Title: Sussex IFCA Nearshore Trawling Byelaw 2019 Impact Assessment **IA No: SXIFCA007** **Lead department or agency:** Sussex Inshore Fisheries and Conservation Authority (IFCA) **Other departments or agencies**: Department for Environment Food and Rural Affairs (DEFRA), Marine Management Organisation (MMO)	Impact Assessment (IA) **Date:** 22/07/20 **Stage:** Final **Source of intervention: Domestic** **Type of measure:** Secondary Legislation **Contact for enquiries:** Tim Dapling, Chief Fisheries and Conservation Officer, Sussex IFCA, 12A Riverside Business Centre, Brighton Road, Shoreham-by-Sea, West Sussex, BN43 6RE Tel: 01273 454407 e-mail: admin@sussex-ifca.gov.uk
Summary: Intervention and Options	**RPC Opinion**: Opinion Status: N/A

Cost of Preferred (or more likely) Option (in 2019/20 prices)			
Total Net Present Social Value	**Business Net Present Value**	**Net cost to business per year** (EANDCB on 2019 prices)	**Business Impact Target Status**
£1.2m	£1.2m	£-0.1m	-0.7

What is the problem under consideration?

Nearshore marine habitats in Sussex are vital fish breeding, feeding and nursery grounds for many commercial fish species. They are essential fish habitats. Continued use of bottom towed trawling gear in the nearshore environment is not sustainable if these valuable areas are to be protected.

Why is Government intervention necessary?

The nature of fisheries means that without public sector intervention, most stocks would be overfished. Sussex IFCA considers that commercial pressures would lead some trawlers to pursue stocks in the area and damage the provision of public goods and services in the marine environment.

What are the policy objectives and the intended effects?

The policy objective is to review and update the current 'Trawling Exclusion Byelaw' (made in 1997 and confirmed in 1998) according to best available evidence, and to implement fisheries management measures that best protect the natural capital assets within the Sussex nearshore area. 304 square kilometres (km^2) of important nearshore habitat in the Sussex IFC District will be protected. The intended effect is to protect essential fish habitats and fish populations in the nearshore area leading to an overall improvement in biomass and the fisheries themselves. This would stop the degradation of underlying natural capital assets (species, habitats and ecological processes) caused by trawling activity, in order to ensure that people, including commercial and recreational fishers, can continue to enjoy the full range of possible services and benefits into the future.

What policy options have been considered, including any alternatives to regulation? Please justify preferred option (further details in Evidence Base)

- Option 0 Do nothing
- Option 1 Voluntary agreement
- Option 2 Sussex IFCA nearshore trawling byelaw
- Option 3 Prohibition of all activities year round within the whole area

All options are compared to option 0. The preferred option is option 2 which will promote both sustainable fisheries and conserve the marine environment while ensuring compliance with the Marine and Coastal Access Act 2009 (MCAA). This option has been chosen as it enables the protection of natural capital assets within the nearshore environment in the Sussex IFC District. It is considered that, on the basis of available evidence, the benefits of this protection outweigh the costs of the closure to those fishing with trawls.

Will the policy be reviewed? It **will** be reviewed. **If applicable, set review date: April 2024**

Does implementation go beyond minimum EU requirements?		Yes		
Is this measure likely to impact on trade and investment?		No		
Are any of these organisations in scope?	**Micro** Yes	**Small** Yes	**Medium** No	**Large** No
What is the CO_2 equivalent change in greenhouse gas emissions? (Million tonnes CO_2 equivalent)		**Traded: N/A**	**Non-traded: N/A**	

I have read the Impact Assessment and I am satisfied that, given the available evidence, it represents a reasonable view of the likely costs, benefits and impact of the leading options.

Signed by the responsible Chief Fisheries and Conservation Officer  Date: 22nd July 2020

Summary: Analysis & Evidence

Policy Option 2

Description:

FULL ECONOMIC ASSESSMENT

Price Base Year 2020	PV Base Year 2020	Time Period Years 10	Net Benefit (Present Value (PV)) (£m)		
			Low: Optional	**High:** Optional	**Best Estimate:** 1.4

COSTS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant	Total Cost (Present Value)
Low	Optional		Optional	Optional
High	Optional		Optional	Optional
Best Estimate	0		0.1	0.7

Description and scale of key monetised costs by 'main affected groups'

As a result of the proposed regulation it is the pair trawl activity that will be impacted the most, with the other trawl methods having minimal effort within the prohibition area. Cost to business is calculated as £90,000 per annum. An estimated one-off familiarisation cost is £200 in total, based on the assumption that each fisherman takes two hours in the first year of operation to familiarise themselves with the new regulations and to take any adaptive actions. Byelaw guidance will be available to aid interpretation of the new regulation.

Sussex IFCA will monitor exclusion area through the use of education and communication strategies, land and sea-based patrols, joint agency working & monitoring and research: at a cost of £20,000 per annum, see section 6.2.2. for details.

Other key non-monetised costs by 'main affected groups'

A maximum of nine vessels for which trawls are the main gear used have been sighted in the proposed exclusion area and may be displaced. Any displacement may increase fuel and maintenance costs.

BENEFITS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant	Total Benefit (Present Value)
Low	Optional		Optional	**Optional**
High	Optional		Optional	**Optional**
Best Estimate	0		0.2	**2.1**

Description and scale of key monetised benefits by 'main affected groups'

The cost of £90,000 per annum to the pair trawlers as a result of the proposed byelaw, will translate to approximately £90,000 per annum benefit to the rest of the fleet, predominantly the netting fleet, recreational and charter fleet, due to the exclusion of the pair trawlers from the area resulting in greater access to the area for other fishers (see section 6 for details).

Pair trawlers catch a significant bycatch of bass that is subsequently discarded with an associated mortality. The removal of this estimated mortality would lead to £150,000 worth of bass being available for the wider fishery per annum, based on the current sea bass management measures.

Other key non-monetised benefits by 'main affected groups'

Studies that attempt to compare the total value of global ecosystems demonstrate the high relative value of marine, coastal and transitional environments. The range of habitats across the nearshore area support a valuable flow of ecosystem services. The removal of the abrasive pressure of trawling on sensitive and valuable nearshore habitats, as well as the reduction in bycatch of juveniles and non-target species, will benefit the range of ecosystem services these natural capital assets provide.

Key assumptions/sensitivities/risks **Discount rate** 3.5%

Estimates for the impacts on fishers of a loss of landing has involved making several simplifying assumptions, which were tested during consultation and were proven to be valid assumptions: assumption of full compliance with existing legislation, assumption about the part of fleet that will be impacted, assumption that data used is applied across the full ten-year appraisal period, assumptions of stock boundaries and that habitat maps are a good reflection of actuality.

There are potential reputational risks with the introduction of the proposed management, from being: negatively perceived by the fishing community and wider stakeholders due to imposing restrictive measures, negatively perceived by stakeholders for not protecting the nearshore area, negatively perceived by Government for not implanting legislation and statutory failure of duty.

BUSINESS ASSESSMENT (Option 2)

Direct impact on business (Equivalent Annual) £m:			**Score for Business Impact Target (qualifying provisions only) £m:**
Costs: 0.1	**Benefits:** 0.2	**Net: -**0.2	

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1.0 Introduction

1.1 Area in question

The proposed nearshore trawling exclusion area encompasses 304 square kilometres (km^2) of the Sussex Inshore Fisheries and Conservation Authority (IFCA) District. This equates to 17% of the total District area of 1746km^2, when including Chichester Harbour in its entirety.

The current trawling exclusion byelaw prohibits trawling from 58 km^2 of the District between May and October. Under the proposed trawling restrictions an additional 246km^2 of the nearshore area will be protected year round, equating to a 5.2 times increase in area (Figure. 1).

There is a diverse range of seabed habitats in Sussex inshore waters. In the area very close inshore between Selsey to Brighton there is evidence of a dense historic kelp bed (Worthing Borough Council, 1987 and testimony from local fishers), which has now largely disappeared (see section 4.3.3 for more details).

The Sussex Inshore Fisheries and Conservation Authority (IFCA) is moving towards an ecosystem approach to fisheries management, through identifying the environmental value of the District from local habitat complexity, sensitivity and ecosystem services. The highest environmental value is found inshore compared to offshore, and the highest value was in the west of the District, south of Selsey and within the inshore 1km coastal strip from Selsey to Brighton. More detail on this approach is found in section sections 4.4 and 4.5. The nearshore area is also important for many fish species during important life stages, for example as spawning and nursery grounds (Ellis et al., 2012). Fishing sightings data collected by the Sussex IFCA over the past 20 years indicate that there is a relatively low trawling effort in the nearshore area compared to further offshore.

Selsey Bill and the Hounds Marine Conservation Zone (MCZ), designated in May 2019 (tranche 3), has been included in the proposed trawling exclusion zone. Its designated features include several habitats (see Annex 2 for full list of features) with a recover to favourable condition general management approach due to the potential impacts of bottom towed trawling. Trawling management in this MCZ should aim to achieve the same outcomes as the inshore trawling review. The majority of this MCZ was included within the original trawling exclusion zone proposals, which were being developed before its formal designation. Therefore, after designation, it was decided by the IFCA governing committee that it is appropriate to include the whole MCZ within the proposed prohibition area.

More detail on the approach taken and final exclusion area proposals is outlined in section 5.

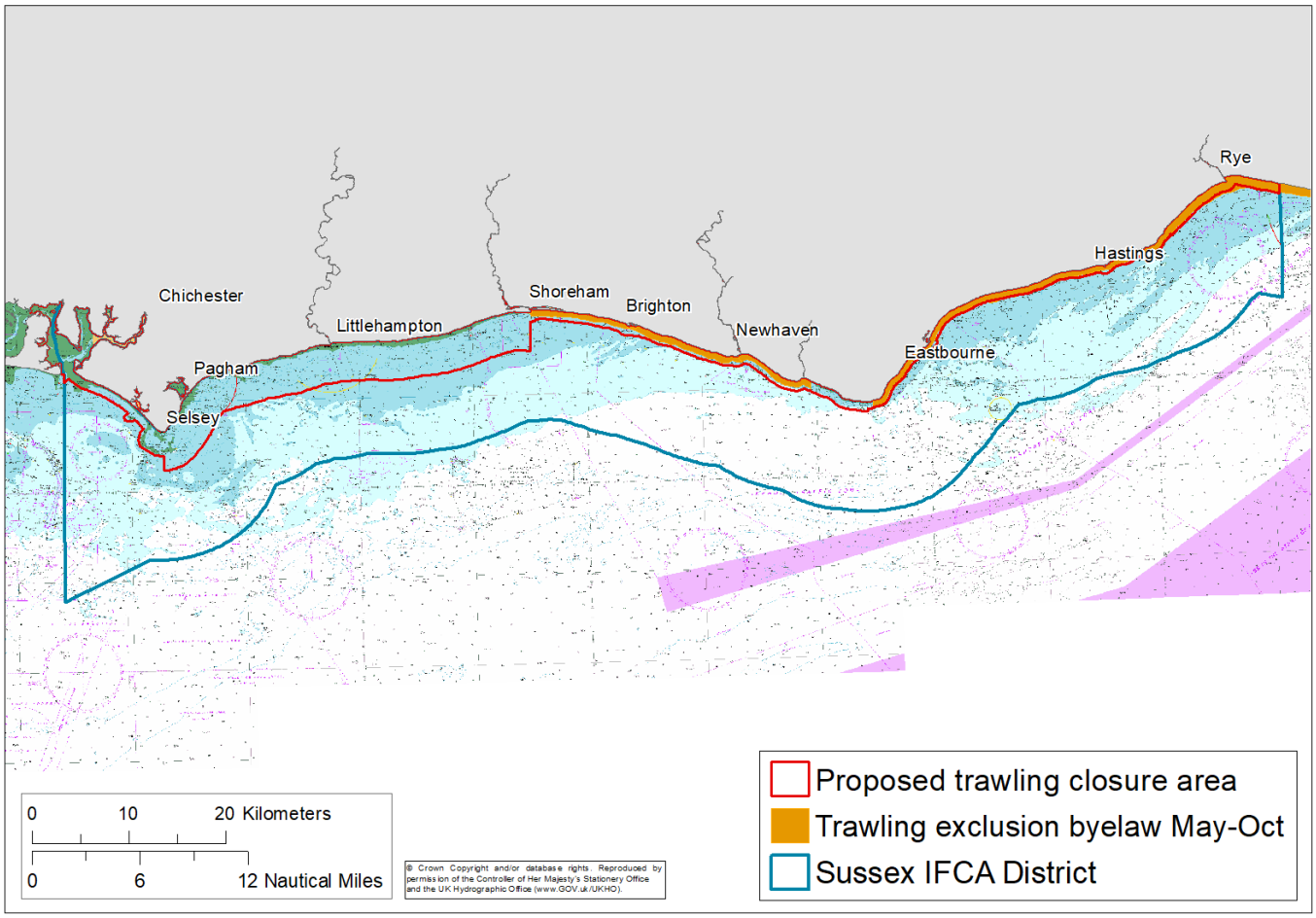

Figure 1. Proposed trawling closure area with existing seasonal trawling exclusion byelaw area overlaid.

1.2 Impact Assessment purpose

This impact assessment (IA) assesses the costs and benefits of the recommended option. It also considers why the recommended option is being recommended rather than others.

It follows an informal public consultation which took place in June 2018, and a formal public consultation which took place in September and October 2019.

1.3 Inshore Fisheries and Conservation Authority duties

The IFCAs must manage the exploitation of sea fisheries resources in their Districts as set out in section 153 of the Marine and Coastal Access Act (MCAA). The Sussex IFCA governing committee consists of members of West Sussex, East Sussex and Brighton & Hove councils, persons appointed by the Marine Management Organisation (MMO), and employees of the MMO, Environment Agency (EA) and Natural England (NE). The appointed members of the Authority must comprise of those acquainted with the needs and opinions of the fishing community of the District, and those with knowledge of, or expertise in, marine environmental matters. The IFCA committee delegates functions to the Chief Officer. The Chief Officer manages the professional staff of the IFCA.

Section 153 of the MCAA details the duties of the IFCA, stating that “the authority for an IFC District must:

(a) seek to ensure that the exploitation of sea fisheries resources is carried out in a sustainable way,
(b) seek to balance the social and economic benefits of exploiting the sea fisheries resources of the district with the need to protect the marine environment from, or promote its recovery from, the effects of such exploitation,

(c) take any other steps which in the authority's opinion are necessary or expedient for the purpose of making a contribution to the achievement of sustainable development, and
(d) seek to balance the different needs of persons engaged in the exploitation of sea fisheries resources in the District."

In addition, section 154 provides that the authority for an IFC District "must seek to ensure that the conservation objectives of any Marine Conservation Zones in the District are furthered."

1.4 Recommended option and rationale summary

The recommended option is a year round prohibition of trawling along the entire Sussex coast. The area between Chichester and Selsey Bill and the Hounds MCZ, Shoreham to Beachy Head, and Rye Bay will have a prohibition of trawling from MHWS out to 1km. The area between Beachy Head and Fairlight will have a prohibition of trawling from MHWS to 0.75km. The area from Selsey Bill to Shoreham by Sea will have a prohibition from MHWS out to 4km, and the area from Selsey Bill to the western end of Selsey Bill and The Hounds MCZ follows the seaward boundary of the MCZ (Figure 1).

To support the initial informal consultation and analysis, the District was divided into five areas (Appendix I) based on their geographical nature, the habitats within them and the depth contours (https://www.sussex-ifca.gov.uk/consultation-archive). The trawling exclusion boundaries within each of these areas reflects the habitat distribution and needs of the fisheries which utilise those habitats, based on Sussex IFCA's evidence collection and informal community consultation.

The proposed nearshore trawling management will protect a range of sensitive and valuable habitats inside and outside of marine protected areas (MPAs) and the limited areas of the Sussex IFC District which are currently afforded some seasonal protection from the documented impacts of trawl fisheries. It aims to allow the natural capital of valuable sensitive sites (essential fish habitats) within the nearshore area to reach its full potential, and deliver improved ecosystem services.

Many coastal fish species are highly dependent on shallow and sheltered coastal habitats for their reproduction. Coastal habitats are also utilised as spawning and nursery areas of migratory marine species, such as black seabream *(Spondyliosoma cantharus)*, bass *(Dicentrarchus labrax)*, herring *(Clupea harengus)* and flatfishes. These nearshore areas therefore provide essential fish habitat, which have a disproportionate ecological value in supporting critical fish life stages, hence sustaining healthy fish populations and provision of the associated ecosystem services. As such, they are of key interest when prioritising areas for protection.

These wider ecosystem services benefits are central to the current management proposals rationale, with the Authority adopting a move towards an ecosystem approach to fisheries management in response to current Government policy and guidance, such as the Government's 25 Year Environment Plan (HM Government, 2018). This comprises a more holistic approach to managing fisheries which balances ecological well-being with human and societal well-being, rather than the conventional target species approach focussed on biological objectives for maximising sustainable yield (Defra et al., 2019). The key evidence for informing such an approach is the identification of the type, quality and extent of natural capital assets, with mapped habitats based on best available information being the recommended approach by Government. Importantly, Government's steer is that habitats, species and ecological processes don't degrade for the benefit of future generations and that a precautionary approach is taken with the management of our natural capital assets (Defra et al., 2019).

Detailed habitat mapping for the District, with the assignment of different areas of environmental value based on seabed habitat type and their ecosystem services provision, diversity and sensitivity, clearly supports the ecological case for protection, with higher environmental value found closer to the coast across the whole District.

Evidence around the demise of a historical dense kelp forest along the West Sussex coastline, with first-hand accounts from fishers, adds additional weight to protection of the nearshore area from trawling and associated proposed restoration of this habitat. Macroalgae are considered an ecosystem component critical to ecosystem services delivery, meaning this habitat should be given special attention when

considering management. Kelp specifically provides a wide range of associated ecosystem service benefits, including fish breeding, feeding and nursery grounds (Smale et al., 2013).

The recommended option would allow other activities to continue and even increase to some extent, including static gear fisheries, scuba diving and sea angling. Concomitant fisheries enhancement is anticipated, supporting local lower-impact fisheries within the nearshore area and associated societal benefits.

Another key benefit would be the prevention of the additional mortality on bass from pair trawlers which are taking a significant by-catch of bass (see section 4.9.2.4), which are then being discarded, with associated mortality. The proposed regulation will make this valuable catch available for the wider fishery and improve stock condition.

2.0 Rationale for intervention

2.1 Overarching rationale for Government intervention

Fishers and the public derive benefits from the nearshore marine environment in Sussex and the ecosystem goods and services which the habitats within it provide. If trawling continues within the nearshore area then these benefits would diminish. Thus, Government intervention is necessary to ensure protection of a valued resource and to ensure an improved outcome for society and the environment. Without intervention commercial pressures would lead some fishers to continue to pursue activities without adequate regard for the wider costs of their actions on the environment and other marine environment users.

As outlined in the Government's 25 Year Environment Plan (HM Government, 2018), without effective regulation and management fisheries can suffer from what is called the 'tragedy of the commons', where open access to a common valuable resource results in a tendency to over-exploit (HM Government, 2018). Most marine areas are under national jurisdiction with common access, as such there is a lack of a sense of responsibility and stewardship (Jones, 2014).

Unsustainable fishing practices do not just deplete stocks, they threaten the environment and marine ecology and can also have an impact on coastal communities (HM Government, 2018). While overfishing may provide immediate benefits in the form of increased income, it limits the availability of resources in the longer term and thereby jeopardises the livelihood of fishers. It also undermines the resilience of our marine ecosystem and its ability to support sustainable fisheries in the future, including adaptation to climate change impacts.

An ecosystem approach to fisheries management, as underpins the current proposals, aims for more sustainable management and accounts for and seeks to minimise impacts on non-commercial species and the marine environment generally.

Failure to consider the true costs resulting from the degradation of ecosystems can result in a reduction of those beneficial flows which humans derive from nature. Using an ecosystem services framework, to both appreciate and where possible quantify the contribution made by natural ecosystems can enable regulation and investment to protect and conserve those flows of benefits, while also allowing these interventions to be targeted (Williams et al., 2018).

2.2 Government vision for fisheries

The Government's vision for fisheries is set out in "Fisheries 2027, a long-term vision for sustainable fisheries" (HM Government, 2011b). In this publication the Government indicates that its overall priority for fisheries management is to get the best possible long-term economic benefits for society through effective management and moderate levels of exploitation, within the following two constraints:

- Fishing is managed according to an ecosystem approach including use of the precautionary approach to make sure that healthy ecosystems are maintained and rare, vulnerable or valued species and habitats protected. This means more environmental protection than before,

especially in the context of climate change and the need to increase the resilience of the marine environment.

- Access to fisheries continues to be available to small scale fishing vessels, even if in some cases this is not the most economically efficient way of harvesting the resource. This is because the wider economic, social and environmental benefits of small scale fishing can outweigh the comparative inefficiency in harvesting the resource and make a significant economic and social contribution to the lives of individuals and coastal communities, for example, by providing jobs, attracting tourists, providing high quality fresh fish and maintaining the character and culture of small ports throughout England.

Government also states in this publication that the benefits of sustainable fisheries and long-term environmental protection outweigh the costs of any short-term economic losses through the supply chain and to Government. It also proposes that environmentally damaging behaviour will incur a financial cost, with fishing techniques that cause damage to non-targeted species and habitats carrying an economic cost proportionate to the damage caused.

Sussex IFCA considers intervention is necessary within the Sussex nearshore area to ensure fisheries are managed within the above two constraints outlined in Fisheries 2027, and to ensure the best measures are adopted to protect the natural capital and ecosystem services they provide within the area. Whilst Sussex IFCA is committed to supporting small scale fishing vessels and the coastal communities they support, using trawls within the sensitive, valuable nearshore area is not considered to be sustainable due to the degradation of seabed habitat natural capital assets, bycatch of juveniles and non-target species assets, and associated reduction in the ecosystem services they provide.

3.0 Policy objectives

3.1 Overarching policy objective

The overall policy objective is to fulfil Sussex IFCA's obligations to implement management measures that ensure fisheries are exploited sustainably to safeguard their health and best protect the natural capital assets within the nearshore area. This supports the UK's commitments under the EU Biodiversity Strategy to 2020 (2011) and the Marine Strategy Framework Directive (2008), which promote an ecosystem based approach to fisheries management by member states (Table 1). A sustainable fisheries sector is essential for delivering the Government's vision of *clean, healthy, safe, productive and biologically diverse oceans and seas*, and their overall aim to *leave our natural environment in a better state than we inherited it*. This suggests two guidelines for IFCA's management decisions:

- The Authority should consider the benefits of alternative options for managing available resources;
- The overall stock of natural assets in the District should be improved.

Section 3.2 summarises the wide range of policy and legislative instruments which guide the current approach to nearshore trawling management.

Government's 25 Year Environment Plan is a strong driver for environmental policy, particularly in the context of natural capital, and so provides the most appropriate overarching framework. An ecosystem approach to fisheries management is also promoted within the 25 Year Environment Plan, to account for and seek to minimise impacts on non-commercial species and the marine environment generally (HM Government, 2018). Central to this plan is embedding natural capital approaches into the decisions we take, whereby natural capital is managed effectively to deliver multiple benefits to the environment, conservation and people. It is this more holistic approach to managing fisheries which is being adopted by Sussex IFCA.

