Application to Vary an Existing Environmental Permit from NNB Generation Company (HPC) Limited at Hinkley Point C Nuclear Power Station (Permit application number EPR/HP3228XT/V004)

A Review by Dr Andy Turnpenny, Fisheries Consultant

About the Respondent:

My name is Dr Andrew Turnpenny and I have a detailed knowledge of the Hinkley Point C (HPC) site and of the NNB project development since its inception. I started my professional career in 1976 as a Research Officer for the Central Electricity Research Laboratories Marine Biological Laboratory, where I specialised in research into the behavioural and physiological aspects of fish impingement and entrainment, and into methods of mitigation. I have written numerous scientific papers and reports on this subject and presented at many major international scientific conferences. I have advised UK regulators and conservation bodies on best practice for fish protection at water intakes[1] and on international environmental practice in cooling water (CW) system design for large power stations[2]. Both publications have formed the basis of the fish protection strategy for HPC. I have had an ongoing working association with the Hinkley site since the late 1970s and have worked on fish populations of the Severn Estuary from this time onwards in connection with the several power stations that rely on the Estuary as a CW source and the various tidal power initiatives. My own involvement in the HPC NNB project began in 2007 when I was invited to join the BEEMS Expert Panel (EP), on which I served until its disbandment in December 2017. The EP comprised a group of industry experts, academics and regulators with particular experience of power stations and regulatory processes. My particular role on the EP concerned biological issues relating to protection of fish and other biota, and I and other EP members gave scientific and regulatory guidance on how information presented in the Environment Agency reports[1,2] should be applied to HPC and other NNB projects.

From 2010 until recently I served as a director of THA Aquatic Ltd (formerly Turnpenny Horsfield Associates Ltd). I retired from the post in January 2019 and now act as an independent consultant.

During the course of the HPC development I provided consultancy advice to the Environment Agency (EA) on CW system design and was subsequently commissioned by the EDF Energy CWS design team to provide design advice to the HPC Fish Protection Working Group.

From the early 1990s, I led a research team pioneering the development of acoustic fish deterrents and have continued to advance AFD technology to this day. I have worked on AFD and R&D projects across the globe and collaborated extensively with academic and industry scientists in Europe, USA, Canada and elsewhere.

I was a founding director of Fish Guidance Systems Ltd (FGS), manufacturers of acoustic fish deterrents (AFDs) and other behavioural fish guidance and protection systems. I fully retired from FGS in 2015 and relinquished my directorship and bulk of my shareholding. I remain a minor shareholder and act for the company as a specialist fisheries consultant as and when required.

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[1] TURNPENNY, A.W.H AND O'KEEFFE, N. 2005. Screening for intake and outfalls: a best practice guide. Environment Agency. Science Report. SC030231.

[2] TURNPENNY, A.W.H., COUGHLAN, J., NG, B., CREWS, P., BAMBER, R. & ROWLES, P., 2010. Cooling Water Options for the New Generation of Nuclear Power Stations in the UK. SC070015/SR3, 214 pp.

Summary of the Developer's Case for Removing the AFD Requirement

Having read the relevant reports made available to consultees, the key points of the Developer's case can be summarised as follows; the citations shown are just examples from the supplied technical reports and in many cases are repeated in different forms at other points in the reports:

1. The Developer has explored the engineering requirements to install and maintain a suitable AFD system at the HPC intakes and concluded there are insurmountable practical and Health & Safety issues that preclude successful implementation of AFD technology at HPC. These they indicate arise from a number of factors not experienced at other sites where AFD systems are successfully operated, *viz.*:
    a. The long distance offshore (~3.3 km) at which the intake heads will be located, which prevents access other than by boat (NNB-308-REP-000710 v.2.0, s.5.3.2);
    b. The difficult sea conditions at the intake locations (fast tidal currents and high suspended sediment loads/poor underwater visibility) and short time windows for diver access (NNB-308-REP-000710 v.2.0,s.7.4.4 *et seq.*; s. 7.4.23);
    c. Large tidal range (max ~15 m) which is likely to challenge pressure compensation capabilities of available AFD equipment (NNB-308-REP-000710 v.2.0, para. 4.3.37);
    d. Incompatibility of a 12 month maintenance cycle for submerged AFD equipment with outage frequency of the nuclear plant (diver access can only be permitted when the CW system is not operating (NNB-308-REP-000710 v.2.0, s.7.5 *et seq.*)
    e. That there is not prior experience, nationally or internationally, of operating an AFD system in conditions similar to the Severn Estuary/Bristol Channel (NNB-308-REP-000710 v.2.0, s.5.3.2; NNB-308-REP-000721 v.2.0, s,1.1.5).
2. That the provision of other fish protection measures in the form of the low-velocity side-entry (LVSE) intake head design and of a fish recovery and return (FRR) system, in accordance with best practice[1] will adequately meet fish protection requirements for the site (NNB-308-REP-000721 v.2.0;p.35 of TR456, which states, *"The LVSE intake heads are therefore, expected to provide substantial reductions in impingement at HPC regardless of whether an AFD is fitted or not*").
3. That extensive analysis of fish impingement data from the RIMP and CIMP survey programmes provide evidence that that fish impingement levels at HPC will in any case fall well below the stated sustainability criterion (TR456 provides convincing argument for adopting a sustainable mortality threshold of 1% of spawning stock biomass, SSB for this purpose).

