Development of Type-Specific Reference Conditions

Development of Hydromorphological Reference Conditions and Draft Classification Scheme For Transitional and Coastal Waters

Work Package 8: Final Report

Reference number/code SC040037

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Environment Agency
Rio House
Waterside Drive, Aztec West
Almondsbury, Bristol BS32 4UD
Tel: 0870 8506506
Email: enquiries@environment-agency.gov.uk
www.environment-agency.gov.uk

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Author(s):

Freeman, S., Hull, S. (ABPmer)
Whitehouse R (HR Wallingford)

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Research Contractors:

ABP Marine Environmental Research Ltd (ABPmer)
Pathfinder House, Maritime Way, SO14 3AE
Tel: 023 8033 8100

HR Wallingford (HRW)
Howbery Park, Wallingford, Oxon., OX10 8 BA
Tel: 01491 835381

Institute of Estuarine and Coastal Studies (IECS)
University of Hull, Cottingham Road, Hull, HU6 7RX
Tel: 01482 465503

Centre for Environment, Fisheries and Aquaculture Science (CEFAS)
Pakefield Road, Lowestoft, Suffolk, NR33 0HT
Tel: 01502 562244

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Environment Agency's Project Manager:

Andrew Richman, Rivers House, Lower Bristol Road, Bath. BA2 9ES.

Collaborator(s):

CEFAS, DEFRA, EHS (NI), FRS (Marine Lab), SEPA, SNIFFER.

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A Richman Environment Agency Project Manger

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1. Introduction

A consortium comprising ABPmer, HR Wallingford, CEFAS and IECS was contracted to undertake a study to develop hydromorphological reference conditions and a classification scheme for transitional and coastal waters (TRaC Waters), compatible with the achievement of high and good ecological status as required under Article V of the Water Framework Directive. The project was undertaken on behalf of the Environment Agency and the Scotland and Northern Ireland Forum for Environmental Research (SNIFFER).

The project has used current understanding of the inter-relationships between hydrology, geomorphology and ecology to develop a conceptual framework upon which the consideration of hydromorphological reference conditions and classification can be based.

Using this conceptual framework, type-specific reference conditions were defined and a classification scheme developed and tested using case studies. However, because of the considerable limitations in current understanding and availability of data the threshold limits proposed remain largely based on expert judgement.

Over the course of the project a total of eight discrete work packages were conducted and subsequently followed up with separate working papers that were reviewed by the Project Board Group. The eight packages and papers were as follows.

- **Work Package 1:** Literature review, consultation and conceptual framework (working paper 1).
- **Work Package 2:** Development of draft reference conditions (working paper 2).
- **Work Package 3:** Workshop with invited external participation (working paper 3).
- **Work Package 4:** Development of type-specific reference conditions (working paper 4).
- **Work Package 5:** Development of a decision-making framework for managing alterations to the morphology of TRaC waters (working paper 5).
- **Work Package 6:** Development, testing and refinement of a hydromorphological classification scheme (working papers 6a and 6b).
- **Work Package 7:** Identification and collation of supporting datasets (working paper 7).
- **Work Package 8:** Finalisation of outputs (working paper 8).

There were a number of work package specific objectives, which are outlined below. The outputs from WP1 to 7 are appended to this final report.

1.1 Work Package 1

- Assess present knowledge of dynamic hydrological and geomorphological processes (hydromorphology) and their relationship with ecological function for transitional and coastal waters of the UK.
- Identify and review other hydromorphological classification schemes, particularly those that aim to define reference conditions and assess hydromorphological condition and quality classes.

- Review and integrate with ongoing work to define the reference conditions and classification schemes for the biological quality elements (benthic invertebrates, fish and plants).

- Ensure broad consistency with the equivalent project for classifying river and lake systems.

- Ensure that the requirements of the Water Framework Directive are considered and adhered to, with particular attention paid to the hydromorphological elements identified in Annex V (Tables 1.2.3 and 1.2.4) of the Directive.

