect estimates as demonstrated by the reasonableness tests in this paper

ii. The use of an SPF EAV is incompatible with ICES stock estimates unless both the station catch and the SSB/landings comparators are adjusted in the same manner as explained in BEEMS Scientific Position Paper SPP102 which has previously shared with the Environment Agency. To reiterate it is not the SPF EAV calculation that is an issue, but it is the use of the results in effects assessment which is incompatible with internationally accepted fisheries management practice unless appropriate adjustments are made to all of the relevant parameters in the assessment calculation. However, as demonstrated in SPP102, to do so adds unnecessary additional complexity as the net effect conclusion then becomes approximately the same as before the use of the SPF methodology.

iii. The Environment Agency SPF EAV method omits the effects of fishing mortality which would prevent most cod from undertaking repeat spawning in future years. TB010 states. "*This means that the Spawning Production Foregone method may overvalue older fish to some extent by not considering fishing mortality. However, for key species of concern such as Atlantic cod, and many of the diadromous species, fishing mortality is limited given the current status of the stocks*." This is incorrect and fishing mortality (F) for cod is very high (ICES WGCSE). A recently updated version of TB010 (June 2020) essentially states that it is too difficult to apply F to the EAV calculations. However, application of F is an essential component in fisheries stock assessments and not to include F cannot simply be described as precautionary as it is an unreasonable approach given the assumptions in the SPF methodology that cod can survive to their natural lifespans. Examination of

ICES cod assessment reports clearly demonstrates that this is an unreasonable assumption that is not evidence based.

1.2.2 Cod stock area and SSB

TB011 considers that the ICES stock area 7e-k is too large and proposes a revised stock definition based upon an interpretation of tagging experiments reported in Neat *et al* 2014. We were fully aware of this paper when TR456 was written (the paper's main author for cod outside of Scottish waters is a senior scientist at Cefas). After careful consideration of TB011 we conclude that the authors of the technical brief have both misunderstood what Neta *et al* 2014 states and the limitations of such tagging experiments. The following observations are made about TB011:

i. TB011 claims that Neat *et al* 2014 identifies a home range for cod released in the Western Channel (south of Cornwall) that is more appropriate for assessing the Bristol Channel stock than the ICES stock definition 7e-k. Neat *et a*l 2014 make no claim that the ICES 7e-k stock definition is incorrect nor that it needs to be redrawn. In fact, the paper demonstrates a considerable amount of mixing between cod released in the Celtic Sea, the Western channel and at different times of the year in the Eastern Channel and the Irish Sea. The only tentative suggestion that the paper makes on stock identity concerns cod in the Northern North Sea (which also is supported to some extent by recent genetic data)
ii. TB011 Figure 9 has been represented from Neat *et al* 2014 without showing the intersection of the home ranges of cod released in the Celtic sea, Irish Sea, Western and Eastern Channel in the Bristol Channel area. As drawn, using non-transparent data layers, the considerable degree of mixing in the Bristol Channel is not clear and the figure could mislead readers who have not read the original paper.
iii. TB011 only deals with adult fish and makes no comment upon the juvenile nor the pelagic part of the population. The latter have previously been estimated to travel distances of 100's km in the Irish Sea and Celtic Sea
iv. The lead author for cod in English waters in Neat *et al* 2014 considers that he would be hesitant about making statements on stock identities solely from this paper and from any tagging experiment. Stock identity considerations must weigh up all of the available evidence as each experimental method has its advantages and disadvantages and different biases.
v. Tagged fish were only released from a limited number of locations in the work reported in Neat *et al* 2014 and only a few fish were released in the Bristol Channel. No fish were captured from the Trevose Head spawning ground to the North of Devon (due to hard ground and weather) which is one of the most important spawning areas in ICES 7e-k and the closest to Hinkley Point. This is a significant omission for understanding fish movements in the Bristol Channel area. Depending when and where fish are released in tagging experiments, different conclusions can be drawn from the data. This is a well-known limitation of tagging experiments.
vi. The overlapping home ranges shown in Neat *et al* 2014 tends to support at least 7e, f, g and h as a minimum stock area. However, no fish were released in 7j or 7k so no conclusions can be drawn about that area from Neat *et al* 2014.
vii. Complementary genetic evidence from Heath *et al* 2014 using much more sensitive approaches than in older work indicates that the ICES 7e-k area may underestimate the size of the cod stock area.
viii. ICES have weighed up all of the evidence for cod (of which the information contained in TB011 would have formed a small subset) and have found no weight of evidence to redefine stock identities in the 7e-k area which has remained unchanged since the publication of Neat *et al* 2014. However, as stated previously ICES do reconsider definitions when the balance of evidence indicates the possible need for change and a rebenchmarking of stock definitions for cod from north-west Scotland to the northern North Sea using independent experts in fish stock assessment is underway. This may or may not lead to proposals for revised stock area definitions in those areas, dependent upon the evidence.

