Appendix 12: Consideration of sensitivities of Biotopes[1] within Features to pressures "Abrasion/disturbance of the substrate on the surface of the seabed" and "Removal of non-target species" in relation to the Wash & North Norfolk Coast beam trawl shrimp fishery

This document presents an in-depth assessment of the effects of shrimp beam trawling on the Wash & North Norfolk Coast SAC by examining individual biotopes within sub-features of the site. It considers the sensitivity of named characterising species for each biotope to the two pressures that required further assessment (abrasion/disturbance of the substrate on the surface of the seabed, and removal of non-target species). The results provide further evidence to conclude on the impacts of the fishery on the conservation objectives of the site.

Identifications and descriptions of biotopes, and levels of sensitivity to specific pressures, taken from Natural England "Designated Sites View – Advice on Operations" (https://designatedsites.naturalengland.org.uk/Marine/FAPMatrix.aspx?SiteCode=UK0017075&SiteName=was&SiteNameDisplay=The+Wash+and+North+Norfolk+Coast+SAC&countyCode=&responsiblePerson=&SeaArea=&IFCAArea, accessed 26 Jan 2018).

Sensitivity information is taken from the "Relevant Biotopes" description linked to from that site.

Figure 1 and 2 show the number and sensitivity of biotopes within features remaining after the screening exercise (described in Appendix 3) for the abrasion and removal of non-target species pressures respectively. Table 1.EUNIS level 2 habitats relevant to this assessment

EUNIS code	Habitat description (equivalent to SAC sub-feature)
A2.1	Intertidal coarse sediments
A2.2	Intertidal sand
A2.3	Intertidal mud
A5.1	Subtidal coarse sediments

[1] A biotope is a part of a habitat with a particular ecological community

A5.2	Subtidal mud
A5.3	Subtidal sand
A5.4	Subtidal mixed sediments
A5.6	Subtidal biogenic reef

N.B. colours selected for approximate consistency with Natural England habitat maps

Table 2 and Table 1. list the EUNIS codes and corresponding descriptions for the biotopes considered within this review.

There are instances where a biotope is described as “Not Relevant” or “Not Sensitive”. In all these cases, the possibility of specific local conditions indicating otherwise was considered. When it was determined that further consideration was needed, this is included below. If there are no specific local indications, the deduction is made that there is no need to consider the impact of the pressure on that biotope any further.

The “Notes” in the tables dealing with each biotope are intended only to identify those most pertinent points specifically in connection with the Wash shrimp fishery and WNNC SAC. For full details, see the Natural England “Designated Sites View – Advice on Operations”.

Please note:

All references to the MarLIN online system for further information relating to biotopes, and references to primary or secondary literature from that system, have been omitted from the text below in the interests of clarity and brevity. The reader is directed to the MarLIN online system for this information.

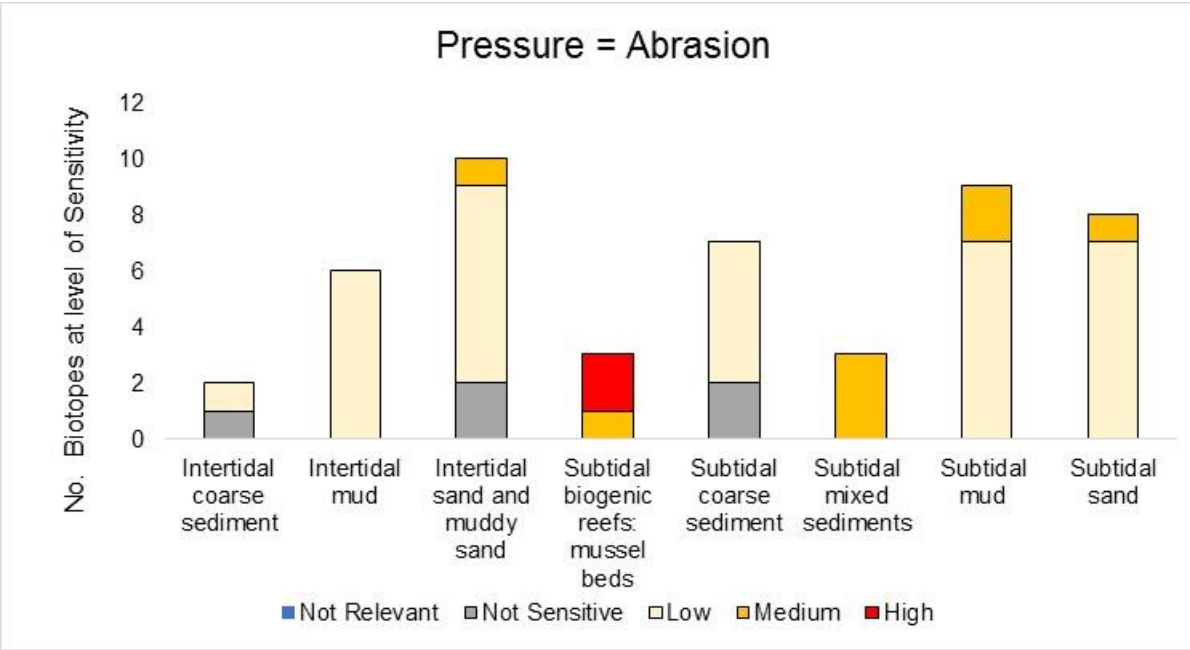

Figure 1 Number and sensitivity levels of Biotopes in "scoped in" features of WNNC SAC for Abrasion/disturbance of substrate on the surface of the seabed. N.B. Harbour Seal considered separately

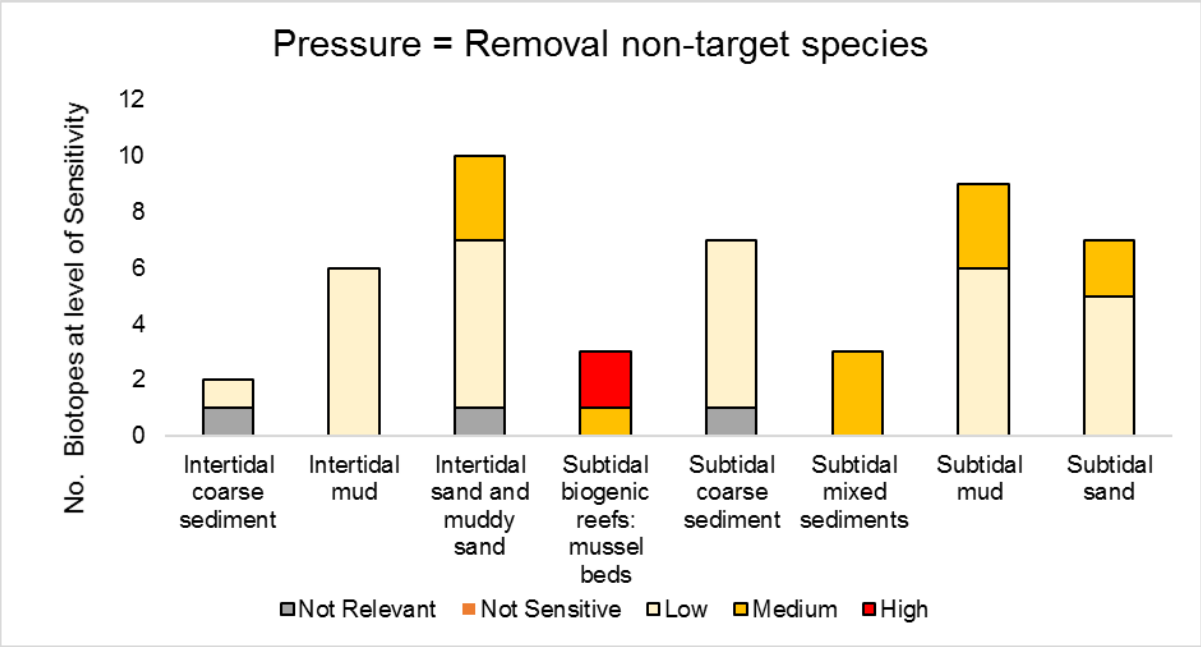

Figure 2. Number and sensitivity levels of Biotopes in "scoped in" features of WNNC SAC for Removal of non-target species. N.B. Harbour Seal considered separately

Table 1.EUNIS level 2 habitats relevant to this assessment

EUNIS code	Habitat description (equivalent to SAC sub-feature)
A2.1	Intertidal coarse sediments
A2.2	Intertidal sand
A2.3	Intertidal mud
A5.1	Subtidal coarse sediments
A5.2	Subtidal mud
A5.3	Subtidal sand
A5.4	Subtidal mixed sediments
A5.6	Subtidal biogenic reef

N.B. colours selected for approximate consistency with Natural England habitat maps

Table 2 List of EUNIS (Level 4) codes and Descriptions for biotopes

EUNIS code	Description
A2.111	Barren littoral shingle
A2.112	*Pectenogammarus planicrurus* in mid shore well-sorted gravel or coarse sand
A2.211	Talitrids on the upper shore and strandline
A2.221	Barren littoral coarse sand
A2.2221	Oligochaetes in full salinity littoral mobile sand
A2.223	Amphipods and *Scolelepis* spp. in littoral medium-fine sand
A2.231	Polychaetes in littoral fine sand
A2.241	*Macoma balthica* and *Arenicola marina* in muddy sand shores
A2.242	*Cerastoderma edule* and polychaetes in littoral muddy sand
A2.243	*Hediste diversicolor*, *Macoma balthica* and *Eteone longa* in littoral muddy sand
A2.244	*Bathyporeia pilosa* and *Corophium arenarium* in littoral muddy sand
A2.245	*Lanice conchilega* in littoral sand
A2.311	*Nephtys hombergii*, *Macoma balthica* and *Streblospio shrubsolii* in littoral sandy mud
A2.312	*Hediste diversicolor* and *Macoma balthica* in littoral sandy mud
A2.313	*Hediste diversicolor*, *Macoma balthica* and *Scrobicularia plana* in littoral sandy mud
A2.321	*Nephtys hombergii* and *Streblospio shrubsolii* in littoral mud
A2.322	*Hediste diversicolor* in littoral mud
A2.323	*Tubificoides benedii* and other oligochaetes in littoral mud
A5.131	Sparse fauna on highly mobile sublittoral shingle (cobbles and pebbles)
A5.134	*Hesionura elongata* and *Microphthalmus similis* with other interstitial polychaetes in infralittoral mobile coarse sand
A5.135	*Glycera lapidum* in impoverished infralittoral mobile gravel and sand
A5.136	Cumaceans and *Chaetozone setosa* in infralittoral gravelly sand
A5.137	Dense *Lanice conchilega* and other polychaetes in tide-swept infralittoral sand and mixed gravelly sand

A5.141	*Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles
A5.143	*Protodorvillea kefersteini* and other polychaetes in impoverished circalittoral mixed gravelly sand
A5.22	Sublittoral sand in variable salinity (estuaries)
A5.231	Infralittoral mobile clean sand with sparse fauna
A5.232	*Sertularia cupressina* and *Hydrallmania falcata* on tide-swept sublittoral sand with cobbles or pebbles
A5.233	*Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand
A5.241	*Echinocardium cordatum* and *Ensis* spp. in lower shore and shallow sublittoral slightly muddy fine sand
A5.242	*Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand
A5.243	*Arenicola marina* in infralittoral fine sand or muddy sand
A5.261	*Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment
A5.321	*Polydora ciliata* and *Corophium volutator* in variable salinity infralittoral firm mud or clay
A5.322	*Aphelochaeta marioni* and *Tubificoides* spp. in variable salinity infralittoral mud
A5.323	*Nephtys hombergii* and *Tubificoides* spp. in variable salinity infralittoral soft mud
A5.325	*Capitella capitata* and *Tubificoides* spp. in reduced salinity infralittoral muddy sediment
A5.331	*Nephtys hombergii* and *Macoma balthica* in infralittoral sandy mud
A5.333	*Mysella bidentata* and *Abra* spp. in infralittoral sandy mud
A5.334	*Melinna palmata* with *Magelona* spp. and *Thyasira* spp. in infralittoral sandy mud
A5.336	*Capitella capitata* in enriched sublittoral muddy sediments
A5.354	*Virgularia mirabilis* and *Ophiura* spp. with *Pecten maximus* on circalittoral sandy or shelly mud
A5.432	*Sabella pavonina* with sponges and anemones on infralittoral mixed sediment

A5.444	*Flustra foliacea* and *Hydrallmania falcata* on tide-swept circalittoral mixed sediment
A5.445	*Ophiothrix fragilis* and/or *Ophiocomina nigra* brittlestar beds on sublittoral mixed sediment
A5.621	*Modiolus modiolus* beds with hydroids and red seaweeds on tide-swept circalittoral mixed substrata
A5.622	*Modiolus modiolus* beds on open coast circalittoral mixed sediment
A5.625	*Mytilus edulis* beds on sublittoral sediment

Pressure: Abrasion/disturbance of the substrate on the surface of the seabed

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Pressure – Abrasion/disturbance of the substrate on the surface of the seabed

(i) Feature – Harbour (common) seal (*Phoca vitulina*)

Pressure considered "Not Relevant" for this feature

Site and Activity Specific assessment

There is no need to consider the impact of the pressure "Abrasion/disturbance of the substrate on the surface of the seabed" on the feature "Harbour Seal" any further.