"Fisheries 2027" (HM Government, 2011b) states that the Government's role is to manage our fish and shellfish natural capital assets on behalf of society, getting the best possible economic and social benefits for today's citizens with the least environmental cost, including safeguarding for future

generations. The need for an ecosystem-based approach to fisheries management is stressed, including the use of the precautionary approach to make sure healthy ecosystems are maintained and rare, vulnerable or valued species and habitats are protected.

The proposed management's objective is to update the existing Sussex IFC District byelaws in line with the duties of the IFCA under MCAA. Specifically, the objectives are to protect sensitive valuable habitats and the fish that utilise them for breeding and nursery ground life stages, and to balance the exploitation of resources by commercial netting fisheries, potters, mobile gear (trawl) fisheries and recreational sea anglers.

The recent history and policy context of trawling management in Sussex inshore waters

The current trawling regulations in the Sussex IFC District (and notably the Sea Fisheries Committee (SFC) District before it) has evolved to accommodate larger vessels and increased trawling effort over recent decades. In terms of the Sussex SFC's byelaw history in the 1990's, there are two important byelaws to consider, the 'Fishing Instruments Byelaw' (made in 1996 and confirmed in 1997) and Byelaw No.3 Vessel Length (made in 1996 and confirmed in 1997). It's important to recognise that during the 1990's the extent of the SFC's District changed from three to six nautical miles from territorial baselines (1996 SI No. 847, The Sussex Sea Fisheries District (Variation) Order 1996, dated 18th March 1996). Therefore any byelaws that were made prior to 18th March 1996 only apply to that those areas of the District within the three nautical mile limit. From a practical perspective virtually all of those regulations have been subsequently replaced or revoked.

The 'Fishing Instruments Byelaw 1996' underwent a significant change on 28th July 1995 when the prior byelaw was revoked and the new regulation allowed for pair trawling for both pelagic species (anywhere within the District) and demersal species (west of Shoreham Breakwater). This byelaw enabled the commencement of the pair trawl fishery on black bream/bass and the associated expansion of trawling effort west of Shoreham to Selsey inside the three nautical mile limit.

In 1997 the Fishing Instruments Byelaw was amended further to take into account the extension of the District, in so doing it included provision for scallop dredging between the three and six nautical mile limit, we can assume that it already occurred in this area beforehand.

Vessel length is used by IFCAs, and previously SFCs, as a proxy for individual vessel effort management. Originally the maximum length within the District was 12 metres registered length, prior to the introduction of a new byelaw on the 14th January 1990 which increased the size to 14 metres overall length (this is longer than registered length). It would be reasonable to assume this change can be associated with a subsequent increase in nearshore trawling effort and the change was made in response to increased industry pressure for nearshore trawling. The ability of larger vessels to come nearshore fits with single boat efforts at trawling on areas west of Shoreham in the early 1990's, later to develop into highly effective pair trawling. On 17th September 1997 the new 'Byelaw No.3 Vessel Length' was confirmed and incorporated vessels operating from three nautical miles to the new six nautical mile limit, grandfather rights (via written authorisation) were written into the byelaw for those who wished to apply at the time.

3.2 Wider environmental legislation and policy drivers underpinning proposal

Numerous policy and legislative instruments support Sussex IFCA's proposed ecosystem approach to fisheries management, promoting consideration of natural capital, ecosystem services and related concepts in the marine environment and their sustainable use (Table 1).

In the European Environment Agency report on the State of Europe's Seas (EEA, 2015), the need to better represent marine systems through the lens of natural capital thinking is highlighted due to their critical importance to many services, goods and benefits that support human societies.

The Millennium Ecosystem Assessment (MEA) (2001-2005) assessed the condition and trends in the world's ecosystems and the services that they provide, including consequences of changing ecosystems for human wellbeing. It provided the scientific basis highlighting the need for action to improve the conservation and sustainable use of ecosystems. The main findings of the MEA were:

- Between 1950 and 2000, ecosystems were impacted and changed faster than ever before in human history, largely as a result of human activity.
- Any benefits derived from exploiting nature came at the cost of significant degradation of ecosystem services.
- The long-term impacts for future generations were shown to be a severely depleted resource / natural capital base.
- 'Non-linear' changes including fish stock collapse and coastal 'dead zones' were identified.
- Significant policy changes were needed.
- Scientists linked ecosystem services to human well-being and development needs.

An ecosystem approach to fisheries management is becoming an increasingly popular management framework to address the impacts humans are having on global ecosystems and implement the principle of sustainable development (Garcia et al., 2003).

Table 1 (overleaf) Policy and legislative instruments supporting a natural capital and ecosystem-based approach in the UK marine environment (ordered from the most recent to oldest drivers). Key points include mentions of ecosystem services, natural capital, ecosystem approach to fisheries management or related terms

Policy / Legislation	Key points	Mechanisms that promote natural capital / ecosystem services consideration
Defra 25 Year Environment Plan (HM Government 2018)	Natural capital / ecosystem services / essential fish habitats / ecosystem approach to fisheries management	The 25 Year Environment Plan published in 2018 reaffirmed the Government's position that the environment underpins well-being and prosperity and provides quantifiable economic benefits. It sets out the ecosystem approach to fisheries management being pursued, which aims for more sustainable management and accounts for, and seeks to minimise, impacts on non-commercial species and the marine environment generally. The plan reaffirms the Government's position that the environment underpins well-being and prosperity and provides quantifiable economic benefits. It expresses the aspiration for the UK to lead the world in the application of the natural capital approach as a tool in decision-making. The plan places an emphasis on embedding an environmental net gain principle. It uses this in the traditional context of infrastructure development, but for the marine environment this concept opens up the opportunity for a change of public mind-set to consider environmental improvements more generally (Hooper et al., 2019). Thus, values amongst the public for improvements to the health and functioning of the marine environment at the systems level could be explored, moving away from protection targeted at specific species or habitats towards the gain of more naturally functioning ecosystems.
South Marine Plan (HM Government 2018)	Ecosystem goods and services / ecosystem approach / natural capital	The plan takes an ecosystem approach and reflects the benefit of clean and healthy seas and natural capital to provide ecosystem goods and services.
Conservation 21: Natural England's Conservation Strategy for the 21st Century (2016)	Natural capital / resilient seas / ecosystems approach	Growing natural capital and creating resilient seas are two of the guiding principles of Natural England's conservation strategy. An ecosystems approach is highlighted as vital.
United Nations Sustainable Development Goals (SDG) (within the 2030 Agenda for Sustainable development, adopted by UN member states in 2015)	Conserve marine resources / sustainable use of marine resources / sustainable development / strengthen resilience / healthy and productive oceans	Government's commitments under the SDG guide many of its priority work areas. Current management proposals will help the Government deliver its commitments under the SDG including the 14th: "Conserve and sustainably use the oceans, seas and marine resources for sustainable development" (HM Government, 2018).
The UK Marine Strategy (P1 2012; P2 2014; P3 2015)	Seas goods and services / resilient seas	The strategy sets out Government's overall ambitions for the marine environment. Based on an improved understanding of the marine environment, Government is committed to delivering effective management of our seas to make sure they are resilient to climate change while delivering the full range of goods and services. These are essential concepts underpinning current management proposals.
Paris Agreement (2015)	Conservation of marine habitats / regulating services / ocean protection	"Because The Ocean" declaration, signed by the UK, highlights the relevance of ocean protection in the implementation of the Paris Agreement. It calls for all parties to include ocean protection in their Nationally Determined Contributions, both in mitigation and adaptation action (HM Government, 2018). This includes the conservation or creation of marine habitats important for carbon sequestration, which provide a globally important climate regulating service.

Policy / Legislation	Key points	Mechanisms that promote natural capital / ecosystem services consideration
Marine Spatial Planning Directive 2014/89/EU	Natural capital / natural resources / ecosystem based approach	Directive requires Member States to have 'due regard' to impacts on natural resources and to consider economic, social and environmental aspects in establishing marine planning.
Environmental Impact Assessment (EIA) Directive 2014/52/EU	Ecosystem services / natural capital / natural resources	Annex III includes reference to use of natural resources and natural capital. Annex IV includes a requirement that the EIA report includes details of likely significant effects to natural resources.
EU Biodiversity Strategy to 2020 (2011)	Ecosystem services / natural capital / natural resources / ecosystem based management / sustainable management	Progress towards achieving the overall strategy vision and target need to be measured with reference to ecosystem services. Target 2 stipulates the maintenance and restoration of ecosystems and their services, promoting a no net loss approach to biodiversity and ecosystem services. Target 4 relates to sustainable use of fisheries resources and promotes an ecosystem based approach to fisheries management.
UK Marine Policy Statement (MPS) (2011)	Ecosystem goods and services / ecosystem based approach	Provides a framework for the development of marine plans. Sets out key considerations that must be taken into account.
Fisheries 2027 – a long term vision for sustainable fisheries (HM Government, 2011b)	Ecosystem-based approach to fisheries / sustainable fisheries	Outlines the Government's long term vision for sustainable fisheries to guide future fisheries policy and provide direction for everyone with an interest in marine fisheries. Explains changes in fisheries and fisheries management over past 30 years and what we are now trying to achieve, namely a balance between economic, social and environmental priorities.
Natural Environment White Paper (HM Government 2011a)	Natural capital	This White Paper entrenched the natural capital concept within UK policy, establishing the Natural Capital Committee as an advisory body to *"put the value of England's natural capital at the heart of our economic thinking"* and committing to the full inclusion of natural capital in UK Environmental Accounts.
UK High Level Marine Objectives (Defra, 2009)	Ecosystem goods and services / ecosystem approach	Government's vision is for clean, healthy, safe, productive and biologically diverse oceans and seas. Use of the marine environment which benefits society as a whole is promoted, contributing to resilient, cohesive communities, as well as contributing to physical and mental well-being. Biodiversity is protected and conserved, with healthy, marine and coastal habitats. People appreciate the diversity of the marine environment, its seascapes, its natural and cultural heritage and its resources and act responsibly. Some objectives articulate outcomes centred on human derived benefits (e.g. achieving a sustainable marine economy). Ecosystem approach is mentioned as a way of integrating and managing a range of demands placed on the natural environment in such a way that it can be conserved and indefinitely support essential services and provide benefits for all.
Marine and Coastal Access Act (MCAA) 2009	Natural resources	Yes – the framework nature of MCAA in relation to marine plans and the MPS enables the statement of policies for contributing to the sustainable development of the marine area. Ecosystem services could be adopted within the MPS and marine plans.

Policy / Legislation	Key points	Mechanisms that promote natural capital / ecosystem services consideration
Marine Strategy Framework Directive (MSFD) 2008/56/EC	Natural marine resources / ecosystem-based approach / ecological services / marine ecological services	Promotes an ecosystem-based approach by Member States, with closely related terms utilised allowing ecosystem services to be taken into account.
Safeguarding Our Seas: A Strategy for the Conservation and Sustainable Development of our Marine Environment (2002)	Ecosystem goods and services / natural resources / ecosystem based approach / ecosystem based management / sustainable management	The term “ecosystem goods and services” is used in context of defining an ecosystem based approach.
World Summit on Sustainable Development (2002)	Ecosystem approach / ecosystem approach to fisheries	Encouraged the application by 2010 of the ecosystem approach, noting the Reykjavik Declaration on Responsible Fisheries in the Marine Ecosystem and Decision V/6 of the Convention on Biological Diversity At the Food and Agriculture-Iceland Conference in Reykjavik (2001) FAO were requested to develop guidelines for an ecosystem approach to fisheries. The principles that underpin this clearly emerged in the 1995 Code of Conduct for Responsible Fishers, inherited from the 1982 Convention on the Law of the Sea, the 1992 United Nations Conference on Environment and Development, its Agenda 21 and the 1992 Convention on Biological Diversity (CBD).
Water Framework Directive (WFD) 2000/60/EC	Natural resources / sustainable management	Recognises the use and management of water resources for human benefit and enables derogations of Good Ecological Status (GES). Ecosystem services can be used to help develop catchment management plans to maximise ecosystem services while achieving GES.
US Sustainable Fisheries Act (1996)	Ecosystem-based management / essential fish habitat	The essential fish habitat concept was introduced as part of this Act alongside the ecosystem-based management approach, which considers the interactions between resources, activities and sectors. Identification of nursery areas as essential fish habitat using measures of relative fish abundance or size distribution can help prioritise areas of the seabed for protection and ultimately sustain healthy fish stocks.
Convention on Biological Diversity (CBD) (1992)	Natural resources	Yes – The European Union, CBD and other United Nations bodies are promoting an ecosystems-based approach or ecosystems based-management as cornerstone concepts for long-term and sustainable development schemes, especially where development strategies are based on natural resources such as fish stocks (Acott et al., 2014). Article 2 of the CBD makes reference to biological resources, the definition of which includes reference to their actual or potential use or value for humanity
Convention for the protection of the marine environment of the North-East Atlantic (OSPAR) (1992)	Sustainable management / ecosystem approach	OSPAR Commission applies the ecosystem approach, defined as “the comprehensive integrated management of human activities based on the best available scientific knowledge about the ecosystem and its dynamics, in order to identify and take action on influences which are critical to the health of marine ecosystems, thereby achieving sustainable use of ecosystem goods and services and the maintenance of ecosystem integrity

Policy / Legislation	Key points	Mechanisms that promote natural capital / ecosystem services consideration
UN Convention on the Law of the Sea (1982)	Natural resources	Sets out sovereign rights of States for the purpose of exploring and exploiting, conserving and managing natural resources, whether living or non-living

3.3 IFCA's key duties, obligations and internal policies

The Authority's key duties, obligations and internal policies in respect to introducing appropriate nearshore trawling management are summarised as follows:

- Managing the exploitation of fish stocks within the Authority's jurisdiction to ensure sustainable commercial and recreational fisheries and continued social-economic benefits from the fisheries in line with the obligation placed upon IFCAs by MCAA section 154.
- Conserving stocks through management of inshore nursery areas helps protect a wide range of commercial and non-commercial fish stocks and can help increase local fish stocks.
- Preventing or removing any trawling pressures would reduce the potential for damage to Ramsar Sites, Special Protection Areas (SPA), Special Areas of Conservation (SAC), Sites of Special Scientific Interest (SSSI) and MCZ features and contribute toward Authority section 153 duties under the MCAA 2009.
- Helping to achieve the broad scale objectives of the EU Marine Strategy Framework Directive by meeting descriptors 1 - Biodiversity, 3 - Commercial Fish Stocks, 4 - Food Web and 6 - Seafloor Integrity.

The suite of management measures iare wide ranging and include:

- Prohibitions and restrictions on fishing
- Permitting systems
- Gear restrictions
- Monitoring of activities
- Provision of information

Section 155 of MCAA 2009 gives the Authority powers to create byelaws for the District. Through a review process; as required within Defra guidance to IFCAs describing IFCA Success Criteria and High Level Objectives the Authority is committed to:

1. Reviewing its suite of byelaws (and other management measures if appropriate).
2. Extinguishing redundant or duplicate byelaws.
3. Putting in place a plan for updates for making and drafting new byelaws, but not necessarily having all proposed new byelaws in place.

In 2013 the Authority established the approach to reviewing its existing management measures. As part of the process the Authority conducted a comprehensive public consultation exercise. The community engagement process invited comments and feedback on a number of proposed objectives and priorities. The process was facilitated through various mechanisms including online and workshop engagement with the commercial and recreational fishing sectors and members of coastal communities. Subsequent to the public consultation process, the Authority, supported by recommendations from the Technical Subcommittee, considered all the responses and adopted the Review of Management Measures Strategy. Five core priorities and objectives were identified as follows:

1. Implement measures to manage the MPA network in Sussex.
2. Apply appropriate minimum sizes to fish and shellfish.
3. Manage effort on key stocks (including gear identification) and establish objectives to manage shellfish.
4. Effectively manage fishing close inshore.
5. Reduce unwanted bycatch.

To translate the priorities and objectives into suitable work packages and prioritise activities against available resources the Authority identified common themes to progress a strategy for the Review of Management Measures. It was agreed that the process for reviewing management measures under common themes should be conducted in parallel with and inform the byelaw review process. It broadly consists of the identification of themes and potential management options, the review of legacy byelaws, the identification of gaps and the development of management options (for example a shellfish permit, repeal and/or maintain and/or extend some of the existing byelaws and develop new byelaws). Importantly, during the progress and prioritisation of individual themes, additional influences were considered such as community expectations, scientific evidence, economic value and the need for a developmental assessment. The common themes agreed were:

1. European marine site (EMS) Management and MCZ development;
2. shellfish;
3. netting (static and mobile);
4. trawling;
5. bait digging/hand gathering.

The prioritisation process (the next stage after identifying themes) applied a matrix approach to score each common theme management measures against a range of eight agreed ‘considerations’ based on evidence and member knowledge and input. For the purpose of combining the byelaw review needs and defining appropriate packages of work, the themes were split out into fishery/metier and byelaw related component elements within the matrix. With reference to existing prioritisation processes the Authority has now undertaken the process of reviewing nearshore trawling management within the District. The core internal and external drivers for commencing a review of nearshore trawling management were summarised and described to the IFCA Technical Subcommittee as follows:

- Review of Management Measures.
- Effectively manage fishing close inshore.
- Reduce unwanted bycatch.
- Review Fixed Engine and Instrument byelaws.
- Status of stocks (for example bass).
- Changes to wider regulatory framework.
- Migratory fish protection EA/IFCA regulations in transitional waters.
- Developments in commercial fisheries (mechanisation, bycatch).

There are a number of other policies currently being considered or implemented that are relevant to introducing the proposed regulation which have been taken into account. The tranche 3 MCZs, Beachy Head East and Selsey Bill and the Hounds, is one such policy, this trawling management proposal encompasses Selsey Bill and the Hounds MCZ. Beachy Head East will be addressed under a separate process. Previous NE Conservation Advice recommends management of bottom towed gear over rocky reef features, which are encompassed within both sites. Sussex IFCAs review of netting management is another such policy. Existing byelaws including the trawling exclusion byelaw and the fishing instruments byelaw will be reviewed in light of this proposed regulation.

4.0 Evidence base

4.1 IFCA evidence requirements

In proposing the recommended option, Sussex IFCA has responded to Government's current steer on the best fisheries management approach for the achievement of sustainable fisheries. Namely, an ecosystem approach which balances ecological well-being with human and societal well-being, and aims to stop the degradation of underlying natural capital assets to ensure people can continue to enjoy the full range of services and benefits into the future. For definitions of key terms and concepts underpinning the Authority's current approach refer to section 4.2 below.

The Authority has subsequently reviewed and aimed to establish using 'best available evidence' as directed by Government:

- the impact of demersal trawlers on habitats;
- the type and extent of natural capital assets within the District, their sensitivity, diversity, associated ecosystem goods and services and value;
- the importance of the nearshore area;
- an indication of current natural capital assets condition and risks to these;
- the impacts, costs and benefits of management proposals on the trawling fleet, static gear operators, wider marine users, the general public and the environment.

Evidence on the impacts, costs, and benefits of the recommended closed area is set out in section 6.

The Government has advised a precautionary approach should be adopted with fisheries management (HM Government, 2011b). The FAO Code of Conduct for Responsible Fisheries (FAO 2018) defines this as follows: 'the absence of adequate scientific information should not be used as a reason for postponing or failing to take conservation and management measures'.

The natural capital approach has particular relevance to the marine environment: Studies that attempt to compare the total value of global ecosystems repeatedly demonstrate the high relative value of marine and coastal environments compared to their terrestrial and freshwater counterparts (Constanza et al., 1997; de Groot et al., 2012).

4.2 Concepts underpinning management

4.2.1 Essential fish habitat

> 'Aquatic habitats which are necessary for fish breeding, feeding or growth to maturity, such as spawning grounds, nursery grounds, feeding areas and migration corridors.' (MMO, 2016)

Many coastal and migratory fish species depend on estuarine and coastal habitats for spawning and nursery areas, and the range of habitat types within these areas for feeding.

4.2.2 Natural Capital

> 'The elements of nature that directly or indirectly produce value to people, including ecosystems, species, freshwater, land, minerals, the air and oceans, as well as natural processes and functions.' (Natural Capital Committee, 2017)

The concept of natural capital helps us understand what we get from the natural world,simply those assets provided by nature which have the capacity to generate goods and services.

4.2.3 Ecosystem Services

> ‘The functions and products from nature that can be turned into human benefits with varying degrees of human input.’ (Natural Capital Committee, 2017)

The ecological components of the environment produce a flow of services and benefits to the economy, society and the health and wellbeing of people.

Essential fish habitats are part of our marine natural capital that deliver ecosystem services, supporting fish populations and fisheries. As well as providing nursery grounds for fish, coastal ecosystems offer a range of other essential ecosystem services, such as coastal protection and sequestering and storing ‘blue’ carbon from the atmosphere and oceans.

The Common International Classification of Ecosystem Services provides a standard classification system which can be used in ecosystem service assessment (Hooper et al., 2019). These can be provisioning, regulating or cultural services. Figure 2 illustrates the three key elements of the natural capital system: Natural capital and ecosystem services (both provided by nature), and goods and benefits, which are realised through human interactions with the environment and require, for example, skills, equipment and investment of time and/or money (Defra et al., 2019).

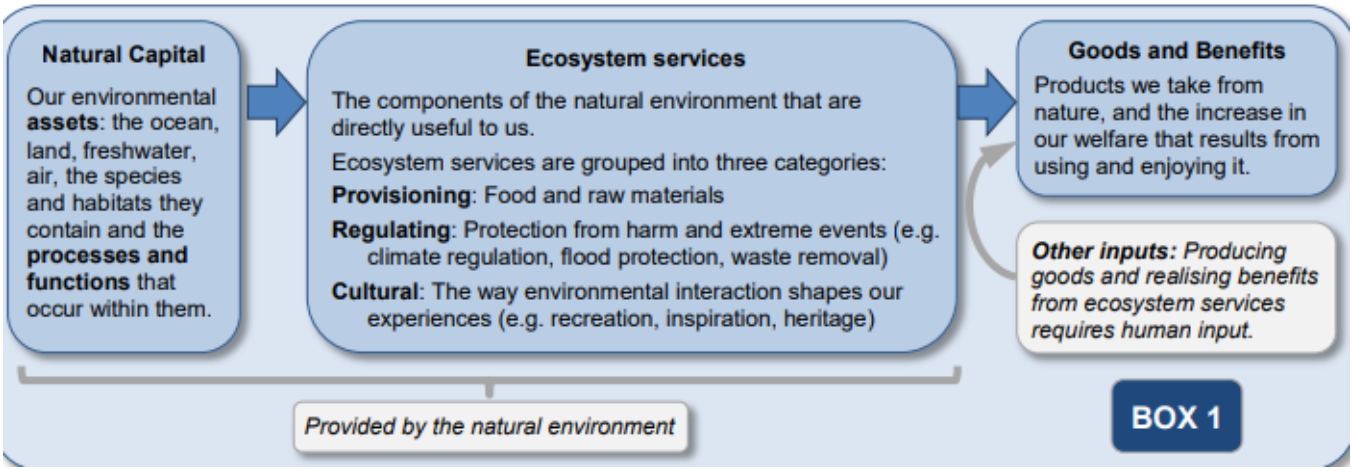

Figure 2. The natural capital system (Defra et al., 2019).