In conclusion we find no evidence to contradict ICES's decision in regard to the appropriateness of cod stocks in the 7e-k area. Indeed, the weight of evidence in Neat *et al* 2014 and Heath *et al* 2014 lends weight to the current ICES Stock definition.

1.2.3 Stock Area SSB

Having proposed a redefined stock definition for cod, TB011 then makes a significant error by scaling the ICES SSB estimate by the relative spatial areas between the new proposed area and the area of 7e-k i.e. by assuming that the population density is uniform in 7e-k. TB011 claims that there is no evidence to distribute the population other than uniformly. This is incorrect and ICES WGCSE reports show clearly that fishing activity is highly skewed to a relatively small area of 7e-k. In fact, negligible landings take place from most of 7j or 7k which contribute 64% of the area of 7e-k. Fisherman are driven by economic imperatives to only fish where fish are the most abundant and therefore the distribution of fishing activity is a good first approximation for abundance in an area as well fished as this region.

The use of a uniform density assumption biases the results presented in TB011.

1.2.4 Conclusion on HPC effects on cod

We have considered all of the factors that make up the Environment Agency cod assessment and we consider it is likely that the maximum impingement increase is not 438 times the TR456 estimate but more likely approximately 1.2 times the TR456 figure which is within the reported uncertainties in that report.

1.3 Implications for the assessment of predicted HPC effects

The cod differences are extreme but large differences exist for many of the other species analysed in TR456 where attempts have been made to derive alternative stock areas to the internationally accepted ICES definitions or where different assumptions or potentially inappropriate data have been used to derive EAVs.

2 An alternative approach to assessing HPC effects on the local fish assemblage

Consultees have stated that they need to assess HPC effects on the local fish assemblage in the SAC and in effect the concern is that the local fish assemblage (i.e. those in the SAC) may have their own dynamics that are significantly different from the population in the accepted ICES stock definitions. This has led the Environment Agency to attempt to construct different, more local 'stock identities' for some species. The difficulty with this approach is that the fish assemblage at Hinkley Point does not respect the SAC spatial boundary and virtually all of the fish found at Hinkley Point spend most of their lives outside of the Severn Estuary/Bristol Channel and by definition the geographical limits of the SAC. The risk then is that the proposed alternative stock definitions are in direct contravention with accepted international fisheries science, are not evidence based nor peer reviewed. We have only examined the cod example in detail to date, but we found that the conclusions reached in the Environment Agency report for that species are not supported by the scientific evidence. It is also very difficult to reconcile adopting a different approach to assessing the much smaller effects of the power station compared to the much larger effects of commercial fishing.

In addition to differences regarding stock identity it has not been possible to date to clarify other areas of difference e.g. on EAV calculations.

However, there is an alternative approach to local effects assessment that avoids the need for agreement on stock areas, SSBs and EAVs and this is discussed below.

In TR456 20 fish species were selected as representative of the fish assemblage at Hinkley Point. These include all of the conservation species, the most important commercial species and ecologically important species. The assessment of these species in TR456 can be divided into 2 groups:

A. 8 commercially exploited species that are assessed by ICES scientists and benefit from defined stock identities (whiting, sole, cod, herring, plaice, bass, thornback ray and blue whiting); and
B. 12 species for which assessments are either based upon local estimates of adult populations (sprat, eel, twaite shad, marine lamprey, river lamprey, sea trout, salmon), local trend analysis (thin lipped grey mullet, flounder, five bearded rockling, sand goby) and one species that TR456 treats as a rare straggler from a European stock (Allis shad)

From this list only 9 of the 20 fish species do not already involve a local population assessment. In all 20 cases TR456 finds the effects of HPC to be negligible with no adverse effects on the sustainability of the fish populations. i.e. for 11 species TR456 finds no effect on the SAC/Ramsar assemblage.