Pressure – Abrasion/disturbance of the substrate on the surface of the seabed

(ii) Feature – Intertidal coarse sediment

Site and Activity Specific assessment

Pressure – Abrasion/disturbance of the substrate on the surface of the seabed		
Feature – Intertidal coarse sediment		
Biotope	Sensitivity	Notes
A2.111	Not Sensitive	Scoped out – not sensitive
A2.112	Low	Scoped out - Not found where shrimp fishing occurs

The specific sediment type “well-sorted gravel or coarse sand” does not occur in the areas fished by the Wash Shrimp Fishery; neither does the non-sensitive “Barren littoral shingle”. Therefore, it is considered that the feature “Intertidal coarse sediment” will not be impacted by the pressure “Abrasion/disturbance of the substrate on the surface of the seabed” and there is no need to consider the impact of the pressure on the feature “Intertidal coarse sediment” any further.

Pressure – Abrasion/disturbance of the substrate on the surface of the seabed

(iii) Feature – Intertidal mud

Site and Activity Specific assessment

Pressure – Abrasion/disturbance of the substrate on the surface of the seabed		
Feature – Intertidal mud		
Biotope	Sensitivity	Notes
A2.311	Low	Low Resistance, High Resilience. Soft mud with fine sand, variable salinity, typically close to the head of estuaries. *N. hombergii* and *M. (Limecola*) *balthica* are rapid recolinisers. *S. shrubsolii* an indicator species, high abundance indicates stressed environments.
A2.312	Low	Medium Resistance, High Resilience. Mainly in mid and lower shore sandy mud or mud in lower estuaries, sheltered bays and marine inlets, often subject to variable salinity. Recovery of *H. diversicolor* populations rapid. *Limecola (Macoma) balthica* - strong recoverability. Other (non- characterising) species also exhibit the ability to recover rapidly.
A2.313	Low	Medium Resistance, High Resilience. Mainly mid shore mud or sandy mud subject to variable salinity on sheltered estuarine shores. Recovery of *H. diversicolor* populations rapid. *Limecola* (*Macoma) balthica* - strong recoverability. *S. plana* from higher latitudes tended to show lower abundance, shorter reproduction periods and lower growth rates. Other (non- characterising) species also exhibit the ability to recover rapidly.
A2.321	Low	Low Resistance, High Resilience. Soft wet mud with a fine sand fraction, on the mid and lower shore of sheltered estuaries. *N. hombergii* is a rapid recoliniser. *S. shrubsolii* an indicator species, high abundance indicates stressed environments.
A2.322	Low	Medium Resistance, High Resilience.

		Mud and sandy mud shores in sheltered marine inlets and estuaries subject to variable or reduced salinity. Typically found on the mid and lower shores in the upper and mid estuary. Recovery of *H. diversicolor* populations relatively rapid.
A2.323	Low	Medium Resistance, High Resilience. Extreme upper estuarine fine sandy mud, sometimes with fine sand, in very sheltered conditions and subject to reduced salinity. Species poor, usually consisting of few species of oligochaetes and sometimes the polychaete, although numbers of individuals may be high. *T. benedii* is opportunistic, but with a longer lifespan than usual for opportunistic species and somewhat prolonged reproductive period. Recolinisation of habitats can therefore be expected to be somewhat slower than for other species with shorter lifespans and more rapid reproduction.

MarLIN describe all of the habitat types listed within the feature “Intertidal Mud” as associated with variable or reduced salinity, or sheltered estuarine conditions, or in soft mud, or in some other way to be associated with the sheltered, definitely estuarine areas. The biotopes are therefore “stressed” to a greater or lesser degree by the natural factor of reduced / variable salinity. There is a high likelihood of such conditions occurring in the constricted estuaries through which the rivers and watercourses feed into The Wash, but within The Wash embayment itself conditions are much more akin to the open sea, with levels and variability of salinity associated with marine rather than estuarine habitat (except for those occasions of defined significant freshwater floods, when there can be appreciable but short-lived excursions of reduced salinity water into The Wash). In addition, the Wash embayment is subject to much greater levels of natural disturbance by waves – both generated within The Wash and arising in the North Sea – than indicated by the descriptions of the sheltered-environment biotopes within the feature “Intertidal Mud”.

Relatively little shrimp fishing activity in the Wash and North Norfolk Coast occurs in areas as described in these biotopes. In fact, such fishing métiers (light towed demersal gear fisheries) will typically actively avoid areas of soft mud – the nets would tend to sink into the seabed, and the relatively low powered vessels would not be able to pull their nets through such sediment types. Although Biotopes A2.312 and A2.321 are described as occurring in the mid and/or lower shore, regions which are likely to be fished by shrimp vessels in The Wash targeting the channels between intertidal mudflats, these specific biotopes are described as occurring in estuaries or sheltered bays/marine inlets, which does not match the more exposed environment of the Wash embayment.

Where the feature Intertidal Mud occurs within the open Wash embayment, it is likely that the physical conditions are different from those in the descriptions of the biotopes above. One condition – increased exposure to natural disturbance in The Wash – is likely to result in reduced sensitivity of the biotopes to the pressure "Abrasion/disturbance of the substrate on the surface of the seabed" (van Denderen *et al* 2015) – because their component communities are naturally adapted to a dynamic physical environment where the upper layers of seabed sediments are constantly in a state of flux (when not exposed at low water).

It is concluded that the shrimp fishery is highly unlikely to be affecting these biotopes.

It is suggested however that consideration should be given to the management of the shrimp fishery in some areas of intertidal mud habitat, to provide a "reference area" of zero fishing activity of any sort against which areas experience fishing pressure could be compared. Protection of the sheltered, estuarine biotopes could be afforded by management of activity within the defined "estuary" sections of watercourses feeding The Wash and North Norfolk coast.

Pressure – Abrasion/disturbance of the substrate on the surface of the seabed

(iv) Feature – Intertidal sand and muddy sand

Site and Activity Specific assessment

Pressure – Abrasion/disturbance of the substrate on the surface of the seabed		
Feature – Intertidal sand and muddy sand		
Biotope	Sensitivity	Notes
A2.221	Not sensitive	Scoped out – not sensitive
A2.245	Not sensitive	Although described as “Not sensitive”, this biotope is known to occur in areas of shrimp trawling, and as *Lanice* protrudes above the seafloor, it could be considered that there may be an effect. However, observation indicates that the species rebound without damage from the displacement, thus supporting the “Not sensitive” classification.
A2.211	Low	Scoped out – shrimp beam trawling does not occur on this biotope
A2.242	Low	Scoped out – The Wash cockle beds are closely monitored by Eastern IFCA and are in favourable condition in terms of cockle biomass and distribution. There is an annual cockle fishery which highly regulated, and subject to HRA each year, including examination of “in combination” effects. This represents adequate mitigation for this biotope; therefore, the impact of the pressure on this biotope is not considered any further here.
A2.2221	Low	Medium resistance, high resilience Biotope a “species-poor community of oligochaetes occurring in fully marine conditions on open shores” Such infaunal oligochaetes tend to bury and avoid direct exposure to abrasion. Sediment disturbance of surface layers has little impact. Abrasion causing greater compaction may have greater impact (not an anticipated consequence of beam trawling).
A2.243	Low	Medium resistance, high resilience Fine muddy sand on mid shore at lower extremes of estuaries, and in moderately exposed/sheltered bays and marine inlets

		Most characterising species are infaunal burrowing species, unlikely to be affected by abrasion. However, abrasion from beam trawling could impact bivalves, tube-dwelling polychaetes and *Hydrobia ulvae* abundance.
A2.244	Low	Low resistance, high resilience Wave-sheltered, mainly upper and mid shore flats of medium to fine sand, often muddy sand. Burrowing habits of characterising species *Corophium volutator* provides some protection from surface abrasion. Despite this, abrasion is likely to reduce density of *Corophium* spp. (by emigration and increased mortality). Resilience assessed as high based on migration from adjacent populations and reproduction by surviving amphipods.
A2.223	Low	Low resistance, high resilience Mobile sandy beaches on exposed/moderately exposed shores Characterising species include polychaetes, isopods and burrowing amphipods generally in low abundances, and adapted to frequent disturbance. Amphipods and isopods are agile swimmers, able to withstand sediment disturbance and *Scolelepis squamata* (a polychaete worm) is adapted to life in unstable sediments through rapid burrowing.
A2.231	Low	Low resistance, high resilience Occurs in moderately exposed/sheltered beaches of medium and fine, usually clean, sand, though sediment may occasionally contain small silt /clay fraction. Sediment is relatively stable, mainly on lower part of shore, and sometimes mid shore. Infaunal polychaetes dominate. Amphipods frequently occur, nemerteans (ribbon worms) often present. Characterising species are usually present in low abundances and adapted to frequent disturbance, although *Nephtys cirrosa* (a bristle worm) show longer recovery times.
A2.241	Medium	Low resistance, medium resilience. Muddy/fine sand occurring as extensive intertidal flats on open coasts and in marine inlets. Scattered stones, cobbles and boulders with attached fucoids may occur. Characterising species: *Arenicola marina*, *Limecola balthica*. Natural disturbance/bottom-towed gear may damage seabed surface. Burrowing traits may provide some

		resistance. Decreases in naturally occurring aggregations of *A. marina* seen in trawled areas. *Scoloplos armiger* (a bristle worm) demonstrated recovery after ~50 days.

As noted in the text above, biotopes A2.221, A2.245, A2.211 and A2.242 are considered to not require further examination in connection with this assessment.

Biotopes A2.2221 is a species-poor biotope chacterised by a species typically found buried at depths greater than likely to be impacted by the relatively lightweight shrimp beam trawl gear.

The mobile sediment and relatively high energy environment defining these intertidal biotopes support the general conclusion that the light weight and low levels of the pressure *Abrasion/disturbance of the substrate on the surface of the seabed* generated by the shrimp beam trawl fishery[2] will have little effect. This conclusion is borne out by assessment of the specific conditions currently prevailing in these biotopes following many years of shrimp fishing activity (e.g. as described in Appendices 9, 10 & 11). Of particular relevance is the fact that the trajectory of condition as described in those appendices is stable, and definitely not declining.

The biotope sensitivity information presented above shows it is likely that repeated trawling activity, even at the low levels occurring in these intertidal sand areas, could reduce abundance and inhibit recovery of species with a low resistance to abrasion (e.g. the bivalves *L. balthica* and *S. plana*, the gastropod *H. ulvae* or certain polychaetes e.g. *A. marina*). Although the site-specific investigations supporting this assessment (e.g. appendices 9, 10 & 11) indicate that species diversity and abundance are not declining despite the shrimp fishery ongoing, a precautionary management option could be to ensure shrimp fishing activity levels do not increase above typical recent levels, to prevent the adverse effects arising in future.

Ongoing targeted monitoring of this feature in areas of low, medium and higher levels of shrimp beam trawling will continue to develop and refine this understanding. Consideration of removing all fishing pressure from one area of this feature would allow comparison with an un-impacted area, and further enhance this understanding.

[2] See section 3.1 of main report for description of fishing gear and fishing activity location. Vessels primarily target shallow subtidal areas, including channels between intertidal banks. Intertidal sandflats and mudflats are not specifically targeted but a low level of shrimp fishing can occur on these features. This is illustrated in the fishery sightings data (Figure 10 of main report).