4.2.4 Natural capital approach

> The natural capital approach is based on recognising the contribution of nature to human welfare, and hence improving the manner in which the natural environment is traded-off against other things that are important to society (Defra et al., 2019)

The concept of value is central to the natural capital approach, as it seeks to better integrate environmental, social and economic information and thus to redress the historic trend of undervaluing and overexploiting marine ecosystems (Defra et al., 2019). It is important to highlight that a focus on the monetary valuation of the natural capital approach may be less appropriate for marine areas in the absence of a sufficient number of robust monetary values (Defra et al., 2019).

An essential component of the natural capital approach is that it does not just aim to maintain the flow of those ecosystem services and benefits that are most important to us now. Equal importance is given to ensuring that the underlying natural capital assets (species, habitats and ecological processes) are not allowed to degrade in order to ensure that we can continue to enjoy the full range of possible services and benefits into the future (Defra et al., 2019).

This approach enables a more holistic view of options for fisheries management to be taken that can provide broad information in making the case for a policy intervention, as is being adopted by Sussex

IFCA in its review of nearshore trawling management and outlined within this IA. It can take into account the food provision and economic return of the sector while also considering the costs to other natural capital assets and ecosystem services affected by different fishing strategies (Defra et al., 2019). The natural capital approach can also be used to monitor 'net gain', where a development leaves biodiversity in a better state than before.

4.2.5 Ecosystem approach to fisheries management

> 'Ecosystem approach to fisheries management' and 'ecosystem-based fisheries management' are often used interchangeably to represent:
>
> 'A more holistic approach to management that moves away from fisheries management systems that focus only on the sustainable harvest of target species, towards systems and decision-making processes that balance ecological well-being with human and societal well-being. Both the impacts of the environment on fisheries health and productivity and the impacts that fishing has on all aspects of the marine ecosystem are considered.' (UN Food and Agriculture Organisation training course document)

The concept represents a practical way to achieve sustainable development, addressing the multiple needs and desires of societies, without jeopardising the options for future generations to benefit from the full range of goods and services provided by marine ecosystems (Garcia et al., 2003; FAO 2003, 2011). It strives to balance conservation of biodiversity and ecosystem structure and functioning with harvesting resources for food, income and livelihoods for the benefit of humans.

4.3 Local marine environment

4.3.1. Overview

There is a diverse range of seabed habitats in Sussex inshore waters (Figure 3). This indicative habitat map from the SCHIP 2 project is currently the IFCA's best understanding of the habitats in Sussex coastal waters and is based on 'best available evidence'[1] at the time of writing. The map covers the entire District and is informed by over 2500 data points from video, grab and dive surveys from Marine Recorder (JNCC 2017) and Sussex IFCA survey data, which were used to identify 177 habitats. An interactive map is available from the Sussex IFCA website https://www.sxbrcmapping.org.uk/ifca/mapping.html.

The polygons have been drawn with their boundaries equidistant between neighbouring data points and do not necessarily represent actual boundaries between habitats. This is an established modelling technique referred to as Voronoi polygons, used to create continuous spatial coverage of the study area (Tomline & Burnside, 2015). Confidence contour maps for the habitat data are included within Annex 3. Habitats are classified utilising the European Nature Information System (EUNIS), which is recommended as the foundation for natural capital assessments as it provides a consistent classification with a logical basis (Hooper et al., 2019).

Sussex IFCA has access to the Natural England habitat data maps for designated features in Marine Protected Areas. This data shows the habitats in the majority of the Marine Conservation Zones. However there is very limited or no data for the majority of the District (areas outside MPAs) with this data. Sussex IFCA has access to the EU Seamap data, but the data extent is from Iceland to Norway and down to Spain, so the detail for the Sussex IFC District is minimal and there are large areas of no data at all, particularly close inshore.

Sussex IFCA uses SCHIP2 (Sussex Coastal Habitat Inshore Pilot) data which is based on over 2500 data points, mostly from JNCC's Marine Recorder, with the addition of Sussex IFCA survey data which does not appear on the Marine Recorder database. This is a database containing a mix of surveys which are all high quality. This, combined with the SCHIP1 1km coastal strip (created by the Coastal Channel Observatory using bathymetry data and ground truth data) is the basis of our decision making for the byelaw. The data used is high quality, and verified with local knowledge which includes first hand

observations. We believe that the SCHIP habitat maps are the best available representations of the seabed habitats in the Sussex IFC District and use robust data at an appropriate spatial scale.

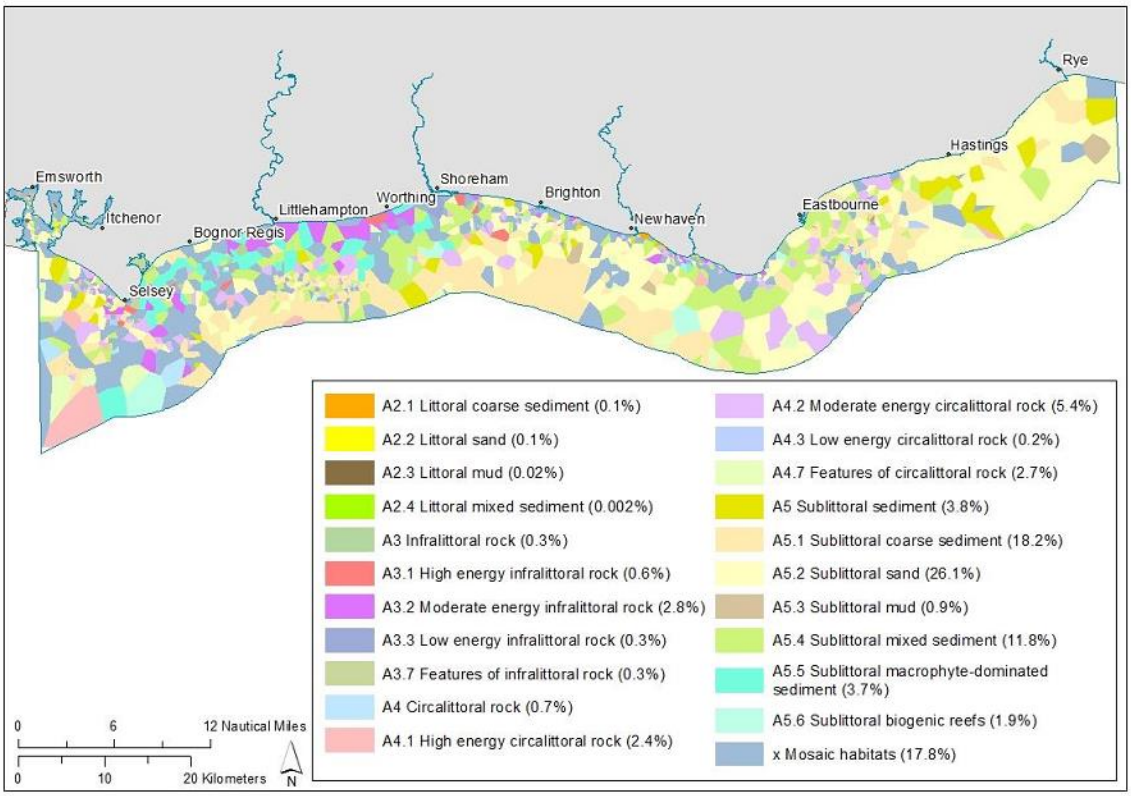

Figure 3. Indicative habitat map of Sussex District from the SCHIP2 project at EUNIS level 2 and 3 (Tomline & Burnside, 2015)[2]

In terms of extent, A5.2 Sublittoral sand covers the largest area (26.1%), followed by A5.1 Sublittoral coarse sediment (18.2%) and x Mosaic habitats (17.8%) where more than one habitat was recorded at a single survey location (Table 2). The diversity of habitats within the District is in itself a feature. There is often more biodiversity when the habitat is more heterogeneous and structurally complex. Chichester and Pagham harbours are muddy with some sand and coarse shelly sediment, as well as features such as seagrass and saltmarsh. Inshore, there is a mix of rocky reef, bedrock and mobile sediment. In some areas there are patches of seaweed dominated sediment and ephemeral mussel beds. In the further offshore areas of the District there is coarse sediment. In the east of the District there is more sand.

Table 2. List of seabed habitats in the Sussex marine environment

EUNIS Level 2	EUNIS Level 3		% of total area	Area (km^2)
A2 littoral sediment	A2.1	Littoral coarse sediment	0.1	1.28
	A2.2	Littoral sand	0.1	1.54
	A2.3	Littoral mud	0.02	0.32
	A2.4	Littoral mixed sediment	0.002	0.03
A3 infralittoral rock	A3	Infralittoral rock	0.3	4.8
	A3.1	High energy infralittoral rock	0.6	9.8
	A3.2	Moderate energy infralittoral rock	2.8	49.0
	A3.3	Low energy infralittoral rock	0.3	4.76
	A3.7	Features of infralittoral rock	0.3	4.61
A4 circalittoral rock	A4	circalittoral rock	0.7	12.92
	A4.1	High energy circalittoral rock	2.4	42.48
	A4.2	Moderate energy circalittoral rock	5.4	94.64
	A4.3	Low energy circalittoral rock	0.2	3.4
	A4.7	Features of circalittoral rock	2.7	46.46

[2] Voronoi polygons from point survey data from Marine Recorder and Sussex IFCA. Colours follow the EUNIS standard. Figures in brackets are the proportion of the study area covered by the habitat.

EUNIS Level 2	EUNIS Level 3		% of total area	Area (km^2)
A5 sublittoral sediment	A5	Sublittoral sediment	3.8	65.79
	A5.1	Sublittoral coarse sediments	18.2	317.20
	A5.2	Sublittoral sand	26.1	455.08
	A5.3	Sublittoral mud	0.9	14.87
	A5.4	Sublittoral mixed sediment	11.8	206.63
	A5.5	Sublittoral macrophyte-dominated sediment	3.7	65.27
	A5.6	Sublittoral biogenic reefs	1.9	33.60
Mosaic Habitats			17.8	311.56

4.3.2 Chalk habitat

The subtidal chalk habitat is classified as either infralittoral or circalittoral rock EUNIS classifications. The chalk coasts of the south-east are very different from the harder rock coastlines of western and northern Britain. The chalk seabed can continue below the low water mark, with the largest areas of these underwater chalk seascapes found in Kent and Sussex. These areas also contain sandstone and claystone reefs. Chalk reef is a very important fragile and rare habitat. Underwater habitats of chalk are rare in Europe, with those occurring on the southern and eastern coasts of England accounting for the greatest proportion. This is a UK Biodiversity Action Plan (BAP) Priority Habitat (BAP habitats are now Habitats of Principal Importance/Priority Habitats), and chalk reefs are listed in Annex 1 of the Habitats Directive.

Sussex is the only location on the British Isles where chalk strata appear as offshore exposed northward-facing vertical cliffs one to four metres (m) in height. Figure 4 below illustrates the documented discontinuous underwater chalk cliff extent following the 10m contour off Sussex, between Worthing Lumps marine Site of Nature Conservation Importance (mSNCI) in the west, to Ship Rock mSNCI in the east, and encompassing South-West Rocks mSNCI 4.5km SW of Hove and Looe Gate mSNCI 4km SW of Hove (Williams & Clark, 2010).

The chalk wave cut platforms, with their gully features, are exemplified in Beachy Head West MCZ, located between Brighton Marina and Beachy Head in the centre of the District. Abundant wildlife is supported by these chalk reefs, such as sea squirts, ross coral, limpets, mussels and oysters. Boring animals like piddocks (*Pholadidae*) make holes in the rock in which other creatures, such as crabs, may later live.

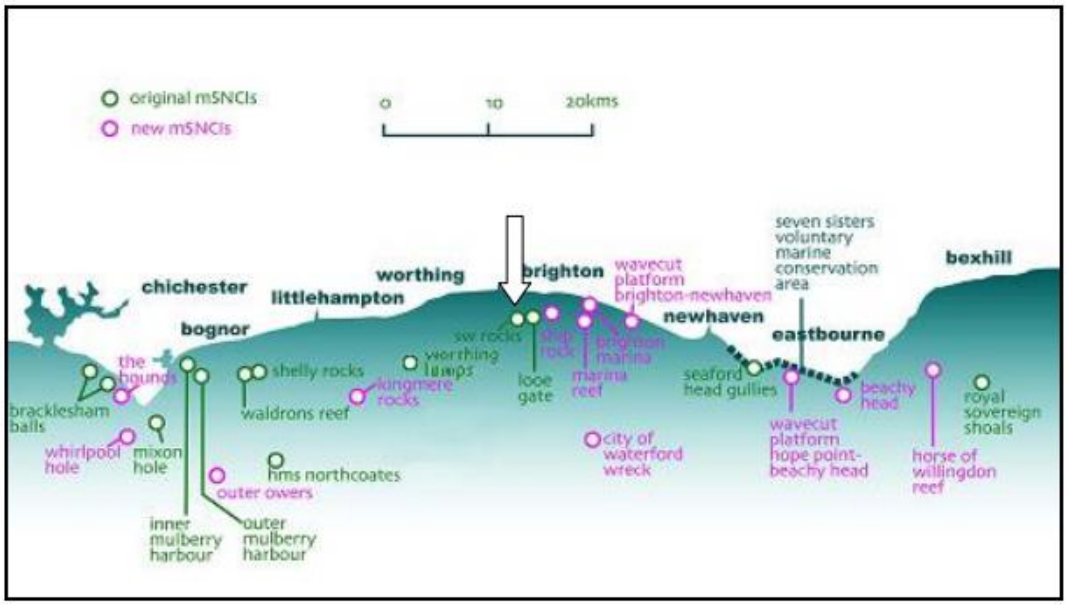

Figure 4. Sussex marine Sites of Nature Conservation Interest (mSNCI). Illustrating the documented discontinuous chalk cliff extent, from Worthing Lumps in the west to Ship Rock in the east (Williams & Clark, 2010). Seaford Head gullies near Beachy Head are comprised of nearshore chalk gullies.

4.3.3 Kelp habitat

The infralittoral rock (includes habitats of bedrock, boulders and cobbles which occur in the shallow subtidal zone and typically support seaweed communities) which is particularly prevalent in the inshore area of the west of the District, from Selsey to Brighton, provides a high level of ecosystem services. Within this area an historic particularly dense kelp bed area very close inshore between Shoreham and Bognor Regis has been reported widely through coastal and scuba dive surveys as well by the local community. Fishers from Worthing tell of how when they had launched their small open boats off the beach, they had to row out nearly two nautical miles before they could start their outboard motor without the propeller becoming tangled in the kelp. In winter storms, seaweed washed up on the beaches from Lancing to Bognor (even said to be covering the entire beach at Worthing in the 1960's (http://www.feestspada.com/worthing_history/history_pages/html/Seaweed.html) and local farmers would come down in their tractors to collect it to use as fertiliser on their fields. Divers in the 1980's recorded the presence of kelp as abundant or common from Selsey to Eastbourne, in over 50% of their dive sites. Three species were recorded: *Laminaria hyperborea, Laminaria digitata* and *Saccharina latissima*.

Based on a report by Worthing Borough Council in 1987, the historic kelp bed was 177km^2 in total, equating to 10% of the Sussex District (Figure 5). Within this area, 10km^2 of the kelp bed was described in the report as 'very dense', estimated to be greater than 40 tonnes/hectare with peak densities of 100 tonnes/hectare.

Based on Seasearch data and local community reports, these historic dense kelp forests are understood to have largely disappeared (Figure 6). Divers in the 1990's recorded the presence of kelp as occasional or rare at less than 5% of their dive sites and fishers have commented on the reduction in commercial species. By the late 2010's only small remnants of kelp remain, covering an area of 6.28 km^2 (a 96.4% decline in terms of area coverage compared to 1987 (Williams & Davies 2019)). In total, around 530 species were recorded in conjunction with kelp habitat during these dives. Crab, whelk, wrasse, cockle and lobster are all examples of commercially harvested species which were also found in Seasearch surveys of kelp habitat (https://jncc.gov.uk/our-work/marine-recorder/).

The anecdotal causes implicated in the demise of kelp forests include the development of the pair trawl fishery off Worthing in the late 1980's and storm damage (https://brightonboat.co.uk/inshore-trawling-eric-smith/). The fishers say that during the famous autumn storm of 1987, large amounts of kelp were washed ashore, including some with the holdfasts still attached to cobbles. Members of the fishing community believe this severely decreased the density of the main kelp bed which, alongside the development of new fishing technology, allowed trawlers to tow their nets through the area. This is suspected to have inhibited the recovery of the kelp forest.

Local fishers report a devastating effect on the abundance and diversity of marine species in the region. This in turn, had a negative impact on the profitability of the Worthing fishers. These kelp beds were highly productive regions and played host to a diverse range of marine organisms. The fishers of Worthing and other local ports found the productivity of the kelp beds highly profitable. One fisher recalled that during the summer months, he could shoot a single fleet of between eight and ten trammel nets in close proximity to the kelp beds and after a short soak time of between four and five hours he would be rewarded with between ten and 15 stones of sole, as well as a box of high grade plaice and some large turbot. The same fisher, fishing in the same area in 2017, with 11 fleets of trammel nets landed just two and a half stones of sole, a box of small to medium plaice and a few huss after a 48 hour soak time. During the winter months the kelp beds would hold large numbers of high grade cod. Some fishers reminisced over the days when it was a struggle to fit all of the cod from a single fleet of nets safely on-board the fishing vessel. The kelp beds also supported a successful shellfish fishery, with good catches of lobster being landed from pots shot in areas adjacent to the kelp beds (SxIFCA report Centuries of Sussex Seas, 2019: https://secure.toolkitfiles.co.uk/clients/34087/sitedata/files/Research/Centuries-of-Sussex-Seas.pdf).

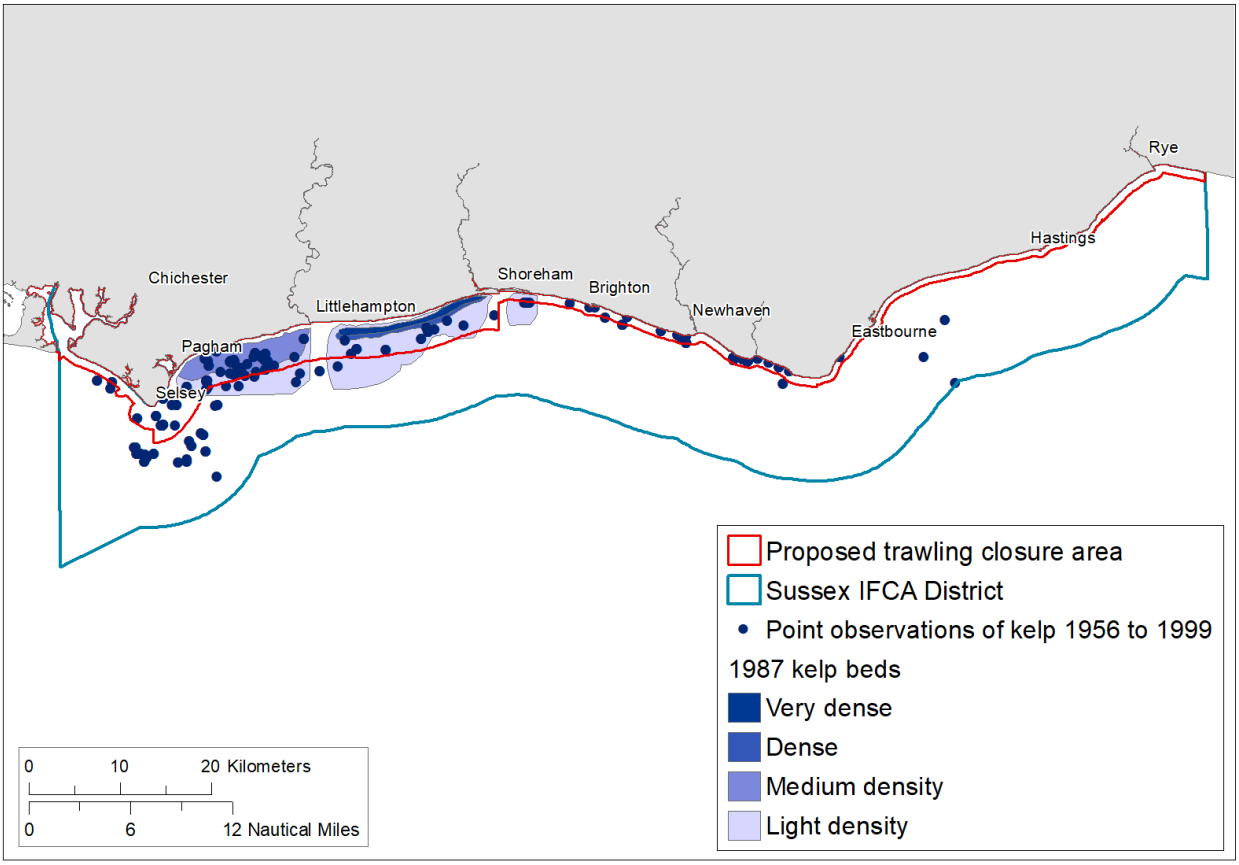

Figure 5. Historic kelp bed extent and kelp observations point data up to 1999 within the Sussex District, with proposed trawling exclusion area illustrated.

