

Appendix 10: Consideration of Infaunal Quality Index indicators

Consideration of Indicators (IQI) in the assessment of the overall ecological status of the Wash & North Norfolk Coast SAC in relation to anthropogenic activities.

Background & Description of IQI

The IQI (Infaunal Quality Index) was developed to support Water Framework Directive (WFD) assessment of inshore waters. (Phillips *et al* 2014). The index makes use of two measures of general “Ecological Status” (Number of Taxa and Simpson’s Evenness, which indicate the level of biodiversity) and in addition the AMBI metric (AZTI Marine Biotic Index) which was initially developed to indicate disturbance by organic enrichment (pollution). Since its development, the AMBI has demonstrated responsiveness to a wide range of disturbances and impacts in marine environments in diverse inshore areas (Muxika *et al* 2005, Borja *et al* 2011).

The IQI produces a number between 0 (indicating a severely impacted environment) and 1 (indicating effectively “reference conditions” of a totally unimpacted environment).

Green & Burlinson (2016) equated the IQI value to an “Ecological status” value as per the WFD, as below (Table 1).

Table 1 Equivalence of WFD "Status" to IQI value, from Green & Burlinson (2016)

Status	Score
High	>0.75
Good	0.64 – 0.74
Moderate	0.44 – 0.63
Poor	0.24 – 0.43
Bad	<0.24

(WebRef 1 equates the WFD Ecological Status value with a definition of that status, as reproduced below (Table 2).

Table 2 Equivalence of WFD Ecological Status and description of the habitat (WebRef 1).

	High	Good	Moderate	Poor	Bad
Normative definitions	The level of diversity and abundance of invertebrate taxa is within the range normally associated with undisturbed conditions. All the disturbance-sensitive taxa associated with undisturbed conditions are present.	The level of diversity and abundance of invertebrate taxa is slightly outside the range associated with the type-specific conditions. Most of the sensitive taxa of the type-specific communities are present.	The level of diversity and abundance of invertebrate taxa is moderately outside the range associated with the type-specific conditions. Taxa indicative of pollution are present. Many of the sensitive taxa of the type-specific communities are absent.	Waters showing evidence of major alterations to the values of the biological quality elements for the surface water body type and in which the relevant biological communities deviate substantially from those normally associated with the surface water body type under undisturbed conditions, shall be classified as poor.	Waters showing evidence of severe alterations to the values of the biological quality elements for the surface water body type and in which large portions of the relevant biological communities normally associated with the surface water body type under undisturbed conditions are absent, shall be classified as bad.
Expanded normative definitions	Species richness and diversity high. Evenness high. Abundance ratio (Abundance/ No. of taxa) low. Taxonomic range high. Community Abundances (assessed by AMBI) – normal, unpolluted: Sensitive Taxa (EG I) of dominant abundance. Indifferent and Tolerant Taxa (EG II & III) absent or have sub-dominant abundance. Opportunistic Taxa (EG IV) absent or have negligible abundance. Indicator Taxa (EG V) absent or have negligible abundance.	Species richness and diversity slightly reduced. Evenness slightly reduced. Abundance ratio slightly elevated. Taxonomic range slightly reduced. Community Abundances (assessed by AMBI) – slightly unbalanced, slightly polluted: Sensitive Taxa (EG I) abundance may range from high sub-dominant to absent. Indifferent Taxa (EG II) have low, sub-dominant abundance. Tolerant Taxa (EG III) have dominant abundance. Opportunistic Taxa (EG IV) & Indicator Taxa (EG V) abundance may range from negligible or low to equi-abundance with Indifferent Taxa.	Species richness and diversity moderately reduced. Evenness moderately reduced. Abundance ratio moderately elevated. Taxonomic range moderately reduced. Community Abundances (assessed by AMBI) – transitional unbalanced to moderately polluted: Sensitive Taxa (EG I) have negligible abundance or absent. Indifferent Taxa (EG II) have low sub-dominant abundance. Tolerant Taxa (EG III), Opportunistic Taxa (EG IV) & Indicator Taxa (EG V) co-dominate the abundance.	Species richness and diversity shows major reduction. Evenness shows major reduction. Abundance ratio shows major elevation. Taxonomic range shows major reduction. Community Abundances (assessed by AMBI) – transitional moderately to heavily polluted: Sensitive and Indifferent Taxa (EG I & II) have negligible abundance or absent. Tolerant Taxa (EG III) have sub-dominant abundance. Opportunistic Taxa (EG IV) & Indicator Taxa (EG V) co-dominate the abundance.	Species richness and diversity shows severe reduction. Evenness shows severe reduction. Abundance ratio shows severe elevation. Taxonomic range severely reduced. Community Abundances (assessed by AMBI) – very heavily or extremely polluted: Azoic or if fauna present: Sensitive, Indifferent, & Tolerant Taxa (EG I, II, & III) absent. Opportunistic Taxa (EG IV) have sub-dominant abundance. Indicator Taxa (EG V) have dominant abundance.