Pressure – Abrasion/disturbance of the substrate on the surface of the seabed

(v) Feature – Subtidal biogenic reefs: mussel beds

Site and Activity Specific assessment

Pressure – Abrasion/disturbance of the substrate on the surface of the seabed		
Feature – Subtidal biogenic reefs: mussel beds		
Biotope	Sensitivity	Notes
A5.625	Medium	Low resistance, Medium resilience. Requires the presence of dense *Mytilus edulis* beds. Populations have a strong ability to recover from environmental disturbance. While good annual recruitment and rapid growth are possible, recovery of the mussel population may take up to 5 years. In certain circumstances and under some environmental conditions recovery may take significantly longer. The associated community is likely to colonize the substratum or mussel matrix rapidly.
A5.621	High	A5.621 *Modiolus modiolus* beds with hydroids and red seaweeds on tide-swept circalittoral mixed substrata.
A5.622	High	A5.622 *Modiolus modiolus* beds on open coast circalittoral mixed sediment Applicable to both – Low resistance, Low resilience. Patches extending over >10m^2 with >30% cover by mussels should definitely be classified as “bed”. However, mosaics also occur where frequent smaller clumps of mussels influence ecosystem functioning - for management purposes lower thresholds can be accepted for defining beds. *Modiolus* communities consist of very dense aggregations of horse mussel shells forming a single or multi-layered framework; a rich community of free living and sessile epifauna and predators; a very rich and diverse community of species, with low abundance, which shelters between the shells and byssus threads of the horse mussels and thrives on the rich sediment, and an infauna living within the rich sediment deposits built up by the bed.

There are no areas of EUNIS habitat type A5.62 (subtidal biogenic reef – mussel beds – either *Mytilus* or *Modiolus*) identified in WNNC SAC.

Subtidal *Mytilus* beds have been identified on several occasions in or near the WNNC SAC, tending to be in water deeper than ten metres below chart datum, and comprised of juvenile mussels. These beds have always been ephemeral, dying before ever becoming established into adult mussel beds. The existence of permanent beds is thought to be precluded by high levels of predation by starfish, or loss of beds of juvenile mussels during intense physical disturbance from storms (Eastern IFCO, pers. comm.). There are no known permanent sublittoral mussel beds in the Wash and North Norfolk Coast SAC or in the wider area of the Wash approaches.

Shrimp fishers avoid trawling over known mussel beds, in order to avoid both damage to the fishing gear and time spent sorting out an unusable bycatch. If subtidal *Mytilus* beds are identified, they are on occasion the subject of commercial fisheries. These fisheries are always subject to bespoke HRA, including in combination effects.

The six records for *Modiolus* within the EIFCA compiled dataset (results of benthic sampling surveys between 1995 and 2015)[3] record a total of 61 individuals. 55 of these originate from one sample. This single sample of a dense aggregation of *Modiolus* could have been an error of either identification or recording at some stage (since juvenile *Modiolus modiolus* and *Mytilus edulis* can be confused). Whether or not the identification of *Modiolus* was correct, the results over the prolonged time period show that *Modiolus* is present at very low levels, if at all, within the area fished by the Wash shrimp fishery.

Furthermore, a study of the bycatch of the Wash shrimp fishery (Catchpole *et al*, 2008) recorded no instances of either *Mytilus* or *Modiolus* within the bycatch of the fishery.

The assessment of sensitive species (Appendices 7 and 8) identified a decline in the abundance of mussels, based on benthic survey data from 1995-2015. It is not known whether this reflects a decline in the occurrence of ephemeral sublittoral mussel beds, but this cannot be ruled out. “Permanent” sublittoral mussel beds (i.e. forming biogenic reefs) are not known to occur in the site. Although considered unlikely, the assessment concluded that the shrimp fishery could potentially constrain the formation of the biotope Subtidal biogenic reefs: mussel beds, if sublittoral mussels settled in areas where they could survive into adult beds but are disturbed incidentally by shrimp beam trawling. There is considered to be a low likelihood of this occurring, given the infrequent occurrence of sublittoral mussels in the site and especially because of their ephemeral nature.

[3] See Appendix 7a for information on dataset used in this assessment

It is therefore concluded that the shrimp fishery will not constrain the biotope Subtidal biogenic reefs: mussel beds from achieving the conservation objectives for the site. Therefore, there is no need to consider the impact of the pressure on the biotope any further.

Pressure – Abrasion/disturbance of the substrate on the surface of the seabed

(vi) Feature – Subtidal coarse sediment

Site and Activity Specific assessment

Pressure – Abrasion/disturbance of the substrate on the surface of the seabed		
Feature – Subtidal coarse sediment		
Biotope	Sensitivity	Notes
A5.131	Not Sensitive	Scoped out – not sensitive
A5.137	Not Sensitive	Although described as “Not sensitive”, this biotope is known to occur in areas of shrimp trawling, and as *Lanice* protrudes above the seafloor, it could be considered that there may be an effect. However, observation indicates that the species rebound without damage from the displacement, thus supporting the “Not sensitive” classification.
A5.141	Low	Scoped out - This biotope is not found within those areas of the WNNC SAC where shrimp fishing occurs (Circalittoral cobbles and pebbles in The Wash are found in deeper waters, where they are stable rather than unstable. Such areas are protected by EIFCA closures to bottom towed gear.) Therefore, there is no need to consider the impact of the pressure on the biotope any further.
A5.134	Low	Medium Resistance, High Resilience Loosely packed grains of sand in high energy areas, forming waves up to several metres high, often with gravel, or occasional silt, in the troughs of the waves. Low diversity, lack of sedentary forms (especially bivalve molluscs) and the numerical dominance of agile swimmers that are able to withstand continual sediment disturbance. Shrimp fishers tend to avoid areas of sand waves, due to the difficulties in maintaining proximity of the gear to the seabed in these areas of undulating topography.
A5.135	Low	Medium Resistance, High Resilience. Infralittoral mixed slightly gravelly sands on exposed open coasts, impoverished communities characterised by the polychate *Glycera lapidum.*

		Exclusion of other species as a result of continued or periodic sediment disturbance from wave action, preventing the establishment of a more stable community.
A5.136	Low	Medium Resistance, High Resilience. Shallow medium-fine sands with gravel, on moderately exposed open coasts. Characterised by species that have strong recoverability from physical disturbances - either mobile as adults or opportunistic species that rapidly colonise disturbed sediments and that may benefit from the removal of competitors and predators. Recovery of *Scoloplos armiger* may take longer than some species but may be complete within two years - biotope may be considered to have recovered where this species is still increasing in abundance
A5.143	Low	Medium Resistance, High Resilience Coarse gravelly or shelly sand sometimes with some mud, along open coasts in depths of 10 to 30m, and in shallower offshore areas. Impoverished community, several species found in low abundance. Characterising species *Protodorvillea kefersteini* has a high recoverability.

Very little shrimp fishing activity takes place in areas where this sub-feature is found. Characterising species have strong recoverability from disturbance, or the biotopes do not have stable communities because of regular disturbance. The mobile sediment and high energy environment defining these biotopes leads to the general conclusion that the light weight and low levels of the pressure *Abrasion/disturbance of the substrate on the surface of the seabed* generated by the shrimp beam trawl fishery would have little effect (van Denderen *et al* 2015), particularly in shallow areas (<10m water depth).

It is considered that no specific protection of the feature is required. However, where areas described as “coarse sediment” occur in deep, sheltered low energy areas, they can be associated with rich fauna and therefore abrasion from shrimp trawling could have an effect on community composition. [Such areas also tend to have sufficient fine fraction in the sediment that they are not correctly classed as “coarse sediment”.] It is therefore suggested that protection of deep, sheltered areas of coarse sediment (e.g. by spatial fisheries restrictions) is considered.

Pressure – Abrasion/disturbance of the substrate on the surface of the seabed

(vii) Feature – Subtidal mixed sediments

Site and Activity Specific assessment

Pressure – Abrasion/disturbance of the substrate on the surface of the seabed		
Feature – Subtidal mixed sediments		
Biotope	Sensitivity	Notes
A5.432	Medium	Low Resistance, Medium Resilience Muddy gravelly sand with pebbles off shallow, sheltered or moderately exposed coasts or embayments. *Sabella pavonina*, sponges and anemones characterising species, with hydroids also important. *S. pavonina* can increase numbers rapidly, especially if some adults remain in the vicinity. Abundance of sponges varies annually even in unfished areas, and can recover within a few years. Larger anemones can be expected to take several (about 4) years to recover.
A5.444	Medium	Low Resistance, Medium Resilience Tide-swept circalittoral mixed sediment. *Flustra foliacea* and *Hydrallmania falcata* characterise this biotope, which has a high recovery potential. *Hydrallmania falcata* was used as an example species of Hydroids in Appendix 8f, which examined species selected as potentially sensitive based on biological traits. *Flustra foliacea* was only recorded in three years, with 25% of samples in 2007, 31% in 2011 and 32 % in 2015 recording the species. Although the number of data points was low, the species abundance analyses for each of these species (Appendices 8e and 8f) showed upward trends over time. This suggests that despite the shrimp fishery continuing, neither it nor other activities are impeding achievement the conservation objectives for the site in relation to the component communities of this sub-feature.
A5.445	Medium	Low Resistance, Medium Resilience. *Ophiothrix fragilis* and/or *Ophiocomina nigra* brittlestar beds on sublittoral mixed sediment. (Biotope is brittlestar beds, rather than individuals.) *O. fragilis* recruits initially settle on the arms of adults – not known if this is obligatory. Settlement of larvae dependent on

		hydrographic conditions and may be unpredictable – resettlement of lost populations not guaranteed. *O. nigra* grows slowly, lives for up to 14 years. Juvenile *Ophiocomina* appear not to settle among adults. Ophiuroidea were considered in Appendix 8j, which examined species selected as potentially sensitive based on biological traits. This indicated a difference in abundance of the species depending on whether samples came from waters shallower or deeper than 10m below chart datum. Whilst there was no clear trend in the shallower samples, those from deeper areas tend to show a decline in abundance recorded over the period of the dataset (1995 – 2015).

Biotopes associated with this feature are characterised by epifaunal species. Eastern IFCA's examination of trends in populations of such species indicated stability or increasing abundance for the colonial bryozoan (*Flustra foliacea*) and hydroid (*Hydrallmania falcata*) across habitats, but declines in the *Ophiuroidea* taxa in deeper subtidal areas. This suggests that ongoing activities – primarily the shrimp fishery, one of the few human activities regularly interacting with benthic habitats in the Wash & North Norfolk Coast – could be having a negative effect on brittlestar abundance. It is therefore proposed that some form of protection through management could be beneficial in deeper parts of the site (the depth of 10 m. below chart datum having been identified as an important cut-off point).

Pressure – Abrasion/disturbance of the substrate on the surface of the seabed

(viii) Feature – Subtidal mud

Site and Activity Specific assessment

Pressure – Abrasion/disturbance of the substrate on the surface of the seabed		
Feature – Subtidal mud		
Biotope	Sensitivity	Notes
A5.321	Low	Low resistance, High resilience. Variable salinity clay and firm mud characterised by a turf of the polychaete *Polydora ciliata*. MarLIN 34 records no occurrences in WNNC SAC, and notes this biotope may be specific to The Humber estuary. Depends on turf of *P. ciliata* - in EIFCA Compiled Dataset, no records of the species prior to 2010, and then recorded in every year to 2015 for which sample data is available. Not recorded at high levels, and no turf observed during EIFCA activities.
A5.322	Low	Low resistance, High resilience. Variable salinity cohesive muddy sediment (sometimes with some coarser material) in sheltered areas with moderately strong and weak tidal streams. Dominated by fast growing opportunistic polychaetes likely to reach maturity within one year of space becoming available. Abundances of these species are known to fluctuate with seasonal changes. Recoverability of *T. benedii* high. *A. marioni* has no pelagic phase in its lifecycle; where the community is severely reduced recruitment is likely to depend on dispersal by hydrodynamic conditions.
A5.323	Low	Low resistance, High resilience. Variable salinity soft infralittoral mud and sandy mud. Biotope dominated by opportunistic polychaetes likely to reach maturity within one year of space becoming available. Abundances of these species are known to fluctuate due to seasonal recruitment processes. Recoverability of *T. benedii* high. *N. hombergii* is a rapid recoliniser.
A5.325	Low	Medium resistance, High resilience Reduced salinity, muddy sediment.