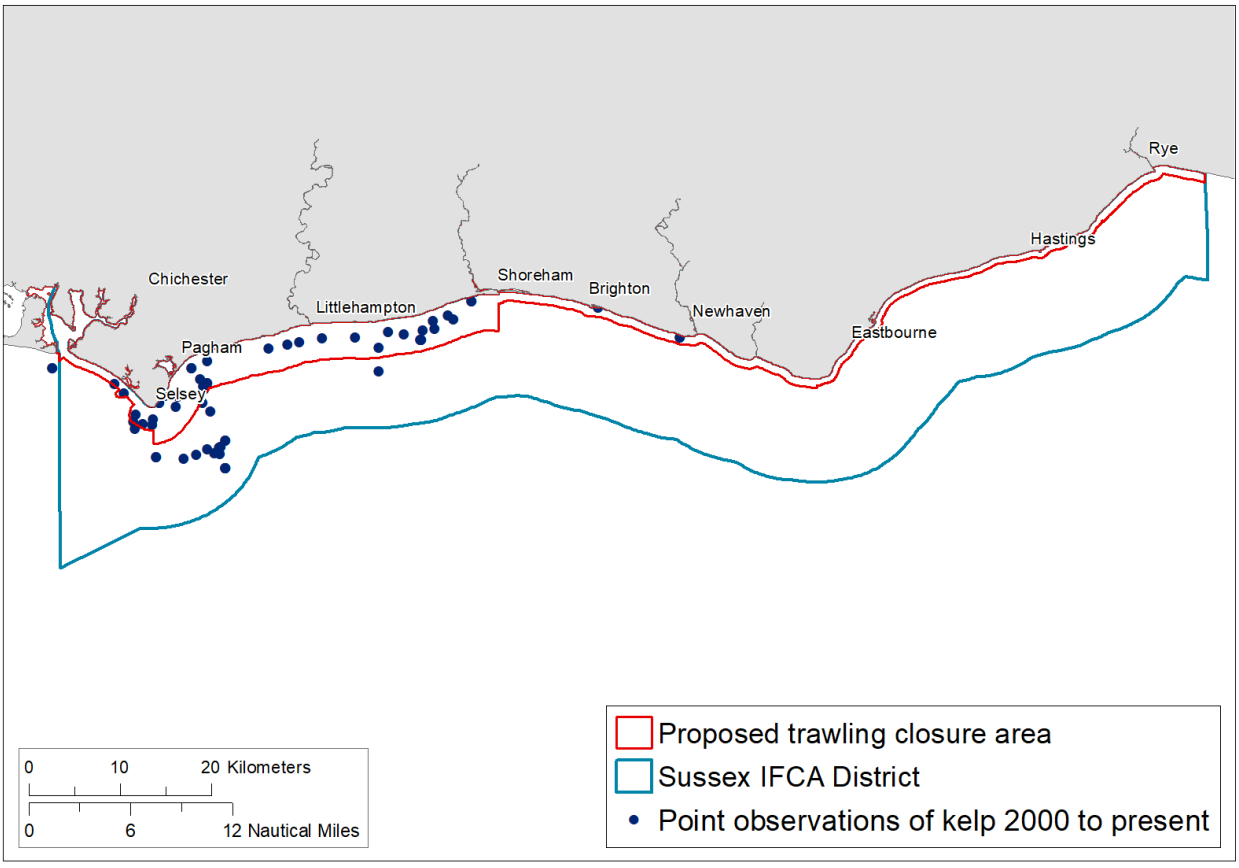

Figure 6. Current kelp extent. Point observations 2000 to present within the Sussex District, with current proposed trawling exclusion area illustrated.

Kelp forest provides habitat both on the benthos and throughout the water column to a host of associated species. The forests typically hold distinct communities within their holdfasts, mid-water fronds/stipes, and within the surface floating canopy, just as within the vertically stratified layers of forests on land (Bayley et al., 2017). The kelp-associated species range from small sessile invertebrates such as bryozoans and hydroids which typically encrust the holdfast and surface of the kelp, to the mobile fish, urchins and crustaceans which utilise the food resource and shelter it provides. Birds, pinnipeds, large predatory fish, and cetaceans are also frequent users of this environmental resource, together making up a diverse and often abundant ecosystem (Graham et al., 2007 in Bayley et al., 2017).

Kelp provides a range of ecosystem service benefits including the capture of carbon dioxide and the production of oxygen, the support of biodiversity, the support of commercial and non-commercial marine species, cultural heritage, and as a harvestable resource. Research indicates that macroalgae are an ecosystem component critical to the delivery of a broad range of ecosystem services (Smale et al., 2013) (see section 6.3.2), meaning this habitat should be given special attention when considering management.

4.4 Habitat natural capital assets – diversity, sensitivity, ecosystem services and value

A natural capital asset register is described in Government guidance as the 'key foundation of the evidence base' when adopting a natural capital approach to management, and is an inventory of the type, extent and quality of assets (Defra et al., 2019). This provides the baseline against which the impacts of management and development options can be evaluated. The building blocks of natural capital assessment are habitats because they are distinct environmental 'units' which can be mapped spatially. As such, the creation of a habitat map for the District through Sussex IFCA's SCHIP 2 project, using **'**best available information', underpins the evidence base for this IA (Tomline & Burnside, 2015).

Utilising the District wide indicative habitat map (see Figure 3), the Authority has sought to identify different areas of environmental value from local habitat complexity, sensitivity and ecosystem services, and assess the relative importance of the nearshore area. These assessments were conducted through a Sussex IFCA funded Masters of Science project (Nelson, 2017), which was subsequently peer-reviewed and published (Nelson & Burnside, 2019). Thus supporting the robustness of the underpinning research.

This methodology represents a move by the Sussex IFCA towards an ecosystem approach to fisheries management. Assigning a value to the marine environment can guide decision making on the use of marine resources and provide evidence for the development of management strategies. Refer to Annex 3 for data confidence maps.

4.4.1 Habitat diversity

There are a range of different seabed habitats in Sussex inshore waters (see Figure 3, section 4.3). Assessing diversity is an important aspect of valuing the marine environment, being a key factor in the functioning and resilience of ecosystems (McLeod & Leslie, 2009). As such, identification of biodiversity hotspots is used to prioritise conservation efforts (Wilson et al., 2006). There is often more diversity where the habitat is more heterogeneous and structurally complex (Bazzaz, 1975).

Habitat diversity was assessed across the District using the ArcGIS entropy option in the geostatistical analyst Voronoi tool (Figure 7). This analysed how similar each of the habitat data points were to their neighbouring points, ranging from very low diversity where neighbouring data points were the same (rated 0) to very high diversity where all of the neighbouring points were different habitats (rated 5). 1403.34km^2 of the District has medium to very high habitat diversity and there are areas of very high diversity throughout the District, in particular south of Selsey, within the nearshore area between Littlehampton and Shoreham, east of Eastbourne and near Rye. Figure 7 below illustrates the habitat diversity across the District and highlights the current proposed exclusion area boundaries (refer to section 5.3.3 for further management area information).

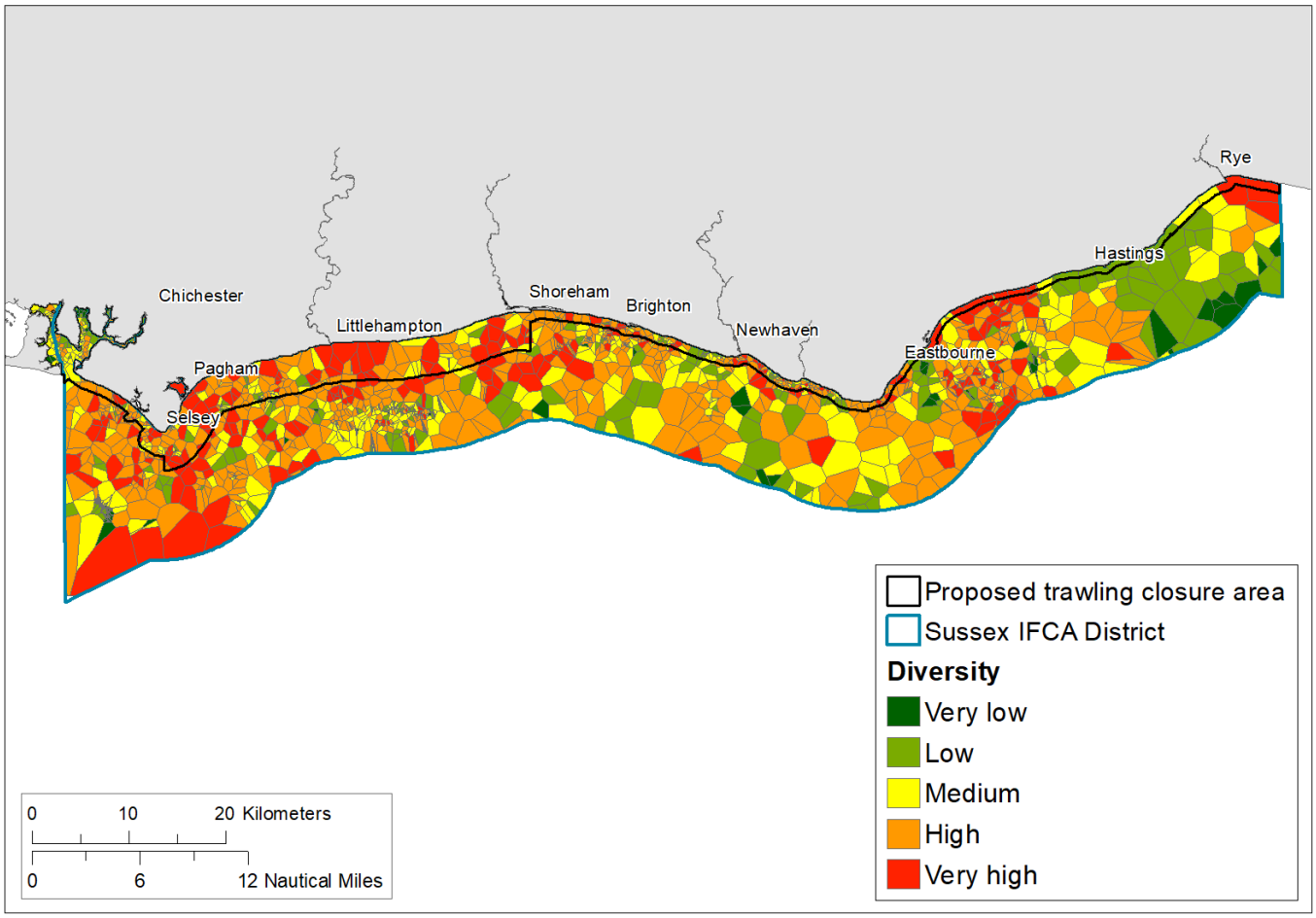

Figure 7. Habitat diversity within the Sussex District, with current proposed trawling exclusion area illustrated.

4.4.2 Habitat sensitivity

Habitats vary in their sensitivity to abrasion from activities such as demersal fishing, thus a measure of sensitivity is a useful element in understanding the vulnerability of habitats to threats and pressures. Particularly sensitive or valuable areas should be protected from damaging activities, as the current recommended trawling management strives to do. The sensitivity of each habitat was assessed by researching the typical and key associated species, their resistance to abrasion and how quickly they could recover from damage using Marine Life Information Network data (MarLIN) (Table 3). Sensitivity scores were coded numerically (low to high sensitivity, from zero to five) and linked to the habitat layer, linking sensitivity information based on the most detailed habitat class information available.

Table 3. Sensitivity matrix after MarLIN (2017b) and Eno et al (2013), where sensitivity was assessed as a combination of resistance and resilience.

		Resistance		
		Low Significant decline in species/habitat	**Medium** Some decline in species/habitat	**High** Very little decline in species/habitat but may affect function
Resilience	**Low** >10 years to recover	**5: Very high**ly sensitive fragile habitat with long recovery time	**4: High**ly sensitive habitat with some resistance but long recovery time	**3: Medium** sensitive habitat with high resistance but long recovery time
	Medium 2-10 years to recover	**4: High**ly sensitive fragile habitat with medium term recovery	**3: Medium** sensitive habitat with some resistance and medium term recovery	**2: Low** sensitive habitat with high resistance and medium term recovery
	High <2 years to recover	**3: Medium** sensitive fragile habitat with rapid recovery	**2: Low** sensitive habitat with some resistance and rapid recovery	**1: Very low** sensitive habitat with high resistance and rapid recovery

Generally, the habitats were vulnerable to damage but were able to recover in two to ten years. 721.03km^2 of the District has medium to very high sensitivity habitats. Where there is high sensitivity this means that physical damage would cause some decline in key species and it would take up to ten years to recover. Rock with attached animals or algae (circalittoral and infralittoral rock) were found to be the most sensitive habitats. In the west of the District, large areas of high sensitivity were identified, four to six miles south of Chichester Harbour and Selsey Bill, as well as the nearshore area stretching from Selsey to Shoreham. More isolated areas of high sensitivity habitats are found inside three miles from Brighton heading east towards Eastbourne. For further details on the sensitivity analysis (Annex 4).

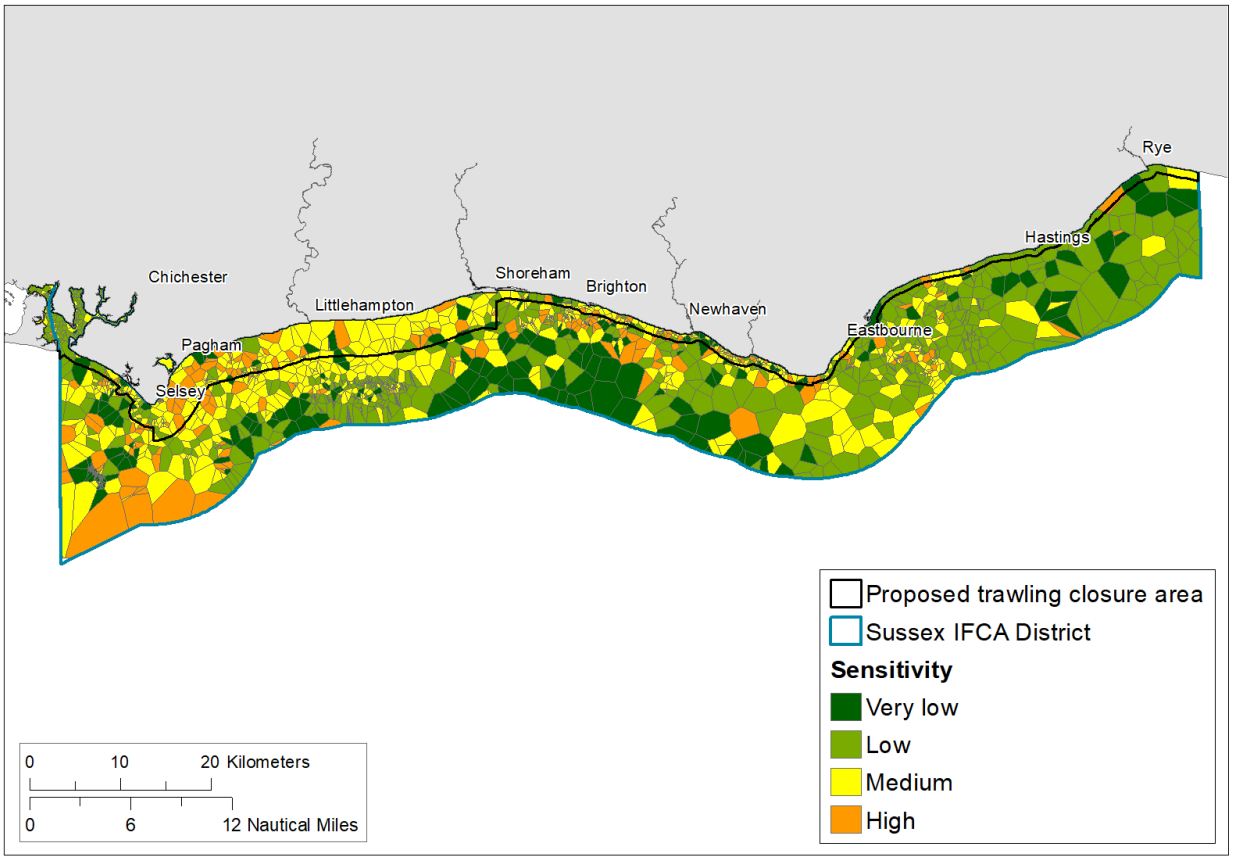

Figure 8. Habitat sensitivity within the Sussex District, with current proposed trawling exclusion area illustrated.

4.4.3 Ecosystem services

Different habitats provide different ecosystem services, and the sensitivity of ecosystem services has been found to be closely linked to the sensitivity of the benthic habitat as a whole (Hooper et al., 2019). Data from peer-reviewed literature was used to assess the ecosystem services provision of each of the District's seabed habitats (Tables 5 and 6, Figure 9). The provision of 12 ecosystem services was assessed, as outlined in Table 4 below.

Table 4. **The 12 ecosystem services assessed using information from studies in the European North Atlantic Ocean (Galparsoro et al., 2014), in European waters (Salomidi et al., 2012) and in UK Marine Protected Areas (Fletcher et al., 2012) – from Nelson (2017)**

Category	Ecosystem service
Provisioning	Food provision
	Raw materials
Regulating	Air quality and climate regulation
	Disturbance and natural hazard prevention
	Photosynthesis, chemosynthesis and primary production
	Nutrient cycling
	Reproduction and nursery
	Maintenance of biodiversity
	Water quality regulation
Cultural	Cognitive value
	Leisure, recreation and cultural inspiration
	Feel good or warm glow

For habitats found within Sussex waters, the level of provision of each ecosystem service identified was assigned a score. For each habitat, each service was assigned a score from one (negligible provision) to five (high level of provision) and then averaged to provide the overall score for each habitat (Tables 5 and 6, Figure 9). Similar scoring systems have been used successfully in other studies (Galparsoro et al., 2014; Potts et al., 2014). Maps for each of the 12 ecosystem services assessed are included within Annex 5.

Table 5. Summary table of the ecosystem services provided by the seabed habitats are EUNIS level 2, on a scale from 1 negligible provision (pale green) to 5 high level of provision (dark green). Assessed using information from Galparsoro et al (2014), Salomidi et al (2012) and Fletcher et al (2012) – taken from Nelson (2017)

Habitat name	EUNIS code	Food	Raw material	Air quality & climate regulation	Disturbance & natural hazard prevention	Photosynthesis and primary production	Nutrient cycling	Reproduction/ nursery	Biodiversity maintenance	Water quality	Cognitive value	Leisure, recreation, cultural	Feel good/ warm glow	AVERAGE score
Intertidal sediment	A2	5.0	2.5	4.0	5.0	4.0	4.0	5.0	4.5	2.5	4.5	5.0	4.5	4.2
Infralittoral rock (rock with seaweed)	A3	4.5	4.0	4.0	3.0	4.5	4.0	4.5	4.3	4.8	5.0	4.5	3.5	4.2
Circalittoral rock (rock with attached animals)	A4	3.5	3.0	3.0	2.0	1.5	4.0	4.5	5.0	4.0	5.0	4.0	3.0	3.5
Subtidal sediment	A5	4.9	2.8	1.7	2.0	1.8	3.7	4.0	3.5	2.8	1.7	2.3	2.3	2.8

Table 6. The level of provision 0-5 very low to very high by 19 seabed habitats at EUNIS level 3 for 12 ecosystem services: A Food; B Raw materials; C Air quality and climate regulation; D Disturbance and natural hazard prevention; E Photosynthesis and primary production; F nutrient cycling; G Reproduction and nursery; H Biodiversity maintenance; I Water quality; J Cognitive value; K Leisure, recreation and cultural; L Feel good, warm glow. In order of average score highest to lowest – from Nelson (2017)

Habitat	EUNIS code	A	B	C	D	E	F	G	H	I	J	K	L	Average score
High energy infralittoral rock	A3.1	5	5	5	5	5	3	5	5	5	5	5	5	4.8
Intertidal sand	A2.2	5	3	5	5	5	5	5	5	3	5	5	5	4.7
Intertidal mud	A2.3	5	3	5	5	5	5	5	5	3	5	5	5	4.7
Intertidal mixed sediment	A2.4	5	3	5	5	5	5	5	5	3	5	5	5	4.7
Moderate energy infralittoral rock	A3.2	5	5	5	3	5	5	5	5	5	5	5	3	4.7
Low energy infralittoral rock	A3.3	5	5	5	3	5	5	5	5	5	5	5	3	4.7
Sublittoral macrophyte dominated sediment	A5.5	5	3	5	5	5	5	5	3	3	5	5	5	4.5
Intertidal rock (high, moderate and low energy)	A1.1/ 2/3	5	3	5	3	5	5	5	5	3	5	5	5	4.5
High energy circalittoral rock	A4.1	5	5	3	5	1	5	5	5	5	5	3	3	4.2
Low energy circalittoral rock	A4.3	5	3	5	1	3	5	5	5	5	5	5	3	4.2
Moderate energy circalittoral rock	A4.2	3	3	3	1	1	5	5	5	5	5	3	3	3.5
Sublittoral biogenic reefs	A5.6	5	2	1	3	2	5	5	5	5	1	3	3	3.3
Intertidal coarse sediment	A2.1	5	1	1	5	1	1	5	3	1	3	5	3	2.8
Features of infralittoral rock	A3.7	3	1	1	1	3	3	3	2	4	5	3	3	2.7
Communities of circalittoral caves and overhangs	A4.7	1	1	1	1	1	1	3	5	1	5	5	3	2.3
Sublittoral coarse sediment	A5.1	5	5	1	1	1	3	4	2	1	1	2	2	2.3
Sublittoral sand	A5.2	5	3	1	1	1	3	4.5	3	1.5	1	2	2	2.3
Sublittoral mixed sediments	A5.4	5	3	1	1	1	3	3	5	3	1	1	1	2.3
Sublittoral mud	A5.3	4.5	1	1	1	1	3	2.5	3	3	1	1	1	1.9

The range of habitats across the District support a valuable flow of ecosystem services that underpin human wellbeing. Results illustrated that no habitat provided ecosystem services at a very low level, and that there was generally higher service provision in the west of the District within the nearshore area from Shoreham to Selsey and in Chichester Harbour, as well as further offshore south of Selsey.

In addition to being the most sensitive habitats, rock with attached animals and algae (circalittoral and infralittoral rock) were found to provide the most ecosystem services, providing 11 of the 12 services at a high level and one at a moderate level**.** This supports findings in peer reviewed literature and government guidance, which report certain habitats having a particularly significant role in providing ecosystem services and benefits. These include coastal plants, seagrass and kelp beds and reefs formed by dense aggregations of animal such as worms, mussels, oysters and cold water corals (Defra et al., 2019).

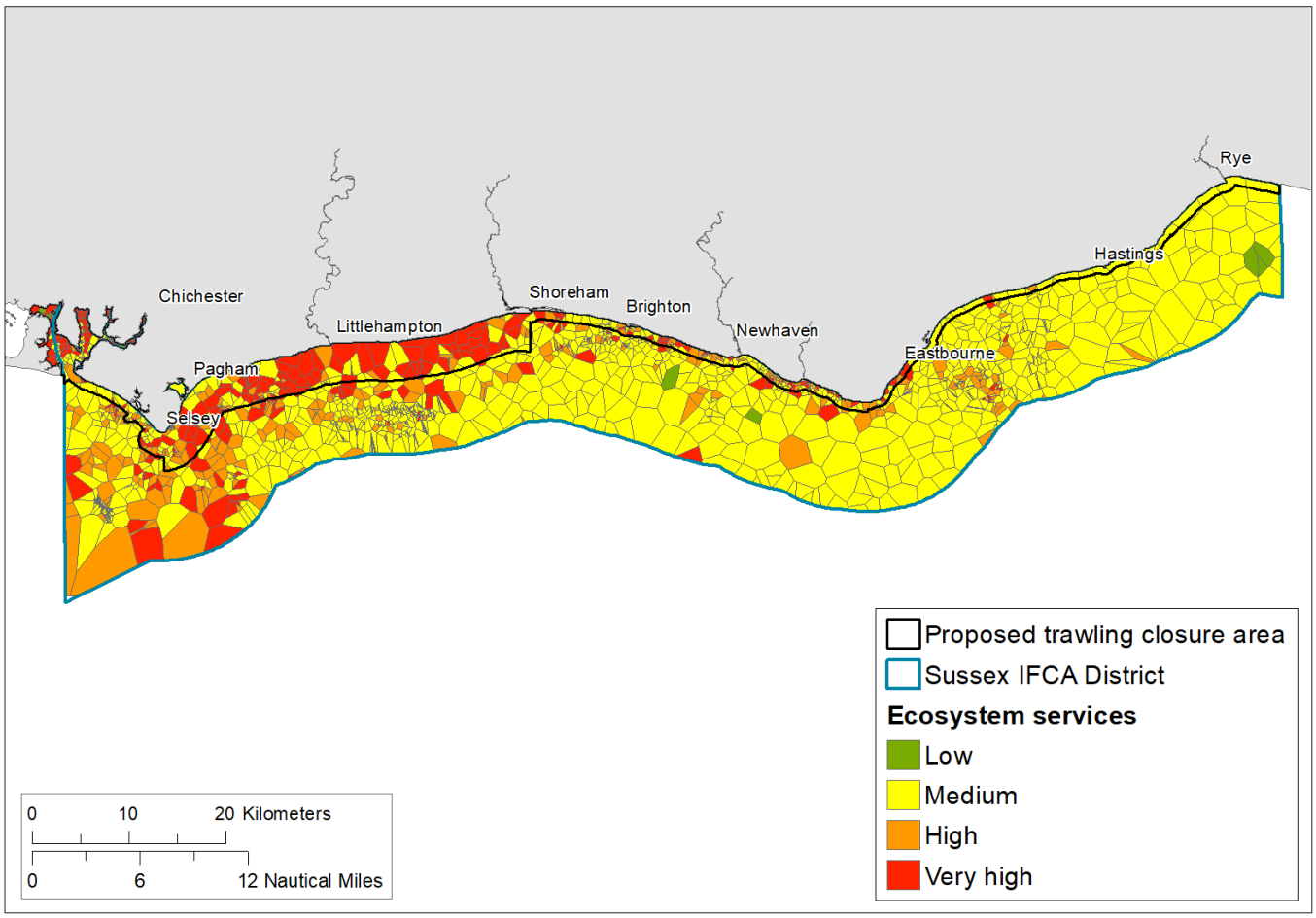

Figure 9. Ecosystem Services Provision within the Sussex District, with current proposed trawling exclusion area illustrated.

