Vattenfall Wind Power Ltd

Thanet Extension Offshore Wind Farm

Appendix 7 to Deadline 4C Submission: Fish Clarification Note

Relevant Examination Deadline: 4C

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Revision A

Drafted By:	GoBe Consultants Ltd
Approved By:	Daniel Bates
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1 Herring Clarification Note

1.1 Background

1 In order to quantify the spatial extent of any potential noise impacts on fish and shellfish populations, predictive subsea noise modelling was undertaken using the maximum design scenario hammer energy of 5,000 kJ for monopile foundations and 2,700 kJ for pin-piled jacket foundations. This was conducted for two representative locations, one in the shallowest part of the proposed array area (south-west), and one in the deepest (east); the locations were agreed as part of the EIA Evidence Plan.

2 In addition to the locations being agreed through the Evidence Plan process, it should be noted all other specifications for the noise modelling, including locations, hammer energies, modelling criteria and effect threshold metrics were agreed through the Evidence Plan process prior to assessment, in which the MMO and Cefas were involved and provided confirmation of agreement through review of the Evidence Plan logs. Further consultation was also undertaken formally through the publication of the PEIR, with the application having demonstrated due regard for all comments received from MMO, and confirmatory teleconferences held with MMO and Cefas.

3 It was agreed through this process that underwater noise modelling would be undertaken inclusive of modelling single-strike SPL_{peak} for stationary receptors, and cumulative noise exposure SEL_{cum} for fleeing receptors. For fish, the fleeing speed applied was 1.5 m/s, through reference to Hirata (1999) on the 'swimming speeds of common fish'. This is considered to be suitably precautionary given the known mean swim speed of herring during the spawning season (the relevant season of concern) of 1.44 m/s when immigrating[1], i.e. not fleeing but responding to a biological stimulus with a sustainable swim speed. A flee speed is likely to increase above this, but the same authors (through reference to other papers including HE & Wardle 1988 and Videler & Wardle 1991) note that the maximum sustainable swim speed is likely to be of a similar speed. The authors further note that the mean swim speed was subject to a strong tidal current, and that downstream/slow current speeds would expected to be greater than the mean of 1.44 m/s. It is therefore considered robust to employ a swim/flee speed when considering impacts and responses to the impact.

[1] Ferno, A., Aksland, M., Misund, O., Nottestad, L., 1996. Schooling dynamics of Norwegian spring spawning herring (*Clupea harengus* L.) in a coastal spawning area. Sarsia.

4 The relevant noise criteria, as agreed with MMO and Cefas, were identified through reference to Popper *et al.* (2014) and also through reference to the recent ORJIP (2018) study on ‘impacts on fish from piling at offshore wind sites’. It is noted that the ORJIP (2018) study has received a positive response from Cefas. The methodology and results of the underwater noise modelling is fully described in the ‘Underwater Noise Technical Report’ submitted with the application (APP-086).

5 As described in the Fish and Shellfish Ecology ES chapter submitted at application (APP-047), the 207 dB SPL_{peak} criteria was modelled, with a maximum predicted impact range of 330 m. 207 dB SEL_{cum} modelled ranges were predicted to be much more localised (<10 m).

1.2 Context

6 The MMO has provided feedback on the Responses to Relevant Representations and in response to Action Point 17 from ISH 3, which was submitted by the MMO for Deadline 4. As outlined in this feedback, the main outstanding issue regards the underwater noise modelling for spawning herring. Specifically, on advice from Cefas and despite the Applicants response to Action Point 17 submitted for Deadline 3, the MMO are not satisfied that spawning herring can be assumed to have a fleeing speed of 1.5 m/s, and that spawning herring should be considered as a stationary receptor. This is based on the assumption that actively spawning herring will remain stationary and continue to spawn, rather than flee.

7 The Applicant notes that the noise modelling was agreed through the Evidence Plan process and that it is not aware of any new scientific literature to suggest that stationary receptor modelling is required, especially given the stage of the project in Examination. Furthermore, as identified previously in this document scientific literature identifies a mean swimming speed during the spawning season which is directly comparable with the flee speed utilised in this document. This underlines the precautionary nature of the assessment.

