



MARINE COASTAL ACCESS ACT (2009). REVIEW OF THE MONITORING PLAN FOR THE SOUTH BANK QUAY PROJECT (PHASE 1) ON THE RIVER TEES BY SOUTH TEES DEVELOPMENT CORPORATION

Reference Number: MLA/2020/00506 L/2021/00333/1

From: Maria Gamaza
Cefas, Lowestoft Laboratory
Date: 1st June 2022

To: Fern Skeldon - MMO (via MCMS)
Cc: Fisheries Advice
Joe Perry - SEAL Case Officer

1. With reference to the above application to review the monitoring plan for the South Bank Quay Project (Phase 1) by South Tees Development Corporation and your request for comments dated 4th May 2022, please find my comments below.
2. This minute is provided in response to your advisory request in relation to the above proposal in my capacity as scientific and technical advisor for fish and fisheries. The response pertains to those areas of the post-application request that are of relevance to this field. This minute does not provide specialist advice regarding benthic ecology, marine processes, shellfisheries, or underwater noise as, whilst these are within Cefas' remit, they are outside my area of specialism.
3. In providing this advice I have spent 7.5 hours of the allocated 7.5 hours by the MMO. I have booked my time to MLA/2020/00506 L/2021/00333/1; C8509.

Documents reviewed

4. South Bank Quay Phase 1 (MLA/2020/00506) Monitoring plan. Royal HaskoningDHV UK Ltd. 25 March 2022.
5. Additional documents reviewed:
 - 5.1. South Bank Quay, EIA Report, Royal HaskoningDHV, 6 November 2020
 - 5.2. The effects of turbidity and suspended sediments on ESA-Listed Species from Projects occurring in the Greater Atlantic Region, NOAA Fisheries (2018).

Description of the proposed works

6. South Tees Development Limited (STD L) hold a marine licence (ML: L/2021/00333/1) for Phase 1 of the South Bank Quay project (reference MLA/2020/00506). As part of the ML conditions (see **Annex 1** for further details), STD L must seek approval from the Marine Management Organisation (MMO) at least 10 weeks prior to the commencement of any dredging activities (condition 5.2.7) which will only be granted providing only 1 dredge campaign is taking place at a time (condition 5.2.8). Additionally, if permission is granted to dredge during 1st July to 31st August, dissolved oxygen levels must be monitored prior the dredging activity (condition 5.2.9) and dredging must be limited to working on one side of the river at a time (condition 5.2.10).

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7. This monitoring plan has been prepared to present alternative mitigation to allow both maintenance and non-maintenance dredging to proceed during the months of July and August (i.e., it seeks to provide alternative acceptable mitigation to that stipulated in Condition 5.2.8) as well as to replace that required for Condition 5.2.9.
8. In providing my advice I have considered previous Cefas fisheries, underwater noise and bioacoustics, and sediment specialists advice comments for Tees South Bank Quay project¹.

Responses to Questions posed by the MMO Case Officer. Note that all responses are observations unless otherwise stated.

To the attention to the MMO case officer only: Regarding this consultation, and to reinforce our latest comments¹, I would like to highlight the following points i – vii, related to the case history and current stance of advice on salmonids within the Tees:

- i. Please note that our previous recommendations¹ were related to avoiding piling and dredging works during key migratory periods for salmonids (i.e., from late March to August – please see **Annex 2** for further details) due to outstanding uncertainties of multiple dredging and piling activities occurring simultaneously within the Tees estuary as the consequences to fish populations, particularly salmonids, resulting from potential impacts (e.g., increased suspended sediment concentrations, poor water quality and underwater noise causing an acoustic barrier to fish movement) remain unknown (see **Annex 2**).
- ii. Thereafter, Cefas SEAL advisors were consulted by the MMO and provided a response² to a request from Royal Haskoning to conduct dredging during the seasonal restriction stipulated in the Marine Licence conditions. However, it should be noted that Cefas fisheries advisors were not party to this Consultation or further consultations on this issue. Therefore, we have not had the opportunity to advise on the appropriateness of these conditions.
- iii. Nonetheless, the SEAL case officer did liaise with fisheries advisors during their last consultation in March² to seek our thoughts. Risks to salmon receptors were highlighted, additional mitigation measures were recommended, and further information was requested. However, to the best of my knowledge, we have not received further response to this.
- iv. More recently, STDL submitted a scheme of monitoring proposal for examining dissolved oxygen (DO) concentrations and turbidity at two monitoring locations close to the boundaries of the dredge footprint. Cefas fisheries advisors provided comments on the monitoring proposal and highlighted concerns in writing to the MMO (see advice minute¹ dated 19th March 2022 by Maria Gamaza), but, to date, no further response has been received.
- v. Therefore, based on our current knowledge and the evidence presented at this stage, outstanding concerns remain on the consequences to fish stocks, particularly migratory fish species, from cumulative impacts (i.e., noise and SSC) from simultaneous/sequential dredging and piling operations occurring in the Tees. In this regard, based on the strong likelihood and risk of the proposed dredging/piling activities to overlap with the peak salmon migration which are likely to cause an acoustic/physical barrier and behavioural effects that may prevent or delay migration, I cannot support either the dredging works being conducted during peak migration times for adult salmonids in the Tees, nor the proposed monitoring.