To operationalise its recommended natural capital approach, Defra created four Pioneer projects to inform the development and implementation of the 25 Year Environment Plan (HM Government, 2018). The North Devon Marine Pioneer Project (NDMP) (Rees et al., 2019), summarised the goods and services provided by each broad habitat type within its area and described how each provides goods/services. Table 7 below utilises and builds on these findings for Sussex, and Table 8 summarises the flows of five key goods and services identified in the NDMP.

Table 7. Goods/services from intertidal and seabed habitats (adapted from the North Devon Marine Pioneer project, Rees et al., 2018)

Intertidal and subtidal reef communities and saltmarsh ***Intertidal and subtidal reefs with algae (kelp) communities and attached animals, and coastal saltmarsh provide a high contribution to multiple Ecosystem Services (ES).**	
Intertidal and subtidal reef habitats with algae (kelp) and attached animals	• In Sussex, infralittoral rocky reef habitats were found to deliver very high provision for 11 out of the 12 ES assessed. Intertidal and circalittoral rock also provided a high contribution to multiple ES. • Goods / benefits provided, identified in both Sussex and NDMP assessments, include food (very high provision), healthy climate (carbon sequestration) (moderate to high), disturbance and natural hazard prevention (moderate to very high). • Algae communities such as kelp *Laminaria spp.* communities, associated with infralittoral reef provide a high contribution to productivity, habitat, carbon sequestration and sea defence benefits. • Kelp communities provide shelter for juvenile stages of commercially targeted fishes, crustaceans and bivalve molluscs.

	• Canopy-forming kelps influence their environment and other organisms, thereby functioning as “ecosystem engineers”. • Kelp holdfasts, the attachment between kelp and reef features, provide food resources for flatfish, sea bass and gadoid species. • By altering light levels, water flow, physical disturbance and sedimentation rates kelps modify the local environment for other organisms and provide benefits related to natural hazard protection. • Through direct provision of food and structural habitat, kelp forests support higher levels of biodiversity and biomass than simple, unstructured habitats. • Healthy climate benefits are supported by Kelp communities *Laminaria spp.* as fuels for marine food webs, through the capture and export of carbon. • Broad scale habitats associated with reef features provide surfaces for epibiota such as corals and sponges to attach. • Sessile epifauna that colonise reef features capture and recycle water column nutrients through filter feeding and produce planktonic larvae further supporting higher trophic levels which includes fish and shellfish species. • Biodiversity related to reef features supports fishing activities and recreational diving/nature watching.
Saltmarsh	• Saltmarsh extents are mapped under the mosaic category in Sussex IFCA mapping so the District extents cannot be extrapolated separately, but can be obtained from Natural England mapping. Information on this habitat’s associated ecosystem services have been included from the NDMP projects as pertinent. • Contributes significantly to ES benefits of healthy climate, clean water and sediments • Have a carbon sequestration value of 210grams of carbon per square metre per year (C m^{-2} yr^{-1}) and sequestration from UK saltmarshes is 0.64–2.19 tonnes of carbon per hectare per year (t C/ha/yr). • Vegetation within saltmarsh has the ability to baffle water currents and stabilize sediments, resulting in organic matter and nutrients becoming stored within the accreting sediments, sequestering carbon nitrogen and phosphorous, while the remaining organic material is recycled or exported. • The flood water storage and attenuation of water currents and wave energy provided by saltmarsh also delivers significant benefits to natural hazard regulation. • Shelter and food availability within the three-dimensional structure of saltmarsh vegetation during high tide, provides significant benefits to juvenile fish species
Intertidal and subtidal biogenic reef and sediment ***Intertidal and subtidal biogenic reef and sediment habitats provide important contributions to species habitat, protection of coastal land from flooding and extreme weather (sea defence), and leisure/tourism benefits**	
Intertidal and subtidal biogenic reefs	• High level of ES provision from subtidal biogenic reefs in Sussex. • Biogenic reef structures, including mussels, oysters and *Sabellaria* spp. shelter a high number of species. • Small-scale topographic environmental complexity creates numerous spatial and trophic niches for colonisation by other invertebrates • Fish and crustacean species, including those supporting recreational and commercial fisheries find food resources amongst biogenic reefs. • Biogenic reefs also form physical structures that aid the ES. Natural hazard regulation and sea defences, as features reduce sheer stress, slow water currents and reduce wave heights, thus reducing erosion in coastal regions.
Intertidal sediments	• Intertidal sand, mud and mixed sediment were found to deliver high level of ES provision in Sussex and moderate to significant level of ES provision in the NDMP including: formation of habitats, food, carbon sequestration and natural hazard regulation linked to sea defence and prevention of erosion. • Intertidal sediments such as intertidal mud provide high biological productivity and abundance of organisms that provide food resources for fish, shellfish and wildfowl. • Intertidal sediment habitats also dissipate wave energy, thus reducing the risk of damage to coastal defences and flooding of low-lying land.

	• Levels of carbon sequestration in intertidal mud sediments within the UK are recorded at 16 g C m^{-2} yr^{-1} and in some places intertidal mud habitat adjacent to salt marsh provides high accretion and burial of organic carbon. • Intertidal mud also provides good provision of carbon sequestration, clean water and sediments, immobilisation of pollutants as well as food.
Subtidal sediments ***Subtidal sediments provide an important contribution to food resources for commercial fish species**	
Subtidal sediments	• All subtidal sediments in both the NDMP and Sussex were found to provide significant provision of food resources for fish, with a high level of food ES provision identified. • Subtidal coarse sediment and sand also provide a very high contribution to reproduction and nursery ES. • Subtidal sediments supply moderate provision of the benefit of clean water and sediments. Sublittoral mud and mixed sediments also supply moderate provision of immobilisation of pollutants. • Bioturbation (biogenic modification of sediments through particle reworking and burrow ventilation) by benthic organisms living within soft substratum habitats provides a mechanism for nutrient cycling. • Through burial and release of pollutants, behaviour traits of bioturbating organisms also influence the provision of clean water and sediment ES benefits.

Table 8. **Type of good/service and associated flows of goods and services provided by marine habitats. From the North Devon Marine Pioneer project (Rees et al., 2019).**

Goods/Service	Contribution by marine natural capital assets
Food (Wild food)	A range of marine habitats support food provision (fisheries) at both a local and regional scale. Together these provide structure, shelter, habitat and food for both fish and shellfish. For example, the three-dimensional structure of saltmarsh vegetation during high tide provides significant benefits to juvenile fish species. Reefs (including biogenic reefs) and kelp communities provide shelter for juvenile stages of commercially targeted fishes, crustaceans and bivalve mollusc. Sediment habitats provide food resources for fish. The water column itself supports the provision of food via its current, chemical composition, transition zones (nutrient rich water and stratified water) and areas of primary production.
Healthy Climate	A healthy climate is dependent on the balance and maintenance of the chemical composition of the atmosphere and the oceans by marine living organisms. The capture and export of carbon is central to this process. Saltmarsh plant communities, algae and kelp communities capture carbon and soft substratum sediments contribute towards storage / sequestration. The water column supports the carbon cycle though oceanic primary production harvesting light to convert inorganic to organic carbon.
Natural Hazard regulation (flood prevention/ sea defence)	Marine habitats play a valuable role in the defence of coastal regions. The physical structures dampen wave energy from tidal surges, storms (e.g. reefs). The floodwater storage and attenuation of water currents and wave energy provided by habitats such as saltmarsh also delivers significant benefits to natural hazard regulation. Sediment habitats also dissipate wave energy, thus reducing the risk of damaging coastal defences and flooding low-lying land. Intertidal habitats not only provide sea defence benefits in relation to present sea level (and sea conditions), but unlike man made defences, natural intertidal habitats such as saltmarsh will migrate with rising sea levels, predicted under future climate scenarios. Salt marsh, intertidal sand and coarse sediment (beaches), in particular, support multiple benefits in addition to sea defence including food and recreation. Restoring extents of saltmarsh in unfavourable condition and maintaining habitat extents of saltmarsh and intertidal sand and coarse sediment habitats will ensure ecosystem service provision is maximised.

Goods/Service	Contribution by marine natural capital assets
Clean water and sediments	Marine living organisms store, bury and transform waste though assimilation and chemical decomposition and re-composition. Vegetation within saltmarsh has the ability to baffle water currents and stabilize sediments, resulting in organic matter and nutrients becoming stored within the accreting sediments, sequestering carbon, nitrogen and phosphorous, while the remaining organic material is recycled or exported. Bioturbation (biogenic modification of sediments through particle reworking and burrow ventilation) by benthic organisms living within soft substratum habitats provides a mechanism for nutrient cycling (Queirós *et al.*, 2013; Sturdivant & Shimizu, 2017).
Tourism and Recreation	Marine natural capital assets provide the basis for a wide range of tourism and recreational activities. Tourism and Recreation opportunities include water sports, wildlife watching, fishing, appreciating scenery (e.g. from a viewpoint), swimming outdoors, visits to a beach (sunbathing or paddling in the sea), walking (e.g. walking the coast path). Saltmarsh (which provides coastal access points, nature watching, aesthetic interest and supporting species of interest to recreational fishing and foraging) and littoral sand, coarse and mixed sediments (which provide beaches and coastal access points) provide significant contributions to the provision of Tourism and Recreation related benefits and services.

In light of proposals to restrict trawling over the range of habitat types within the nearshore area, rather than just reef areas, a key element to highlight from both the NDMP and Sussex assessments is the importance of sediment habitats for a range of ecosystem services.

4.4.4 Environmental value

When determining value, it is not always possible to monetise goods and services, and the natural capital approach allows for their relative importance to be highlighted in other ways. Approaches to support decision making, such as multi-criteria analysis allow for information in diverse units to be systematically evaluated and compared (Defra et al., 2019). Such an approach has been adopted in developing the current evidence base.

The diversity, ecosystem services provision and sensitivity of each habitat can be combined to calculate a score for environmental value (from zero to five). This is highest where there is high diversity, a high level of ecosystem services provision and the habitats are highly sensitive. Figure 10 shows the areas in the District which could be deemed high priority, and therefore benefit from environmental management measures. Results of this multi-parameter analysis found environmental value to be highest in the west of the District, with 1443.67Km^2 of the District found to have medium to very high environmental value. No habitat was found to have a very low environmental value.

The environmental value across the study area based on the sum of the ecosystem services provision, diversity and sensitivity scores. Four classes, equal interval. No cells in the 0.1 – 1.0 very low class. Score of 1.1 – 2.0 = low, score of 2.1 – 3.0 = medium, score of 3.1 – 4.0 = high and score of 4.1 – 5.0 = very high.

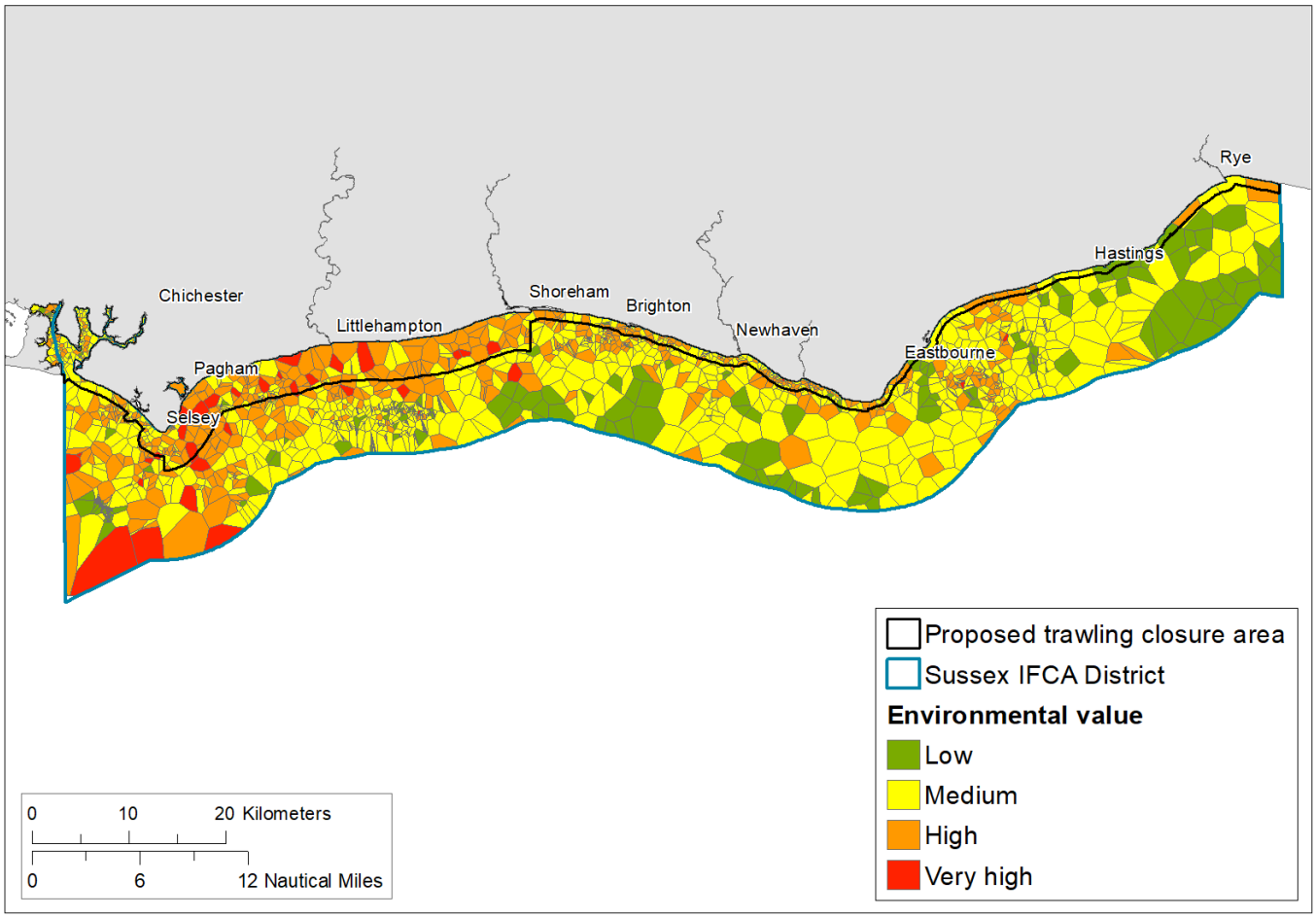

Figure 10. Environmental Value with the Sussex District, with current proposed trawling exclusion area illustrated.

4.5 Importance of the nearshore area

4.5.1 Environmental value and potential management areas

The environmental value parameters outlined in section 4.4.4 were assessed to understand how they vary with distance from the coast and within the District (Figure 11). The proposed management will be to exclude trawling activity from nearshore areas in order to protect valuable sensitive habitats. The proposed exclusion boundaries reflect the habitat distribution and needs of the fisheries which utilise those habitats. For the informal consultation, the District was initially divided up into five areas according to their geographical nature (Figure 11).

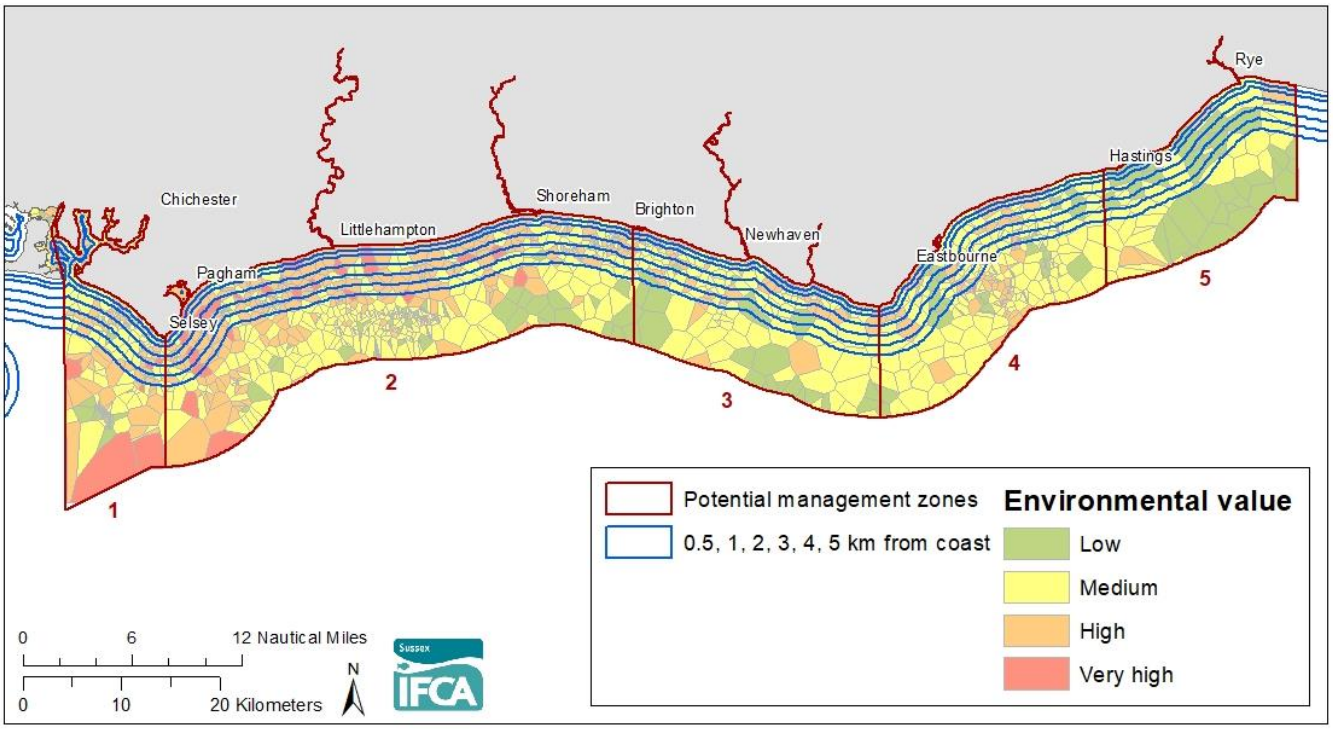

Figure 11. The environmental value of the seabed within the District, overlaid by early potential management zones and contours out to 5km, the potential management zones refer to the initial zones for the informal consultation.

Coastal ecosystems are reported to be some of the most productive on Earth. As well as providing nursery grounds for fish, they offer a range of other essential ecosystem services, such as coastal protection and sequestering and storing 'blue' carbon from the atmosphere and oceans. Thus they are a key piece of the solution to global climate change. The state of the marine environment has the potential to affect a range of ecosystem services. This is supported by the body of evidence outlined in section 4.4, together with the additional analysis in relation to potential management areas summarised above, which clearly illustrate the importance of the nearshore area within the Sussex District.

In summary, key findings include:

- **Very high habitat diversity in the nearshore areas between Littlehampton & Shoreham, Pevensey Bay and Rye Bay (Figure 7).**

  Habitat diversity was found to be highest within three and five kilometre distance contours (Figure 7);

- **High sensitivity areas within the nearshore area from Selsey to Shoreham, and Brighton to Eastbourne (Figure 8).**

  Sensitivity was found to be highest within three kilometres (Figure 8);

- **The highest average ecosystem services provision was found to be within half a kilometre from the coast (Figure 9)**.

  Higher ecosystem service provision was found in the west of the District, within the nearshore one kilometre area from Shoreham to Selsey and in Chichester Harbour (Figure 9), and;

- **Higher environmental value was found in the inshore areas of the District compared to the offshore areas (Figure 10).**

  An assessment of environmental value with distance from the shore found that environmental value was higher closer to the coast compared to further offshore at all distances. Environmental value was highest in the west of the District, south of Selsey and within the inshore one kilometre coastal strip from Selsey to Brighton (Figure 10) (Nelson, 2017).

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4.5.3 Sussex Small Fish Survey data

Juvenile fish stocks are found very close to the shore, and the following reports indicate which species are abundant, and thus support the protection of nearshore waters from commercial towed gear within the District. The potential destruction of habitat and the removal or disturbance of these important juvenile fish species could have wider implications in future for both commercial and recreational fisheries.

Sussex IFCA have been conducting small fish surveys throughout the District since 2010, a summary of the 2018 report is detailed below. Using a seine net, data has been collected from March through to September at Chichester Harbour, Medmerry realignment site and Rye Harbour.

There was a total abundance of 4359 fish and a total of 37 species. Juvenile goby (*Pomatoschistus spp*.) was the most abundant (19%), followed by sand goby (*Pomatoschistus minutus*) (17%) and bass (*Dicentrarchus labrax*) (14%). Full details of the surveys are on the Sussex IFCA website (https://secure.toolkitfiles.co.uk/clients/34087/sitedata/files/Research/SxIFCA-Small-Fish-Surveys-2018.pdf)

With a written authority signed by the Clerk from the Sussex IFCA under 'Byelaw 1' (made July 1988 and confirmed in 1991) for the purpose of fishing for sea fish for 'scientific purposes, or breeding purposes'. Angling Trust volunteers have collected data in order to gain a better understanding of the juvenile fish species found in the Sussex nearshore waters. Multiple beach locations along the Sussex coastline were sampled in the spring and summers from 2015 to 2018 (https://www.youtube.com/watch?v=8PEcYL0lpxc). The sample area for these surveys covers a large part of the District that is not surveyed by the IFCA thus making this information invaluable.

Fish species of note that were identified in the surveys include juvenile plaice, sole, turbot and bass. Brown shrimp and various species of crab were also caught at all of the sites. The Angling Trust made their reports available to Sussex IFCA (Angling Trust, 2015, 2017 and 2018).