8 Within Deadline 4 submissions the MMO notes:

'The MMO has reviewed the applicant's position set out in its deadline 3 submission in response to action point 17. This remains an item under discussion in the SoCG. The MMO's position is unchanged from that stated in its relevant representation where the MMO advised that it is not aware of any empirical evidence that fish will flee from the source. It is therefore not appropriate to use an assumed fleeing speed to calculate the impact ranges based on SELcum thresholds, and the noise modelling for SELcum should be undertaken based on a stationary receptor. 1.2.2 A generic fish swimming speed of 1.5m/s, rather than fleeing speed was used by the applicant based on a publication by Hirata K, (1999)[2] which considers swimming speeds of various fish species. This is not empirical evidence that fish will flee from the source. There is some evidence that fish will respond to loud noise and vibration, through observed reactions including; schooling more closely, moving to the bottom of the water column, swimming away, and burying in substrate (Hawkins et al. 2014)[3]. However, this is not the same as fleeing, which would require a fish to flee directly away from the source over the distance shown in the modelling.'

9 Therefore, the MMO do not agree that significant impacts to spawning herring can be ruled out, and that additional modelling is required, assuming no fleeing speed, or further mitigation should be considered. This mitigation would be in the form of seasonal restrictions (November – January for the Autumn spawning Downs/Eastern Channel stock; and February – April for the spring-spawning Thames/Herne Bay stock). This seasonal restriction would equate to over four months, but the MMO note that the use of bubble curtains could be used to reduce this seasonal restriction.

1.3 Applicant Response

10 It is the position of the Applicant that the assessment has adequately presented noise metrics that are appropriate and were agreed with the relevant stakeholders through the formal EP process following receipt of scientific advice, and that the impact ranges are sufficiently small to negate the need for further mitigation either in the form of seasonal restrictions or the use of bubble curtains.

11 However, since receiving feedback from Cefas and the MMO, advising additional modelling of spawning herring as a stationary receptor (considered using cumulative noise metrics; SEL_{cum}), this has been undertaken by the Applicant. This is despite the scientific literature identifying herring swim speeds to be in line with that considered within the assessment, and despite previous agreement with the MMO and Cefas under the EP process.

[2] Hirata K (1999). Swimming speeds of some common fish. National Maritime Research Institute (Japan). Data Sourced from Iwai T, Hisada M (1998). Fishes – Illustrated Book of Gakken (in Japanese), Gakken

[3] Hawkins, A. D., Roberts L., and S. Cheesman (2014a) Responses of free-living coastal pelagic fish to impulsive sounds, J. Acoust. Soc. Am., 135, PP3101-3116

12 The re-modelled impact ranges are described in Table 1 and are illustrated against the herring spawning grounds in Figure 1.

13 Of particular relevance with respect to the comments raised by the MMO are the metrics for:

- damage to eggs and larvae (210dB SEL_{cum});
- potentially mortal injury to adult fish (207dB SEL_{cum});
- recoverable injury to adult fish (203dB SEL_{cum}); and
- temporary threshold shift (TTS) in adult fish of 6dB (186dB SEL_{cum}).

14 It should be noted that the metrics presented above are for species which are considered to be particularly sensitive to underwater noise, with those species which are considered less sensitive thought to be affected by potential mortal injury, recoverable injury and TTS at an undefined noise level above these metrics (i.e. with a reduced range of effect).

15 The Applicant notes that the MMO are concerned that if fish do not flee, and as such the SELcum metric not sufficiently precautionary, there may be potential that the impact ranges for underwater noise may extend further from Thanet Extension and be more likely to interact with the main components of the spawning grounds for herring and overlap with a greater proportion of the sole spawning grounds.

16 As demonstrated Figure 2, even when considering a static receptor, the only metric which has the potential to overlap with the areas of higher importance for herring spawning is TTS (East Channel stock only, the Herne Bay stock is sufficiently far away to be outside any modelled impact ranges), with a slight overlap (2.62km^2) with the 207dB SELcum metric. This latter sum, when considered in the context of the spawning potential calculations presented in Annex A to this submission results in a worst case impact of 0.007% on spawning potential. As such, the Applicant considers that the conclusions of the ES remain unchanged with respect to any potential injury effects to fish or eggs and larvae, even when considering a static receptor.

17 The Applicant notes that TTS is a non-lethal, non-permanent impact where the hearing ability of herring is thought to be temporarily reduced. There have been no studies to date that have examined the frequency range within which underwater noise from piling may cause TTS in herring and it is further not known whether this would even be within the effective hearing range of herring.

18 The authors of the paper from which the impact metric thresholds detailed in paragraph 9 above identified research questions which would further aid in the update of these metrics, one of which was: Does TTS matter, especially if it is only a few dB (e.g., less than 6 dB) and brief? (Popper *et al*., 2014).