The same publication (in Figure 1 of that document) also suggested an Environmental Quality Ratio (EQR) for the WFD Status classes, with an indication of level of disturbance associated with the class. See Figure 1.

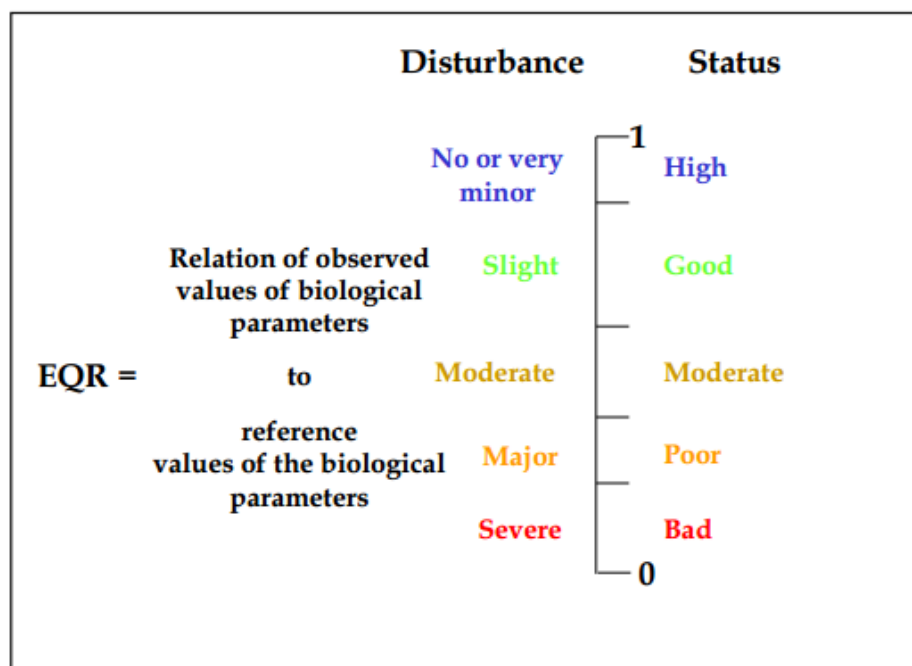


Figure 1 Suggested equivalence of Environmental Quality Ratio (EQR) to WFD Status class, and an indication of the level of Disturbance associated with these levels (WebRef 1).

A comparison of descriptions of measures which are considered equivalent to the WFD status of “Good” is presented in Table 3.

Table 3 Comparison of WFD Status, Normative Definition and Disturbance for benthic invertebrate ecology (WebRef 1)

WFD Status	Good
Normative Definition	The level of diversity and abundance of invertebrate taxa is slightly outside the range associated with the type-specific conditions. Most of the sensitive taxa of the type-specific communities are present
Expanded normative definition	Species richness and diversity slightly reduced. Evenness slightly reduced. Abundance ratio slightly elevated. Taxonomic range slightly reduced. Community Abundances (assessed by AMBI) – slightly unbalanced, slightly polluted: Sensitive Taxa (EG I) abundance may range from high sub-dominant to absent. Indifferent Taxa (EG II) have low, sub-dominant abundance. Tolerant Taxa (EG III) have dominant abundance. Opportunistic Taxa (EG IV) & Indicator Taxa (EG V) abundance may range from negligible or low to equiabundance with Indifferent Taxa.
Disturbance	Slight

These considerations suggest that IQI can give an indication of “Ecological Status”, notwithstanding the fact that one of the elements used to calculate it (the AMBI) was not specifically developed for this purpose.