		Dominated by the opportunistic polychaete *Capitella capitata* & oligochaetes *Tubificoides* spp with a very low species richness but possibly large numbers of individuals. *C. capitata* dominated biotope is likely to reach maturity very rapidly, reaching maturity within about four months and reproducing throughout the year. Other species within the biotope may colonize more slowly but the biotope is considered likely to have recovered within two years for any level of impact.
A5.333	Low	Low resistance, High resilience. Cohesive sandy mud, sometimes with a small quantity of shell in shallow water. Very sheltered conditions with very weak tidal streams. Resilience of the biotope is considered high if habitat is suitable and recruitment from neighbouring areas is possible. This biotope is likely to recover rapidly because the key characterising species are short lived and reach maturity rapidly.
A5.334	Low	Low resistance, High resilience. Infralittoral cohesive sandy mud, in sheltered marine inlets, and occasionally variable salinity environments, where the characterising species may be present in large numbers. Polychaete *Melinna palmata* is a characterising species. EIFCA Compiled Dataset shows low and patchy occurrence of the species, with maximum density of 50 / m^2 cf the 500 – 1000 / m^2 defining the biotope in MarLIN.
A5.336	Low	Medium resistance, High resilience Large numbers of the opportunist polychaete *Capitella capitata* in organically enriched and polluted sediments. A *Capitella capitata* dominated biotope is likely to reach maturity very rapidly because the species are short lived, reaching maturity within about four months and reproducing throughout the year. Other species within the biotope may colonize more slowly but overall recoverability and resilience is considered high
A5.331	Medium	Low resistance, Medium resilience. Near-shore shallow sandy muds and muds, and sometimes mixed sediments. MarLIN does not identify this biotope as present in the WNNC SAC, but does describe a biotope that EIFCA observations there recognise, particularly as *Crangon crangon* is considered an important biotope component.

		The life history characteristics of the species which characterise the biotope suggest that the biotope would recover from major perturbations and be recognisable as the biotope within 5 years. This protracted recovery is due to *Echinocardium cordatum*, with other species components typically recovering in 1 – 2 years. No *Echinocardium* were recorded in a study of the bycatch from the Wash shrimp fishery (Catchpole et al 2008). The species occurs within the EIFCA compiled dataset, but at low abundances and without consistency over time, although two of the five records are in the last two years for which samples have been taken (2011 & 2015).
A5.354	Medium	Medium resistance, Medium resilience. Circalittoral fine sandy mud. Recovery likely to be protracted, and the emergent animals could well be damaged by bottom towed gear. However, see expanded narrative for assessment of likelihood of this biotope occurring in WNNC SAC

The shrimp fishery largely occurs within areas of The Wash embayment which experience more constant and higher "open sea" salinity regime, rather than the reduced or variable salinity regime associated with some of the biotopes identified above (A5.321, A5.322, A5.323 and A5.325). There is on occasion some shrimp fishing activity within the larger river estuaries which feed into The Wash, and there remains the possibility for interaction with these biotopes in those locations.

A5.354 *Virgularia mirabilis* and *Ophiura* spp. with *Pecten maximus* on circalittoral sandy or shelly mud

This habitat type occurs in circalittoral fine sandy mud and is primarily identified on the basis of its epifauna and may be an epibiotic overlay over other closely related biotopes. A variety of species may occur, and species composition at a particular site may relate, to some extent, to the proportions of the major sediment size fractions. Several species are common to most sites including *Virgularia mirabilis* (slender sea pen) which is present in moderate numbers, brittlestars *Ophiura albida*, and *Ophiura ophiura* which are often quite common, and *Pecten maximus* (king scallop) which is usually only present in low numbers. *Virgularia mirabilis* is usually accompanied by occasional *Cerianthus lloydii* (a tube-dwelling anemone), *Liocarcinus depurator* (swimming crab) and *Pagurus bernhardus* (hermit crab). Brittlestars *Amphiura chiajei* and *Amphiura filiformis* may also occur in some examples of this biotope. Polychaetes and bivalves are generally the main components of the infauna, although the nemerteans, *Edwardsia claparedii*, *Phoronis muelleri* and *Labidoplax buski* may also

be widespread. Of the polychaetes *Goniada maculata*, *Nephtys incisa*, *Minuspio cirrifera*, *Chaetozone setosa*, *Notomastus latericeus* and *Owenia fusiformis* are often the most widespread species whilst *Myrtea spinifera*, *Lucinoma borealis*, *Kurtiella bidentata*, *Abra alba* and *Corbula gibba* are typical bivalves in this biotope.

The relevant Marine Life Information Network webpage identifies that the medium sensitivity for this biotope arise from a combination of medium resistance and medium resilience for the pressure *Abrasion/disturbance of the substrate on the surface of the seabed* with generally good levels of confidence in the available data.

Ophiuroidea were considered in Appendix 8j, which examined species selected as potentially sensitive based on biological traits. This indicated a difference in response of the species depending on whether samples came from waters shallower or deeper than 10m below chart datum. Whilst there was no clear trend in the shallower samples, those from deeper areas tend to show a decline in abundance recorded over the period of the dataset (1995 – 2015). There are no records of *P. maxiumus* or of *V. mirabilis* in the Eastern IFCA compiled dataset, and no known occurrences of either of these species in the area (Eastern IFCO, pers comm). It is unlikely that the physical conditions of The Wash are suitable for *V. mirabilis,* with the MarLin website (http://www.marlin.ac.uk/species/detail/1396, 1 Feb 2018) stating "*Virgularia mirabilis lives in fine sediments (muddy sand to soft mud). The species is found in sheltered inshore waters, or in deeper water offshore, from 12 - 400 m depth. The species is often very abundant in sea lochs or man-made harbours*." Therefore, although the biotope *in toto* is unlikely to be found in areas where shrimp fishing occurs, some component species (i.e. typical of this biotope) that do occur may be impacted.

Mud sediments within WNNC SAC are found at shallow (usually intertidal) depths, and in deep water. There is relatively little in between these extremes. The few shallow mud areas are typically found in locations subject to high levels of wave energy, and tend to be well consolidated and firm (there are exceptions to this in the channels of the true estuaries, where soft mud is found). In the absence of primary evidence from controlled experiments, the best assessment of overall sensitivity of the shallow/intertidal areas that can be undertaken is afforded by assessment of the specific conditions currently prevailing in these biotopes following many years of shrimp fishing activity (e.g. as described in Appendices 9, 10 & 11). Of particular relevance is the fact that the overall trajectory of condition as described in those appendices is stable, and definitely not declining.

Ongoing targeted monitoring of this feature in areas of low, medium and higher levels of shrimp beam trawling will continue to develop and refine this understanding. Consideration of removing all fishing pressure from an area of this feature would allow comparison with an un-impacted area, and further enhance this understanding.

In deep areas (typically deeper than 10m below chart datum), as described in assessment of Biotope A5.354 above, there is a case for management to ensure

protection of a potentially sensitive habitat. This could be considered precautionary, as there are no indications that the characterising species *P. maximus* and *V. mirabilis* would be found in WNNC SAC. Any management measure introduced for the purpose of furthering the conservation objectives in relation to this sub-feature must be subject to appropriate review to identify if recovery to the anticipated biotope is indeed occurring.

Pressure – Abrasion/disturbance of the substrate on the surface of the seabed

(ix) Feature – Subtidal sand

Site and Activity Specific assessment

Pressure – Abrasion/disturbance of the substrate on the surface of the seabed		
Feature – Subtidal sand		
Biotope	Sensitivity	Notes
A5.22	Low	Low resistance, high resilience Clean gravels/sands in upper reaches of marine inlets/estuaries. Variable salinity. Characterised by robust fauna adapted to frequent disturbance and resistant to surface abrasion. Amphipod/isopod species can withstand disturbance and *Nephtys cirrosa* has adapted to burrow to survive in unstable sediment. Only low levels of beam trawling occur in this biotope.
A5.242	Low	Medium resistance, high resilience Bivalves dominate in stable, fine, compacted sands. Abrasion likely to damage epifauna/flora and may damage a proportion of the characterising species. Opportunists likely to recruit rapidly and some damaged characterising species may recover/recolonize. As *Magelona mirabilis* is a burrower, adapted for life in unstable sediments, it is unlikely to be impacted by beam trawling.
A5.261	Low	Medium resistance, high resilience Non-cohesive muddy sands or slightly shelly/gravelly muddy sand. Important taxa include: *Nephtys* spp., *Chaetozone setosa* and *Spiophanes bombyx*. Opportunistic species likely to recruit rapidly, some damaged characterising species may recover/recolonize. *Abra alba* vulnerable to trawling, however generally able to maintain population despite fishing effort. *Nucula nitidosa* show high recoverability and small size relative to trawl meshes ensure survival of a proportion of individuals.
A5.231	Low	Low resistance, high resilience Medium-fine sandy sediment in shallow water, formed into dunes, on exposed or tide-swept coasts often contains very little infauna due to the mobility of the substratum. Opportunistic infaunal amphipods may occur, along with low numbers of mysids. These mobile sand species are

		generally of low abundance and adapted to frequent disturbance. Amphipod and isopod species are agile swimmers and able to withstand sediment disturbance. *Nephtys cirrosa* is adapted to life in unstable sediments.
A5.232	Low	Low resistance, high resilience Shallow sands with cobbles and pebbles, exposed to strong tidal streams, with conspicuous colonies of hydroids *Sertularia cupressina* and *Hydrallmania falcata*, which are tolerant to periodic burial and scour by sand. EIFCA analysis indicated no decline in occurrence in samples of *Hydrallmania falcata*. Therefore considered that there is no impediment to achieving conservation objectives arising from abrasion caused by ongoing beam trawling.
A5.233	Low	Low resistance, high resilience Well-sorted medium and fine sands up to 30m. Subject to physical disturbance caused by wave/tidal action. Species associated with mobile sands generally present in low abundances and adapted to frequent disturbance. Amphipods/isopods able to withstand sediment disturbance. *Nephtys cirrosa* are adapted to life in unstable sediments.
A5.243	Low	High resistance, high resilience Characterised by *Arenicola marina* in shallow fine sand or non-cohesive muddy sand. *A. marina* lives in sediment to 20-40 cm and is protected from abrasion and physical disturbance at the surface, by shrimp beam trawling, as this only slightly penetrates sediment.
A5.241	Medium	Low resistance, medium resilience Sheltered lower shore and shallow sublittoral sediments of sand or muddy fine sand. Infaunal position of species provide some protection against surface abrasion, however *Echinocardium cordatum* has a fragile test and *Ensis ensis* have been reported to be “killed or damaged” by dredges.

The Wash shrimp fishery largely occurs within areas of the embayment and open coast that experience more constant and higher “open sea” salinity regime, rather than the reduced or variable salinity regime associated with the biotope A5.22 identified above. A very limited level of shrimp fishing activity within the river estuaries which feed into The Wash, and there remains the possibility for interaction with the biotopes in those locations. However, the specific biotope A5.22 is extremely rare or unknown in WNNC SAC, and characterised by robust resistant fauna. It is not considered that the shrimp fishing activity will impact this biotope in WNNC SAC.

The abrasion/disturbance and shallow penetration effects caused by the shrimp fishery to the seabed are repeated regularly rather than being a one-off event. However, these effects have been judged to be very similar to natural disturbance in shallow subtidal areas (because of regular wave action) – see Appendix 9 – and so are not considered likely to affect component communities to a significant extent, because they are adapted to disturbed conditions. The mobility of the sediment and relatively high energy environment defining these biotopes, and their low sensitivity to abrasion (seen in all but one biotope) leads to the general conclusion that the light weight of gear and limited disturbance depth of the pressure *Abrasion/disturbance of the substrate on the surface of the seabed* generated by the shrimp beam trawl fishery will have little effect on subtidal sand communities.

Most of the characterising species in this sub-feature are adapted to frequent disturbance, e.g. through their ability to burrow or swim away. Some characterising species (e.g. bivalves[4]) are more sensitive, so it would be expected that should the shrimp fishery be having an adverse effect on the component communities, the proportions of bivalves in affected areas would be declining whilst proportions of burrowing polychaetes and opportunistic species would increase. This effect has not been identified in the analysis of sensitive species, and the abundance and species richness assessment for The Wash (Appendices 7 and 8). It is acknowledged that the data supporting these analyses is limited (particularly when broken down into single taxa or sub-features), but the weight of evidence in the various analyses suggests that widespread adverse effects are not occurring to the benthic communities within the site.