Where the Developer's Case is Flawed

1. Availability of Suitable AFD Equipment

While I do not underestimate the technical and engineering and H & S issues associated with installing and maintaining an AFD system at HPC, the Developer makes a number of incorrect or outdated assumptions about AFD hardware capabilities and maintenance requirements. These are best addressed separately by equipment suppliers but I am aware for example that maintenance cycles are now typically 18-24 months rather than 12 months.

2. Assumption that LVSE Intake will be Effective without AFD

To assume that a combination of LVSE intake heads and an FRR system by themselves will adequately protect fish populations identifies a lack of understanding of advice contained in regulatory guidance documents[1,2] regarding how a combination of mitigation measures work together to provide fish protection at large direct-cooled power stations. The use of an AFD *in combination with* a low velocity intake is intended to deflect the more fragile hearing-sensitive species that are unable to survive passage through the tunnels and forebay and water channels and handling by the CW screens. The more robust species such as eels and flatfish tend to have poor hearing but are very resistant to handling and survive well after return to the water body via the FRR.

An earlier CEGB research publication RD/L/3301/R88[3] lists 'three vital elements' for fish exclusion from water intakes as indicated in the following extract:

> (1) the fish must be able to detect its approach to an intake before it can attempt to escape; (2) the direction of water flow must be horizontal, since fish are ill-equipped to react to vertical flow components; (3) the water velocity must be within the fish's swimming performance range. All three requirements must be met simultaneously; it is futile, for example, to reduce intake current velocities where waters are perpetually turbid, since fish would be unlikely to detect their approach to the intake.

This point is further elaborated in advice to the Developer contained in BEEMS TR117[4]:

"It is important to understand that the performance figures given in Table 8 represent only one aspect of fish protection performance, namely achieving intake velocities that a greater percentage of fish would be physically strong enough to escape from. This should not be taken to imply that these proportions of fish would in practice escape, as the outcome would also depend on whether or not fish were able to detect and respond to the structure. At the high turbidities usually present at Hinkley Point, in the absence of visual cues, this would depend upon the presence of suitable hydraulic stimuli, e.g. turbulence generated at the periphery of the intake structures by screen slats, or by artificial stimuli such as from acoustic fish deterrents (AFDs)."

While the coarse-screen bars to be fitted to the HPC intakes may create local turbulence, the design does not allow for the reaction time needed for fish to take avoidance action; whereas the AFD would be designed to project sound to a sufficient reaction distance.

In my opinion, the benefits of the LVSE intake head design will be lost without provision of suitable warning cues, for which purpose sound has been assessed as the best option (strobe lights provide a potentially effective addition where turbidity is not a factor[1,2]).

3. Predictive Methods for Impingement at HPC

A number of aspects of the methods used in TR456 concern me. In particular:

(a) P.35, para. (a), ref Sizewell comparison. Sizewell A was an open-topped intake and not comparable with the HBP pill-box caisson design which has both horizontal and vertical flow components. It is unlikely that the benefit of the capped design will be realised to this extent

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[3] TURNPENNY, A.W.H., 1988. The behavioural basis of fish exclusion from coastal power station cooling water intakes. Central Electricity Generating Board. Report No. RD/L/3301/R88.

[4] Assessment of Effects of CW Intake Velocity on Fish Entrapment Risk at Hinkley Point. BEEM Technical Report TR117

at HPC. Re. p.35, para (b): while I would expect there to be a difference between risk of fish entrapment when comparing HPB and HPC, Sizewell is not a good comparison, being an open coastal site bordering a sandy beach whereas Hinkley is an estuarine site with a rocky shoreline and fluid mud bed in the channel.

(b) P.36, para. 1 suggests that the impingement estimates presented are conservative as no allowance has been made for the deeper siting of the intakes. While this may turn out to be the case, no evidence appears to have been presented to support this statement. Devon and Severn IFCA expand further on this matter in their response[6].

(c) P.35, first two bullet points below Table 3: these figures are open to challenge. They assume a quantifiable benefit for using a capped structure but the assumed benefit versus the HPB semi-capped structure may be exaggerated in the figures shown here for pelagic fish as the HPB structure is effectively partly capped.