1.2 Work Package 2 - Draft Reference Conditions

- To derive a set of draft hydromorphological reference conditions for a representative subset of UK coastal and transitional water body types.

1.3 Work Package 3 - Workshop

- To organise and run a workshop involving the Project Board, key members of the Project Team, and individuals with expertise in the fields of transitional and coastal water. Its objectives were to review the work that had been undertaken to date on Work Packages 1 and 2 of the study, and consider issues surrounding the development of hydromorphological reference conditions and hydromorphological classification schemes in order to identify potential ways forward with subsequent work packages.

1.4 Work Package 4 - Draft Reference Conditions

- To ensure the proposed reference conditions take account of the findings of Work Packages 1-3, particularly in relation to the key recommendations arising from the Workshop.

- To develop a draft report defining a set of type-specific reference conditions (hydrological and morphological) for all UK transitional and coastal water body types.

1.5 Work Package 5 - A Decision-Making Framework

Work Package 5 forms part of the work on development of hydromorphological classification for Transitional and Coastal Waters, although the package was redefined during the Steering Group meeting to include the following tasks.

- A review of thresholds used in Article V characterisation.

- A review of thresholds used in FEPA licensing, EIA, etc.

- A review of habitats directive in terms of morphological pressures, in terms of the decisions made.

- All of the above to be dome with a view to clear consistency in terminology.

- Characterising sensitivity in order to provide an initial view on habitat sensitivity, but also addressing morphological sensitivity.

- Characterising hazards of engineering works. This will indicate how hazards to ecology are manifest.

- Production of saltmarsh dataset. This will involve the amalgamation of saltmarsh data from the OS Master map Dataset purchased by the Environment Agency to produce a single saltmarsh tile for Transitional and Coastal Waters in England and Wales. New water body boundaries will then be generated, including the saltmarsh areas.

It was later agreed that initiated scoping for a decision-making framework for managing alterations to the morphology of Transitional and Coastal Waters should be undertaken and presented with a view to possible ways forward.

1.6 Work Package 6 - A Hydromorphological Classification Scheme

Work package 6 was divided into two parts. The first to develop the metrics to support the classification scheme and the second to test them through a number of case studies. However, the broad objectives of the package were as follows.

- To develop a draft hydromorphological classification scheme to quantitatively assess, for each hydromorphological quality element, high status and the level of deviation from high status allowable to achieve good and moderate status.

- To establish the boundary between 'high' and 'good' and if necessary to identify conditions representing only 'minor' anthropogenic disturbances where possible for the boundary between 'good' and 'moderate', conditions must be identified corresponding to 'slight' anthropogenic disturbances.

1.7 Work Package 7 - Identification and Collation of Supporting Datasets

- To collate data and information of relevance to the classification metrics developed in work package 6 and provide a metadata base of all datasets.

1.8 Work Package 8 - Final Report

- To integrate all the findings of each work package towards developing hydromorphological reference conditions and a classification scheme for transitional and coastal waters.

- To provide recommendations and outline specific areas for future work.

This final report summarise the most important aspects of each working package in order not to repeat unnecessary work. It was intended to integrate what has been agreed as the proposed classification scheme to be adopted by the Environment Agency and SNIFFER.

The main body of this report represents the output from Work Package 4 and it is supported by Appendices B to C, detailing the output from Work Packages 1 to 3, respectively.

2. Summary of Work Package Outcomes

For each work package a number of different approaches were undertaken. The following section provides a summary of these methods by work package.

2.1 Work Package 1: Review of Existing Knowledge

- Discussions were held with the Project Board to define more precisely the scope of work (see Working paper 1, Annex A).

- A literature review to provide scientific basis for the conceptual framework.
  A comprehensive literature review was undertaken to:

- Highlight present understanding of hydromorphological (hydrological and morphological) processes.
- To understand their interactions over different spatial and time scales.
- Identify the relationships between hydromorphology and ecology.
- Identify relevant classification schemes that are in existence and may be of use to the study.