2.1 Will there be an unsustainable increase in the effects on local fish populations when HPC becomes operational?

In addition to the embedded impingement mitigations fitted to HPC (LVSE intake heads, FRR system plus head depth) an important additional mitigation is that Hinkley Point B will cease operation before HPC becomes operational. At face value 33.7 cumecs of abstraction from HPB will be removed and 131.86 cumecs added from HPC. However, the embedded impingement mitigation features built into the design of HPC will reduce the losses of fish per cumec abstracted:

i. LVSE intake heads – reduces fish abstraction to 72.6% of HPB per cumec (BEEMS Scientific Position Paper SPP105 which uses the Environment Agency methodology reported in TB006 to calculate the HPC intercept area).

ii. Capped intakes – reduces fish abstraction of pelagic fish (sprat, herring, shads) to 23% of HPB per cumec (factor derived in EA technical brief TB007),

iii. Fish Recovery and return system – that will reduce impinged fish mortality by safely returning as many fish as possible to sea (expected fish mortalities are presented in TR456 or Environment Agency TB008. There are differences in these two sources but for many species the differences are not material) (approximate mortalities of 20% for benthic species, 50% for demersal species, 100% for pelagic species)

These embedded mitigations will directly reduce the effect of HPC on fish as shown in Table 3 for the 21 representative species assessed in TR456 (20 fish and 1 crustacean).

Table 3 Equivalent effect of HPC with embedded impingement mitigation expressed in cumecs compared with HPB (green cells:lower effect when HPC operational, pink cells: greater effect). FRR mortalities from TR456.

Species	HPC equivalent cumecs with LVSE intakes	FRR mortality	HPC equivalent cumecs with LVSE and FRR	Comparison with HPB effect
sprat	22.0	100.0%	22.0	-11.7
whiting	95.7	54.5%	52.2	18.5
sole	95.7	20.4%	19.5	-14.2
cod	95.7	55.3%	52.9	19.2
mullet	95.7	54.5%	52.2	18.5
flounder	95.7	43.0%	41.2	7.5
5 bearded rockling	95.7	20.0%	19.1	-14.6
herring	22.0	100.0%	22.0	-11.7
sand goby	95.7	20.0%	19.1	-14.6
bass	95.7	69.7%	66.7	33.0
plaice	95.7	42.5%	40.7	7.0
thornback ray	95.7	40.5%	38.8	5.1
blue whiting	95.7	54.5%	52.2	18.5
eel	95.7	20.0%	19.1	-14.6
shad, twaite	22.0	100.0%	22.0	-11.7
shad,allis	22.0	100.0%	22.0	-11.7
lamprey marine	95.7	20.0%	19.1	-14.6
lamprey river	95.7	20.0%	19.1	-14.6
salmon	95.7	54.5%	52.2	18.5
sea trout	95.7	54.5%	52.2	18.5
c.crangon	95.7	20.0%	19.1	-14.6

We have not had the opportunity to discuss TB008 which provides the Agency's views on FRR system mortalities and so for completeness in Table 5 the equivalent of Table 3 is provided using TB008 data on FRR mortality with one exception for marine lamprey where TB008 calculated the losses using morphometric data for eels instead of marine lamprey. By so doing TB008 predicted that some marine lamprey would not pass through the trash rack bar spacing at HPC thereby increasing the predicted mortality from 20% to 40.7%. Using width measurements of marine lamprey corrects this figure to 20% (TR456 and supplemental data previously provided to the Environment Agency).

Table 4 Equivalent effect of HPC with embedded impingement mitigation expressed in cumecs compared with HPB (green cells: lower effect when HPC operational, pink cells: greater effect). Uses TB008 FRR mortality data.