19 Furthermore, Popper *et al*. (2014) noted that in the studies from which the metrics were derived, TTS of up to 20dB in fish was recorded and recovery from this was completed within 18 – 24 hours). The 186dB SEL_{cum} metric is defined as the point at which TTS of 6dB occurs. Since recovery from a TTS of 20dB occurred within 18 – 24 hours, it is to be expected that recovery from a lower TTS impact would be more rapid (as there would consequently be less hearing damage to recover from).

20 As such, while a small number of the adult herring may be present within the higher importance spawning areas subject to the TTS impact ranges, recovery would be expected to occur within 24 hours at the most. This assumes that the herring would not choose to move in order to avoid the source of disturbance, at a speed which aligns with an average swimming speed during the spawning season.

21 In addition to the above, the Applicant notes that, while the static TTS ranges overlap with the higher importance spawning grounds, the core of the active spawning area for herring is still far outwith the TTS range from piling at Thanet Extension (Figure 2). At this range, for a demersal (seabed) spawning species the impact ranges are likely to be highly precautionary as the topography and rugosity of the seabed will attenuate the noise and therefore ameliorate the effect.

22 The Applicant notes that the MMO also raised the potential for behavioural effects from underwater to impact on herring spawning. There are no recommended metrics for which to quantitatively assess the potential behavioural impacts of underwater noise on herring (Popper *et al*., 2014) and therefore, behavioural effects must be assessed qualitatively as presented in the ES.

23 It is accepted that herring show a highly varied reaction to disturbances depending on the activity they are involved in (Skaret *et al*., 2005). Specifically, herring are considered to be potentially less responsive to noise when involved in either feeding or actively spawning compared to when generally swimming. It is noted that literature also identifies that mean swimming speeds during this period are in the region of 1.44 m/s. This variation in reaction is considered to be due to a balance between predator avoidance (i.e. survival) and biological imperatives (i.e. feeding to maintain energy or spawning to pass on genetic material).

24 Therefore, it is considered that behavioural impacts are unlikely to significantly impact on spawning activity and that the conclusions of the ES in respect to behavioural impacts remain unchanged. In the event that noise levels were realised there would be no physical injury to either adult fish, eggs or larvae as a result of the interaction, and as such any behavioural reaction would be negligible at most.

25 In response to the MMO's D4 submission in which they request further information regarding noise impacts to sole, see the Applicant's response in Appendix 5 of this D4c Submission for responses, the Applicant has also produced an Annex to this document (Annex A to Appendix 7 to the Deadline 4C submission), detailing a the extents of 'spawning potential' for sole and herring, as a way of contextualising the spatial interaction with spawning grounds in terms of the temporal overlap with spawning periods for these species. As detailed in Figure 6-4 of the Fish and Shellfish ES chapter (APP-043), the development is located within high intensity sole spawning grounds as defined by Ellis *et al.,* 2012.

26 Taking the worst-case modelled range at 186 dB SELcum, and assuming that an adult fish will not respond to the stimulus this covers an area of approximately 1,224 km^2, the effect on spawning potential for sole is limited to 0.786% of the higher intensity spawning grounds in the region (which cover approximately 31,866 km^2). Assuming a more robust approach, which incorporates the likely scenario that the fish will flee the source of noise, the potential impact on sole spawning potential is limited to a maximum of 0.105%. It is noted in the Applicant's response to D4 submissions (Appendix 5 to this D4c submission) that the assessment guidance (Popper *et al*., 2014), that the threshold for TTS onset in species such as sole is >>186 dB SELcum, i.e. a much greater level (smaller range) than for herring and as such the scale of effect is considered to be less in reality and highly unlikely to result in any significant or long term injury.

Table 1 Re-modelled mean noise impact ranges for fish at the modelled locations and noise levels for monopile installation (5,000 kJ hammer energy). Where the maximum/minimum range differs from the mean, these values are indicated in brackets.