- Consultation and advice gathering from independent experts.

- Liaison with biological task team.

A number of methods were examined as a result of these consultations and presented in work package 1 under the following categories (see working paper 1 for more detail).

- Hydromorphological processes and their inter-relationships.

- Relationships between hydromorphological processes and ecological function.

- Existing classification tools and classification schemes.

One of the main results from the literature review was the development of a conceptual framework, which was needed to provide the scientific basis to underpin the development of the classification scheme and reference conditions. Landform was considered the principal integrator of hydromorphological pressures and ecological function.

2.2 Work Package 2 - Draft Reference Conditions

Water Framework Directive Annex V definitions for high, good and moderate hydromorphological status in transitional and coastal waters include statements in relation to the tidal regime and morphological conditions. It was agreed by the Project Board that derivation of reference conditions should be based on these parameters. ECOSTAT (2003) guidance on the overall approach to the classification of ecological status was adopted here (see working paper 2, Figure 1).

To achieve the aim of work package 2 a variety of research-based activities were undertaken following a brain-storming session amongst project team members to develop ideas and outline different approaches to identifying reference conditions. The approach produced preliminary tests of concepts and suggestions for alternative approaches. The following methods were proposed.

- A predictive approach to identifying reference conditions through the coupling of hydromorphological and ecological elements. This could take advantage of the JNCC's existing EUNIS classification scheme for biotopes.

- An ecological modelling approach to predict habitat type and infaunal invertebrate distributions on the basis of hydrological and morphological process parameters derived from numerical models. This used ABPmer's 3D hydrodynamic model for the Humber as a test case.

- An approach to identify reference conditions through the coupling of observed hydromorphological and ecological elements. This approach relied on existing habitat maps within Regulation 33 Advice packages or other spatial plans.

Further detail relating to each possible approach was presented at the Workshop (work package 3).

2.3 Work Package 3 - Workshop

A structured workshop held in December 2004 at HR Wallingford (for agenda see working paper 3, Appendix A) was organised by the project team. A range of recognised experts in

the fields of hydromorphology and ecology were invited and their participation and contributions recorded in working paper 3 (Appendix 1). Through this workshop a number of key themes and approaches were discussed, namely.

- Hydromorphological concepts and classification schemes.
- Links between hydromorphology and ecology.
- The range of different methods potentially available. These were identified in the previous work package 2.
- The way forward for appropriate methods.
- Issues relating to data and monitoring, and the need for an appropriate decision-making framework.

2.4 Work Package 4 - Draft Reference Conditions

Throughout work packages 1-3, potential methods for establishing hydrological and morphological reference conditions were considered. A summary of these is as follows:

- Work package 1 reviewed available scientific literature and applied specialist knowledge to provide a conceptual basis for the development of later stages of the study.
- Work package 2 specifically tested three potential approaches that were then discussed in considerable detail at the Workshop. These methods sought to provide both reference conditions and a basis for hydromorphological classification. Whilst some of these approaches found some favour and were considered worthy of further consideration it was recommended that given the timescales within which output was required and the complexities of these possible methods a considerably more simplified approach was required. The method used in this element of the study was to develop some of the ideas for a more simplified approach that was initially proposed at the Workshop.
- Work package 3 collated the workshop results.
- Work package 4 compiled work package 1-3 into a single document.

2.5 Work Package 5 - A Decision-Making Framework

There were two components to work package 5 that included a detailed review of the legislation and guidelines associated with morphological alterations and the pressures and impacts analyses. The method for assessing potential morphological changes introduced by the pressures and the consequent impacts on ecological receptors was divided into two key stages.

- Stage 1: The information required to assess the likely impact to the receiving environment is the degree of morphological change that is likely to arise from a particular pressure.
- Stage 2: An assessment of the sensitivity of ecological receptors to those morphological changes.