¹ Advice references MLA/2020/00506 L/2021/00333/1 dated 19th March 2022; MLA/2020/00506 dated 5th February 2021, and MLA/2020/00506 consultation 2 dated 13th April 2021 by Maria Gamaza.

² Advice reference MLA/2020/00506/1 L/2021/00333/1 dated 1st March 2022 by Joe Perry.



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- vi. However, whilst I do not support dredging activities to be undertaken within the Tees during the peak migration times (May, July-August) for those protected and sensitive species such as salmon and European eel, I have provided a brief response to your questions below. Please note that specific requirements and best practice related monitoring of dissolved oxygen, turbidity and suspended sediment concentrations (SSC) levels falls outside my remit as a fisheries advisor. In my opinion, due to the sensitiveness of the fish receptors and ongoing dredging/piling works in the Tees, any monitoring programme should be agreed by relevant experts in the field including representatives from Cefas Salmon and Freshwater team, SEAL advisors, Environment Agency, MMO, Licence holders in the Tees and other statutory / non-statutory parties.
- vii. Without new evidence or a response to previous comments being provided, Cefas' advice is not likely to change. Any decision regarding the implementation of the recommended mitigation and or monitoring must be made by the Licensing Authority.

Monitoring

MMO Question 1. Are the objectives of the monitoring set out appropriately within the report?

9. Yes, the objectives of the monitoring are clearly stated within the document provided for review. For instance, STDL is proposing additional monitoring of SSC by installing two monitoring buoys (see Figure 1) at least one week prior to dredging commencing to recover baseline readings. During this period, turbidity, temperature and dissolved oxygen will be recorded as well as water samples be collected and sent for analysis to develop the correlation graph and determine an appropriate baseline (see response to question 3 for further details).

MMO Question 2. Are the specifications for the survey appropriate and follow best practice where available?

10. As the monitoring is designed to monitor turbidity and SSC this is beyond my expertise as a fisheries advisor.

Major Comments

11. In my opinion the proposed monitoring is not sufficient to prevent or reduce significant impacts to sensitive fish receptors (please see comments 18-25). Nonetheless, I defer to colleagues with specialisms in coastal processes and sediment transport, to comment on the appropriateness of the proposed monitoring specifications related to their expertise.
12. Additionally, due to the importance of the fish receptors potentially being affected by the large volumes of dredging currently occurring in the Tees, either simultaneously or in sequence, the MMO may wish to liaise with other relevant experts in the field including representatives from Cefas Salmon and Freshwater team, SEAL advisors, Environment Agency as well as other developers in the Tees to agree on a suitable monitoring programme and mitigation measures.

MMO Question 3. Are the specifications for the survey appropriate for addressing the objectives of the monitoring?

13. Generally, yes. I note that two monitoring buoy locations (at each side of the estuary) have been proposed based on the results of the sediment plume modelling that was undertaken as part of the Environmental Impact Assessment (EIA) (see Figure 1)
- Site 1: this site would reflect concentrations of suspended solids on the east side of the channel.



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- Site 2: this site would reflect concentrations of suspended solids on the west side of the channel.

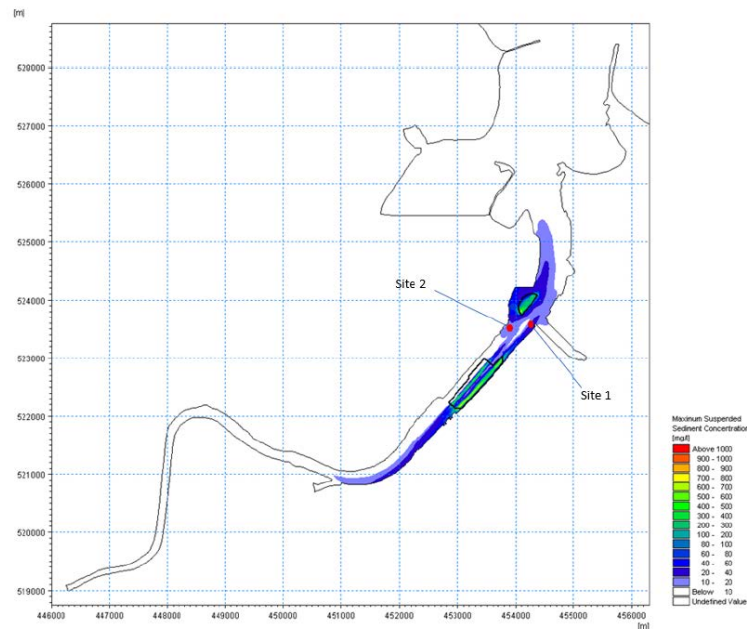


Figure 1. Proposed monitoring buoy locations (extracted from Figure 2-3, documents reviewed, point 4).