Receptor	Criteria	Threshold (dB re 1 µPa^2 s SEL_{cum})	Distance from east monopile location (m)	Distance from south-west monopile location (m)	Overlap with herring spawning grounds (Coull *et al.* 1998)?
Mortality and potentially mortal injury					
Group 1 fish	SEL_{cum}	>219	655 (650-660)	561 (550-570)	No
Group 2 fish	SEL_{cum}	210	2,138 (2090-2,180)	1,682 (1,640-1,720)	No
Group 3 and 4 fish	SEL_{cum}	207	3,082 (2,980-3,180)	2,354 (2,300-2,440)	Yes
Eggs and larvae	SEL_{cum}	>210	2,138 (2090-2,180)	1,682 (1,640-1,720)	No
Recoverable injury					
Group 1 fish	SEL_{cum}	>216	981 (970-990)	819 (810-830)	No
Group 2 fish	SEL_{cum}	203	4,857 (4,490-5,110)	3,547 (3,400-3,740)	Yes
Group 3 and 4 fish	SEL_{cum}	203	4,857 (4,490-5,110)	3,547 (3,400-3,740)	Yes
TTS					
Group 1 fish	SEL_{cum}	>>186	19,542 (14,540-26,610)	12,764 (8,450-15,950)	Yes
Group 2 fish	SEL_{cum}	>186	19,542 (14,540-26,610)	12,764 (8,450-15,950)	Yes
Group 3 and 4 fish	SEL_{cum}	186	19,542 (14,540-26,610)	12,764 (8,450-15,950)	Yes