AMBI has proven to be responsive to a range of pressures aside from organic pollution (Muxika et al 2005, Borja et al 2011). There have been several “intercalibration exercises” of the index against expert judgement of the ecological status, both being based on the same sample data. (e.g. Weisberg et al 2008, Teixeira et al 2010, Dauvin et al 2012, Borja et al 2014.). These identify that the assessments based on the AMBI align with those derived from expert opinion.

Eastern IFCA sought expert advice in relation to using IQI data to inform the current assessment of shrimp beam trawling on SAC subfeatures. The potential value of IQI was borne out by discussions with experts in the field of assessing ecological status of inshore areas (Professor Mike Elliott, Professor of Estuarine and Coastal Sciences/ Research Professor, Institute of Estuarine and Coastal Studies, University of Hull, 12th October 2017). In summary, these discussions led to the following conclusions:

- There is no tool available specifically to detect changes in benthic communities resulting from physical pressures (including fishing abrasion/penetration).

- It is sensible and appropriate to use IQI in the absence of tools for directly assessing physical pressures.
- It makes sense to consider the trajectory of species richness (and IQI overall) over time – this would show if there were problems in terms of the numbers of species declining.

Use of IQI values in assessments of environmental quality in relation to human activity

The Natural England Designated Sites View webpage (WebRef 2) provides conservation advice for marine protected areas. It incorporates the ability to sort by features and sub-features, and then to filter by attributes.

This system was accessed 20th June 2017, and showed the IQI as a quantitative metric within the “*Supporting Notes*” for the targets for several features and sub-features, where within the attribute “*Structure: Species composition of component communities*”, the targets were variously “*Maintain the species composition of component communities*” or “*Recover the species composition of component communities*”.

The text used was –

“Species composition of communities includes a consideration of both the overall range of species present within the community, as well as their relative abundance. Species composition could be altered by human activities without changing the overall community type. Within each component community, species composition and population structure should be taken into consideration to avoid diminishing biodiversity and affecting ecosystem functioning within the habitat (Joint Nature Conservation Committee (JNCC), 2014”.

“The sediment community composition will change when the habitat is subjected to pollutants and other forms of disturbance (Joint Nature Conservation Committee (JNCC), 2014), but will also be subject to significant natural variation annually. Benthic invertebrate communities are a good indicator of the health of the feature, if assessed over time”

“Maintain the faunal quality of the subfeature at Good Status (a minimum mean IQI score of ≥ 0.64), with no sustained deterioration within the status (Environment Agency Marine Monitoring Service 2014).”

“Community presence/distribution may be affected by trawling”

As far as could be determined, the IQI was the only quantitative target identified. Text above was incorporated within features/sub-features –

- Subtidal Mud
- Subtidal mixed sediments
- Sandbanks which are slightly covered by seawater all the time

and possibly others, as not all combinations were checked.

In an update to the Designated Sites view conservation advice on 15th September 2017, the text within the first three paragraphs above was changed to read (substantive changes highlighted in yellow) –

“Species composition of communities includes a consideration of both the overall range of species present within the community, as well as their relative abundance. Species considered need not be restricted to sessile benthic species but could include mobile species associated with the benthos. Species composition could be altered by human activities without changing the overall community type. Within each component community, species composition and population structure should be taken into consideration to avoid diminishing biodiversity and affecting ecosystem functioning within the habitat (Joint Nature Conservation Committee (JNCC), 2004).

The sediment community composition will change when the habitat is subjected to pollutants and other forms of disturbance (Joint Nature Conservation Committee (JNCC), 2004), but will also be subject to significant natural variation annually. Benthic invertebrate communities are a good indicator of the health of the feature, if assessed over time.”