(d) On p.36 para.2, it is stated that there will be a benefit of HPC over the A/B stations in terms of cross-sectional area of the tidal flow sampled. The argument presented here is spurious. Fish are delivered to the intake at a rate determined by the volume abstracted. The cross-sectional area influenced is determined by the area needed to deliver the abstracted CW flow according to the tidal velocity. This will not achieve an HPC versus HPB benefit. The correct calculation would be to adjust for volume and proportion of fish that are theoretically vulnerable to entrapment at the escape velocity occurring at any state of the tide, as set out in TR117. Table 3 figures therefore do not apply.

4. Assumption that HPC Impingement Catches can be Extrapolated from RIMP/CIMP Results

TR456 provides a comprehensive analysis of the significance of predicted impingement catches in relation to population sizes of the various species, leading to the conclusion that catches will not be significant in overall stock terms (see also comments on stock size in s.7 below). The methods and the data sources used to estimate and frame these losses are generally in accordance with best practice but nonetheless are based on sampling from the nearshore location of the Hinkley A/B intakes rather than the offshore location of the HPC design. This introduces an (unavoidable) degree of uncertainty into the conclusions. A purpose of providing the proposed comprehensive fish protection measures with AFD outlined in the HPC Environmental Statement and included within the DCO is to mitigate against this risk. The Developer's DCO submission NNB-209-REP-000130 (Para. 11.2.41, p92) makes clear that once built, there will be no contingencies:

"There is no contingency plan should the Acoustic Fish Deterrent (AFD) system and Low Velocity Intake, Side Entry (LVSE) intake heads not work as predicted. The performance of both the Acoustic Fish Deterrent (AFD) system and the Fish recovery and Return (FRR) system will be optimised, where possible, but it is not be feasible to change the intake heads once the station is in operation".

The proposal to remove the AFD component of fish protection at HPC therefore appears to be a particularly risky strategy for fish and is at odds with the 'adaptive management' policies outlined by Devon and Severn IFCA for other anthropogenic impacts (viz. fishing activities) on the estuary's fish communities[6] Should future monitoring on the HPC site show further fish protection measures to be necessary, the retrofitting of AFD would be made considerably more difficult if the required signal and power cabling provision out to the offshore intake heads has not been made at the marine works construction stage. Also, the initial design planning for AFD indicated a likely requirement for additional offshore civil works to accommodate power and signal distribution hubs. Installing such facilties after site commissioning would entail not only substantial extra mobilisation costs but also generating downtime which could only occur during a major planned outage. Further permitting would also be required for these works.

5. Combined Effects of Entrainment and Impingement

In their response to this consultation, Devon and Severn IFCA[5] correctly point out that the screening out by the Developer of fish entrainment as a significant factor in the Habitats Regulations Assessment (HRA) is an error because the effects of entrainment and impingement should be taken in combination to estimate total fish mortality due to CW abstraction. This is standard procedure, as set out in Environment Agency (2010: p.102-104). Although entrainment rates will not be affected with or without AFD, the effects on total fish mortality cannot be assessed without following this process.

6. Climate Change Effects

TR456 also addresses long-term effect including climate change and reveals from the RIMP and CIMP datasets that there has been a 204% increase in fish numbers for all species over the period 1981 to 2017. It also identifies that over this period there have been winners and losers among species recorded, relating to climate change, fishing practice, etc. Increasing sea temperatures associated with climate change are expected to favour the increase of warm-water Lusitanian species which are close to their northern limit and reduce populations of some cold-water species. The Developers submission HPC-DEV024-XX-000-RET (p.98) cites Simpson *et al.* 2011, stating that in Northeast Atlantic fishes '*three times more species [are] increasing in abundance with warming than declining*'. Fish catches may therefore be expected to increase over the lifetime of the station. The required operating life of the CW system is 70 years.

Twaite shad offer a particular example, being of high conservation importance. While the 18-year historical dataset examined in s.9.7 of TR456 might seem reasonable, given the availability of the 37 y RIMP dataset and the planned lifetime of the station, it is important to recognise that higher numbers of Twaite shad have been recorded in the past. Notably according Henderson, Seaby & Holmes 2006 during 1988-91 ('warmer years') when seasonal peak numbers of around 40 fish per 6h were being recorded. Shads being Lusitanian species, the expectation is that they will become commoner in UK waters with climate change[6] and therefore the case for not installing AFD should acknowledge the likelihood of significantly greater numbers of shad being impinged during the lifetime of the station.