4.5.4 Key fish species that utilise the nearshore habitat in Sussex

There is a strong body of evidence indicating the importance of the nearshore area for many fish species during important life stages, supporting spawning and nursery grounds (Ellis et al., 2012). These include numerous important commercially targeted fish species as listed in Table 10 below, (further information is on the Sussex IFCA website: https://secure.toolkitfiles.co.uk/clients/34087/sitedata/files/Research/Species-Specific-Management-Plans.pdf).

Table 9. Key information for important Sussex marine fish species

Fish species	Spawning and nursery grounds	Management and value
Dover Sole *Solea solea*	High intensity spawning grounds in Sussex coastal waters, the area west of Beachy Head to the Isle of Wight has been identified as a Dover sole spawning ground. Sole spawns between April and June, in shallow coastal waters and is a marine species that utilises estuarine habitats and coastal zones as nursery grounds. Studies suggest they use the same spawning grounds each year.	The EU Commission in June 2016 advised that the sole stocks within the Eastern Channel area remained in 'poor shape' and there has been a management strategy in place since 2015. International Council for the Exploration of the Sea (ICES) advice from 2016 suggests spawning stock is declining while mortality is increasing, putting more pressure on current populations. According to MMO landings data from 2013-17, overall landings into Sussex are decreasing, with 40% being caught by trawling methods. Sole represent the second highest value of landings into Sussex ports and fourth highest by weight.
Plaice *Pleuronectes platessa*	Marine species that utilises estuarine habitats and coastal zones as nursery grounds. Centre for Environment, Fisheries and Aquaculture Science	ICES' 2018 advice is that population levels are increasing and the fishing mortality is currently declining. According to MMO landings data from 2013-17, the overall landings into Sussex ports is

Fish species	Spawning and nursery grounds	Management and value
	(Cefas) maps indicate spawning grounds are found along the Sussex coast.	increasing, with 61% being caught by trawling methods. Plaice represent the sixth highest value of landings into Sussex ports and third highest by weight.
European sea bass *Dicentrarchus labrax*	Spawn in the English Channel from February to June (Pawson 1995) juvenile bass occupy defined nursery areas in estuaries whilst adults return to the same offshore spawning sites each year.	In 2015 emergency measures to protect declining bass stocks were introduced by the European Commission, based on data from ICES indicating that they had a spawning stock biomass which has been in decline since 2005 and that they were now below safe ecological limits. This advice also showed that fishing mortality had increased between 1985 and 2015, peaking in 2013 before a rapid decline to below FMSY (fishing mortality consistent with achieving maximum sustainable yield - MSY). Recruitment is estimated to be have been poor since 2008, with the exception of the 2013 and 2014 year-class estimates which show average recruitment. (ICES, 2018). On a national level Defra have introduced bass nursery areas (BNAs) including Chichester Harbour in Sussex District. Bass are in need of protection in vulnerable locations, such as our harbours and estuaries, if the stock is to recover. In 2019 the Defra guidance on a maximum unavoidable bycatch limit for demersal trawls with authorisations is 1% by weight of all marine organisms per day, with an unavoidable bycatch of 400kg per two consecutive calendar months (https://www.gov.uk/government/publications/bass-industry-guidance-2019/bass-fishing-guidance-2019). In 2016 this was set at 1%, 3% in 2017 and 1% in 2018 and 2019. Historically, European sea bass (*Dicentrarchus labrax*) was a key target species of the local pair-trawl fishery, comprising the second highest proportion of landings after black seabream.
Black seabream *Spondyliosoma cantharus*	Adult black seabream overwinter in deep water (50m-100m) in the western English Channel. They arrive in Sussex with the warmer waters around March and inhabit shallow waters to feed prior to spawning April to June. After breeding, some may remain and others continue moving eastwards, feeding inshore until autumn when they return to the western Channel.	Stocks currently appear to be in a healthy state, however there is a lack of stock assessment and management measures in force for the species. Commercially, they are mainly caught using pair trawls, stern trawls and static nets. They are also an important recreational species. According to MMO landings data from 2013-17, the overall landings into Sussex ports has decreased but their value has increased. Black seabream represent the 11th highest value of landings into Sussex ports and 13th highest by weight. They are an important species for recreational sea anglers along the Sussex coast.
Cuttlefish *Sepia officinalis*	The English Channel population of cuttlefish undertakes a seasonal migration every year. During the winter they move into the deeper waters and aggregate in the western approaches of the English Channel. From early spring,	The cuttlefish fisheries in the English Channel can be separated into the inshore and offshore fisheries. The inshore fishery operates during the summer months and predominately uses static gears such as traps and nets. The offshore fishery targets cuttlefish during the winter months using towed fishing gear such as otter and beam trawls. The offshore fishery targets cuttlefish of all age

Fish species	Spawning and nursery grounds	Management and value
	cuttlefish begin to move inshore towards their breeding grounds.	groups with landings of sub-adults as well as juveniles. According to MMO landings data from 2013-17, the overall landings into Sussex ports have fluctuated, with a marked increase in 2016, followed by a significant decrease in 2017. Cuttlefish represent the seventh highest value of landings into Sussex ports and sixth highest by weight.
Cod	Marine species that utilises estuarine habitats and other coastal waters as nursery grounds. Cefas maps show that cod have spawned in the eastern English Channel.	
Whiting	Marine species that utilises estuarine habitats and other coastal waters as nursery grounds. Cefas maps show that the inshore area of east Sussex have historically been a nursery area for this species.	
Herring	Spawn on gravel and similar habitats (e.g. coarse sand, shell, maerl). A marine species that utilises estuarine habitats as nursery ground, with certain stocks also spawning in estuaries. Cefas maps show that the Eastern English Channel as a spawning area for this species	
Tope	Marine species that may utilise the outer reaches of some estuaries and coastal waters as a parturition and nursery ground. The Solent may act as nursery ground for tope.	
Undulate ray	Coastal marine species that utilises the outer reaches of some estuaries as a nursery ground. Cefas maps show that Sussex is a nursery ground for this species.	
Horse mackerel	Fully marine species that is common in coastal waters, but only recorded occasionally in estuaries. Cefas maps show some evidence of spawning in the south eastern English Channel. There are not enough sample records to say whether the Eastern English Channel is a nursery ground.	
Sandeels	One species *Ammodytes tobianus*, is often found in estuaries with this and other species occurring in coastal waters. Cefas maps show that the eastern English Channel are used as spawning and nursery grounds.	
Mackerel	Fully marine species that is common in coastal waters, and is only recorded occasionally in estuaries. Cefas maps show that eastern English Channel are a nursery ground for this species.	

4.6 Condition of natural capital assets

4.6.1 Background

The status of natural capital assets is determined in ecological terms through condition assessment, and the relative importance of goods and benefits using valuation (Defra et al., 2019) (Figure 12).

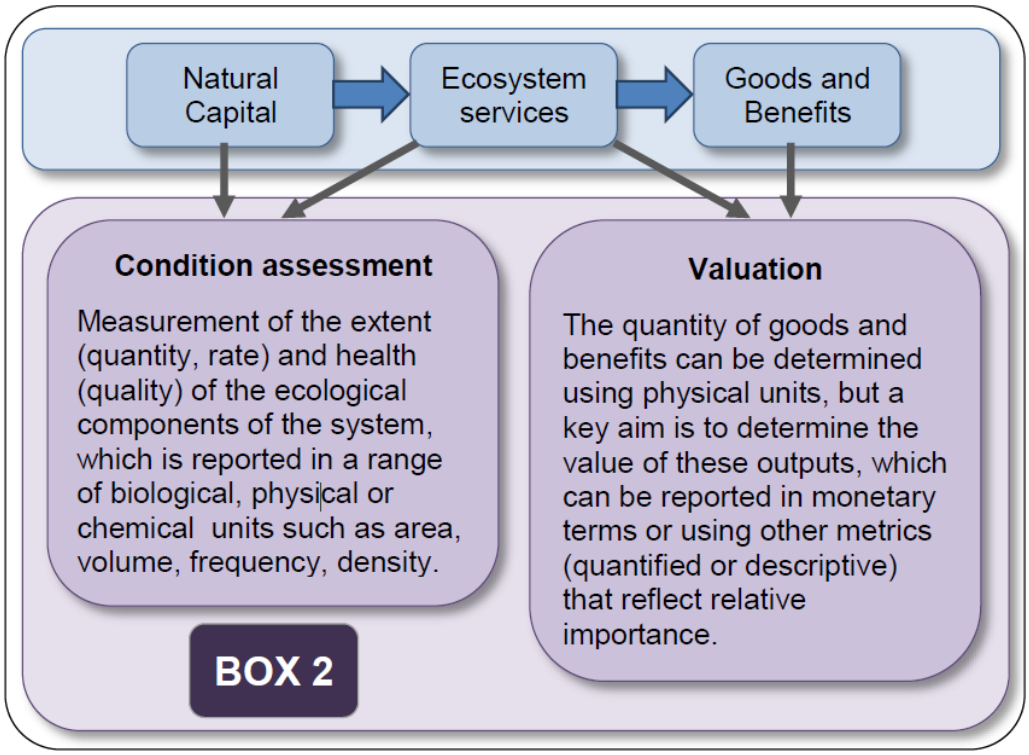

Figure 12. Status of natural capital assets in ecological terms (Defra et al., 2019)

In addition to the measurement of the extent of habitats already outlined, the results of the NDMP (Rees et al., 2019) provide the below suggestions for assessing the condition of natural capital assets which could be adapted for use in Sussex. These focus on the condition of habitats to produce ecosystem services, based on the premise that it can be considered that various levels of past fishing are impairing the functionality of habitats and that benefits to the ecological and social system would be realised by reducing this pressure.

In addition to the NDMP condition assessments, the environmental value approach adopted by Sussex IFCA as outlined in section 4.4 can essentially be used as a proxy indicator that flags risk level to habitat assets from disturbance and thus the flow of services and benefits from these. As such it can be used to identify areas of priority for restriction of damaging fishing practices.

4.6.2 Condition of habitats and species within designated Marine Protected Areas

514km^2 of the Sussex IFC District's marine environment is included within designated MPAs (Figure 13). This figure excludes overlap between some MPAs (e.g. Pagham Harbour SPA and MCZ). These include:

- Special Areas of Conservation (designated under the EU Habitats Directive 92/43/EEC).
- Special Protection Areas (designated under the EU Birds Directive 2009/147/EC).
- Marine Conservation Zones (designated under the UK Marine and Coastal Access Act 2009).
- Sites of Special Scientific Interest (not included on map as limited areas extend below Mean High Water Mark (MHWM).

Information on habitat extents within these areas is useful because:

i. these areas are likely to be monitored by survey data, and thus changes in extent through time can be tracked with more confidence than extents that are calculated using modelled data; and

ii. when considering habitat condition these areas will be covered by specific management objectives and measures in relation to condition, whereas those outside MPAs are less likely to be so.

There is very little survey condition information yet available for the MPAs in Sussex. Initial surveys carried out for the purpose of their designation have identified the main features and habitats and proposed management objectives (which are either 'maintain' or 'recover to favourable condition'). In most cases these objectives have been applied due to the vulnerability of many of the features to pressures to which they are sensitive. See Annex 2 for a description of MPAs in Sussex waters, including designated features, associated objectives and condition assessments and management in place.

Within MPAs which overlap with the proposed management area, rocky and biogenic reef features generally have an objective of 'recover', while sediment and species features are 'maintain'.

Currently 1133km^2 of the District is either within MPAs (514km^2) or within areas with a management measure to reduce benthic impact i.e. demersal gear management, namely the existing Trawling Exclusion Byelaw (58km^2), the Fishing Instruments Byelaw which includes no scallop dredging within three nautical miles (959km^2), and the Oyster Dredging Permit Byelaw (30km^2). Currently trawling is prohibited May to October within 58km^2 (the existing Trawling Exclusion Byelaw), April to June in all of Kingmere MCZ (47km^2) and in part of Kingmere MCZ (42km^2) July to March and all year round within Beachy Head West MCZ (24km^2), Pagham Harbour (3km^2) and Utopia MCZ (3km^2). See section 4.10 for current management.

The proposed management would equate to 304km^2 of habitat with management measures to protect benthic features all year round. An increase of 232km^2 from the current all year round trawling prohibition in Beachy Head West MCZ, Pagham Harbour MCZ, Utopia MCZ and Kingmere MCZ.

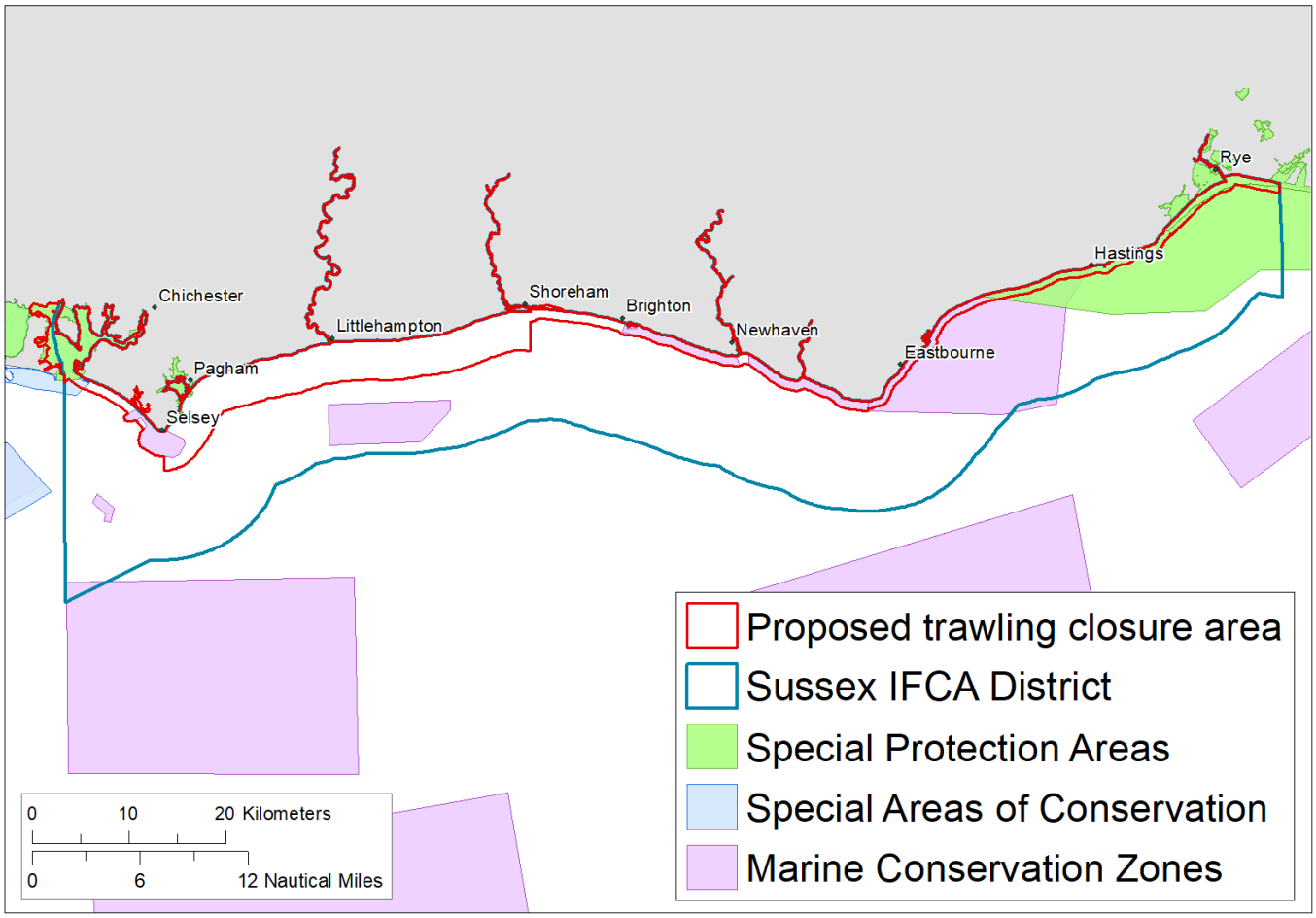

Figure 13. Designated MPAs within Sussex IFC District in relation to proposed trawling exclusion area.

See Annex 11 for a breakdown of extents and percentage of each habitat in and outside MPAs and in areas where there is currently demersal gear management.

4.6.4 Condition of seabed habitats (modelled approach)

The use of proxies based on known pressures, such as abrasion by fishing, their impacts and habitat sensitivity are recommended by experts as a pragmatic approach to overcoming the lack of habitat condition information available (Hooper et al., 2019).

To obtain an indication of asset condition that can be applied consistently across a proposed management area a proxy approach was developed within the NDMP (Rees et al., 2019). This is based on knowledge of habitat sensitivity to pressures and fishing activity data that may contribute to pressures. By combining data layers on habitat sensitivity and exposure to activity levels the Likely Relative Condition (LRC) of that habitat can be determined. This is a method that can be developed further for Sussex IFC District in the future. For further information see Annex 12.

The data used in the LRC analysis all have various sources of uncertainty associated with them, the only way to truly determine the condition of a feature is to carry out direct condition assessments. Interpretation of LRC and appropriate thresholds (to maintain flows of ecosystem services) remains a key point of discussion in the development of this method (Rees et al., 2019).

4.6.5 Kelp bed reduction

Understanding around the marked demise of local Sussex kelp beds is outlined in section 4.3.3. The current trawling management proposals aim to protect nearshore essential fish habitats from damage such that they can function as key fish feeding and breeding grounds. Protection of the known historic dense kelp forest within Area 2 forms a key supporting element for the proposed restrictions. In parallel with the development of management proposals, Sussex IFCA is working with a variety of partners to deliver research which focusses on kelp restoration and habitat enhancement.

4.7 Risk to habitats and potential for recovery

Currently, only the proportion of valuable sensitive habitats that fall within designated MPAs (excluding newly designated Tranche 3 MCZs) are managed for the impacts of trawl fisheries within the Sussex IFC District, together with a limited seasonal protection of some nearshore areas of the District out to a quarter of a nautical mile.

The environmental value approach adopted by Sussex IFCA as outlined in Section 4.4.4, can essentially be used as a proxy indicator that flags risk level to habitat assets from disturbance and thus the flow of services and benefits from these.

For more detailed information on the ability of the District's habitats to recover from trawling abrasion pressure, refer to the sensitivity assessment breakdown in Annex 4. This includes a summary of the resistance, resilience and sensitivity of the main broadscale habitat types, based on information provided by the Marine Life Information Network (MarLIN, 2017a).

Seabed habitats are at risk from a range of drivers/pressures, with bottom towed gear being one of the most widespread and pervasive pressures. These include:

- abrasion/disturbance of seabed (e.g. trawling, dredging, aggregate extraction; subsea cables, construction on seabed);
- water quality (pollution -from both sea and land-based sources);
- disposal of waste/aggregates;
- siltation;
- underwater noise;
- over-extraction of species; and
- climate change (acidification, invasive species, increased sea temperature, sea level rise, extreme weather events).

To determine the nature and severity of risk to natural capital assets within the District and the benefits they provide, their performance could be assessed against UK policy targets as outlined in the NDMP project (Rees et al., 2019). This is outside of the scope of the current IA but would be useful future information for Sussex IFCA to assess. The NDMP (Rees et al., 2019) described risks to the natural capital assets and the benefits which flow from them which are listed below. There are substantial gaps in knowledge about the marine asset-benefit relationships and therefore the associated risk of loss of ecosystem service benefits. Asset-benefit relationships represent the relationship between the condition of the natural asset and the benefit provided to people.

- Food (wild food fish and shellfish) is at high risk due to the extent of sublittoral habitat without management objectives, and with impaired quality based on knowledge of current fishing activity.
- Healthy climate benefits are at risk due to the degraded kelp and rock/reef habitats. Kelp communities capture carbon and soft substratum sediments contribute towards storage/sequestration.
- Sea defence services provided by kelp are impaired based due to the significant reduction in its extent.
- Clean water and sediments supported by the ecological functions and processes in the sublittoral sediments are considered to be at risk due to the impaired quality (condition) based on knowledge of previous fishing activity.

MPAs and the management of features of conservation interest have long been considered the main policy tool to underpin human wellbeing. Whilst MPAs may play a significant role in achieving this, ecosystem service benefits are linked to habitats and species with and without conservation designations for management (Rees et al., 2019).

Laminaria hyperborea beds recover well with respect to growth and biomass after trawling when the pressure is removed, but re-colonisation of the kelp forests by associated flora and fauna after disturbance is slower (Christie et al., 1998). Evidence from Scotland shows that the pervasive nature of intensive trawling and dredging over the past 150 years in the Firth of Forth led to damage that was dramatic and transformed near-shore and estuarine environments and the associated functioning of the marine ecosystem to a considerable extent (Williams and Clarke 2019).

The 'ecosystem approach' (holistic management systems and decision-making processes that balance ecological well-being with human and societal well-being in an equitable way) (Beaumont et al, 2017) to fisheries management needs to consider not only the target species and bycatches, but also the wider impacts on marine habitats resulting from fishing activity. The impacts cover the disturbance of the upper layers of the seabed (re-suspension of sediments), direct removal, damage, displacement or death of flora and fauna living in or on the seabed, a short-term attraction of carrion consumers into the path of the fishing gear and finally the alteration of habitat structure (Kaiser et al., 2003). These negative impacts can directly affect essential fish habitats and therefore the future of the fishery and associated marine flora and fauna.

Case studies from California show the long term impacts of trawling and kelp restoration projects (including the creation of artificial reefs, transplanting, adding suitable substrate and securing plants into sediment) which were successful (although this is a different species of Kelp, *Macrocystis pyrifera) (*California Department of Fish and Game, 2008)(from Williams & Davies, 2019).

4.8 Fishing activity evidence

4.8.1 Main Sussex IFC District fisheries

Most fishing activity in the Sussex District is undertaken by small inshore vessels with one to three fishers on board and on trips of less than 24 hours duration. Fishing vessels longer than 14m are prohibited from fishing within the District, as are non-UK registered vessels (Fisheries Convention, 1966). Importantly, most vessels engage in several different fishing methods throughout the year, sometimes concurrently.

In its assessment of Sussex fisheries, Nelson (2017) defined a fishery as a combination of the species and the method used to catch it (Dapling et al., 2010). A total of 872 fisheries were identified in Sussex, which included 104 species and 22 fishing methods. Based on the aggregation of fishing methods into five classes (angling, dredging, netting, potting and trawling) and species landings weight, 37 major fisheries were identified – see Annex 6 for methodology and fisheries details.

4.8.2 Trawling

4.8.2.1 Sussex IFCA sightings data

There is a good understanding of fishing activity level and location within the District. Sussex IFCA has conducted a review of observed fishing activity within the District and constructed 2013-2017 trawling activity and effort maps (see Annex 7 for fishing activity confidence maps). Fishing activity sightings data has been collected by Sussex IFCA and its predecessor, the Sussex Sea Fisheries Committee, for almost 20 years. The District is wholly within the six nautical mile limit and is only fished by UK vessels. See Annex 8 for sightings data from 2001 to 2018. The sightings maps show that trawling occurs at varying frequencies across the whole District.