“Site-specifics:”

“The infaunal quality index (IQI) is a tool which was developed as an indicator of organic enrichment and pollution. It is useful when considering whether sediment communities have been impacted by pollutants. The faunal quality of the subfeature should be maintained at Good Status (a minimum mean IQI score of ≥ 0.64), with no sustained deterioration within the status (Environment Agency Marine Monitoring Service, 2014). The IQI measures particular aspects of the infaunal community, when evaluating the overall status of the species composition of the component communities this metric should be considered alongside other measures or indicators of pressures.”

The statement *“It is useful when considering whether sediment communities have been impacted by pollutants.”* underplays the value of the IQI as a tool to appreciate the overall ecological status of habitats, and does not reflect that a major component of the calculation of the IQI is dependent only on measures related to biodiversity.

Correspondence between Natural England and Eastern IFCA indicates that Natural England accept the need for further changes to the content of the webpage in order to better reflect the value of the IQI.

Application of IQI data in Eastern IFCA's assessment of the impacts of shrimp beam trawling on the Wash & North Norfolk Coast SAC

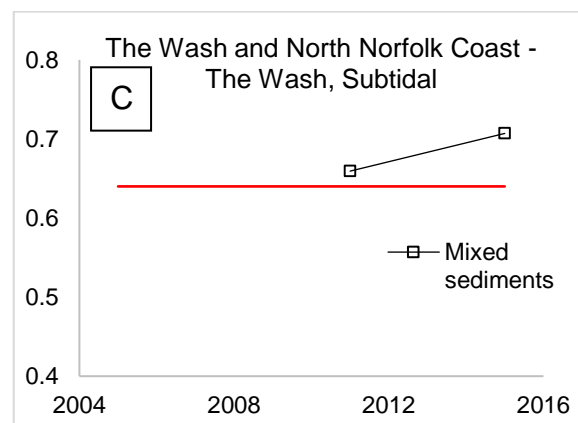
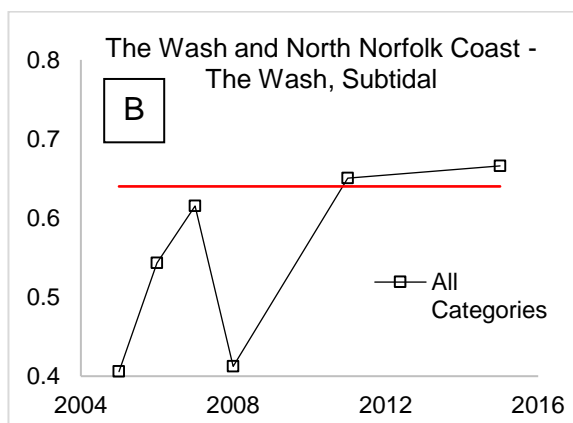
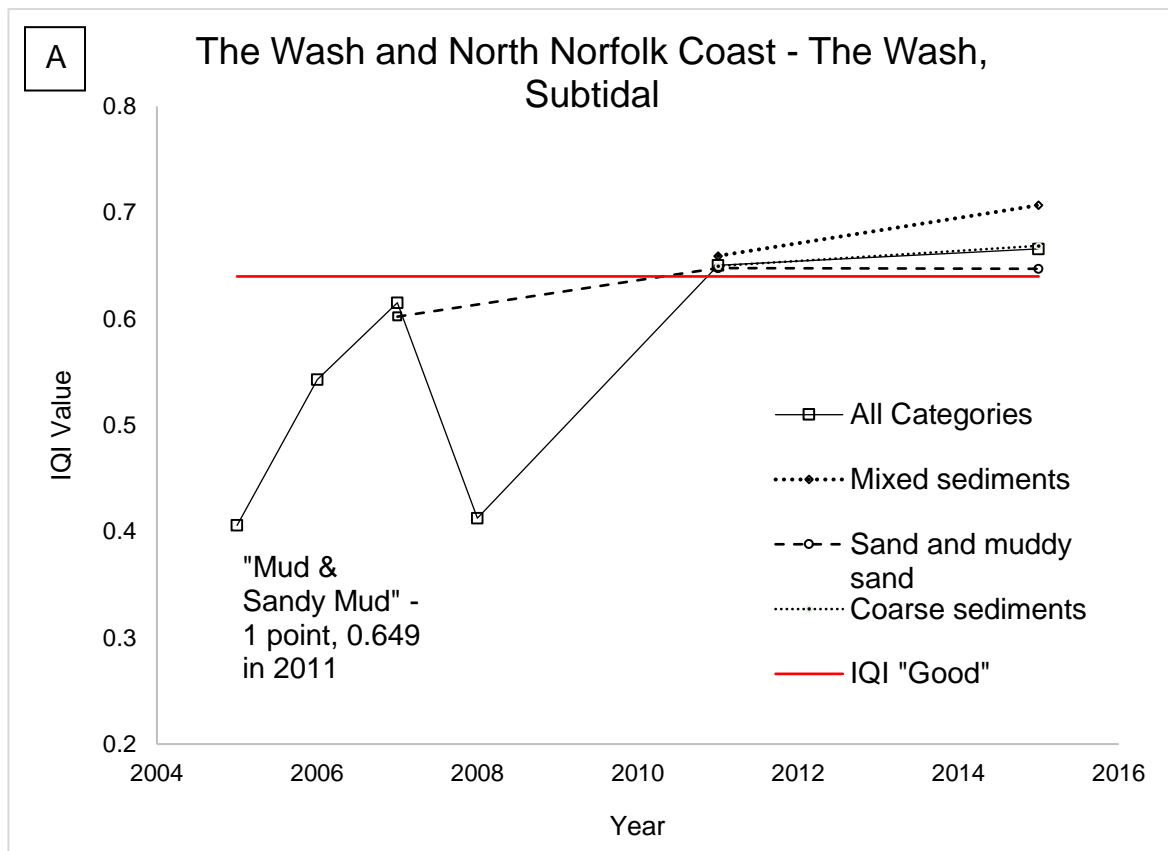
There is a lack of primary evidence (direct studies) on the impact of shrimp beam trawling on habitat features, and their sediment communities, of The Wash & North Norfolk Coast SAC. Eastern IFCA has therefore considered available data on the condition of site features as part of the evidence base used to support expert judgement about impacts from this ongoing activity. Caution must be applied with this approach to ensure data are used in an appropriate manner and unfounded assumptions are avoided.