This conclusion is borne out by assessment of the specific conditions currently prevailing in these biotopes following many years of shrimp fishing activity (e.g. as described in Appendices 9, 10 & 11). Of particular relevance is the fact that the trajectory of condition as described in those appendices is stable, and definitely not declining. The current “good” (and increasing) IQI scores for the Wash and North Norfolk coast do not suggest benthic communities are being adversely affected by the ongoing shrimp fishery. The AMBI element of the Infaunal Quality Index metric (see Appendix 10 for full details) relates to the relative abundance of species in undisturbed benthic communities compared with species that thrive in heavily disturbed/polluted environments. Although initially developed as a measure of ecological health in relation to organic pollution, AMBI has been applied to measure other pressures and is recommended for use with other metrics when assessing ecological health in relation to fishing impacts. The IQI measure reflects the AMBI score in addition to

[4] Although the razor clam *Ensis ensis* can be damaged by dredging, these clams exhibit a defensive response to disturbance, rapidly propelling themselves deeper into the substratum, to depths that are not likely to be disturbed by the surface abrasion/shallow penetration (upper few cm) created by shrimp beam trawling. Razors were not recorded as bycatch in the Wash shrimp fishery study (Catchpole *et al* 2008).

diversity and species richness metrics. In The Wash and North Norfolk coast, since 2011 all subtidal habitats have recorded average IQI scores above the “good” threshold, which is the conservation objective target.

Ongoing targeted monitoring of subtidal sand communities in areas of low, medium and higher levels of shrimp beam trawling will continue to develop and refine this understanding.

Pressure – Removal of non-target species

Pressure – Removal of non-target species

(i) Feature – Harbour (common) seal (*Phoca vitulina*)

Site and Activity Specific assessment

The Natural England Designated Sites View, Advice on Operations (Nat Eng 1) identifies High Sensitivity for this feature arising from a combination of Low Resistance and Low Resilience for pressure Removal of non-target species, with high levels of confidence in the assessment.

It seems evident that Nat Eng 1 considers that the main effect of the pressure "Removal of non-target species" on the feature "Harbour seal" would arise through direct capture of the seals within the fishing gear. This assessment will consider that pathway, and in addition the pathway for potential impact of the bycatch of the Wash shrimp fishery being the removal of a food source for Harbour Seals.

The level of impact via direct capture of Harbour Seals within the fishing gear used by the Wash shrimp fishery is assessed to be negligible. The shrimp beam trawl gear is relatively narrow across the mouth, and the height of the top of the net when fishing is low (less than 1 m.). The towing speed is relatively low, and there is not incentive for seals to enter shrimp beam trawls as there is for instance in fish otter trawls, when seals enter to take captured fish. All these factors, coupled with the well-developed senses and intelligence of seals, suggest that there is a low likelihood of seals being caught in shrimp beam trawl gear as bycatch. This is borne out by the (limited) available evidence:

- There are no records of seals as bycatch from the EIFCA obligatory shrimp returns, which run from Dec 2015 to Feb 2018, 1396 return.
- Opinion from EIFCA officers with long experience in the Wash indicates extremely low level of seal bycatch, to the point that it would be considered a truly exceptional event. (Simon Lee, Ron Jessop, *pers comm* February 2018).

Whiting and sole are the dominant food species for Harbour Seals in the southern North Sea (SMRU 1). Both these species have been identified as components of the bycatch of the Wash shrimp fishery (Catchpole *et al* 2008), with whiting forming a significant component of the bycatch, but sole much less so. All vessels operating within the Wash shrimp fishery are legally required to use a screening system such as a veil net (Council Regulation (EC) No 850/98), which has been demonstrated to be very effective in reducing the bycatch of larger fish (Catchpole *et al* 2008), with a very considerable reduction of whiting > 25 cm being recorded.

Harbour Seals are opportunistic predators, targeting whichever species are most available locally (SCS 1), including shrimps which some sources cite as being particularly important for the young seals (Mac 1). Harbour seals tend to target small to medium fish (SCS 1, Mac 1).

Those attributes which could conceivably interact with shrimp beam trawling, and associated targets for the feature Harbour (common) seal (*Phoca vitulina*) are presented in Table 1.

Table 1 Selected Attributes and associated Targets for Harbour Seal in WNNC SAC. Information from Natural England Designated Sites View, accessed 8 February 2018

Attribute	Target
Population: population size	Maintain the population size within the site.
Population: recruitment and reproductive capability	Maintain the reproductive and recruitment capability of the species.
Presence and spatial distribution of the species	Maintain the presence and spatial distribution of the species and their ability to undertake key life cycle stages and behaviours.
Supporting habitat: extent and distribution	Maintain the extent and spatial distribution of the following supporting habitats: foraging and haulout sites.
Supporting habitat: food availability	Maintain the abundance of preferred food items required by the species.

Thompson *et al* (2016) presents numbers of adult Harbour Seals in The Wash annually since before 1975, and numbers of pups since 2001. The numbers of adults typically shows a year on year increase from some 1500 individuals to of the order of 3000 individuals. There have been two phocine distemper virus (PDV) outbreaks, which clearly impacted the abundance of adult Harbour seals in 1988 and 2002. In each case, the numbers of adult seals fell very considerably, before resuming its climb from a reduced level.

The number of pups shows appreciable inter-annual variation, with the smoothed line showing a sustained increase of 7.5% each year since 2001.

The distribution of seal haul-out and pupping sites is also shown in Thompson *et al* 2016; some variation has been seen between 2004 and 2016. The larger number of sites used in 2016 are more widespread, with evidence of a shift towards the south

east of The Wash (although without “abandoning” sites used in 2004). The south east of The Wash is an area which supports some of the higher levels of shrimp fishing.

From Thompson *et al* (2016), it is evident that the conservation objective for the feature “Harbour seals” is being met for the following attributes –

- Population: population size
- Population: recruitment and reproductive capability
- Presence and spatial distribution of the species
- Supporting habitat: extent and distribution

It is not possible to find evidence directly linked to the target “Maintain the abundance of preferred food items required by the species”, as such surveys are not conducted. It is judged logical to deduce that the expanding population of adults, and the increasing breeding success, are indicative of a system where suitable food is not limiting. It is therefore concluded that the Wash shrimp fishery is not preventing the attainment of the conservation objectives of the site in relation to this feature.

Pressure – Removal of non-target species

(ii) Feature – Intertidal coarse sediment

Site and Activity Specific assessment

Pressure – Removal of non-target species		
Feature – Intertidal coarse sediment		
Biotope	Sensitivity	Notes
A2.111	Not Relevant	Scoped out – not relevant
A2.112	Low	Scoped out - Not found where shrimp fishing occurs

The specific sediment type “well-sorted gravel or coarse sand” does not occur in the areas fished by the Wash Shrimp Fishery. Therefore, it is considered that the feature “Intertidal coarse sediment” will not be impacted by the pressure “Removal of non-target species” and there is no need to consider the impact of the pressure on the feature “Intertidal coarse sediment” any further.

Pressure – Removal of non-target species

(iii) Feature – Intertidal mud

Site and Activity Specific assessment

Pressure – Removal of non-target species		
Feature – Intertidal mud		
Biotope	Sensitivity	Notes
A2.311	Low	Low Resistance, High Resilience. Soft mud with fine sand, variable salinity, typically close to the head of estuaries. *N. hombergii* and *M. (Limecola) balthica* are rapid recolinisers. *S. shrubsolii* an indicator species, high abundance indicates stressed environments.
A2.312	Low	Low Resistance, High Resilience. Mainly in mid and lower shore sandy mud or mud in lower estuaries, sheltered bays and marine inlets, often subject to variable salinity. Recovery of *H. diversicolor* populations rapid recovery. *Limecola balthica* - strong recoverability. Other (non- characterising) species also exhibit the ability to recover rapidly
A2.313	Low	Low Resistance, High Resilience. Mainly mid shore mud or sandy mud subject to variable salinity on sheltered estuarine shores. Recovery of *H. diversicolor* populations rapid. *Limecola* (*Macoma) balthica* - strong powers of recoverability. *S. plana* from higher latitudes tended to show lower abundance, shorter reproduction periods and lower growth rates. Other (non- characterising) species also exhibit the ability to recover rapidly.
A2.321	Low	Low Resistance, High Resilience. Soft wet mud with a fine sand fraction, on the mid and lower shore of sheltered estuaries. *N. hombergii* is a rapid recoliniser. *S. shrubsolii* an indicator species, high abundance indicates stressed environments.

A2.322	Low	Low Resistance, High Resilience. Mud and sandy mud shores in sheltered marine inlets and estuaries subject to variable or reduced salinity. Typically found on the mid and lower shores in the upper and mid estuary. Recovery of *H. diversicolor* populations relatively rapid.
A2.323	Low	Low Resistance, High Resilience. Extreme upper estuarine fine sandy mud, sometimes with fine sand, in very sheltered conditions and subject to reduced salinity. Species poor, usually consisting of few species of oligochaetes and sometimes the polychaete, although numbers of individuals may be high. *T. benedii* is opportunistic, but with a longer lifespan than usual for opportunistic species and somewhat prolonged reproductive period. Recolinisation of habitats can therefore be expected to be somewhat slower than for other species with shorter lifespans and more rapid reproduction.

MarLIN describe all of the habitat types listed within the feature “Intertidal Mud” as associated with variable or reduced salinity, or sheltered estuarine conditions, or in soft mud, or in some other way to be associated with the sheltered, mid or upper estuarine areas. The biotopes are therefore stressed to a greater or lesser degree by the natural factor of reduced / variable salinity, with the associated reduction in diversity of species which would be expected in such circumstances. There is a high likelihood of such conditions occurring in the constricted estuaries through which the rivers and watercourses feed into The Wash and the harbour systems on the north Norfolk coast, but within The Wash embayment itself and majority of the Norfolk coast conditions are much more akin to the open sea, with levels and variability of salinity associated with marine rather than estuarine habitats (except for those occasions of defined significant freshwater floods, when there can be appreciable but short-lived excursions of reduced salinity water into The Wash).

In addition, the Wash embayment and Norfolk coast is subject to much greater levels of natural disturbance by waves – both generated within The Wash and arising in the North Sea – than indicated by the descriptions of the sheltered/very sheltered biotopes within the feature “Intertidal Mud”. Where the feature Intertidal Mud occurs within the open Wash embayment, it is likely that increased exposure to natural disturbance results in a species composition with a reduced sensitivity to the pressure “Removal of non-target species” (van Denderen *et al* 2015) – because their component

communities are naturally adapted to a dynamic physical environment where the upper layers of seabed sediments are constantly in a state of flux (when not exposed at low water).

Relatively little of the fishing activity of the Wash shrimp fishery occurs in the areas as described in these biotopes. In fact, such fishing métiers (light towed demersal gear fisheries) will typically actively avoid areas of soft mud – the nets would tend to sink into the seabed, and the relatively low powered vessels would not be able to pull their nets through such sediment types. There is on occasion some shrimp fishing activity within the river estuaries which feed into The Wash, and there remains the possibility for interaction with these biotopes in those locations.

There is no evidence of direct impact of the shrimp beam trawling activity on the species associated with these biotopes – the species are predominantly burrowing, and do not feature in the list of species from a study by Catchpole *et al* (2008) as bycatch from the Wash shrimp fishery. The shallow penetration depth of the shrimp trawl shoes (approx. 2-3cm) results in minimal potential for the removal of infauna from the seabed. The polychaetes *N. hombergii* and *H. diversicolor* are found 5-15cm and up to 20cm below the surface respectively. *S. plana* (peppery furrow shell) burrows up to 20cm depth. However, the bivalve *L. balthica* and *S. shrubsolii* (a polychaete) inhabit the top layers of sediment, down to a depth of 2-3cm, meaning they would be potentially disturbed by shrimp trawling (through the passage of trawl shoes) if it occurred in these biotopes. *L. balthica* is reported to have strong powers of recoverability; *S. shrubsolii* is an indicator of stressed (e.g. low oxygen) environments.

It is concluded that the shrimp beam trawl fishery is not having an adverse effect on site integrity through the removal of non-target species in intertidal mud habitats. However, consideration should be given to the management of the activity in some areas in order to provide a “reference area” of zero fishing activity of any sort against which areas experience fishing pressure could be compared. Protection of the estuarine locations of these biotopes would be afforded by management of activity within the defined “estuary” sections of watercourses feeding The Wash.