- The buoys will monitor turbidity, temperature and dissolved oxygen in real time and the data will be automatically transmitted from each buoy to a secure system online for access avoiding the need to physically recover the buoy to retrieve the data.
- Data analysis: The monitoring plan (documents reviewed, point 4) include a review of SSC (critical stress) threshold levels for fish receptors (e.g., Atlantic salmon) based on NOAA (2018). Based on these thresholds (see **Annex 3**) the proposed approach is to determine trigger values against which monitoring can be compared and active management implemented, if required. Both thresholds and trigger values are based on SSC. However, due to logistics and time constraints, to quantify SSC, the licence holder is proposing to measure turbidity instead and produce a correlation graph³ prior to monitoring to allow translation of turbidity into SSC on a site-specific basis. A specialist contractor will be used to deploy the buoys and collect the water samples. The monitoring buoys will remain in place during the dredging and for one week after dredging has been completed.
- Monitoring and management strategy: It is proposed that comparisons of SSC are made between the two monitoring buoys and their determined baseline (collected prior to dredging commencing). If both buoys show an increase in 50mg/l over baseline for more than 24 hours, indicating an effect across the width of the estuary, then the following management actions will be put in place:
 - Adjust the overflow position of the dredger;
 - Minimise the de-watering process

³ The correlation graph will be created by collecting water samples for analysis for both turbidity and SSC and the results plotted to determine the relationship between the two parameters.

If the difference falls below 50mg/l for one or both of the buoys, then the dredging can recommence without the management actions in place.

If either of the buoys measures a concentration of 1000mg/l continuously for two hours, then it is proposed that dredging temporarily pauses for a period of six hours (a tidal cycle). If SSC do not return to below 1000mg/l after six hours, it is proposed that dredging re-commences rather than wait for levels to return to below 1000mg/l if one of the buoys indicates concentrations of lower than 50mg/l. The reason being is that if one side of the channel is relatively unaffected then fish can still migrate.

17. Reporting: All recorded data will be collated and summarised in a short report alongside dredging activity logs. This data will be shared with the EA upon completion of the licensed activities (no later than 10 working days). The MMO will also be sent a copy within seven days of the data being issued. The full report will be provided within two months of dredging activities being completed.

Major comments (all below)

18. There are a number of uncertainties with the proposed monitoring that prevent me from supporting it. For instance, it is unclear what the timescale will be for undertaking the data analysis (e.g., determine SSC levels from turbidity measures) and for reporting these results, plus the time required for the results to be reviewed by a relevant specialist and/or regulator (e.g., EA experts/MMO) to determine if the reported levels of DO and SSC from dredging operations are considered critical/lethal to migratory species. It should be noted that the NOAA (2018) report states: “*Studies evaluating higher levels of TSS (>100 mg/L) demonstrated higher levels of mortality even with relatively low exposure durations (e.g., 26-75% mortality at 100-120 mg/L in under 3.5 days of exposure) (Wilber and Clarke 2001). ‘Behavioural and sub-lethal effects occurred in adult fish during 24 hours of exposure to suspended sediment up to 1,000 mg/L. One study demonstrated 10-25% mortality occurring at the one-day mark at about 500 mg/L. Aside from this study, adults appeared to tolerate exposure to TSS below 1,000 mg/L for up to 10 days, after which mortality began to occur’.*” Therefore, considering the 7-10 working days window (as per comment 17), in my opinion, by the time the results are analysed by experts and action is taken, migratory salmon could potentially have already been impacted, or migration impeded.
19. In line with my previous comment, I am not entirely confident with the response time for informing management decisions if an increase in SSC of 50mg/l-over-baseline for more than 24 hours has occurred. In addition, it is unclear how much over the 50mg/l-over-baseline SSC will reach before a decision is made. Could SSC be allowed to increase all the way up to 1000mg/l before a decision is made? Assuming undeniable behavioural effects occur during dredging operations (with reported peaks up to 350 mg/l, see comment 23 below), regarding management strategies, it is my understanding that dredging will carry on (see comment 16), even when a threshold limit of up to 1000mg/l has been reached or even when one of the buoys’ SSC levels does not return to below 1000mg/l after six hours monitoring. In my opinion, this is an unacceptable risk as behavioural injury from cumulative exposure to dredging should not be dismissed, as evidence shows this can be reached at small SSC levels over the baseline.
20. Related to the evidence base used to support the monitoring proposal, having read the NOAA (2018) report, I note that “*behavioural changes for adult and juvenile salmonids combined begin to occur at relatively low TSS levels around 20 mg/L after one hour of exposure (avoidance response)*”. And “*If animals remain exposed*”, which is likely the case of migratory salmonids in the Tees, “*to elevated TSS levels, sub-lethal effects begin to occur with major physiological stress occurring at approximately 1,100 mg/L for 24 hours of exposure (see Figure 2). However,*



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this exposure can cause physiological effects that could have long-term implications (e.g., long-term reduction in feeding rates or success, poor condition, reduction in fecundity)".

21. Furthermore, the NOAA (2018) report suggests that water temperature and DO levels in the project area during the time of the activity should be taken into account as "Stressful temperature and dissolved oxygen levels could exacerbate the stress an animal may be experiencing from changes in turbidity and TSS, making them less tolerant of sediment concentrations at lower than normal levels". However, to the best of my knowledge, how these parameters will be considered within the data analysis and report has not been stated within the proposal submitted by the Licence holder.