It is noted that the IQI metric was developed as an indicator of ecological status for the Water Framework Directive, and within that the AZTI Marine Biological Indicator (AMBI) component, which makes up 38% of the overall score, reflects the relative proportions of taxa in component communities in five ecological groups of varying sensitivity to pollution (WebRef 1). The same IQI guidance document explains that, *"IQI has been shown to detect the impact of various pressures on benthic invertebrates. These pressures are hazardous substances, organic enrichment and general disturbance (e.g. smothering). For other pressures e.g. physical disturbance from fishing, the ability of the IQI to detect the response of benthic invertebrates is unquantified so the IQI scores should be interpreted with caution."*

Eastern IFCA therefore present the IQI information as one indicator of the ecological status of the habitat features, in terms of their infaunal communities, not as a complete nor definitive indicator of physical disturbance to benthic communities from fishing. We interpret the IQI results as showing the recent and current (2005 to 2015) ecological status of benthic habitats in the site, in the context of ongoing human activities within the site. We use other biological data (from Cefas, Environment Agency and Natural England sources) to evaluate the benthic invertebrate features of subtidal and intertidal habitats over a longer time period, as further evidence to support the overall assessment of impacts of the beam trawl fishery.

Results: IQI Values within the Wash & North Norfolk Coast SAC (WNNC SAC)

Natural England supplied a dataset containing summary information on IQI values for The Wash & North Norfolk Coast SAC in May 2017 (“Infaunal Quality Index (IQI) Scores for MPA sediment sub-features”). Numbers of Surveys and Samples which contributed to the assessment for each location, year and sediment type are detailed in **Table 5**. The IQI values for each sediment type, and the overall results, over the time period for which data was supplied, are presented as Figure 2 for the subtidal areas of The Wash. Note that IQI dataset did not differentiate between sediment type until 2007, and not all sediments were measured in each year.