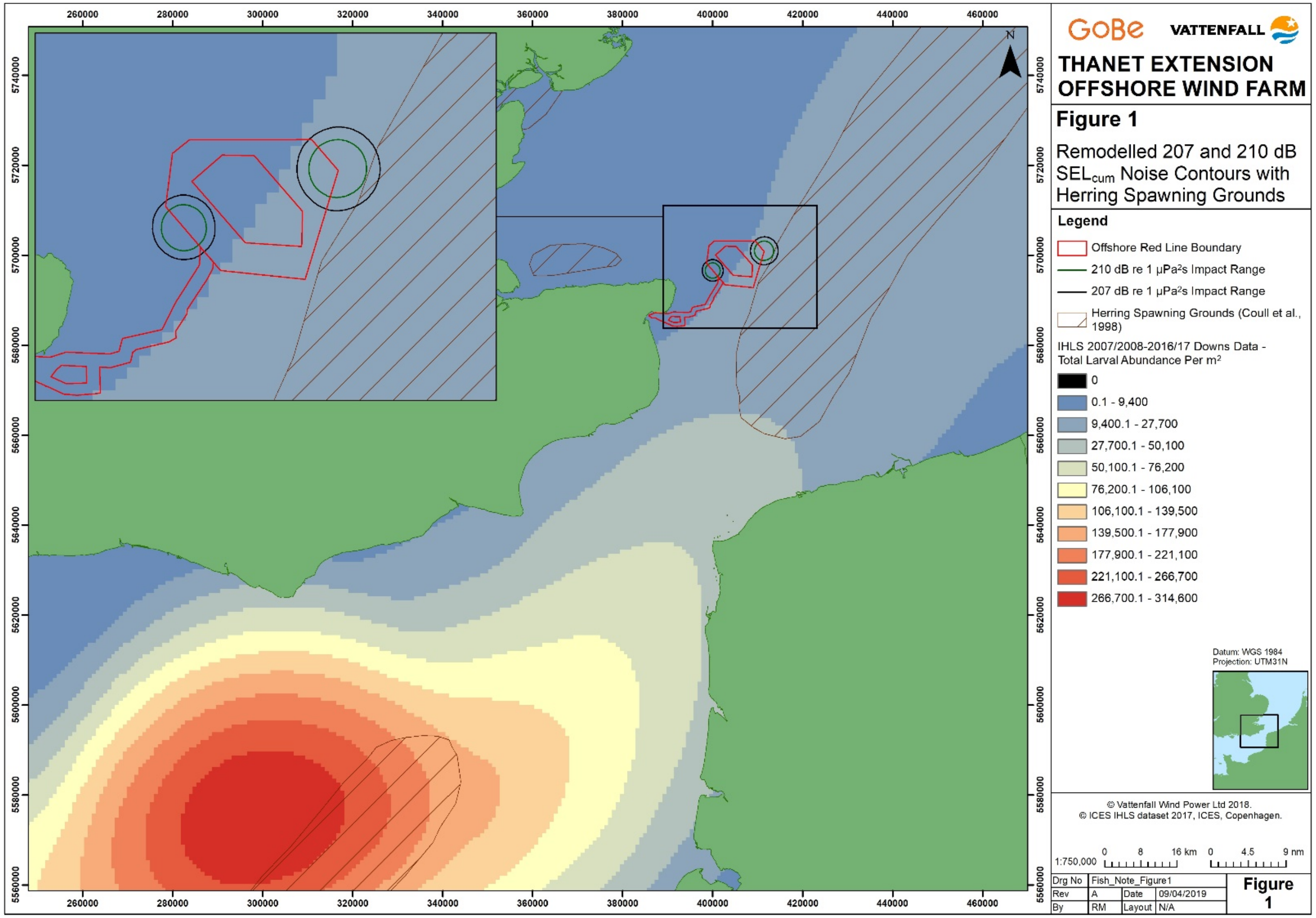

Figure 1 Remodelled 207 and 210 dB SEL_{cum} noise contours against herring spawning grounds.

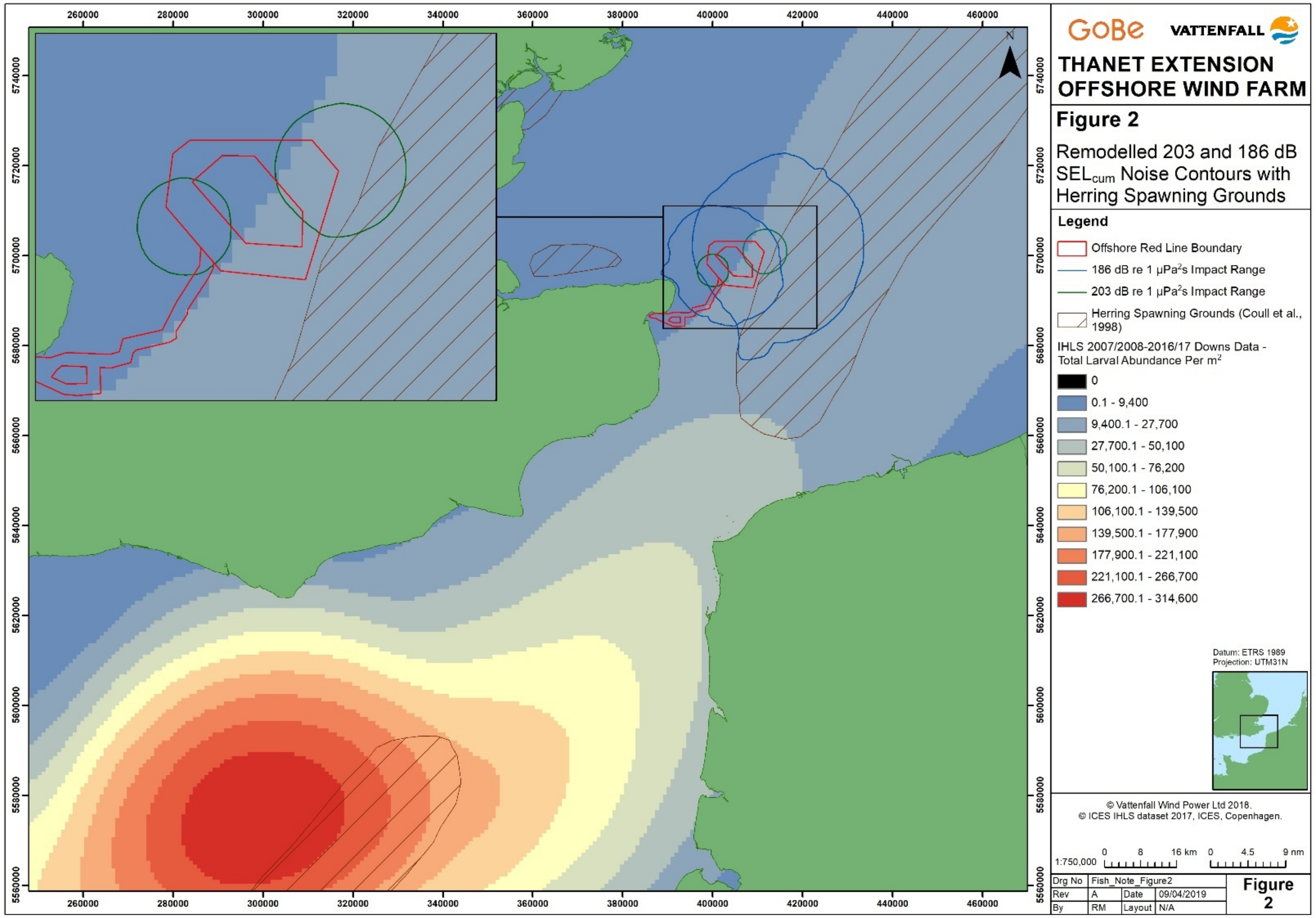

Figure 2 Remodelled 203 and 186 dB SEL_{cum} noise contours against herring spawning grounds.