These were combined in a risk assessment approach to identify the potential risks to environmental receptors associated with specific activities (see working paper 5, HR Wallingford Technical Note R3693/03). Also a review of the relevant legislation was mode and a summary of the relevant hydromorphological parameters in that legislation was brought together in a consistent format. A scoping document was prepared for an appropriate decision making framework (Working paper 5, Appendix 2).

2.6 Work Package 6 - Development and Testing of Draft Classification

The methodology developed in working paper 6a provided an initial basis for developing the classification scheme, which was later revised in working paper 6b. The initial concept proposed that one headline criterion would be used to determine the spatial extent of habitat loss or habitat change due to anthropogenically-induced hydromorphological pressures, which would then be supported by wider-reaching ancillary criteria which took account of broader aspects of hydromorphological pressures. In consultation with the Project Board, a modified version of the scheme was developed based on the one out all out principle to be more consistent with the normative definitions.

2.7 Work Package 7 - Identification and Collation of Supporting Datasets

The datasets used in the Ribble and Sea Loch studies were captured in this paper. A separate metadata database was prepared in Microsoft Access format and supplied as part of the project. The dataset came in two formats: GIS polygons and lines, and raster images such as OS maps. UK GIS datasets used the British National Grid coordinate system and worldwide datasets WGS 84 UTM. Other data was available in digital forms (e.g. spreadsheet or website) and physical data were on paper.

3. Classification

In working paper 6a, the project brief required the development of a draft hydromorphological classification to quantitatively assess for each hydromorphological quality element, high status and the level of deviation from high status allowable to achieve good and moderate status. (Subsequently, it was agreed by the Project Board that it was only necessary to define the high/good boundary and the good/moderate boundary). To achieve this goal a number of tasks were undertaken, namely.

- Revision of classification scheme in light of review comments.
- Testing of the classification scheme through case studies.
- Presentation of preferred options(s) to the Project Board.
- Suggestions for UK wide testing and application of scheme.

The classification sought to define high status and the high/good boundary only. This meant that it was essential that the biological classification schemes incorporated metrics that were sensitive to hydromorphological changes, for example, intertidal/habitat change, or flow metrics relating to migratory fish requirements. If this did not happen, the classification schemes might be insensitive to hydromorphological pressures and thus fail to identify hydromorphological impacts.

A total of nine metrics were tested for the Ribble Estuary and where possible at other sites in order to explore their wider applicability. However, in some cases a more simplistic approach had to be adopted because of non-availability of sufficiently detailed data to apply particular metrics. Individual metrics were also tested for specifications for which data were available. Following the case studies the metrics were revised again (Table 1).

It should be noted that the classification scheme would only define high status and boundary between high/good. It would not define differences between good/moderate of other class boundaries. This places greater emphasis on ensuring that the biological classification scheme incorporated metrics that were sensitive to hydromorphological changes. In particular, intertidal/habitat change and flow metrics relating to migratory fish requirements. Without this consideration the classification schemes might be insensitive to hydromorphological pressures and thus fail to identify hydromorphological impacts.

Table 1. Summary of metrics and thresholds

Final Metric	Interim Metric	Old Name/No	Description	Assessment Threshold
1	1	Headline criterion	% habitat loss	5% habitat loss
2	2a	1a	Changes in sediment budget & composition	15% sediment interruption based on length of frontage influenced by reinforcement or beach management/total length of WB frontage
3a	3	2	Changes in morphology: Bed disturbance	Relative bed disturbance in relation to WB sensitivity High >70% Good 70-30%
3b	2b	1b	Changes in sediment budget & composition	Qualitative assessment based on expert judgement of available evidence & locations/extent of dredging/reclamation activities
4	4	3	Hydromorphological element: Hydrological conditions	10% of area influenced by structures/area of WB
5	5	4	Changes in forces: Tides	Presence/absence of artificial barrages etc
6	6	5	Changes in forces: River flow	Is river flow at downstream assessment point of the adjacent river WB at high status: 10% less than Q95
7a	7	6	Changes in forces: Stratification/flushing	Sea loch (Note that no thresholds were identified as it would be difficult to define them based on current information).
7b	-	6	Stratification	10% of F-value for area or length influenced

The metrics adopted support a range of thresholds covering different direct or indirect effects relating to morphological parameters (i.e. depth, structure and condition of the sub- and inter-tidal areas). The types of changes that were considered important were as follows.