Juvenile and Adult Salmonids												
Concentration (mg SS/L)	162,755	10	11	11	12	12	13	14	14	-	-	-
	59,874	9	10	10	11	12	12	13	13	14	-	-
	22,026	8	9	10	10	11	11	12	13	13	14	-
	8,103	8	8	9	10	10	11	11	12	13	13	14
	2,981	7	8	8	9	9	10	11	11	12	12	13
	1,097	6	7	7	8	9	9	10	10	11	12	12
	403	5	6	7	7	8	9	9	10	10	11	12
	148	5	5	6	7	7	8	8	9	10	10	11
	55	4	5	5	6	6	7	8	8	9	9	10
	20	3	4	4	5	6	6	7	8	8	9	9
	7	3	3	4	4	5	6	6	7	7	8	9
	3	2	2	3	4	4	5	5	6	7	7	8
	1	1	2	2	3	3	4	5	5	6	7	7
		1	3	7	1	2	6	2	7	4	11	30
		Hours			Days			Weeks		Months		

Figure 2. Average severity effects (SEV) for juvenile and adult salmonids (extracted from Figure 1, NOAA (2018) report). Cell highlighting: green = behavioural effects, yellow= sub-lethal effects, red= lethal and para-lethal effects. Dashes mean 'no data'.

22. Data limitations have not been acknowledged within the proposed monitoring. For example;

- The suitability of converting turbidity measurements into SSC.
- The thresholds proposed for use are based on a proxy species, as per NOAA (2018).
- Differences between the experiments used as supporting evidence by NOAA which had variable sediment concentration levels, exposure durations and an ability for fish to vacate the area.

23. Within the EIA report, I note that it states "In the vicinity of the proposed scheme (i.e., in the Tees Dock area) SSCs are, for the most part, less than 20mg/l with short-term peaks from 40 to 80mg/l (Royal Haskoning, 2006)" which are considered to be clear waters by NOAA (2018). However, it was recognised in the EIA (section 6.5.2) that SSC during dredging operations can reach 100 to 200 mg/l with peaks up to 350 mg/l. When considering the worst-case scenario (i.e., maximum enhanced SSCs and riverbed thickness) from the four modelled dredging phases set out in Section 6 of EIA report (documents reviewed, point 5.1, see **Annex 4**), the maximum area affected by increased SSC includes the entire width of the Tees, meaning that there is the potential for a cross-sectional area of the river to be influenced. Furthermore, it has been acknowledged that suspended sediment will fall to the riverbed within the dredged areas from where it will be re-dredged to achieve the necessary bed depths, implying additional volumes of dredging occurring in sequence. I also note that the EIA report concludes that the



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plume effects arising from dredging will be observed continuously, throughout the whole dredging period of 4 months.

24. Furthermore, cumulative effects were only considered to occur if all proposed dredging works for other facilities within the Tees coincide, which was considered unlikely by the Applicant at EIA stage. However, during the EIA review, concerns were raised by Cefas specialists^{1,4} regarding cumulative effects resulting from the proposed dredging works at Tees South Bank with other construction-related and maintenance dredging within the Tees, as even if they do not coincide, then there is still the prospect of very large volumes of dredging occurring in sequence, with the stated consequence of an increase in maintenance dredging in the future.
25. Taking into consideration the EIA findings and the NOAA (2018) report (as latest evidence provided by the licence holder to support the proposed monitoring), due to current uncertainties with the monitoring programme (as per comments 18-23), the large volumes of sediments to be extracted in such a small channel, the large number of ongoing dredging operations occurring simultaneously, or in sequence, in the Tees, the unlikely avoidance reaction of migrating salmonids during the peak migratory season, the fact that the proposed dredging operations will also add additional acoustic disturbance⁵ into the river which has not been considered at all within the proposed monitoring, I have outstanding concerns that localised increases of SSC will create a physical barrier affecting salmonid migration during peak season. Also, the authors of the NOAA (2018) reported *'Due to their critical population status, we suggest avoiding, if possible, sediment-generating activities and TSS exposure in areas and times when Atlantic salmon may be present'*.
26. In my opinion, due to the number of dredging activities occurring in the Tees at the moment, including regular maintenance dredging and other works undertaken under the Harbour Revision Order (HRO) held by PDT, careful consideration should be given to dredging/piling operations occurring simultaneously in the Tees.

MMO Question 4. Is there a need to continue each piece of monitoring or can some parts be terminated?

27. Question not applicable at this stage. The document reviewed is in relation to monitoring being proposed.

MMO Question 5. Are any changes to the proposed monitoring programme needed?

28. Please refer to comments 13-17 as we have concerns regarding the proposed monitoring which should be considered by the MMO.
29. Consideration by the MMO should be given as to how the proposed monitoring will be committed to by the Applicant and compliance monitored by the MMO.

MMO Question 6. Minor presentational comments if they affect the conclusions or overall confidence in the findings

30. It is not clear how conclusions on short lived peaks (ca. one hour) have been concluded from Figure 2-2 presented in documents reviewed point 4.