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27 Notwithstanding the above, the Applicant maintains that a static receptor for fish is inherently unrealistic. Hawkins *et al*. (2014) demonstrated that fish reacted to piling noise (at a lower sound level than that generated from Thanet Extension) and swam out of the detection range of the sonar used in that study. Furthermore, the Hawkins *et al.* (2014) paper referenced by the MMO only records fish either swimming away from the noise source or moving into deeper waters, it did not record fish burying in the substrate. As such, the Hawkins *et al*. (2014) study clearly demonstrated fish taking avoidance action in response to a simulated piling noise.

1.4 Conclusions

28 The Applicant maintains that static modelling of fish is an unrealistic scenario, in so far as fish are known to actively avoid simulated piling noise at a much lower level than that expected close to the piling location (Hawkins *et al*., 2014). Therefore, it remains suitably precautionary to use a “fleeing” model for noise modelling, particularly when the fleeing speed is based on a swimming speed (i.e. a speed which can be comfortably maintained over a long period of time) rather than a startle speed (which may only be maintained over seconds to minutes).

29 However, in light of this re-modelling, it is the position of the Applicant that the impact ranges are sufficiently remote from the Thames/Herne Bay herring stock as defined by Coull *et al*. (1998) (~18 km), that no significant effects on this stock are predicted even when considering a non-fleeing scenario. Furthermore impacts to the Downs stock are also sufficiently low that there will be no significant effect. This is evidenced further with reference to Annex A of this submission which concludes that the worst case effect on spawning potential is 0.049% of spawning potential, reducing down to 0.004% for the most distant piling location. When the more realistic fleeing scenario is considered the total combined effect (for all piling assumed to be in the worst case location) is a 0.2% temporary threshold shift impact on spawning potential, or a 0.005% effect on spawning potential at the worst case location.

30 The Herne Bay stock is not monitored in the same way as the East Channel stock as it spawns at a different time of year to the East Channel stock monitored in the IHLS and therefore Coull *et al.* data has to be relied upon. In addition to this, the stock is outside of the impact ranges identified, the spawning area is located on the other side of the Margate Sands sandbank, which presents a significant barrier which demonstrably attenuates noise (see Figure 2). As regards the Downs/Eastern Channel stock as defined by Coull *et al*. (1998) and refined by ORJIP (2018), the re-modelled 207 dB SEL_{cum} impact range does have a very spatially limited overlap (~2.62 km^2 or 0.007% of spawning potential) with this area. Though as described in the Fish and Shellfish Ecology ES chapter (APP-047), 10-year averaged IHLS data on herring larval abundance for the autumn-spawning Downs stock (as compiled in ORJIP, 2018) has shown that the main spawning area for this stock is further south (Figure 1) and the worst case of 0.007% impact on spawning potential is inherently precautionary when considered in this context.

31 As such, it is the position of the Applicant that this remodelled scenario does not represent a substantial change to what was assessed in the ES and there is no change in effect significance. Therefore, the assessment conclusion that there would be no significant effects (in EIA terms) to fish and shellfish receptors from underwater noise remains appropriate.

32 In conclusion the Applicant has provided the information requested by MMO and considers the results to demonstrate that the impacts associated with the proposed project are not significant and that as such any mitigation such as a seasonal restriction or bubble curtain would be disproportionate to the scale of effect and would have no material benefit.

1.5 References

Coull, K.A., Johnstone, R., and S.I. Rogers. 1998. Fisheries Sensitivity Maps in British Waters. Published and distributed by UKOOA Ltd.

Hirata (1999). Swimming Speeds of Some Common Fish. National Maritime Research Institute.

Offshore Renewables Joint Industry Programme (ORJIP) (2018). Impacts on fish from piling at offshore wind sites: collating population information, gap analysis and appraisal of mitigation options.

Skaret, G., Axelsen B.E., Nøttestad, L., Ferno, A. and Johannessen, A. (2005). The behaviour of spawning herring in relation to a survey vessel. ICES Journal of Marine Science, 62: 1061e1064 (2005) doi:10.1016/j.icesjms.2005.05.001.