- Changes in astronomically driven (i.e. tidal) and meteorologically driven (i.e. river flow, waves, surges) forces impacting on a water body.
- Changes in sediment supply.
- Changes in sediment transport.
- Changes in sediment output.
- Changes in sediment composition.
- Changes in bed level/gradient.
- Changes in area extent of sub- and inter-tidal zones.

It should be noted that even under totally or nearly totally undisturbed conditions, there would be natural degrees of change in depth, sediment composition and structure. In defining suitable criteria to enable classification of hydromorphological status it was necessary to attempt to establish metrics that would discern an anthropogenic effect above this natural variability.

On the assumption that a particular water body can only depart from high status through anthropogenic intervention, some of the key anthropogenic pressures that were considered to potentially influence morphological status included.

- Land claim.
- Construction of flood and coastal defences and other marine developments (e.g. piers, jetties, ports, marinas, etc.).
- Marine aggregate extraction.
- Navigation dredging.
- Disposal at sea of spoil material.

Deviation from high status could be deemed to occur if the degree of anthropogenic intervention (as measured by metrics) exceeds a certain threshold. Setting this threshold, however, was largely 'judgement-based'. In part this was a function of the current limited scientific understanding and limited data availability.

An important next step was to amalgamate metrics within a Draft Classification Scheme. The initial metric based concept was founded on there being one headline criterion applicable to both transitional and coastal waters, which was supported by a number of ancillary criteria. However, this approach has not been taken forward. Rather it has been decided to conform to the normative definitions of the directive and that one out all out should be used for determining the difference between High and Good Status.

In many transitional waters the principal hydromorphological pressure that has occurred historically has been inter-tidal habitat loss due to land claim. This has not only resulted in a direct loss of inter-tidal, but also has altered the morphology and hydrodynamics of whole water bodies (or large parts of them). The issue of inter-tidal land claim and habitat loss is also important to some coastal water bodies.

In developing the thresholds to delineate high and good status for each of the metrics, it was not possible to prescribe absolute values with a high degree of scientific robustness due to the wide range and large number of site-specific issues and factors that always need to be considered.

This is why expert assessment is such a fundamental component of all regulatory bodies' own approaches to specific consenting/assessment issues. It is, however, possible to provide an indication of the typical ranges that, under most circumstances, may be considered to represent 'minor' and 'slight' anthropogenic disturbances – especially if overlap exists between the high to good and good to moderate status bands enabling flexibility to accommodate a degree of expert assessment.

One conclusion is clear from the work that has been undertaken to date: there is no easily identifiable, universally applicable method for developing a draft hydromorphological classification scheme. It appears that many of the hydromorphological processes associated with the metrics tested are poorly understood and that in many cases information specific to testing the thresholds proposed is equally poor.

Based on the classification scheme the following questions were used to classify a water body at High Status. This used estuary and water body interchangeably.

Table 2. Questions used to classify water body at high status

Metric	Question Proposed
1	Is estuary subject to habitat loss to the extent that High Status cannot be achieved?
2	Is the sediment composition altered to the extent that High status cannot be achieved?
3a	Is the estuary bed subject to disturbance to such an extent that High Status cannot be achieved?
3b	Is the sediment budget altered to the extent that High status cannot be achieved?
4	Is the hydromorphological element/hydrological conditions altered to such an extent that High Status cannot be achieved?
5	Is the water body influenced by a barrier or barrage to such an extent that High Status cannot be achieved?
6	Is the water body flow conditions altered to such an extent that High Status couldn't be achieved?
7a	Is stratification/flushing affected to such an extent that High Status cannot be achieved?
7b	Is stratification affected to such an extent that High Status couldn't be achieved?