Species	HPC equivalent cumecs with LVSE	FRR mortlity TB008	HPC equivalent cumecs with LVSE and FRR	Comparison with HPB effect
sprat	22.0	100.0%	22.0	-11.7
whiting	95.7	55.2%	52.8	19.1
sole	95.7	20.0%	19.1	-14.6
cod	95.7	56.3%	53.9	20.2
mullet	95.7	54.5%	52.2	18.5
flounder	95.7	20.0%	19.1	-14.6
5 bearded rockling	95.7	20.0%	19.1	-14.6
herring	22.0	100.0%	22.0	-11.7
sand goby	95.7	20.0%	19.1	-14.6
bass	95.7	60.8%	58.2	24.5
plaice	95.7	20.0%	19.1	-14.6
thornback ray	95.7	54.5%	52.2	18.5
blue whiting	95.7	66.1%	63.3	29.6
eel	95.7	20.0%	19.1	-14.6
shad, twaite	22.0	100.0%	22.0	-11.7
shad,allis	22.0	100.0%	22.0	-11.7
lamprey marine	95.7	20.0%	19.1	-14.6
lamprey river	95.7	20.0%	19.1	-14.6
salmon	95.7	100.0%	95.7	62.0
sea trout	95.7	100.0%	95.7	62.0
c.crangon	95.7	20.0%	19.1	-14.6

In terms of the pattern of effect, the two tables are very similar with the TB008 results showing that for two additional species HPC is predicted to have lower effects than HPB: flounder and plaice. In contrast the net effect would increase for some species e.g. thornback ray, salmon and sea trout.

Table 3 shows that with only LVSE heads fitted, HPC impingement losses would be lower than HPB for sprat, herring, twaite and allis shad. i.e. when HPC becomes operational losses of these species will be lower than they are currently and there will no increase in local fish mortality.

When the effects of the HPC FRR are included, in addition to the four species listed above there would be lower losses when HPC becomes operational for sole, 5 bearded rockling, sand goby, eel, marine lamprey, river lamprey and *C.crangon* (brown shrimp). For all the designated conservation species, with the exception of sea trout and salmon, the fish losses after HPC becomes operational will be lower than they are currently.

After HPC becomes operational the only species where losses are predicted to increase compared with current position are largely demersal species: whiting, cod, mullet, bass, thornback ray, blue whiting, salmon, sea trout plus flounder and plaice if the TR456 FRR mortality rates are used.

For all of these species TR456 predicted negligible effects from HPC without taking into account the additional mitigation of the closure of HPB.

For many populations stock assessment scientists do not have the information to perform a fully quantitative assessment but there are well proven techniques to substantially manage such data poor populations. A frequently employed technique is to make use of trends in fishery catch data and to set fishing mortality so that it does not cause a year to year decline in fish populations. I.e. fishing mortality is then fully sustainable and approximates to the maximum sustainable yield (TR456).

The data to do such an analysis already exists at Hinkley Point from the 37-year time series of HPB impingement data. The trend in impingement numbers have been compared before and after the closure of Hinkley Point A (HPA) in 2000 which had an abstraction of 44 cumecs with no impingement mitigation measures fitted. If the local fish assemblage was sensitive to a change in 44 cumecs this would show up in the impingement trends. In fact, no such change is found for any species (TR456). I.e. the local assemblage is not sensitive to an additional 44 cumecs of impingement pressure. This is what would have been predicted from the TR456 predictions where the effect of an abstraction of 44 cumecs or 30% more than the existing HPB would be predicted to be negligible for all species and therefore no effect would have been expected to be seen in the impingement data.

Table 5 The effect of HPC compared to when HPB and HPA were operational (expressed in cumecs). Uses TB008 FRR mortality data.

Species	HPC equivalent cumecs with LVSE	FRR mortlity TB008	HPC equivalent cumecs with LVSE and FRR	Comparison with HPB effect	Comparison with HPB and HPA effect
sprat	22.0	100.0%	22.0	-11.7	-55.7
whiting	95.7	55.2%	52.8	19.1	-24.9
sole	95.7	20.0%	19.1	-14.6	-58.6
cod	95.7	56.3%	53.9	20.2	-23.8
mullet	95.7	54.5%	52.2	18.5	-25.5
flounder	95.7	20.0%	19.1	-14.6	-58.6
5 bearded rockling	95.7	20.0%	19.1	-14.6	-58.6
herring	22.0	100.0%	22.0	-11.7	-55.7
sand goby	95.7	20.0%	19.1	-14.6	-58.6
bass	95.7	60.8%	58.2	24.5	-19.5
plaice	95.7	20.0%	19.1	-14.6	-58.6
thornback ray	95.7	54.5%	52.2	18.5	-25.5
blue whiting	95.7	66.1%	63.3	29.6	-14.4
eel	95.7	20.0%	19.1	-14.6	-58.6
shad, twaite	22.0	100.0%	22.0	-11.7	-55.7
shad,allis	22.0	100.0%	22.0	-11.7	-55.7
lamprey marine	95.7	20.0%	19.1	-14.6	-58.6
lamprey river	95.7	20.0%	19.1	-14.6	-58.6
salmon	95.7	100.0%	95.7	62.0	18.0
sea trout	95.7	100.0%	95.7	62.0	18.0
c.crangon	95.7	20.0%	19.1	-14.6	-58.6