Summary

In my opinion, due to the importance of the fish receptors potentially being affected by the large volumes of dredging currently occurring in the Tees and based on our current knowledge and the

⁴ Advice reference MLA/2020/00507, dated 19th January 2021 by Steve Wallbridge

⁵ Advice reference MLA/2020/00506 & MLA/2020/00507 dated 8th February 2021 by Rebecca Faulkner.



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evidence presented at this stage, the proposed monitoring is not sufficient to prevent or reduce significant impacts to sensitive fish receptors (please see comments 18-25). In this regard, I believe that any monitoring programme should be agreed by relevant experts in the field including representatives from Cefas Salmon and Freshwater team, SEAL advisors, the Environment Agency, MMO, Licence holders in the Tees and other statutory / non-statutory parties.

Maria Gamaza
Fisheries Regulatory Advisor

<i>Quality Check</i>	<i>Date</i>
Joe Perry	01/06/2022



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Annex 1. Marine Licence conditions relevant to this consultation request

Condition 5.2.7 states that *'The dredging activities approved by this licence may not commence until such a time as a scheme of monitoring has been submitted to, and approved in writing by, the Marine Management Organisation. This must be submitted at least 10 weeks prior to the commencement of activities.'*

The scheme shall include:

- *Baseline assessment prior to commencement.*
- *Programme to monitor dissolved oxygen levels and turbidity (where appropriate)*
- *Programme of post-implementation monitoring. The scheme must be fully implemented and subsequently adhered to, in accordance with the timing/phasing arrangements embodied within the scheme, or any details as may be subsequently agreed, in writing by, the MMO.*

If it is deemed that any parts of this scheme are no longer required, written representation must be submitted to MMO for written confirmation prior to dredging works commencing.

Reason: To monitor impacts to water quality during dredging.

Condition 5.2.8 states that *'No dredging not covered under statutory harbour authority powers can be conducted during the period from 1st July to 31st August (inclusive) without written permission from the Marine Management Organisation (MMO). Permission will only be granted if agreement has been reached that only 1 dredge campaign is taking place at this time. No other dredging will take place on the River Tees during this period'*

Reason: To avoid impacts during peak migration times for species as Atlantic Salmon and European Eel'

Condition 5.2.9 states that *'If permission is granted by the MMO to undertake dredging operation during 1st July to 31st August (inclusive), dissolved oxygen levels must be monitored prior to the dredging activity, as a minimum, monitored every hour during the dredging activity. If a drop of 1m/g of dissolved oxygen is observed, then the dredging activity must temporarily pause for a period of 6 hours (a tidal cycle) or until the reading returns to the previously observed level. Recorded data must be shared with the Environment Agency upon completion of the licensed activities, no later than 10 working days after their completion. The MMO must be sent a copy within 7 days of the data being issued.'*

Reason: To maintain, improve and develop all salmon, trout, lamprey, smelt and freshwater fisheries, under the Salmon and Freshwater Fisheries Act. 1975 (SSFA) as modified by the Marine and Coastal Access Act, 2009.'

Condition 5.2.10 states that *'Dredging must be limited to working on one side of the estuary channel at a time.'*

Reason: To restrict suspended sediment plumes to one side of the estuary at a time, in order to reduce loss of tern foraging habitat.



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Annex 2. Rationale (evidence base) to support Cefas fisheries advisors' recommendations.

The Tees Estuary is recognised as the main salmon river in England and Wales with a Salmon Action Plan enforced by the Environment Agency⁶.

In particular, migrating species, such as salmonids, are known to exhibit avoidance reactions and move away from the vicinity of adverse sediment conditions, if refuge conditions are present (Sigler et al., 1984; Bash et al., 2001). This may increase exposure times to anthropogenic impacts (e.g., UWN from piling or SSC from dredging) whilst waiting in refuge areas. The effects of suspended sediment on swimming ability of juvenile brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*) were explored by Berli et al. (2014) who found both species experienced a decrease in swimming performance as turbidity increased due to impairment in the ability of the fish to utilise anaerobic metabolic pathways in high sediment environments. The authors concluded that the ability of salmonids to maintain swimming performance is hindered when fish are exposed to environmentally relevant, suspended sediment-generated turbidities.

The species known to migrate through Tees include salmon, sea trout, European eel, river lamprey and sea lamprey, all of which are listed under Section 41 of the NERC Act 2006 as species of principal importance. Latest EA data⁷ and studies undertaken in the River Tees (e.g., Moore & Potter, 2014), suggest the peak migration times for smolts (salmon and sea trout) to migrate to sea are late **March/April peaking in May** as the river warms up (Moore & Potter, 2014; Riley et al., 2002). Whereas adults migrating upstream peak times are **July-August** (inclusive).

It should be noted that whilst adults' salmonids might have some capacity to swim away back to sea or wait in refuge areas whilst waiting for more favourable conditions, smolts migrating downstream in their way to sea will not probably be able to move upstream again if facing an acoustic or physical barrier. Also, it should be considered transiting migration times through the estuary differ by species and so resident species will not go too far away from the source or noise/SSC; for example, piling driving more impact on sea trout as they reside in estuaries for longer periods of time.