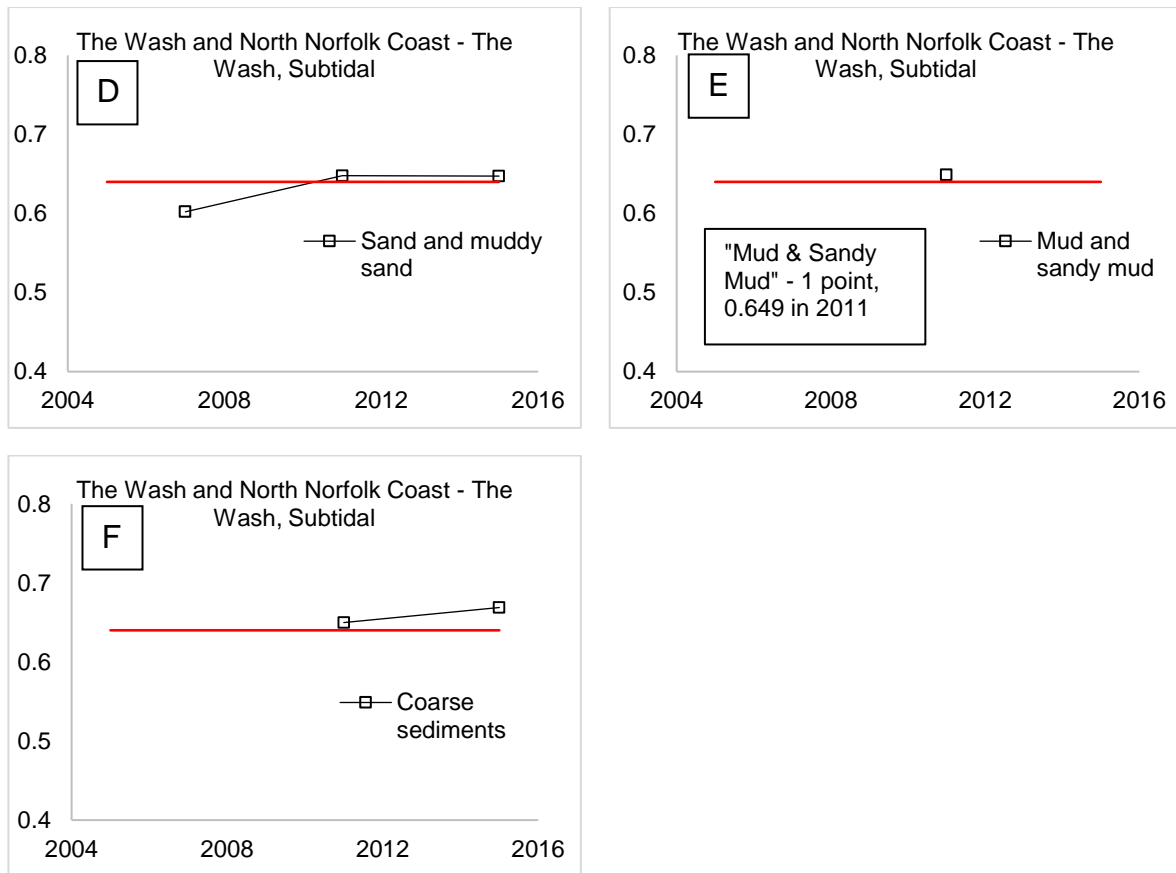


Figure 2 Graphs of mean annual IQI values for sub-tidal areas of The Wash 2004 - 2016. All habitats (A), Combined Habitats (B), Mixed Sediments (C), Sand & Muddy Sand (D), Mud & Sandy Mud (E) and Coarse Sediments (F)

These graphs indicate a pattern of rising IQI over time, with the most recent values all being above the threshold for consideration as “good environmental status” under WFD and therefore the associated Environmental Quality Ratios, indications of Disturbance, and Normative Definitions which describe the habitat. This is the case whether the values are aggregated to look at The Wash as a whole, or the area is examined by sediment type (although in the latter case there are fewer data points per sediment type, and therefore a less complete picture).