4. Testing and Case Studies

All metrics developed and agreed on in working paper 6a were applied to the Ribble Estuary and where sufficient data was available, at a national level (see work package 6b, Appendix 1-5).

The draft classification presented to the Project Board in July 2005 had to be revised to reflect comments from the Board and a subsequent Marine Task Team Meeting. This had resulted in the identification of nine metrics, which were subsequently tested through case studies in work package 6b. The main changes are provided below.

- **Habitat Loss**: C19 OS maps would be used as a baseline to generate reasonably reliable estimates of change for these metrics. While this would not capture older reclamations, it was accepted that it was unlikely to be desirable or practicable to restore such areas and that the first edition OS maps provided a pragmatic and defensible baseline against which to assess changes.

- **Sediment Interruption:** It was recognised that shoreline reinforcement was a crude indicator of interruption at a water body level and the metric was more a risk assessment rather than impact assessment. It was agreed to include training walls in the metric for those water bodies where they were present.

- **Sediment Budgets:** It was agreed to include the sediment budget metric under the heading of morphology. While the examples presented contained considerable detail on sediment inputs and outputs, the assessment could be applied with lower levels of information using expert judgement.

- **Bed Disturbance:** The assessment locations benefited from the availability of relatively good resolution data on the intensity of fishing effort. This was only available for a small number of areas in English Waters. Estimates of bed disturbance would remain problematic until such time as there was better national coverage of fishing effort/intensity. There is scope to develop the sensitivity aspect of the metric, if detailed habitat maps became available. In the interim, sensitivity would need to be based on expert judgement at a water body level. Aspects of temporal change would need to be considered in compiling the metric where possible.

- **Forces - River Flow:** The Q95 from the most downstream river monitoring point could be used to indicate transitional water status. Associated elements, such as the extent of urbanisation were probably less relevant in a Transitional Water body context because of the greater volumes of water associated with Transitional Water body s. It was agreed that the Q95 would not reflect ecological requirements of fish migrating from Transitional Water body s into rivers. Further research was needed in this area. Similarly, the Q95 may not adequately reflect flow impacts on benthic communities, which were more likely to be influenced by periods of extreme high or low flow. Again, further research was required on this.

- **Forces - Stratification:** The ratio of run-off to water body area was seen as a key metric for sea lochs. It was suggested that a metric for Transitional Water body s was also required. An earlier 'salinity' metric had been dropped at the suggestion of MTT but was reinstated under the 'stratification' heading.

- **Forces - Tides:** This metric may not be needed for Transitional Water body s because the normative definition only relates to Fresh Water flows. However, in some Transitional Water body s, Fresh Water flows were important in relation to tidal propagation and therefore couldn't be entirely ignored. Where structures affected tidal propagation, it was helpful to flag this up in the context of cause/effect even if an administrative decision was taken to ignore impacts on tidal propagation per se.

- **Longitudinal Connectivity:** The metric demonstrated types of habitat change well for the selected case study sites. However, any interpretation of the information would be heavily dependant on expert judgement. While the metric was likely to be significant in the context of ecosystem functioning, the science base was not sufficiently developed to demonstrate this. It was suggested that this might be flagged up as an area for future research and that the metric should not be included in the initial classification.