As detailed in the 'Sussex Inshore Fishing Effort 2013-2017' report (found on our website) Sussex IFCA combines the sightings of fishing vessels with the patrol vessel's track data to counteract any bias from patrol effort. This analysis results in a value for 1km x 1km grid cells equal to the number of vessels observed per square km of sea patrolled as an annual average over a five-year period. This is based on a method developed by CEFAS with IFCAs. We use our sightings data rather than remote VMS data (Vessel Monitoring System) as not all relevant vessels have VMS fitted. In addition, VMS data is not able to show a vessel's activity whereas visual sightings data tell us whether or not a vessel is fishing and what method it is utilising.

The sightings data is not processed on an individual year basis as this causes irregularities in the resultant maps due to the nature of the underlying data. The most recent effort maps available are for the period 2013-2017. There is more information on the limitation of this dataset in the report 'Sussex Inshore Fishing Effort 2013-2017'. Fishing effort confidence maps available in the Impact Assessment. The sightings data points, not corrected for patrol effort, were included in the Impact Assessment for the years 2001- 2018 (the entire dataset) and 2014-2018 (the last five years), and show the observations of different types of trawling.

Figure 14 displays the fishing effort for trawling vessels across the IFC District between 2013 and 2017. Fishing effort was calculated as the annual average number of fishing vessels observed per kilometre squared of the sea patrolled by Sussex IFCA's fisheries patrol vessel (FPV) Watchful.

The greatest fishing effort occurred generally between three and six nautical miles from the coast across the entire District, with the most concentrated trawling effort between Beachy Head and Brighton. The lowest fishing effort generally occurs inshore to the west of Selsey. In the east of the District there is moderate trawling effort with the majority occurring being beyond one kilometre of Mean High Water Springs (MHWS). Between Shoreham and Selsey trawling sightings occur at a moderate frequency, with the majority of these being of pair trawlers. There have been a total of 58 trawling vessel sightings across the District from within the proposed management zone between 2013 and 2017, see Figure 15.

This illustrates the relatively low trawling effort in the nearshore area compared to further offshore and therefore the lower anticipated impact on fishers.

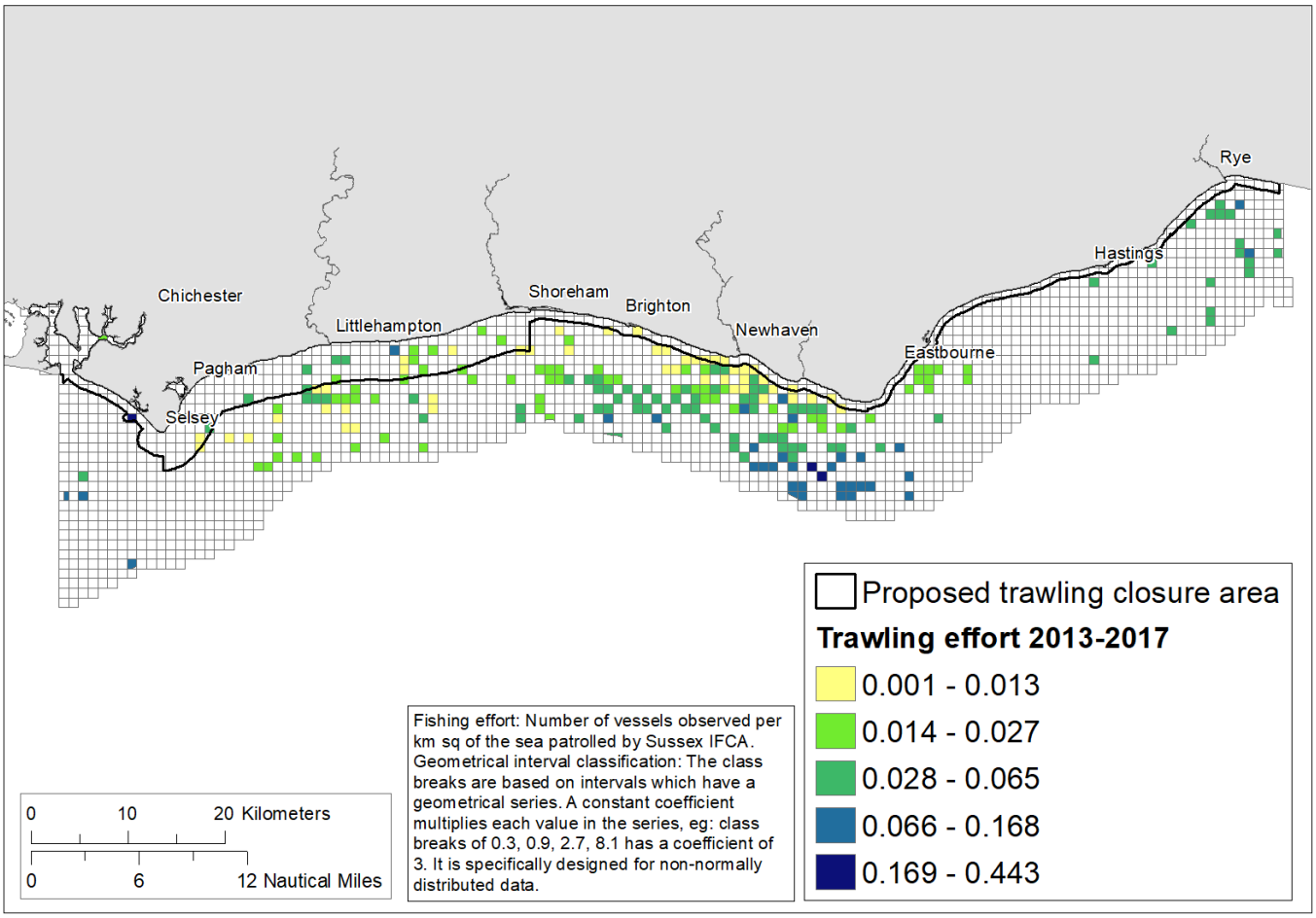

Figure 14. Trawling fishing effort 2013-2017, with proposed trawling closure area.

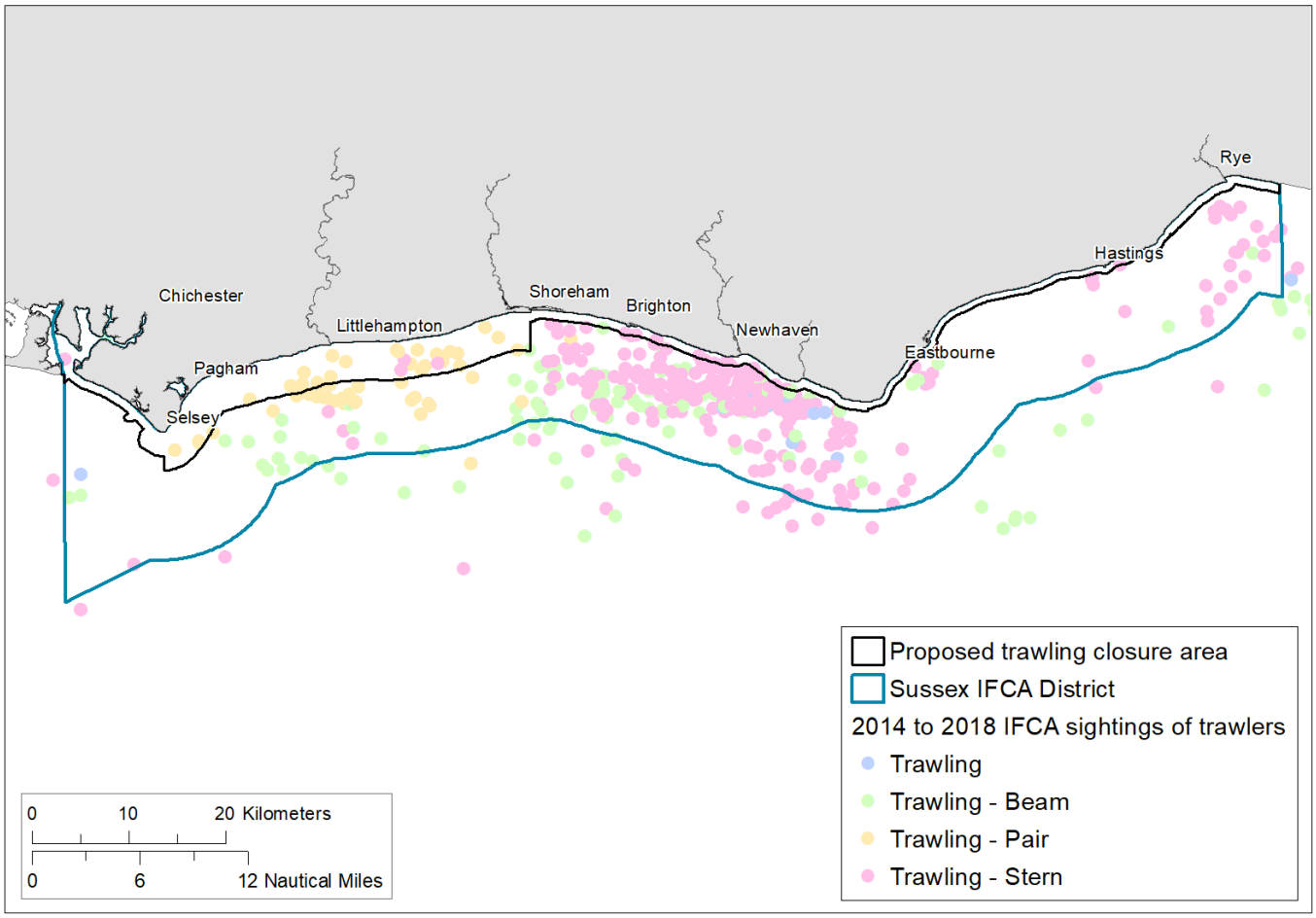

Figure 15. Trawling activity by type within the Sussex District between 2014 and 2018.

The home ports from which trawlers operate in Sussex are Shoreham (circa three vessels), Newhaven (circa five vessels), Hastings (circa five vessels) and Rye (circa eleven vessels).

Seafish analysis

Vessels which utilised the potential trawling exclusion area between 2014 and 2018 were derived from Sussex IFCA sightings data. Bespoke economic analyses of these vessels were subsequently conducted by Seafish. Inactive and low activity vessels were excluded from the analysis, and vessels were grouped according to Seafish segments, which group vessels according the main fishing gear they use based on number of days at sea. Vessels can use other gears during the year in addition to the main gear– see Annex 10 for detailed methods and caveats.

The Seafish economic analysis showed an overall decrease in the number of trawling vessels which utilise the proposed exclusion area between 2014 and 2018 from 12 to nine.

4.8.2.2 District trawl types and target species

Trawling is an important element of the Sussex inshore fishery. The Sussex IFC District trawler fleet falls in to four distinct categories (Table 11):

- less than 14m length overall (LOA) beam trawler;
- less than 14m LOA demersal otter trawler;
- less than 14m LOA single, twin or triple trawlers, utilising one or more trawls simultaneously; and
- less than 14m LOA demersal pair trawlers also utilising a large diameter rubber rock hopper ground rope.

Table 10. Trawl types, description and target species in the Sussex District (for more information on fishing methods see Seafish, 2015)

Trawl type	Description	Target species
Beam trawl	Utilise twin four and a half metre beam trawls or a single beam trawl of an overall length that is less than nine metres. Commonly utilise a chain matrix with additional tickler chains in the beam trawl rig and wheels or fixed flat plate shoes at the ends of the beam. This rig allows the vessel to operate on mixed and varied seabed types.	Target the traditional demersal flat fish species such as sole and plaice and also cuttlefish, with a small bycatch of demersal round fish.
Rock hopper otter trawl	Utilise the rock hopper style ground rope. This ground rope consists of large rubber discs which are circa 400mm to 600mm in diameter, coupled with steel otter boards that allow the vessel to operate on mixed seabed types including harder and rockier areas. Additional tickler chains can also be utilised.	The headline height from the seabed of these trawls also enable semi pelagic species to be targeted in addition to cuttlefish, squid and more traditional demersal flat fish and round fish.
Single, twin or triple rig otter trawl	Utilise a smaller diameter ground rope circa 100mm to 200mm rubber discs with steel or traditional wooden otter boards. The seabed types where these vessels operate tend to be more specific i.e. sand, fine shingle and a softer seabed being the norm, additional tickler chains are also utilised. These trawls have significantly less headline height from the seabed than their rock hopper counterparts.	Primarily target traditional demersal flat fish and round fish species also including cuttlefish.
Pair trawl	Utilise the rock hopper ground rope fitted with large rubber discs circa 400mm to 600mm in diameter. Towed between two vessels of similar capacity the pair trawl can be operated on mixed seabed types including harder and rockier areas.	Target round fish species in the Sussex IFC District, primarily black seabream and bass (bass are now a bycatch species only as a result of recent European protection regulations). The headline height from the seabed of theses trawls also enables pelagic species to be retained in the trawl as a target species or bycatch.

There is a very limited small pelagic trawl fishery with one known vessel under ten metres LOA targeting herring from Sovereign Harbour.

The bespoke Seafish (2019) economic analysis summarised the total combined weight of landings (tonnes) by all trawling vessels known to utilise the potential closure area. Figure 16 illustrates the combined proportions of different species landed by the vessels assessed. Between 2014 and 2018 plaice consistently comprised the highest weight of landings. Overall the total average weight landed of all species increased between 2014 and 2018, from 60.5 to 67.1 tonnes. The total combined weight of landings by all trawlers known to use the area showed an overall decrease over the same period however, from 726.3 to 603.9 tonnes. As outlined in section 4.8.2.1 vessel numbers decreased in the corresponding period.

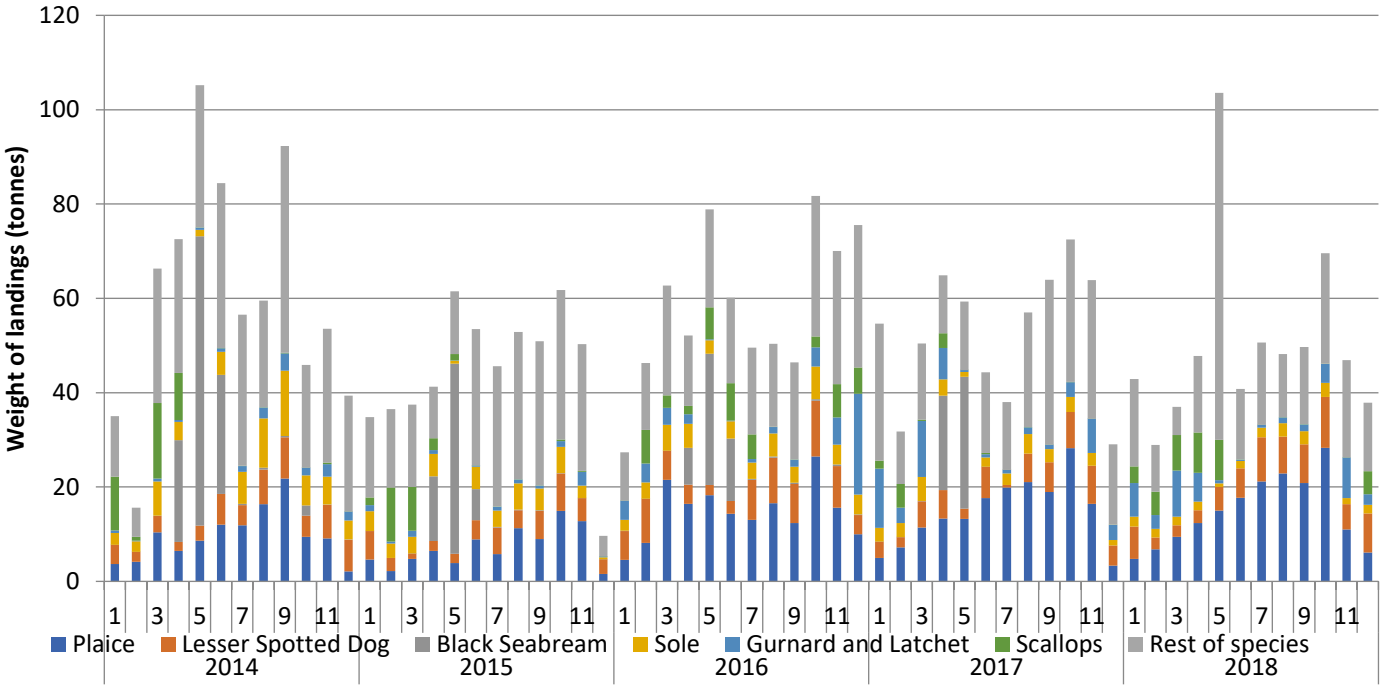

Figure 16. Total combined weight of landings (tonnes) by all trawling vessels sighted within the proposed exclusion area. Seafish, 2019

4.8.2.3 MMO landings data

The MMO collects finfish and shellfish landings data for English ports. Data was requested for all fish landed to Sussex ports (namely Bognor Regis, Brighton, Eastbourne, Emsworth, Hastings, Itchenor, Littlehampton, Newhaven, Rye, Selsey, Shoreham and Worthing) that were caught in ICES rectangles 30E9 and 30F0 (Figure 17). This was the closest spatial scale to the District that was available, comprising 40% of 30E9 and 30% of 30F0.

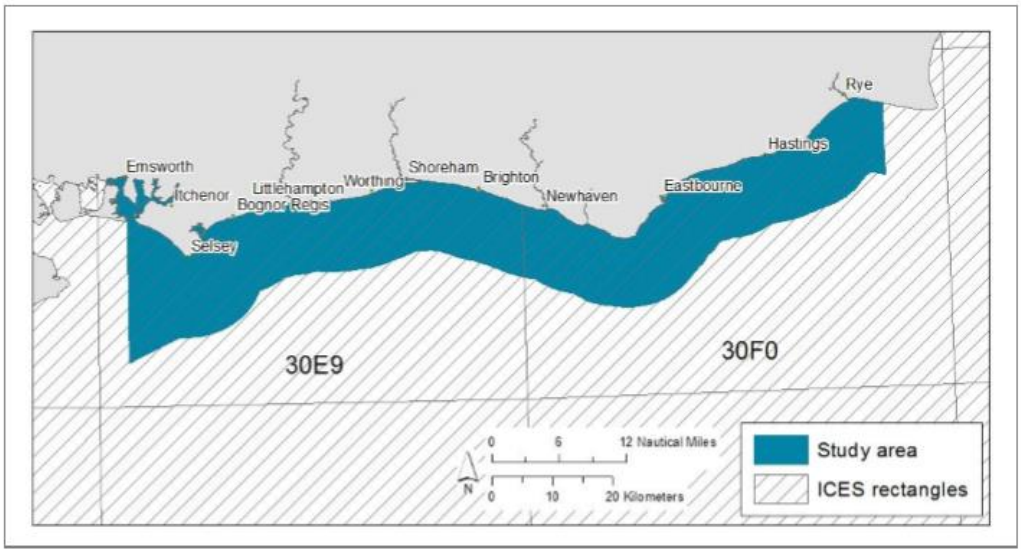

Figure 17. The Sussex District in relation to ICES rectangles (www.data.gov.uk)

It's important to note that MMO statistics do not differentiate between landings from inside or outside the Sussex IFC District. The data for trawler landings is summarised below. It should be noted that this information contains data from vessels that have caught fish outside the District but have landed it within a District port.

Table 11. Percent of total catch for all towed gear types across all Sussex ports from MMO landings data 2012-2016. (The information in this section is from the Sussex IFCA trawling information technical summary document that informed early byelaw development. More up to date data appears later in this section.)

Species	Live weight (T)	% of total catch
Plaice	1,603	29
Sole	833	15
Lesser Spotted Dogfish	432	7.7
Black Seabream	428	7.6
Lemon Sole	248	4.4
Cuttlefish	211	3.7

From 2012 to 2016, otter trawls (all types) have accounted for over half of the landings by weight (55%), with beam trawling making up 34%, followed by pair trawls (9%). The annual average live weight landed was 1116 tonnes (Table 13).

Table 12. Live weight and value for the different towed gear types.

Gear type	Sum of Live Weight(T)	Value (£)
Beam trawls	2755	6,501,102
Otter trawls (not specified)	2910	6,337,102
Pair trawls - bottom	572	1,174,267
Otter trawls - bottom	366	609,760
Otter twin trawls	9.5	18,256
Otter trawls - midwater	0.5	1,260

The greatest species live weight was for plaice which accounted for 29% of the total catch percentage for towed gear, followed by sole (15%), lesser spotted dogfish (7.7%), black seabream (7.6%), lemon sole (4%), and cuttlefish (3.7%) – see Table 12.

In 2016 there were 53 distinct vessels which landed seafood caught with towed gears, with an average live weight of four tonnes per vessel. The most landed by a single vessel was 170 tonnes. Not all of these vessels have home ports in Sussex. Shoreham was the port with most landings from trawling, by weight (43%) and value (45%), followed by Newhaven by weight (27%) and value (22%) and Rye by weight (20%) and value (21%).

The total value of seafood caught by beam trawl was highest of the different mobile gear types for catch landed into Sussex ports. Otter trawls accounted for the second highest landings value within the District, but the highest sum live weight in tonnes.

4.8.2.4 Pair-trawling activity and catch data

Nine pair trawling vessels have reported landings in the District from 2009-2018 (MMO landings data). Note that when pair trawling, only one of the pair of vessels retains and lands the catch. Only one vessel has landed catch every year from 2009-2018. Another vessel has landed every year except 2010. These two vessels are the only vessels which were pair trawling in 2016, 2017 and 2018. In 2009, six vessel pairs were active.

The pair trawl fishery was set up to target black seabream and bass in the area. Landings data collated by the MMO was used to analyse catches from pair trawlers landing their catch into Sussex ports over the last ten years (2009-2018). Black seabream was the species with the greatest amount of landed weight, followed by smoothhound, bass and grey mullet. In total, 57 species were recorded in the landings data. Total catches have declined from 2009 to 2017, with an increase in 2018 principally

caused by a large increase in the ‘other ‘category (Figure 18 and Table 14). On average, pair trawlers account for one percent of all seafood caught by all gears landed to Sussex ports.