Pressure – Removal of non-target species

(iv) Feature - Intertidal sand and muddy sand

Site and Activity Specific assessment

Pressure – Removal of non-target species		
Feature – Intertidal sand and muddy sand		
Biotope	Sensitivity	Notes
A2.221	Not Relevant	Scoped out – not relevant
A2.211	Low	Scoped out – fishery does not occur in areas where this biotope is found.
A2.243	Low	Low resistance, high resilience Fine muddy sand on mid shore at lower extreme of estuaries, in moderately exposed and sheltered bays and marine inlets. Characterising infauna include polychaetes, oligochaetes, crustaceans (*Corophium volutator* and *Crangon* sp.), *Hydrobia ulvae*, *Limecola balthica*. Incidental removal of characterising species would alter biotope character and delivery of ecosystem services. Populations of characterising species provide food, although removal of predators may enhance recruitment of characterising species.
A2.244	Low	Low resistance, high resilience Wave-sheltered, mainly upper and mid-shore flats of medium to fine sand, often muddy sand. Characterising infauna of the biotope include amphipods and *Hydrobia ulvae*. Some characterising species likely to be damaged/directly removed by mobile gear targeting other species. Despite this biotope sensitivity is low due to the burrowing lifestyle and mobility of species, which means a proportion are likely to escape incidental removal. In-situ recovery and migration from adjacent populations reduce sensitivity.
A2.2221	Low	Low resistance, high resilience Species-poor community of oligochaetes occurring in fully marine conditions on open shores with mobile, medium to fine, usually clean, sand.

		Oligochaete populations provide food for macroinvertebrates fish and birds. Loss of this population would therefore impact other trophic levels.
A2.223	Low	Low resistance, high resilience Mobile clean sandy beaches on exposed/moderately exposed shores, sediment ranging from medium to fine, often with coarser sediment. Characterising species include polychaetes, isopods and burrowing amphipods. Burrowing lifestyle and mobility of species mean that a proportion of the population may escape incidental removal, and in-situ recovery and migration from adjacent populations increases resilience in the face of some population loss.
A2.245	Low	Low resistance, high resilience Flats of medium fine and muddy sand. May be tide-swept, and sediment may be mobile, but biotope usually occurs in areas sheltered from strong wave action. Supports dense populations of *Lanice conchilega*. Other polychaetes present are tolerant of sand scour/mobility of sediment surface layers. Incidental removal of *L. conchilega* would cause changes to habitat/ associated species.
A2.242	Medium	Scoped out – The Wash cockle beds are closely monitored by Eastern IFCA and are in favourable condition in terms of cockle biomass and distribution. There is an annual cockle fishery which is highly regulated, and subject to HRA each year, including examination of “in combination” effects. No adverse effects have been identified for *C.edule* or polychaetes characterising this biotope. This represents adequate mitigation for this biotope; therefore, the impact of the pressure on this biotope is not considered any further here.
A2.231	Medium	Low resistance, high resilience Moderately exposed or sheltered beaches of medium and fine, usually clean, sand - may on rare occasions contain a small silt/clay fraction. Characterising infauna dominated by polychaetes, amphipods frequently occur, nemerteans often present. Characterising species are usually of low abundance and adapted to frequent disturbance.
A2.241	Medium	Low resistance, medium resilience

		Muddy/fine sand, often occurring as extensive intertidal flats on open coasts and in marine inlets. Scattered stones, cobbles and boulders with attached fucoids may occur. Characterising species include *Arenicola marina* and *Limecola balthica.* Species recovery rates vary. Up to three years for *A. marina*, and 50-100 days for superabundant polychaetes.

Sand-dominated habitats are the preferred habitat for brown shrimp (shrimps bury themselves in the surface of the sand to avoid predators) and therefore the main target areas for the fishery. The fishery is identified as preferentially targeting subtidal sand areas, but some fishing does occur in intertidal areas.

Biotopes within this intertidal sand and muddy sand feature are characterised by infaunal species, as would be expected for mobile sediments in relatively high energy environments. However, the habits of some of the named species mean they are not typically found under the sediment surface, e.g. *Crangon* is a motile swimmer that can bury itself in the uppermost layer of sediment, *Hydrobia* graze nutrients from the surface of the sediment, *L. conchilega* builds tubes whose ends are exposed on the surface of the seabed. Polychaetes and crustacea (other than the target species *Crangon*) are not likely to be removed by the shrimp fishery because of their burrowing lifestyle and mobility. Shallow-burrowing bivalves (e.g. *L. balthica*) could be affected by the shallow (2-3cm) abrasion caused by shrimp beam trawling, which in turn could result in some loss of individuals of this species, equating to a level of removal of non-target species.

There is potential for impact on *L. conchilega* populations where shrimp trawl shoes pass through beds of their tubes, although observations indicate that the tubes rebound without damage from the displacement. Eastern IFCA has not identified evidence to show whether abrasion of the ends of the tubes results in removal of *L. conchilega* from the sediment, although MarLIN reports the species has a low sensitivity to abrasion and displacement. The limited data available on the abundance and distribution of *L. conchilega* (presented in Appendix 8g) identified no overall declines in abundance of this species in intertidal parts of the Wash between 1995 and 2011.

Shrimp trawling could impact the mud snail *Hydrobia ulvae* and the bivalve Baltic tellin *Limecola balthica*, species typically found on the surface or upper few cm of substratum. No evidence has been identified for abundance and distribution trends of these species, so there remains a level of uncertainty in relation to impacts on these species of the sub-feature. However, although there could be some impact on biotopes of this sub-feature that are characterised by these species, it is considered that the mobile sediment and relatively high energy environment defining these biotopes

means that the light weight and low levels[5] of the pressure *Removal of non-target species* generated by the shrimp beam trawl fishery will have a minimal overall effect in terms of removal of non-target species. Although this is not supported by specific assessments of all characterising species, this conclusion is borne out by assessment of the specific conditions currently prevailing in these biotopes following many years of shrimp fishing activity (e.g. as described in Appendices 9, 10 & 11). Of particular relevance is the fact that the trajectory of condition as described in those appendices is stable, and definitely not declining.

None of the characterising species, nor any other infaunal species and very low levels of epifaunal species were recorded in a specific study of bycatch from The Wash shrimp fishery (Catchpole et al 2008) (most species and individuals recorded were fish).

Ongoing targeted monitoring of this feature in areas of low, medium and higher levels of shrimp beam trawling will continue to develop and refine this understanding. Consideration of removing all fishing pressure from an area of this feature would allow comparison with an un-impacted area, and further enhance this understanding.

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[5] See section 3.1 of main report for description of fishing gear and fishing activity location. Vessels primarily target shallow subtidal areas, including channels between intertidal banks. Intertidal sandflats and mudflats are not specifically targeted but a low level of shrimp fishing can occur on these features. This is illustrated in the fishery sightings data (Figure 10 of main report).

Pressure – Removal of non-target species

(v) Feature – Subtidal biogenic reefs: mussel beds

Site and Activity Specific assessment

Pressure – Removal of non-target species		
Feature – Subtidal biogenic reefs: mussel beds		
Biotope	Sensitivity	Notes
A5.625	Medium	Low resistance, Medium resilience. Requires the presence of dense *Mytilus edulis* beds. Populations have a strong ability to recover from environmental disturbance. While good annual recruitment and rapid growth are possible, recovery of the mussel population may take up to 5 years. In certain circumstances and under some environmental conditions recovery may take significantly longer. The associated community is likely to colonize the substratum or mussel matrix rapidly.
A5.621	High	A5.621 *Modiolus modiolus* beds with hydroids and red seaweeds on tide-swept circalittoral mixed substrata. A5.622 *Modiolus modiolus* beds on open coast circalittoral mixed sediment Applicable to both – Low resistance, Low resilience. Patches extending over >10m^2 with >30% cover by mussels should definitely be classified as “bed”. However, mosaics also occur where frequent smaller clumps of mussels influence ecosystem functioning - for management purposes lower thresholds can be accepted for defining beds. *Modiolus* communities consist of very dense aggregations of horse mussel shells forming a single or multi-layered framework; a rich community of free living and sessile epifauna and predators; a very rich and diverse community of species, with low abundance, which shelters between the shells and byssus threads of the horse mussels and thrives on the rich sediment, and an infauna living within the rich sediment deposits built up by the bed.
A5.622	High	

There are no areas of EUNIS habitat type A5.62 (subtidal biogenic reef – mussel beds – either *Mytilus* or *Modiolus*) identified in WNNC SAC.

Subtidal *Mytilus* beds have been identified on several occasions in or near the WNNC SAC, tending to be in water deeper than ten metres below chart datum, and comprised of juvenile mussels. These beds have always been ephemeral, dying before ever becoming established into adult mussel beds. The existence of permanent beds is thought to be precluded by high levels of predation by starfish, or loss of beds of juvenile mussels during intense physical disturbance from storms (Eastern IFCO, pers. comm.). There are no known permanent sublittoral mussel beds in the Wash and North Norfolk Coast SAC or in the wider area of the Wash approaches.

Shrimp fishers avoid trawling over known mussel beds, to avoid both damage to the fishing gear and time spent sorting out an unusable bycatch. If subtidal *Mytilus* beds are identified, they are on occasion the subject of commercial fisheries. These fisheries are always subject to bespoke HRA, including in combination effects.

The six records for *Modiolus* within the EIFCA compiled dataset (results of benthic sampling surveys between 1995 and 2015)[6] record a total of 61 individuals. 55 of these originate from one sample. This single sample of a dense aggregation of *Modiolus* could have been an error of either identification or recording at some stage (since juvenile *Modiolus modiolus* and *Mytilus edulis* can be confused). Whether or not the identification of *Modiolus* was correct, the results over the prolonged time period show that *Modiolus* is present at very low levels, if at all, within the area fished by the Wash shrimp fishery.

Furthermore, a study of the bycatch of the Wash shrimp fishery (Catchpole *et al*, 2008) recorded no instances of either *Mytilus* or *Modiolus* within the bycatch of the fishery.

The assessment of sensitive species (Appendices 7 and 8) identified a decline in the abundance of mussels, based on benthic survey data from 1995-2015. It is not known whether this reflects a decline in the occurrence of ephemeral sublittoral mussel beds, but this cannot be ruled out. “Permanent” sublittoral mussel beds (i.e. forming biogenic reefs) are not known to occur in the site. Although considered unlikely, the assessment concluded that the shrimp fishery could potentially constrain the formation of the biotope Subtidal biogenic reefs: mussel beds, if sublittoral mussels settled in areas where they could survive into adult beds but are disturbed incidentally by shrimp beam trawling. There is considered to be a very low likelihood of this occurring, given the infrequent occurrence of sublittoral mussels in the site and especially because of their ephemeral nature, meaning the beds do not survive into permanent features because of natural physical and biological pressures.

Sublittoral biogenic reef: mussel beds will be considered in Eastern IFCA’s management of other reef features in the site, namely *Sabellaria spinulosa* reef and

[6] See Appendix 7a for information on dataset used in this assessment

subtidal stony reef. It is not considered that additional management is needed in the shrimp fishery for the potential occurrence of ephemeral sublittoral mussel beds, since (for the reasons set out above) existing mechanisms deal with this in an appropriate manner.