Thus, the IQI aspect of the *species composition of component communities* attribute conservation objective target, “*The faunal quality of the subfeature should be maintained at Good Status (a minimum mean IQI score of ≥ 0.64), with no sustained deterioration within the status (Environment Agency Marine Monitoring Service, 2014)*”, is met for these subtidal sub-features.

There is also data available for the North Norfolk Coast subtidal section of the SAC, but with less complete temporal coverage and only for the sediment types Mixed Sediments, & Sand and Muddy Sand. This data also shows a pattern of IQI levels in excess of the 0.64 threshold for WFD “Good” status.

Both sections of the SAC also have some associated intertidal IQI data, but in each case for only one year (2012), as shown in Table 4.

Table 4 IQI values for Intertidal areas of the WNNC SAC, 2012. Colour coding corresponds to WFD Status as per Table 1

Sediment type	North Norfolk Coast Intertidal	The Wash Intertidal
All Categories	0.60	0.70
Coarse sediments	0.65	0.72
Mixed sediments	No data	No data
Mud and sandy mud	No data	0.73
Sand and muddy sand	0.57	0.67

These results show that The Wash intertidal areas have achieved IQI scores well into the “good” level (>0.64) and towards the “High” level (>0.74). The results for the North Norfolk Coast intertidal area (only available for coarse sediments and sand and muddy sand) returned a “moderate” IQI score for sand and muddy sand, and “good” for coarse sediments. It is noted that the position of the IQI samples for sand and muddy sand in North Norfolk were high up in small estuaries, where there is likely to be a strong influence from reduced salinity affecting biological community composition, which could have resulted in the lower score for this sub-feature. Although shrimp beam trawl fishing is carried out close to the shore along parts of the north Norfolk coast, for example Brancaster Bay, the shrimping vessels cannot fish high up in the small estuaries because of hydrographical limitations. It is therefore stipulated that the sub-target IQI score for intertidal sand and muddy sand in North Norfolk could not be a result of shrimp beam trawling activity¹.

Conclusion

The dataset of IQI values within the Wash & North Norfolk Coast SAC indicates an environment which has been and remains on an upward trajectory of overall environmental quality. A broad-brush assessment indicates that the environment should be considered as “good” status, whether considered directly against the WFD standards, or by the broader descriptions associated with certain defined WFD status levels. The single subfeature showing “moderate” status, below the conservation objective target, is intertidal sand and muddy sand in the north Norfolk part of the site, and this has been ascribed to freshwater influence at the location of the sample.

¹ As at 15 December 2017, Eastern IFCA were working on an examination of the spatial variation in levels of the IQI metric. However, as at 11 Jan 2018, having examined the data in this way, no clear results were found. Mike Elliott (IECS) also advised that, since the overall IQI indicated that no pressures are causing declines in site condition in relation to IQI measures, there would be no point in doing further any analysis.

Were there to be activities having a significant impact on the benthic habitat communities, metrics such as the IQI would indicate that these were present, without necessarily being able to define exactly the specific pressure causing the impacts. As there are no such impacts identified, it is logical that none of the activities currently occurring, alone or in combination, are having these effects. The IQI metric was not designed to detect fishing pressures, having been developed initially to measure infaunal communities in relation to organic pollution, but as set out above, it is reasonable to assert that the parameters measured to provide IQI scores (diversity, evenness and AMBI) will decline if fishing results in long-term damage to infaunal communities.

It is therefore judged that the beam trawl shrimp fishery, which has been ongoing for decades within the site, is not resulting in declines in the IQI score, and is not preventing the conservation objective of “maintain” the species composition of component communities” attribute from being achieved (which applies to subtidal coarse sediments, subtidal sand, intertidal coarse sediments and intertidal mud). For reasons set out above, it is also judged that the “restore” target (for the same attribute in intertidal sand and muddy sand) is not being hindered by the shrimp beam trawl fishery.