Elevated concentrations of suspended sediment can have the following physical effects on all life stage of fish, particularly salmonids (Salmon & Trout Conservation, 2017) by:

- i. Damage to gills as a result of erosion of the mucus coating and abrasion of tissue (Redding and Schreck, 1982). The extent of damage depends on size and shape of particles, suspended sediment concentration, water velocity and gill dimensions (Appleby and Scarratt, 1989). Fish species have been found with increasing levels of deformities, eroded fins, lesions, tumours, gill flaring and 'coughing', all related to increasing SS in the water column (Berg, 1982; Schleiger, 2000).
- ii. A reduction in feeding and foraging effort by visual predators as a result of increased turbidity (Henley et al. (2000).
- iii. An increase in respiration and heart rate (Redding and Schreck, 1982) and altered blood physiology (Salmon & Trout Conservation, 2017).
- iv. An increase in energy expenditure and reserves resulting from the above impacts is likely to inhibit migration activities for species such as sea trout and river lamprey as they attempt to negotiate estuarine environments on their upstream migrations.
- v. Entrainment of demersal and benthic fish, fish eggs and larvae taken up through the drag head of the dredger.

⁶ <http://www.cpwf.co.uk/salmonstrategy%202009%2021.pdf>

<https://www.gov.uk/government/statistical-data-sets/river-tees-upstream-fish-counts>

⁷ <https://www.gov.uk/government/statistical-data-sets/river-tees-upstream-fish-counts>



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- vi. Potential disturbance caused by underwater noise from the dredging process.
- vii. Reduction in suitable spawning habitat and declines in egg/early life stage success (Salmon & Trout Conservation, 2017)

Settlement of sediment around areas of dredging and disposal can have the following impacts:

- i. Smothering of benthic foraging grounds by settlement of sediment.
- ii. Smothering of benthic eggs and larvae by settlement of sediment.
- iii. Reduced oxygen levels in water due to release of sediments containing high organic matter.
- iv. Exposure to contaminants contained within dredged sediment.
- v. Re-suspension of sediments causes nutrient enrichment promoting the formation of algal blooms, causing a reduction in water quality by decreasing oxygen levels or release of toxins.
- vi. Resuspension of sediments resulting from dredging can smother organisms and hinder growth, feeding and survival rates. (Gilmour 1999).

References

Appleby, J.P. and Scarratt, D.J. (1989). Physical effects of suspended solids on marine and estuarine fish and shellfish with special reference to ocean dumping: a literature review. Canadian Technical Report of Fisheries and Aquatic Science No.1681.

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Annex 3. Threshold levels for exposure duration for adult and juvenile Atlantic salmon (based on NOAA, 2018).

Table 2.1 Thresholds for exposure duration for adult and juvenile Atlantic Salmon (reproduced from NOAA Fisheries 2018)

Threshold	Description	Justification (summarised from paper)
1	<1,000mg/l at any one time and not lasting for more than 3 hours	Represents maximum SSC and exposure duration that salmon can experience without mortality. Threshold is set with the assumption that salmon will move away from the sediment generating activity. If they do not, this threshold exposure for three hours is not expected to result in mortality.
2	<50mg/l (above baseline/ambient concentrations) for no more than 24 hours	Set much lower than 1 because fish become less tolerant of higher SSC as exposure duration increases. Below this level, harmful effects are not predicted.
3	<10mg/l (above baseline/ambient concentrations) for no more than 144 hours (six days) after the first 24 hours of exposure	Much lower than threshold 1 as salmon tolerance is lowered with increasing exposure duration. Set at this level to ensure expected effects are insignificant.



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Annex 4. Combined maximum zone of influence from stages 1-4 of dredging activities (extracted from EIA, documents reviewed point 5.1)