Pressure – Removal of non-target species

(vi) Feature – Subtidal coarse sediment

Site and Activity Specific assessment

Pressure – Removal of non-target species		
Feature – Subtidal coarse sediment		
Biotope	Sensitivity	Notes
A5.131	Not Relevant	Scoped out – not relevant. Biotope does not occur in areas of shrimp fishing in WNNC SAC.
A5.137	Low	Low Resistance, High Resilience. Dense beds of *Lanice conchilega* and other polychaetes in coarse to medium fine gravelly sand in the shallow sublittoral, where there are strong tidal streams or wave action. Species tend to have high recovery, including 2 years for *Lanice* to recover from total removal. *Scoloplos armiger* has a low dispersal potential, and characterises the end of the transitional phase and the development of final equilibrium communities following impact or disturbance.
A5.141	Low	Scoped out - This biotope is not found within those areas of the WNNC SAC where shrimp fishing occurs (Circalittoral cobbles and pebbles in The Wash are found in deeper waters, where they are stable rather than unstable. Such areas are protected by EIFCA closures to bottom towed gear.) Therefore, there is no need to consider the impact of the pressure on the biotope any further.
A5.134	Low	Medium Resistance, High Resilience. Loosely packed grains of medium to very coarse sand forming waves up to several metres high, often with gravel, or occasional silt, in the troughs of the waves. Although the general locations of the shrimp fishery have the potential to interact with this habitat type, it is known that shrimp fishers avoid areas of rapidly changing depths and steep banks, due to the difficulties of maintaining correct proximity to the seabed in such areas. None of the species listed as characterising in MarLIN 5 are recorded as bycatch in Catchpole *et al* (2008), and

		the fishing metier is extremely unlikely to exert a negative impact on this biotope via the pressure Removal of non-target species.
A5.135	Low	Low Resistance, High Resilience. Infralittoral mixed slightly gravelly sands on exposed open coasts impoverished communities characterised by the polychaete *Glycera lapidum*. It is not a true biotope, rather an impoverished, transitional community, which in more settled conditions develops into other more stable communities. This seabed type is not favoured as an area for shrimp fishing.
A5.136	Low	Low Resistance, High Resilience. Cumaceans and *Chaetozone setosa* in infralittoral gravelly sand on moderately exposed open coasts. The biotope is characterised by species that have strong recoverability from physical disturbances. Recovery of *Scoloplos armiger* may take longer than some species but may be complete within two years and the biotope may be considered to have recovered where this species is still increasing in abundance. None of the species listed as characterising in MarLIN 7 are recorded as bycatch in Catchpole *et al* (2008), and the fishing metier is extremely unlikely to exert a negative impact on this biotope via the pressure Removal of non-target species.
A5.143	Low	Low Resistance, High Resilience. Coarse gravelly or shelly sand sometimes with some mud, along open coasts in depths of 10 to 30m, and in shallower offshore areas. Impoverished community, several species found in low abundance. Characterising species has a high recoverability. None of the species listed as characterising in MarLIN 8 are recorded as bycatch in Catchpole *et al* (2008), and the fishing metier is extremely unlikely to exert a negative impact on this biotope via the pressure Removal of non-target species.

Brown shrimps favour fine to coarse sand habitat (MarLIN) rather than larger coarse sediments featured in these biotopes, but their presence in these habitats is not

completely ruled out. Coarse sediment habitats are not therefore key fishing grounds for shrimps. The mobile sediment and high energy environment defining these biotopes leads to the general conclusion that the light weight and low levels of the pressure Abrasion/disturbance of the substrate on the surface of the seabed generated by the shrimp beam trawl fishery would have little effect compared with natural disturbance (van Denderen *et al* 2015). Very little shrimp fishing activity takes place in areas where this feature is found.

Characterising species are infaunal. Local knowledge indicates that sand eels will be a component of such habitats. None of the characterising species, nor any other infaunal species and very low levels of epifaunal species were recorded in a specific study of bycatch from The Wash shrimp fishery (Catchpole *et al* 2008) (most species and individuals recorded were fish, but no sand eels were recorded).

It is considered that no specific protection of the feature is required, except where areas described as “coarse sediment” occur in deep, sheltered low energy areas, and are associated with rich fauna. Such areas also tend to have sufficient fine fraction in the sediment that they are not correctly classed as “coarse sediment”. In such areas, emergent epifauna could be impacted by shrimp beam trawl, and consideration will be given to management to mitigate the pressure *Removal of non-target species*.

Pressure – Removal of non-target species

(vii) Feature – Subtidal mixed sediments

Site and Activity Specific assessment

Pressure – Removal of non-target species		
Feature – Subtidal mixed sediments		
Biotope	Sensitivity	Notes
A5.432	Medium	No Resistance, Medium Resilience Muddy gravelly sand with pebbles off shallow, sheltered or moderately exposed coasts or embayments. *Sabella pavonina*, sponges and anemones characterising species, with hydroids also important. *S. pavonina* can increase numbers rapidly, especially if some adults remain in the vicinity. Abundance of sponges varies annually even in unfished areas, and can recover within a few years. Larger anemones can be expected to take several (abt. 4) years to recover. Although there is effectively an extremely curtailed infralittoral zone within the WNNC SAC (due to poor transmission of light through the generally turbid waters), species associated with this biotope have been recorded within the EIFCA compiled dataset, and observed during EIFCA sampling (grab sampling and video sampling). The biotope will therefore be considered. There is a sparsity of records from the EIFCA compiled dataset for species associated with this biotope, with a generally low number of observations and great inter-annual variation. This makes it difficult to draw quantitative conclusions, but it is judged that this biotope is found within the WNNC SAC associated with the mixed sediment type found in deeper areas (deeper than 10m below chart datum) – i.e. a mix of angular gravel / pebbles, sands and mud, rather than with the mixed sediment type associated with the shallower areas – i.e. largely mud, some sand, and with surface shell fragments.
A5.444	Medium	Low Resistance, Medium Resilience Tide-swept circalittoral mixed sediment. *Flustra foliacea* and *Hydrallmania falcata* characterise this biotope, which has a high recovery potential. *Hydrallmania falcata* and *F. foliacea* were considered in Appendix 8, which examined abundance and distribution of

		species selected as potentially sensitive based on biological traits. Data were limited, making interpretation difficult, but for both species no declines in occurrence over the time period of the dataset were observed. It is reasoned that shrimp fishing is not likely to be affecting the presence and ecological functioning of this biotope.
A5.445	Medium	Low Resistance, Medium Resilience *Ophiothrix fragilis* and/or *Ophiocomina nigra* brittlestar beds on sublittoral mixed sediment. Biotope is brittlestar beds, rather than individuals. *O. fragilis* recruits initially settle amongst adults. Settlement of larvae dependent on hydrographic conditions and may be unpredictable – resettlement of lost populations not guaranteed. *O. nigra* grows slowly, lives for up to 14 years. Juvenile *O. nigra* appear not to settle among adults.

Biotopes associated with this feature are characterised by epifaunal species. Eastern IFCA's examination of trends in populations of such species indicated stability or increasing abundance for the colonial bryozoan (*Flustra foliacea*) and hydroid (*Hydrallmania falcata*) across habitats, but declines in the *Ophiuroidea* taxon in deeper subtidal areas.

Ophiuroidea were considered in Appendix 8j, which examined species selected as potentially sensitive based on biological traits. This indicated a difference in response of the species depending on whether samples came from waters shallower or deeper than 10 m below chart datum: weak declines or stability over time was seen in samples from shallower subtidal areas, whereas samples from deeper areas showed a stronger decline in abundance over the period of the dataset (1995 – 2015). A study of the bycatch from The Wash shrimp fishery (Catchpole 2008) records *Ophiothrix fragilis* from 18% of hauls, with an average of 5 individuals caught per haul.

This suggests that ongoing activities – primarily the shrimp fishery, one of the few human activities regularly interacting with benthic habitats in the Wash & North Norfolk Coast – could be having a negative effect on brittlestar abundance, and therefore affecting the community composition of these deeper, subtidal mixed sediment habitats. An effect in shallower areas cannot be ruled out. It is therefore proposed that some form of protection through management could be beneficial, particularly in deeper parts of the site (the depth of 10m below chart datum having been identified as an important cut-off point) although some consideration should be given to protection in shallower areas.

Pressure – Removal of non-target species

(viii) Feature – Subtidal mud

Site and Activity Specific assessment

Pressure – Removal of non-target species		
Feature – Subtidal mud		
Biotope	Sensitivity	Notes
A5.321	Low	Low resistance, High resilience Variable salinity clay and firm mud characterised by a turf of the polychaete *Polydora ciliate*. MarLIN 34 records no occurrences in WNNC SAC, and notes may be specific to The Humber estuary. Depends on turf of *P. ciliate* - in EIFCA Compiled Dataset, no records of the species prior to 2010, and then recorded in every year to 2015 for which sample data is available. Not recorded at high levels, and not turf observed during EIFCA activities.
A5.325	Low	Low resistance, High resilience Reduced or variable salinity, muddy sediment. Dominated by the opportunistic polychaete *Capitella capitata* & oligochaetes *Tubificoides* spp with a very low species richness but possibly large numbers of individuals. *C. capitata* dominated biotope is likely to reach maturity very rapidly, reaching maturity within about four months and reproducing throughout the year. Other species within the biotope may colonize more slowly but the biotope is considered likely to have recovered within two years for any level of impact.
A5.331	Low	Low resistance, High resilience Near-shore shallow sandy muds and muds, and sometimes mixed sediments. MarLIN 31 does not identify this biotope as being present in the WNNC SAC, but EIFCA observations recognise the biotope description from local knowledge of the site, so it is considered important to include in this assessment. *Crangon crangon* is reported as an important biotope component. The life history characteristics of the species which characterise the biotope suggest that the biotope would

		recover from major perturbations and be recognisable as the biotope within 5 years. This protracted recovery is due to *Echinocardium cordatum*, (sea potato)with other species components typically recovering in 1 – 2 years. There are no records of *E. cordatum* in the Catchpole (2008) study of bycatch from The Wash shrimp fishery, and it is unlikely that the gear would penetrate the seabed sufficiently deeply to impact the species (it is usually buried to about 8cm deep).
A5.333	Low	Low resistance, High resilience Cohesive sandy mud, sometimes with a small quantity of shell in shallow water. Very sheltered conditions with very weak tidal streams. Small bivalves typically found in this habitat (e.g. *Mysella bidentata* and *Abra alba*) could be damaged by fishing gear. Sensitive species assessment of *A. alba* (App 8c) showed increase in abundance over time in subtidal muds and across site as a whole. Resilience of the biotope is considered high if habitat is suitable and recruitment from neighbouring areas is possible. This biotope is likely to recover rapidly because the key characterising species are short lived and reach maturity rapidly.
A5.334	Low	Low resistance, High resilience Infralittoral cohesive sandy mud, in sheltered marine inlets, and occasionally variable salinity environments, where the characterising species may be present in large numbers. Polychaete *Melinna palmata* is a characterising species. EIFCA Compiled Dataset shows low and patchy occurrence of the species (recorded in three years between 1995 & 2015), with maximum density of 50 / m^2 cf the 500 – 1000 / m^2 defining the biotope in MarLIN.
A5.336	Low	Low resistance, High resilience Large numbers of the opportunist polychaete *Capitella capitata* in organically enriched and polluted sheltered mud sediments. A *Capitella capitata* dominated biotope is likely to reach maturity very rapidly because the species are short lived, reaching maturity within about four months and reproducing throughout the year. Other species within the biotope may colonize more slowly but overall recoverability and resilience is considered high.

A5.322	Medium	Low resistance, Medium resilience Variable salinity cohesive muddy sediment (sometimes with some coarser material) in sheltered areas with moderately strong and weak tidal streams. Dominated by fast growing opportunistic polychaetes likely to reach maturity within one year of space becoming available. Abundances of these species fluctuates with seasonal changes. Recoverability of *T. benedii* high. *A. marioni* has no pelagic phase in its lifecycle; where the community is severely reduced recruitment is likely to depend on dispersal by hydrodynamic conditions.
A5.323	Medium	Low resistance, Medium resilience Variable salinity soft infralittoral mud and sandy mud. Biotope dominated by opportunistic polychaetes likely to reach maturity within one year of space becoming available. Abundances of these species are known to fluctuate due to seasonal recruitment processes. Recoverability of *T. benedii* high. *N. hombergii* is a rapid recoliniser.
A5.354	Medium	Medium resistance, Low resilience Circalittoral fine sandy mud. Recovery likely to be protracted, and the emergent animals e.g. sea pen *Virgularia mirabilis* could well be damaged by bottom towed gear. However, see expanded narrative for assessment of likelihood of this biotope occurring in WNNC SAC.

The shrimp fishery largely occurs within areas of The Wash embayment which experience more constant and higher “open sea” salinity regime, rather than the reduced or variable salinity regime associated with some of the biotopes identified above (A5.321, A5.322, A5.323 and A5.325). There is on occasion some shrimp fishing activity within the river estuaries which feed into The Wash, and there remains the possibility for interaction with these biotopes in those locations. Many of the biotopes described here for the subtidal mud sub-feature are reported as “shelterered or very sheltered”, whereas much of the subtidal mud habitat considered in this assessment occurs in the more dynamic environment of the Wash and North Norfolk Coast.