Note: the negligible effect conclusions would have been unaffected even if the marine lamprey FRR mortality had not been corrected.

Table 5 shows that taking account of the local fish assemblage's lack of sensitivity to an additional 44 cumecs of impingement pressure, the only species which show an increase in impingement pressure would be salmon and sea trout.

It is useful to examine the evidence for each of these two species.

2.1.1 Sea trout

Sea trout impingement at Hinkley Point is exceptionally rare with only 1 fish caught during the 37 year impingement monitoring record at HPB and none caught during the high intensity impingement campaign in 2009. This is to be expected given that the evidence from tracking tracking studies is that sea trout preferentially migrate in surface waters in the main channel of an estuary (TR456). The HPB intake is on the seabed and is more than 13 km from the main channel of the Severn. The HPC intakes are also more than 13km from the main channel, are in 4m deeper water than the HPB intake and have capped intakes and are therefore even more unlikely to abstract sea trout than the HPB intake. Making a highly precautionary scaling of this one event the effect on the local stock was assessed as negligible in TR456. (There are no differences over stock areas nor EAVs between the Environment Agency approach and TR456 for this species). As far as we can ascertain the Environment Agency agree with the TR456 negligible effect assessment for sea trout (The Environment Agency have not provided their proposed assessment thresholds for our consideration).

2.1.2 Salmon

Only 3 adult fish have been caught in the 37 year HPB impingement monitoring programme. These adults were kelts (adults returning to sea after spawning i.e. after making their contribution to the future SSB). Only 2-5% of salmon survive spawning to return to sea in poor condition and it is not known whether they successfully breed again (TR456). There were an additional 6 juvenile fish (parr and smolts) but in any quantitative assessment the inclusion of these juvenile fish would have a negligible effect due to the EAV scaling and it is only the 3 adults that are relevant to the stock effect calculation.

The last adult salmon caught at HPB was in 2002 (2 smolts were caught in 2004), prior to that one adult was caught in 1989. No salmon were caught in the high sampling intensity impingement survey in 2009 which was at least 13 times more sensitive than the 37 year impingement survey programme (TR456). In TR456 the very low HPB catch numbers were extrapolated in a highly conservative manner to calculate an impingement rate in the assessment year (2009) even though no fish were caught in that year by either survey. Using this highly conservative extrapolation TR456 calculated a predicted impingement of between 0.8 to 1.4 adult salmon per year assuming no FRR survival (the 0.8 fish just extrapolated the one fish caught in 2002 over a 21y period, the 1.4 figure resulted from a more extreme extrapolation using results from the entire 37 year programme). TR456 assessed such catches as negligible and no matter how the assessment parameters are altered the prediction for the number of fish lost remains very low. Even assessing the losses against the adult spawning population could be considered to be questionable because as the fish have already spawned and are in poor condition, they could reasonably be expected to have a low probability of successfully spawning again.

As stated above the TR456 assessment is based upon a questionable extrapolation of data from 2002 and we could reasonably have stated that there was no predicted effect from HPC due to the exceptionally rare occurrence in impingement monitoring data with none since 2002.

In conclusion whilst there will be increased impingement pressure on salmon and sea trout (if we assume that the HPC FRR system will have no benefit for those two species) but the predicted impingement rate is so low that this would have no effect on the sustainability of the stocks. HPC will have much deeper intakes and it is expected that the losses of salmon and sea trout will be lower than at HPB due to the fish preference to migrate in surface waters but we cannot currently put a factor to that hypothesis.

2.2 Sensitivity testing

The above calculations used to derive the effect of HPC have the advantage that they involve few input parameters. We have tested the results using extreme values from the expected ranges for the LVSE head performance (SPP105) and the FRR mortalities (TB008) and the conclusions are unchanged.