7. Stock Units Used to make the Assessments

It is axiomatic that the larger the stock unit used for assessment, the smaller will be the proportionate loss due to abstraction. This was recognised during the early 1980s assessment of impingement impacts at Sizewell, where three frames of reference were adopted in the joint CEGB/MAFF analysis to make separate assessment at the local, regional and whole North Sea levels. In that case units were based on landings data from ICES Rectangles[7]. In an authoritative review, Devon and Severn IFCA[6] have presented evidence to show how the approach taken by Cefas in quantifying the stock size (spawning stock biomass-SSB), which primarily is intended as a practical basis for managing commercial exploitation of stocks, is now seen to mask much finer, genetic segregations at the local

[5] D&S IFCA Response to the Environment Agency Consultation Regarding the EDF Energy Proposal to Remove the Requirement for Acoustic Fish Deterrents at Hinkley Point C, July 2019

[6] NRW Evidence Report No. 6: Modelling the response of the twaite shad (*Alosa fallax*) population in the Afon Tywi SAC to a modified temperature regime. Author(s): KNIGHTS, A.M., 2014

[7] Turnpenny, A.W.H. and Taylor, C.J.L., 2000. An assessment of the effect of the Sizewell power stations on fish populations. *Hydroécologie Appliquée*, 12, 87-134.

level. The implication of this is that if these 'substocks' were used as the unit for comparison, the proportionate effects of abstraction would be larger and might not meet the <1% of SSB criterion adopted by Cefas as a 'significant' effect threshold.

8. Possible use of Ultrasound AFD

Since the AFD options for HPC were last reviewed there have been developments in the field of ultrasound AFDs (FGS Ltd can advise). A limitation of previous ultrasound systems as used at some stations in the USA has been the narrow 'torch' beam transducers that have been used, arising from the use of echo-sounder transducers rather than purpose-designed equipment. FGS has now developed a hemispherical field transducer which allows a much more uniform sound field.

Ultrasound is more limited in its application. To our knowledge only certain clupeid (herring/shad family) species will respond, but it has been shown to deter Twaite shad in particular[8,9], so would provide a mitigation against this risk. It is cheaper and simpler to install than low-frequency AFD systems, requiring fewer transducers to achieve coverage, with virtually no maintenance of underwater components. As the transducers are solid-state, they do not require pressure-compensation systems.

Ultrasound would not therefore mitigate the risk to the wider fish assemblage but could be considered as means of enhancing protection for shad species. There may be some benefits to other clupeid species but these are as yet unknown/ unproven.

9. Concluding Remarks

The documents provided in support of the Developer's case to remove the need to install AFD at HPC are found to contain a number of flaws. First, the objections on technical and H & S grounds merit further discussions with suppliers, as they do not reflect the current state of the market, both in terms of the available technology and the required maintenance frequency. Secondly, there are significant uncertainties in the numerical prediction of likely HPC fish impingement rates associated with assumptions about scaling and transferability of A/B station RIMP/CIMP data to an intake located >2km further offshore. Thirdly, the HRA ignores the in-combination effects of entrainment and impingement, thereby underestimating total fish mortality. Fourthly, the stock units used for estimating mortality as a percentage of SSB may be too large, thereby masking more significant effects at the genetic sub-stock level.

Also, although possible climate change effects are discussed, the outcomes are uncertain and the likelihood of larger numbers of warm-water species occurring in the Bristol Channel /Severn Estuary is identified by this work, which would be likely to increase impingement rates in the future. While it may be argued that the proportion of SSB may not be increased by this effect, the impingement of increasing numbers of fish over the lifespan of the station is surely contrary to conservation interests and to the greener ethos that everyone has sought to achieve for the new generation of water-cooled power stations. Numbers of Twaite and Allis shad, as particular examples of warm-water species

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[8] TEAGUE, N. and CLOUGH, S.C., 2014. Investigations into the response of 0- group Twaite shad (*Alsoa fallax*) to ultrasound and its potential as an entrainment deterrent. In: Turnpenny, A.W.H. & Horsfield, R.A., 2014. International Fish Screening Techniques A. W. H. Turnpenny & R. A. Horsfield, eds., WIT Press., 153-164.

[9] WILSON, M., ACOLAS, M.L., BEGOUT, M.L., MADSEN, P.T, WAHLBERG, M. (2008). Allis shad (*Alosa alosa*) exhibit an intensity-graded behavioural response when exposed to ultrasound. *J. Acoust. Soc. Am.* 124 (4), October 2008, EL243-247.

may be expected to increase from further warming, but also as a result of ongoing efforts to increase access to riverine spawning grounds and nursery habitat. Ultrasound offers an additional potential method of mitigation for these species.

It should be well understood that the possibilities of retrofitting AFD at a later date post-commissioning will be greatly hindered if the required cabling and hub infrastructure is not included in the offshore marine works during initial construction. Extra costs and delays will arise from permitting and access limitations associated with planned plant outages.

The wider effect of the Developer's proposal not to include AFD in the design may be to erode the BAT case for direct cooling elsewhere, leading to greater pressure for tower cooling, with all of its undesirable environmental consequences (visual, air quality and reduced energy efficiency[2]).