<u>MarLIN biotope description for A5.354:</u>

A5.354 *Virgularia mirabilis* and *Ophiura* spp. with *Pecten maximus* on circalittoral sandy or shelly mud

This habitat type occurs in circalittoral fine sandy mud and is primarily identified on the basis of its epifauna and may be an epibiotic overlay over other closely related biotopes. A variety of species may occur, and species composition at a particular site may relate, to some extent, to the proportions of the major sediment size fractions. Several species are common to most sites including *Virgularia mirabilis* (a sea pen) which is present in moderate numbers, *Ophiura albida*, and *Ophiura ophiura* which are often quite common, and *Pecten maximus* (king scallop) which is usually only present in low numbers. *Virgularia mirabilis* is usually accompanied by occasional *Cerianthus lloydii*, *Liocarcinus depurator*, and *Pagurus bernhardus*. *Amphiura chiajei* and *Amphiura filiformis* may also occur in some examples of this biotope. Polychaetes and bivalves are generally the main components of the infauna, although the nemerteans, *Edwardsia claparedii*, *Phoronis muelleri* and *Labidoplax buski* may also be widespread. Of the polychaetes *Goniada maculata*, *Nephtys incisa*, *Minuspio cirrifera*, *Chaetozone setosa*, *Notomastus latericeus* and *Owenia fusiformis* are often the most widespread species whilst *Myrtea spinifera*, *Lucinoma borealis*, *Kurtiella bidentata*, *Abra alba* and *Corbula gibba* are typical bivalves in this biotope.

The relevant Marine Life Information Network webpage identifies that the medium sensitivity for this biotope arise from a combination of medium resistance and low resilience for the pressure *Removal of non-target species* with generally good levels of confidence in the available data.

There are no records of *P. maxiumus* or of *V. mirabilis* in the EIFCA compiled dataset, and local experience of Eastern IFCA officers is that these species either do not occur within the site or have not been recorded during habitat surveys or fishery observations in the site. It is unlikely that the physical conditions of The Wash are suitable for *V. mirabilis,* with the MarLin website (http://www.marlin.ac.uk/species/detail/1396, 1 Feb 2018) stating "*Virgularia mirabilis lives in fine sediments (muddy sand to soft mud). The species is found in sheltered inshore waters, or in deeper water offshore, from 12 - 400 m depth. The species is often very abundant in sea lochs or man-made harbours*."

Ophiuroidea were considered in Appendix 8j, which examined species selected as potentially sensitive based on biological traits. This indicated a difference in response of the species depending on whether samples came from waters shallower or deeper than 10 m below chart datum: weak declines or stability over time was seen in samples from shallower subtidal areas, whereas samples from deeper areas showed a stronger decline in abundance over the period of the dataset (1995 – 2015).

Catchpole *et al* (2008) examined bycatch from the shrimp fishery in The Wash; of the characterising species, only brittlestars (*Ophiuroidea*) were recorded, at low frequency and low levels in shrimp catches.

Therefore, although the biotope A5.354 *in toto* is unlikely to be found in areas where shrimp fishing occurs, some of its characterising species may be impacted.

This suggests that ongoing activities – primarily the shrimp fishery, one of the few human activities regularly interacting with benthic habitats in the Wash & North Norfolk Coast – could be having a negative effect on brittlestar abundance, and therefore affecting the community composition of some subtidal mud habitats, primarily in deeper areas although an effect in shallower areas cannot be ruled out. It is therefore proposed that some form of protection through management could be beneficial, particularly in deeper parts of the site (the depth of 10m below chart datum having been identified as an important cut-off point) although some consideration should be given to protection in shallower areas.

Mud sediments within WNNC SAC are found at shallow (usually intertidal) depths, and again in deep water. There is relatively little in between these extremes. The shallow mud areas are in many locations subject to high levels of wave energy, and tend to be well consolidated and firm (there are exceptions to this in the channels of the true estuaries, where soft mud is found). In the absence of primary evidence from controlled experiments, the best assessment of overall sensitivity of the shallow/intertidal areas that can be undertaken is afforded by assessment of the specific conditions currently prevailing in these biotopes following many years of shrimp fishing activity (e.g. as described in Appendices 9, 10 & 11). Of particular relevance is the fact that the overall trajectory of condition as described in those appendices is stable, and definitely not declining.

Ongoing targeted monitoring of this feature in areas of low, medium and higher levels of shrimp beam trawling will continue to develop and refine this understanding. Consideration of removing all fishing pressure from one area of this feature would allow comparison with an un-impacted area, and enhance this understanding even further.

In deep areas (typically deeper than 10 m below chart datum), as described in assessment of Biotope A5.354 above, there is a case for management to ensure protection of a potentially sensitive habitat. This could be considered precautionary, as there are no indications that many of the characterising species would be found in WNNC SAC. Therefore, any management measure must be subject to appropriate review to identify if recovery to the anticipated biotope is indeed occurring.

Pressure – Removal of non-target species

(ix) Feature – Subtidal sand

Site and Activity Specific assessment

Pressure – Removal of non-target species		
Feature – Subtidal sand		
Biotope	Sensitivity	Notes
A5.242	Low	Low resistance, high resilience Stable, fine, compacted sands where venerid bivalves dominate. Species composition relatively stable, however, numbers of *Magelona mirabilis* and *Fabulina fabula* tend to fluctuate. Infaunal position may protect some burrowing species from removal. Total recovery should occur within two years.
A5.261	Low	Low resistance, high resilience Non-cohesive muddy sands or slightly shelly/gravelly muddy sand characterised by the bivalves *Abra alba* and *Nucula nitidosa*. Infaunal position of species protect a proportion of populations from removal, although species are sedentary/slow moving and therefore likely impacted by removal. Both these bivalves are found in upper few cm of substratum. Some species likely to recolonize quickly hence low sensitivity. Recovery should occur within 2 years.
A5.231	Low	Low resistance, high resilience Medium-fine sandy sediment in shallow water, often formed into dunes, on exposed or tide-swept coasts often contains very little infauna due to the mobility of the substratum. The burrowing lifestyle and mobility of the species that are present mean they are not very vulnerable to removal by shrimp beam trawl fishing.
A5.232	Low	Low resistance, high resilience Shallow sands with cobbles and pebbles, exposed to strong tidal streams, with conspicuous colonies of hydroids. Cobble and pebble not preferred habitat for brown shrimp although underlying sand could be favoured. EIFCA analysis indicated no decline in occurrence in samples of the main characterising species *Hydrallmania falcata*. It is considered unlikely that the shrimp fishery is hindering achievement of “maintain community composition”

		conservation objectives arising through the removal of non-target species.
A5.233	Low	Low resistance, high resilience Well-sorted medium and fine sands characterised by *Nephtys cirrosa* and *Bathyporeia* spp. (sometimes *Pontocrates* spp.) occurring in the shallow sublittoral to at least 30m depth. Occurs in sediments subject to physical disturbance caused by wave/tidal action. Burrowing lifestyle and mobility of species mean a proportion of populations would escape incidental removal.
A5.22	Medium	Low resistance, high resilience Clean gravels and sands in upper reaches of marine inlets/estuaries, where water movement is sufficient to remove silt content of sediment. Characterised by robust fauna, including amphipods, robust polychaetes and mysid shrimps. Characterising fauna are likely to recover quickly. Low levels of shrimping occur in this biotope but where it occurs species such as *Nepthys* spp., may be damaged/directly removed by mobile gear. However, *Nephtys* burrows 5-15cm below surface, i.e. deeper than the shrimp fishing gear disturbs.
A5.243	Medium	Low resistance, medium resilience Community characterised by *Arenicola marina* in shallow fine sand or non-cohesive muddy sand. Resilience is medium due to the isolated nature of sea lochs and lagoons it is commonly found in, however resilience in The Wash is likely higher due to its connectivity with surrounding ecosystems. Burrowing nature of the worm makes it unlikely that beam trawling would significantly impact the species in The Wash.

The Wash shrimp fishery largely occurs within areas of the embayment that experience more constant and higher “open sea” salinity regime, rather than the reduced or variable salinity regime associated with the biotope A5.22 identified above. There is on occasion some shrimp fishing activity within the river estuaries which feed into The Wash, and there remains the possibility for interaction with the biotopes in those locations. However, the specific biotope A5.22 is extremely rare or unknown in WNNC SAC, and characterised by robust resistant fauna. It is not considered that the shrimp fishing activity will impact this biotope in WNNC SAC.

Although biotope A5.22 can therefore be discounted from further consideration, the remaining subtidal sand biotopes require further consideration because they are likely

to be preferred habitat for brown shrimp and therefore the main target areas for the fishery.

The interaction of the shrimp fishery with the seabed is regularly repeated rather than being a one-off event. However, the physical effects have been judged to be very similar to natural disturbance in shallow subtidal areas (because of regular wave action) – see Appendix 9 – and so are not considered likely to affect component communities through the removal of non-target species to a significant extent. The mobility of the sediment and relatively high energy environment defining these biotopes, and their low sensitivity to abrasion (seen in all but one biotope) leads to the general conclusion that the light weight of gear and limited disturbance depth of the pressure *removal of non-target species* generated by the shrimp beam trawl fishery will have little effect on subtidal sand communities.

Most of the characterising species in this sub-feature are adapted to frequent disturbance, e.g. through their ability to burrow or swim away. Some characterising species (e.g. bivalve species[7]) are more sensitive, so it would be expected that should the shrimp fishery be having an adverse effect on the component communities, the proportions of bivalves in affected areas would be declining whilst proportions of burrowing polychaetes and opportunistic species would increase. This effect has not been identified in the analysis of sensitive species, and the species richness assessment for The Wash (Appendices 7 and 8). Data for the number of species (diversity) in subtidal sand suggested a weak decline in shallow areas but no trend in deeper areas (Appendix 8a). Abundance ratio for subtidal sand was seen to be decreasing (suggesting improved ecological quality) over time. It is acknowledged that the data supporting these analyses is limited (particularly when broken down into single taxa or sub-features), but the weight of evidence in the various analyses suggests that widespread adverse effects are not occurring to the benthic communities within the site.

Appendix 8d specifically examined the amphipod *Bathyporeia elegans*; although analysis was hindered by the low number of data points, a possible decline in deeper subtidal sand areas was seen but the overall trend for the Wash was increasing. Appendix 8c considered the bivalve *A. alba;* again the low number of data points resulted in weak confidence in the data, but they suggested that a potential but weak decline was occurring in the abundance of *A. alba* in shallow subtidal sand but the overall trend for this species in the site was increasing.

[7] Although the razor clam *Ensis ensis* can be damaged by dredging, these clams exhibit a defensive response to disturbance, rapidly propelling themselves deeper into the substratum, to depths that are not likely to be disturbed by the surface abrasion/shallow penetration (upper few cm) created by shrimp beam trawling. Razors were not recorded as bycatch in the Wash shrimp fishery study (Catchpole *et al* 2008).

In addition to the sensitive species analysis, consideration of conditions currently prevailing in the site following many years of shrimp fishing activity was undertaken (Appendices 9, 10 & 11), which produced higher confidence results than the individual species analyses. The trajectory of condition as described in Appendices 9, 10 and 11 is stable, and definitely not declining. The current “good” (and increasing) IQI scores for the Wash and North Norfolk coast do not suggest benthic communities are being adversely affected by the ongoing shrimp fishery. The AMBI element of the Infaunal Quality Index metric (see Appendix 10 for full details) relates to the relative abundance of species in undisturbed benthic communities compared with species that thrive in heavily disturbed/polluted environments. Although initially developed as a measure of ecological health in relation to organic pollution, AMBI has been applied to measure other pressures and is recommended for use with other metrics when assessing ecological health in relation to fishing impacts. The IQI measure reflects the AMBI score in addition to diversity and species richness metrics. In The Wash and North Norfolk Coast SAC, since 2011 all subtidal habitats have recorded average IQI scores above the “good” threshold, which is the conservation objective target.

None of the characterising species, nor any other infaunal species and very low levels of epifaunal species were recorded in a specific study of bycatch from The Wash shrimp fishery (Catchpole *et al* 2008) (most species and individuals recorded were fish).

Collectively, the information considered for this pressure/biotope suggests an impact from the shrimp fishery is not likely but cannot be completely ruled out. A cap on effort in this fishery is suggested to be an appropriate management response to ensure any impacts do not escalate into levels of effect that the site cannot withstand. Ongoing targeted monitoring of subtidal sand communities in areas of low, medium and higher levels of shrimp beam trawling will continue to develop and refine this understanding.

References

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