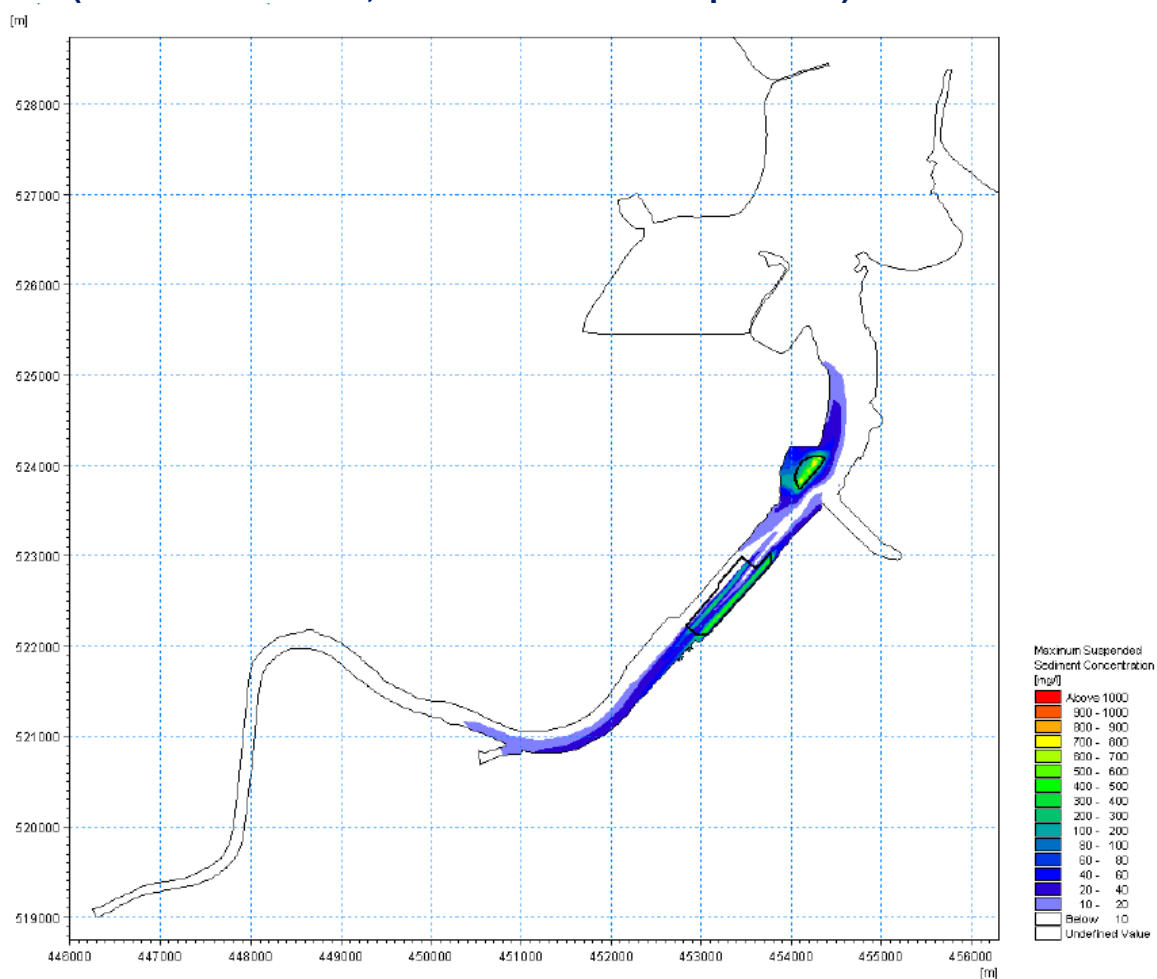


Figure 6.3 Maximum enhanced SSCs (near-bed layer) arising from dredging activities during Stages 1 - 4 inclusive of the capital dredging programme



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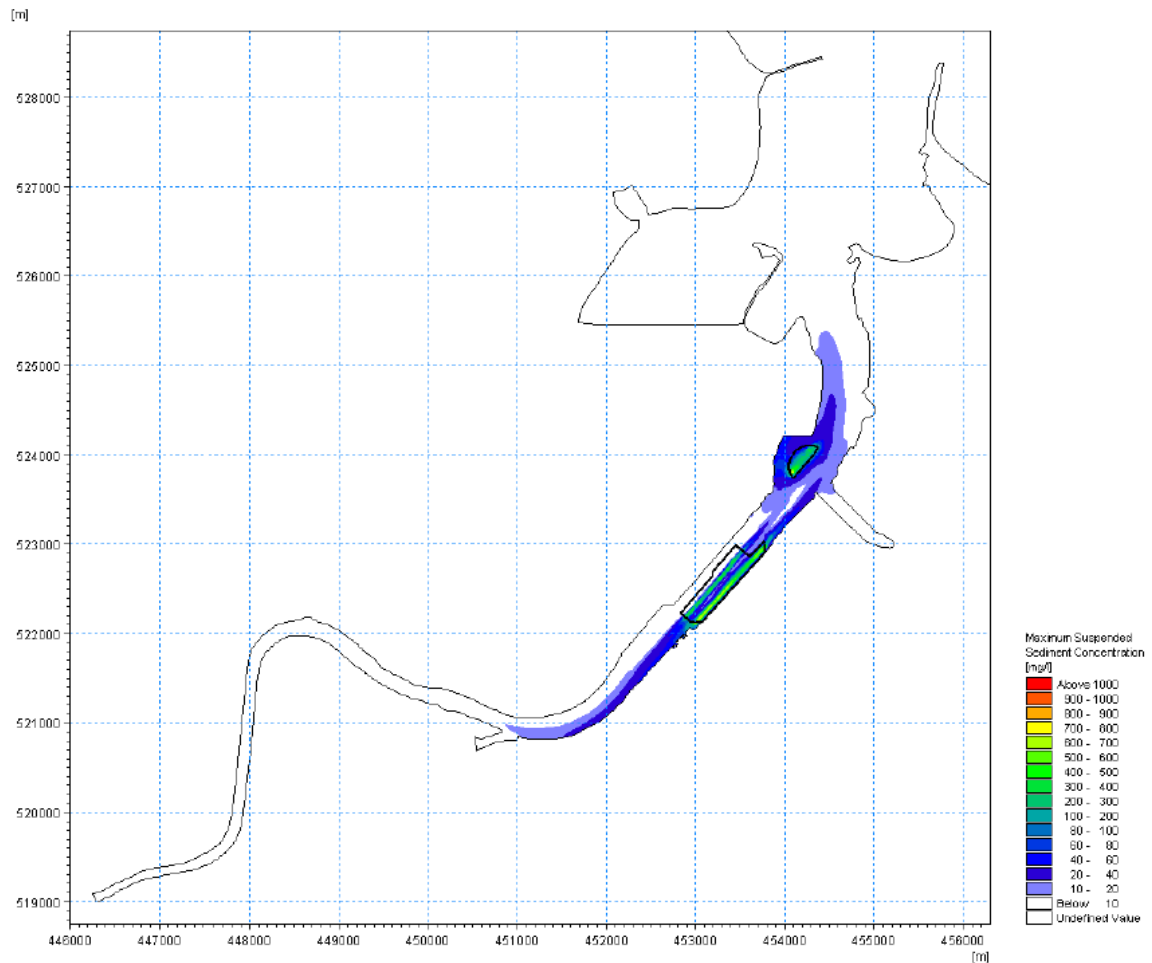