3 Conclusions

Consultees on the HPC WDA permit variation need to have evidence that HPC with no Acoustic Fish Deterrent fitted will not cause adverse effects on the SAC/Ramsar fish assemblage nor on the specific fish species that are qualifying features in their own right. A quantitative effects assessment has previously been prepared in BEEMS Technical Report TR456 that assessed the HPC effects on 20 representative fish species (including all of the designated fish interest features) as negligible.

After the WDA permit variation was submitted by NNB GenCo (HPC) ltd, the Environment Agency have issued a series of technical briefs which collectively propose alternative assessment methodologies and provide different results than those provided in TR456. Some of these differences are material. Where possible the reason for these differences has been determined, but this has not been possible in all cases. As an example, this paper examines the TR456 and Environment Agency results for the predicted HPC effects on cod which currently differ by more than 400-fold. It is considered that a large part of part of this difference has been caused by:

- an unsuccessful approach to identify an evidence backed local stock identity for cod that is different from that produced by the International Council for the exploration of the Sea (ICES); the body that is the technical authority for such matters in Europe; and
- the calculation of an Equivalent Adult Value or EAV (the factor that is used to calculate the number of juvenile cod that would survive to reproduce) using inappropriate values for natural mortality and inappropriate use of the Environment Agency's preferred Spawning Production Foregone EAV methodology in HPC effects calculations.

Some simple reasonableness tests are used to demonstrate that the Environment Agency's predicted effects on cod are not credible. After consideration of the approach set out in the Environment Agency's technical briefs, it is estimated that the TR456 mean effects on cod may have been underestimated by a factor of approximately 1.2 and not the 400-fold+ described in TB020.

In this paper an alternative assessment approach is provided that is based upon impingement trends which avoids the use of more complex models with multiple input parameters described in TR456 and the associated Environment Agency technical briefs. The approach is based upon information already provided in TR456 but now expanded to cover all assessed species.

The effects of HPC are assessed assuming the following embedded impingement mitigations:

- LVSE intakes;
- FRR system;

and the additional mitigation of the closure of HPB before HPC becomes operational.

With the above mitigations in place, it has been demonstrated that the impingement pressure from HPC will only increase over the present impingement from HPB for whiting, cod, mullet, bass, thornback ray, blue whiting, salmon, sea trout plus flounder and plaice if the TR456 FRR mortality rates are used (Table 3, Table 4). In particular, there will be no increase in effects on the HRA/Ramsar designated species twaite shad, allis shad, eel, marine lamprey and river lamprey.

Using trend analysis from the 37-year HPB impingement record it has been demonstrated that the local fish assemblage is not sensitive to an additional 44 cumecs impingement pressure over and above that from HPB from HPA that ceased operation in 2000. Taking that lack of sensitivity into account, the operation of HPC will not increase impingement pressure to a level that will cause any adverse effects with the potential exception, at least in theory, for salmon and sea trout. These species are so rarely impinged at Hinkley Point that it is impossible to draw any sensible conclusions on impingement trends. However, as the TR456 assessment is based upon local stocks, does not involve the use of EAVs and requires no assumptions on the effectiveness of the HPC FRR system, the assessment in TR456 contains few potential areas for material disagreement with the assessments presented by Environment Agency.

The impingement prediction for sea trout is derived from 1 fish caught in 37 years. A quantitative assessment against the local stock based upon a highly conservative extrapolation of the fish catch record demonstrates that the predicted HPC effect on the local stock is negligible at approximately 0.45 adult fish per annum or between 0.04% to 0.0054% SSB (TR456).

The impingement record for salmon is based upon 3 adults over 37 years that were caught whilst returning to sea after spawning in poor condition. Such adults have contributed to the future spawning stock and may never spawn again. The last adult caught at HPB was in 2002. Using a highly conservative data extrapolation it is estimated in TR456 that the annual catch at HPC could be between a negligible 0.8 to 1.4 fish per year or 0.0086% SSB to 0.021% SSB. Given that no catch has occurred since 2002 it could equally have been claimed that HPC would have no effect on the stock at its current levels.

Based on the results of this alternative assessment, we consider that it has been demonstrated that with the mitigations listed above, that HPC will have no adverse effect on the local fish assemblage nor upon the specific qualifying fish interest features.

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