Two sub-features have a “recover” target for species composition of component communities: subtidal mixed sediments and subtidal mud. Supporting notes in the conservation advice states that community presence/distribution in these sub-features may be affected by trawling. There is limited data (7 samples, all from 2011) for subtidal mud and sandy mud, and (12 and 7 samples, from 2011 and 2015 respectively) (see **Table 5** for full breakdown of numbers of samples) for subtidal mixed sediments, but the available data show the IQI levels to be within the “good” category (i.e. above the conservation objective target level) and for subtidal mixed sediments, to be increasing over time. These results suggest that even these sub-features, which are more sensitive to abrasion (and therefore removal of non-target species), are not being significantly affected by ongoing activities within the site. As there is only one year of data for subtidal mud, the data do not show whether recovery (increase in IQI level) is occurring for this sub-feature, but the data for subtidal mixed sediment shows an upward trend from 2011 to 2015.

The IQI results give a broad indication that the infaunal species within biological communities in the Wash and North Norfolk Coast are at least being maintained, and probably showing recovery (shown by the upward trajectory of IQI scores over time).

The availability of quantifiable, definitive metrics and indices – such as IQI – is a major assistance in the effective management and conservation of Marine Protected Areas.

For the purposes of this assessment, the IQI assessment is complemented by the analysis of additional location- and species-specific information, used to understand changes in the distribution in time and space of sensitive species and biotopes which

may not be fully picked up by metrics such as IQI. This analysis is presented in section 5.3.1 – Further assessment of surface abrasion/disturbance and removal of non-target species, supported by the following appendices:

- Appendix 7 – Consideration of species sensitivity data
- Appendix 8 – Abundance and diversity assessment
- Appendix 8a – Number of taxa
- Appendix 8b – Abundance ratio
- Appendices 8 (c-j) - Sensitive Species analysis
- Appendix 9 - Natural Disturbance considerations.

Table 5 Numbers of Surveys and Samples used in assessment of IQI values, presented by Area, Intertidal or Subtidal, Sediment Type and Year

Area	Sediment Sub-feature or BSH		Year	Total Surveys	Total Samples	
The Wash	Intertidal	All Categories	2012	2	109	
		Coarse sediments	2012	2	15	
		Mud and sandy mud	2012	1	34	
		Sand and muddy sand	2012	2	60	
	Subtidal	All Categories	2005	1	5	
		All Categories	2006	1	5	
		All Categories	2007	2	43	
		All Categories	2008	1	5	
		All Categories	2011	2	60	
		All Categories	2015	4	35	
		Coarse sediments	2011	2	10	
		Coarse sediments	2015	2	5	
		Mixed sediments	2011	1	12	
		Mixed sediments	2015	2	7	
		Mud and sandy mud	2011	2	7	
		Sand and muddy sand	2007	1	25	
		Sand and muddy sand	2011	2	31	
		Sand and muddy sand	2015	3	17	
North Norfolk Coast	Intertidal	All Categories	2012	1	87	
		Coarse sediments	2012	1	37	
		Sand and muddy sand	2012	1	50	
	Subtidal	All Categories	2010	1	26	
		All Categories	2011	1	11	
		All Categories	2015	2	20	
		Mixed sediments	2015	2	5	
		Sand and muddy sand	2010	1	26	
		Sand and muddy sand	2011	1	8	
Sand and muddy sand	2015	1	11			

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Web References

WebRef 1 UKTAG Transitional and Coastal Water Assessment Method - Benthic Invertebrate Fauna - Infaunal Quality Index. Water Framework Directive – United Kingdom Technical Advisory Group (UK TAG) 2014

<https://www.wfduk.org/sites/default/files/Media/Environmental%20standards/Annex%2018%20Transitional%20and%20coastal%20waters%20Invertebrates%20IQI.pdf>

WebRef 2 Natural England Designated Sites View webpage - The Wash and North Norfolk Coast SAC.

<https://designatedsites.naturalengland.org.uk/Marine/SupAdvice.aspx?SiteCode=UK0017075&SiteName=the+wash&SiteNameDisplay=The+Wash+and+North+Norfolk+Coast+SAC&countyCode=&responsiblePerson=&SeaArea=&IFCAArea=>