Figure 6.49 Maximum enhanced SSCs (near-surface layer) arising from dredging activities during Stages 1 - 4 inclusive of the capital dredging programme



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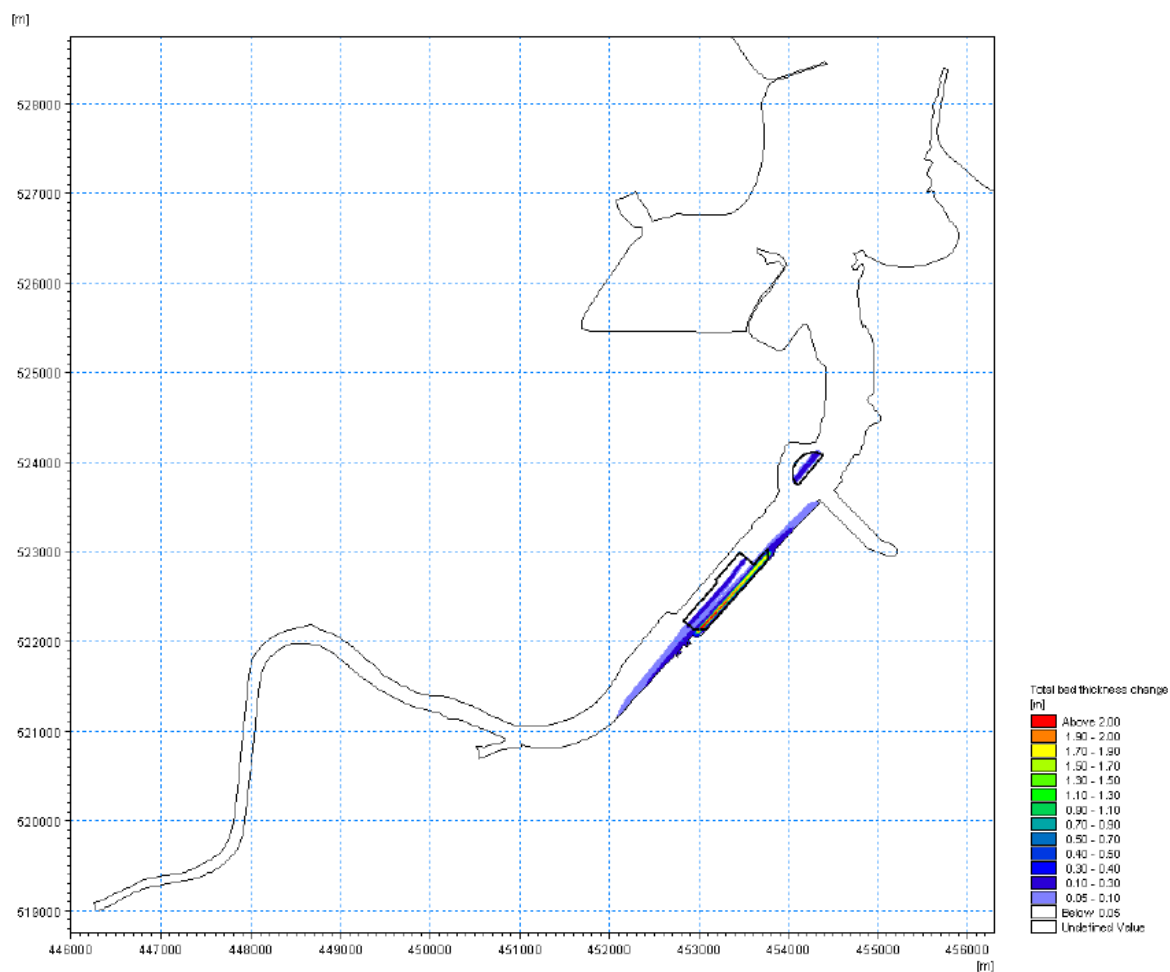


Figure 6.50 Maximum riverbed thickness change due to sediment deposition arising from dredging activities during Stages 1 - 4 inclusive of the capital dredging programme



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