5. Conclusions

The project has taken a staged approach to developing a practical classification in support of identifying the hydromorphological elements that support High or Good Status in transitional and coastal water bodies. This has been derived from in-depth work through seven work packages that have been described in this report. It has reviewed detailed classification schemes for hydraulic and morphological parameters and blended the project team's experience with that of other experts who were invited to a workshop early in the project. The legislation relevant to transitional and coastal water bodies was reviewed and the strands relating to hydromorphological parameters were summarised in a report along with an expert assessment of the characterisation of pressures and sensitivity. The draft reference conditions and water body type-specific reference conditions were developed and evaluated prior to the development of a metric based stepped approach to classification. The classification metrics have been applied to the Ribble Estuary using available datasets, and several of them have also been applied at a number of other coastal and estuarine locations, including sea lochs. The knowledge relating to use of data and application of the metrics gained in the piloting exercise has been recorded in the reports, and the datasets used have been captured in a metadata database and a data report. It appears that the metric based classification approach can form a core for application at a national scale using a variety of existing datasets. To ensure consistency the further development and application might best take place within a decision-making framework and an outline approach for a suitable decision making framework has been proposed.

The development of a hydromorphological classification scheme for transitional and coastal water bodies is based on a combination of quantitative and qualitative methodologies, which are largely a function of the current level of scientific understanding and the tools and data available to assess linkages between hydromorphological and

biological components. Moreover, the present study has identified the gaps in the current knowledge and has provided a 'framework' on which the present classification scheme could be developed.

The main conclusions are as follows:

- A staged approach has been taken to developing a practical classification scheme in support of identifying the hydromorphological elements that support High or Good Status in transitional and coastal water bodies.
- A detailed review has been conducted on the classification schemes for hydraulic and morphological parameters.
- The classification metrics have been applied to the Ribble Estuary and several of them to a number of other coastal and estuarine locations, including sea lochs.
- The metric based classification can form a core for application at a national scale using a variety of existing datasets.
- There are a number of tools commonly used by geomorphologists to express hydrological and morphological dimensions of transitional and coastal waters.
- A number of different metrics are required to broadly describe hydrology and morphology of TraC waters and classification cannot be reduced to a single metric.
- The general freshwater flow metric (Q95) is not appropriate for protecting migratory and resident fish from changes to the flow regime. It remains unclear whether an annual flow metric adequately represents the relationship between salinity and habitat/species distributions in transitional waters.
- It is difficult to identify thresholds representing high/good and good/moderate hydromorphological boundary.
- There are clear linkages between hydromorphological change and ecological response but it is not straightforward to equate a given hydromorphological pressure to ecological status; i.e. it is difficult to quantify the ecological response to a hydromorphological change.
- Expert judgement will remain important in determining hydromorphological status and in identifying ecological responses.

6. Recommendations & Further Work

The following recommendations are proposed:

- Further national scale testing to refine classification and support development of defensible thresholds is required.
- Further development of linkages between hydromorphological change and ecological responses (particularly in relation to changes in Fresh Water flow) is required.
- There is a need to ensure integration of hydromorphological classification with biological classification schemes, as currently there are some obvious gaps e.g. there is no habitat extent tool or any metric to describe fish response in transitional waters to

changes in river flow. See working paper 6b for clarification on metrics. Further research is required to develop appropriate tools.

- There is a requirement to develop metrics based on (daily) flow data and information on returning adult salmon where such data exist. This needs to test whether it is possible to develop generic flow standards or whether it needs to be done on site-specific basis.

- We accept that the metric for lateral connectivity (based on the proportion of shoreline reinforced) is already mirrored by metric 2a (changes in sediment composition). Nevertheless, we think it is important not to lose sight of the importance of lateral connectivity in influencing the ecological quality of water bodies, although we accept that such influences are not well documented in the scientific literature.

- Further work is required to develop longitudinal connectivity concept and how it might be applied.

- Apply metrics using a National dataset and cross correlate with ecological quality data.

- Further development of the decision-making framework.

7. Appendices

The following Appendices are bound separately:

- Appendix 1: Work Packages 1-4

- Appendix 2: Work Package 5

- Appendix 3: Work Package 6

- Appendix 4: Work Package 7

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