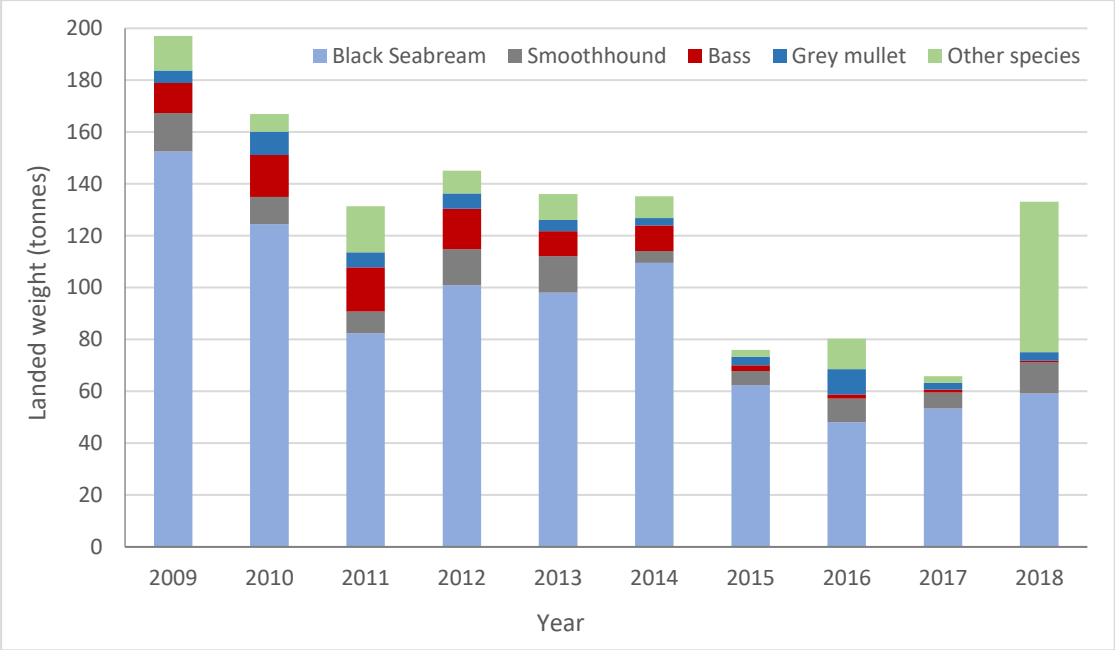

Figure 18. Weight (tonnes) landed to Sussex ports by pair trawlers 2009-2018 from MMO landings data.

The main increase in catches in 2018 was from lesser spotted dogfish (16.1T), plaice (11.6T), thornback ray (9.2T), and mackerel (8.8T). In 2017, landings of lesser spotted dogfish had been 0.2T, plaice 0.2T, thornback ray 0.8T and mackerel 0.1T. The landings of smoothhound also increased to 12.0T from 6.2T in 2017. It could be that as only 1% unavoidable bycatch of bass was allowed, the fishers decided to increase the total amount landed to increase the amount of bass they could land.

Table 13. Weight (tonnes) landed to Sussex ports by pair trawlers 2009-2018 from MMO landings data.

Weight (tonnes)	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Average
Black Seabream	152.48	124.46	82.44	100.97	98.09	109.56	62.38	48.12	53.40	59.16	**89.10**
Smoothhound	14.88	10.45	8.37	13.94	14.05	4.54	5.40	9.06	6.17	12.04	**9.89**
Bass	11.58	16.21	16.97	15.56	9.64	9.90	2.27	1.67	1.11	0.54	**8.55**
Grey mullet	4.83	9.10	5.80	5.87	4.24	2.86	3.38	9.74	2.62	3.32	**5.18**
Other species	13.32	6.68	17.78	8.72	10.04	8.32	2.52	11.69	2.54	58.02	**13.96**
Total	197.09	166.90	131.36	145.05	136.07	135.17	75.95	80.28	65.84	133.09	**126.68**
Total weight of seafood landed by all gears to Sussex ports	11591	16250	13562	13603	11653	11563	9864	9153	13620	11986	**12284.51**
% of all seafood landed attributed to pair trawlers	1.7%	1.0%	1.0%	1.1%	1.2%	1.2%	0.8%	0.9%	0.5%	1.1%	**1.0%**

The historic pair trawl bass catch statistics (which are relatively consistent in respect to the proportion of entire catch) enable predictions of current discarding levels to be reasonably projected during those years in which the bycatch was limited from 1-3%. Furthermore, the assessment of bass catch sampling on trawlers at sea by Inshore Fisheries and Conservation Officers (IFCOs) in 2019 provides an understanding of the proportion of pair trawl catches that are below the present minimum conservation reference size (MCRS) of 42 centimetres (cm).

The proportion of the weight of bass landed has decreased, particularly following the introduction of restrictions in 2015. The proportion of other species increased in 2018 and included large catches of mackerel, lesser spotted dogfish, plaice, thornback ray, horse mackerel, squid and cuttlefish (Figure 18 and Table 14). However, it should be noted that no data was available on effort (e.g. number of trips, number of hauls, and length of tow).

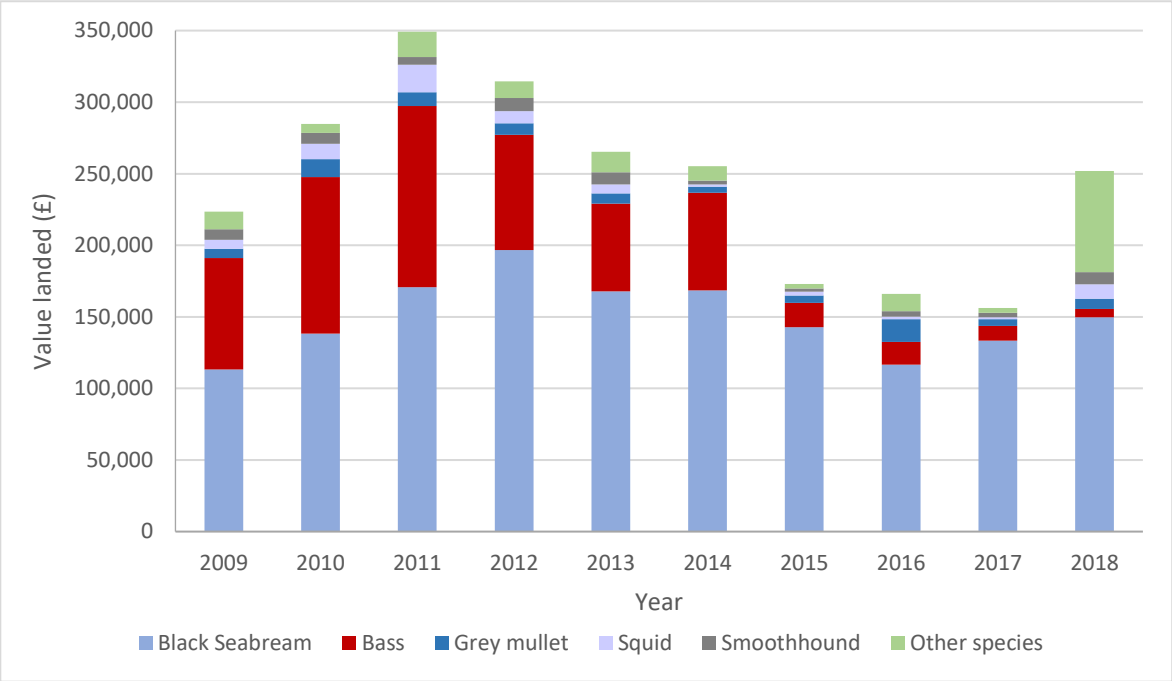

Figure 19. Value landed to Sussex ports by pair trawlers 2009-2018 from MMO landings data.

The value of pair trawl catches decreased from 2011 to 2017, with some increase in 2018. However, it should be noted that no data was available on effort (e.g. number of trips, number of hauls, and length of tow). Black seabream were of greatest vale and weight, and smoothhound was the second greatest weight landed but the fifth greatest by value. Bass was the second greatest value, followed by grey mullet and squid (Figure 19).

The main increase in catches in 2018 was from plaice (£19,700), mackerel (£12,300) and thornback ray (£11,900). In 2017, landings of plaice had been much lower (£275), as had mackerel (£200) and thornback ray (£1,100). The value of lesser spotted dogfish was £5450 in 2018, a huge increase from just £40 in 2017. These values appear as extreme outliers to the normal trend.

When value was divided by the weight landed, the value per tonne of all the species had increased over the last ten years. Black seabream has increased from £742/T to over three times the value at £2,522/T. Bass, already worth nine times more than black seabream, increased in value from £6,731/T to £10,494/T.

In May 2019, samples of bass from two pair trawler teams were measured at sea by Sussex IFCOs. The first pair were based in Newhaven. They conducted three hauls per trip, each haul lasting approximately one hour. Officers inspected their second haul. The footrope of the trawl was 72 feet long, the trawl had a rock hopper, 105.9mm mesh size cod end, 86 meshes in the round, and was 40 meshes long. The total weight of the inspected haul was approximately 360kg. The retained catch comprised of 1kg squid, 2kg cuttlefish, 400kg plaice, 5kg thornback ray, 180kg black seabream. Approximately 170kg of bass was discarded. The average length of bass returned was 39.8cm.

The second pair team were based in Shoreham. They conducted three hauls per trip, each haul lasting two to three hours. Officers inspected their second haul. The footrope of the trawl was 56 feet long, the trawl had a rock hopper, 100.5mm mesh size cod end, 84 meshes in the round, and was 50 meshes long. The total weight of the inspected haul was approximately 1000kg. The retained catch comprised of 20kg thornback ray, 600kg black seabream, 5kg squid, 3kg plaice, 1kg garfish, 200kg mackerel, 100kg

red mullet. Approximately 370kg of bass was discarded. The average length of bass returned was 39.5cm. 73% of the returned bass were below the MCRS of 42cm (Figure 20).

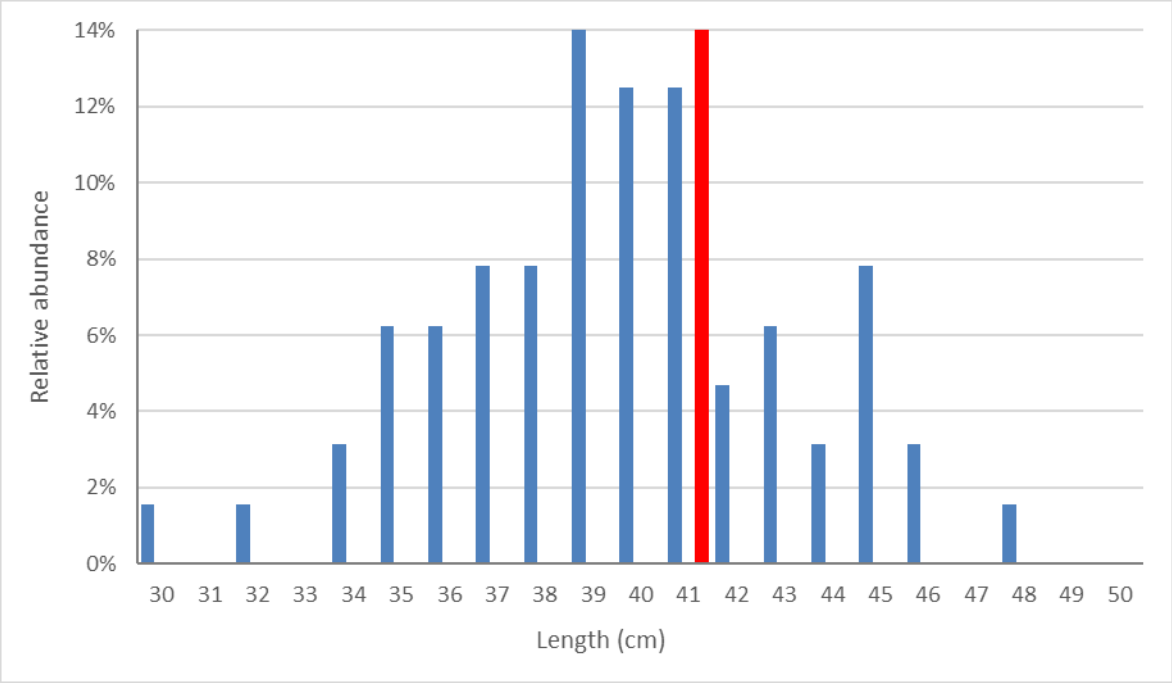

Figure 20. Relative abundance at each length for bass sampled from catches by pair trawlers and returned to the sea. Red bar is the MCRS of 42cm.

The average proportion of bass landed into Sussex ports by pair trawlers between 2009 and 2014 was 9%, which reduced to an average of 2% after restrictions were introduced in 2015. The average annual weight of bass landed 2009-2014 was 13.3 tonnes. This was reduced after the 2015 restrictions to an annual average of only 1.4 tonnes. This may have resulted in approximately 12 tonnes being discarded annually (Figure 21).

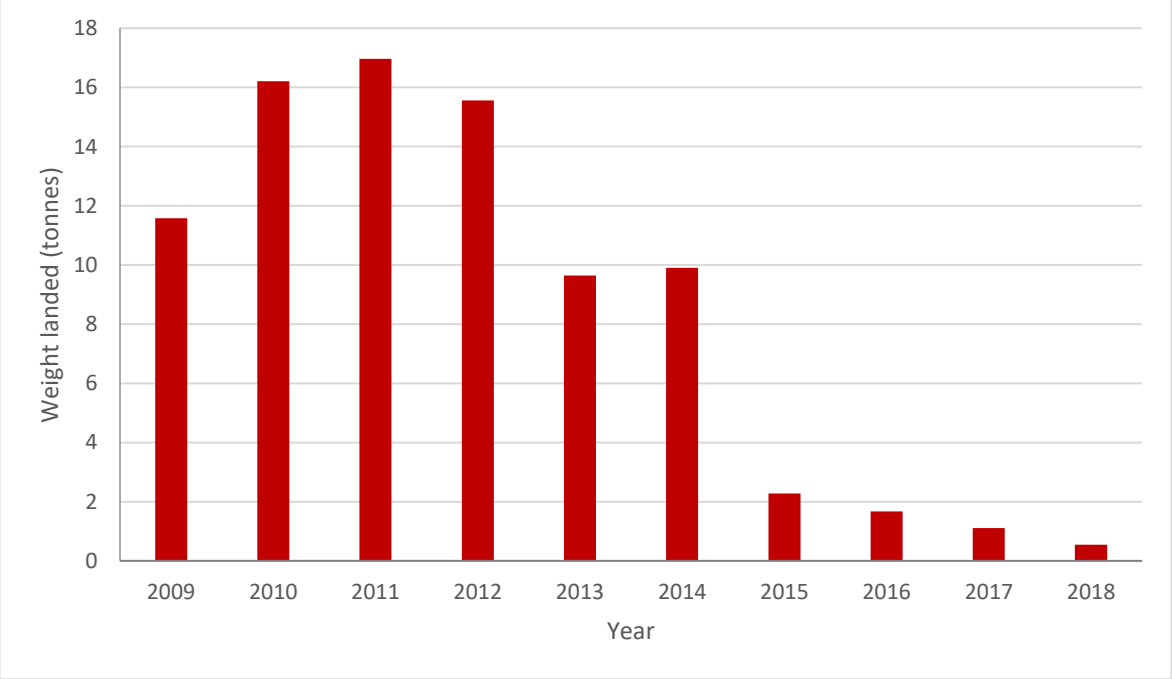

Figure 21. Weight (tonnes) of bass landed to Sussex ports by pair trawlers 2009-2018 from MMO landings data

Discarding impacts are affected by whether bass are returned to the sea alive and their subsequent survival. The survival rate of bass discarded from trawlers is estimated to be 10%. The survival rate is

slightly higher for netting at 20% and is 80% for rod and line caught bass (Williams and Carpenter, 2015). Survival rates can be effected by many factors such as the health and condition of the individual fish, the type of gear, handling processes and environmental factors (Davis, 2002).

Bass take four to seven years to grow to 42cm long at which point they are considered reproductively mature. In the first few years of their lives, estuaries and sheltered coastal areas are crucial for their survival. Fishing effort on particularly the four to five year old bass is detrimental to the population, as is the damage to inshore habitats (Kelley, 1988).

4.8.2.5 Trawling and habitats

Figure 22 illustrates the co-location of all trawling sightings activity over habitats within the District between 2013 and 2017. This map also highlights the area of the District which is fished using towed gear. It should be noted that the sightings data is not adjusted for patrol vessel bias, such that night fishing out of Rye Harbour, for example, may be under represented.

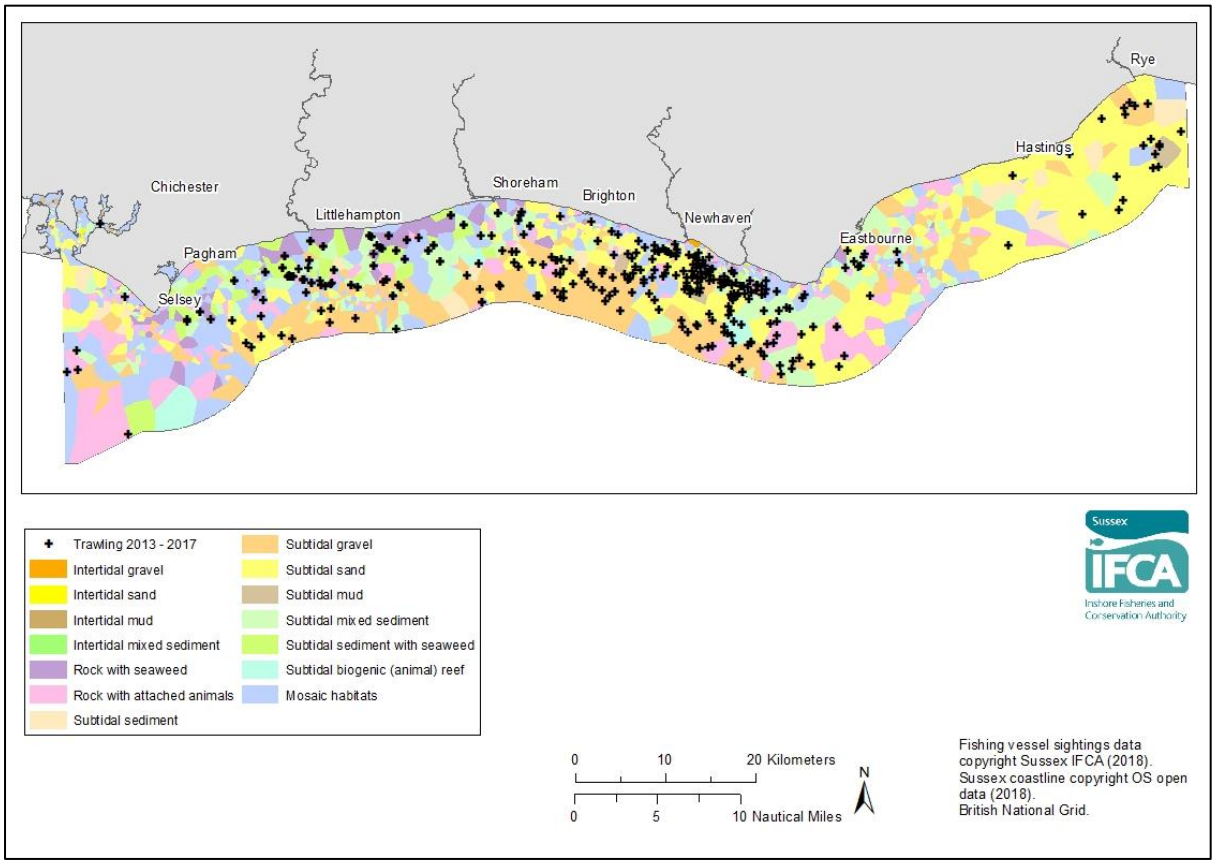

Figure 22. Sightings data for towed gear, overlaid on habitat type, within the Sussex IFC District, data from 2013 to 2017.

Table 14. Trawling vessel sightings (2013-2017) over different habitat types

Habitat Code	Habitat Type	Description	Vessel Sightings
A3.1	Atlantic and Mediterranean high energy infralittoral rock	Rock with seaweed	1
A3.2	Atlantic and Mediterranean moderate energy infralittoral rock	Rock with seaweed	18
A4	Circalittoral rock and other hard substrata	Rock with attached animals	4
A4.1	Atlantic and Mediterranean high energy circalittoral rock	Rock with attached animals	6
A4.2	Atlantic and Mediterranean moderate energy circalittoral rock	Rock with attached animals	17
A4.7	Features of circalittoral rock	Rock with attached animals	6
A5	Sublittoral sediment	Subtidal sediment	3

A5.1	Sublittoral coarse sediment	Subtidal gravel	66
A5.2	Sublittoral sand	Subtidal sand	94
A5.3	Sublittoral mud	Subtidal mud	6
A5.4	Sublittoral mixed sediments	Subtidal mixed sediment	63
A5.5	Sublittoral macrophyte-dominated sediment	Subtidal sediment with seaweed	13
A5.6	Sublittoral biogenic reefs	Subtidal biogenic (animal) reef	7
x	Mosaic	Mixture of habitat	56

Trawling activity occurred across numerous marine habitats between 2013 and 2017 as shown in Table 15. Sublittoral sand (A5.2) was the most common habitat for trawling activity, with 94 vessels recorded. Followed by sublittoral coarse sediment and mixed sediment, with 66 and 63 vessels sighted respectively. Atlantic and Mediterranean high energy infralittoral rock (A3.1) recorded the lowest number of trawling vessels with one sighting.

4.9 Current management

The existing Sussex IFCA Fishing Instruments Byelaw includes a provision to allow for trawls fishing for demersal, pelagic and shellfish species. Cod end restrictions apply to pair trawls. The trawling exclusion byelaw enforces a trawling exclusion zone, but this is limited both seasonally and spatially. Trawling is only prohibited between May and October, enabling exploitation up to the coastline throughout the rest of the year. This seasonal prohibition solely applies out to a quarter of a nautical mile from the shore, and excludes any part of the District that lies to the west of Shoreham Harbour and between Holywell (Eastbourne) and Cuckmere in the east. A large proportion of the District's nearshore areas are unprotected from trawling throughout the year.

The Vessel Length Byelaw also restricts vessels to no more than 14m in order to limit the industrialisation of the fishery. This excludes vessels with historic rights, which now comprises four vessels, only two of which have been seen within the District in the last 10 years (IFCO intel, 2018).

In addition, management of trawl fisheries also occurs within Marine Protected Areas (MPAs) within the District, under Sussex IFCA's Chichester Harbour European Marine Site (Specified Areas) Prohibition of Fishing Method Byelaw and the Authority's MPA Byelaw and associated schedules. These currently include:

- trawling exclusion over seagrass beds within Chichester Harbour EMS;
- fishing activity management, including trawling prohibitions, to protect black seabream and rocky reef features within Kingmere MCZ;
- exclusion of trawling to protect chalk ledges and gullies within Beachy Head West MCZ;
- trawling prohibition within Pagham Harbour MCZ and SPA to protect near pristine habitat; and
- trawling exclusion within Utopia MCZ to protect rocky reef.

Trawling management of Selsey Bill and The Hounds MCZ will be implemented through the proposed prohibition zone and the management of Beachy Head East MCZ will be developed over the next two years on the basis of conservation advice from Natural England.

Whilst MPAs are an important conservation tool, ecosystem-based management is essential in conjunction with feature-based management within MPAs to ensure a healthy marine environment. There is a clear science emerging to support Defra's 'whole-site' approach (e.g. in Solandt *et al*., 2019, Elliot et al., 2017) that supports the current nearshore trawling exclusion proposals and the spatial management of trawling on a much wider basis than within MPAs alone. As such, proposed management will support and add value to the UK MPA network being developed.

4.10 Trawling impacts evidence

4.10.1 Overview

Fishing gear can impact significantly upon marine habitats (Natural England, 2009), and is the most pervasive pressure within coastal waters where the marine environment is particularly productive. For

example, reefs can be severely damaged if heavy gear is towed across them (Natural England, 2009). In their global analysis of depletion and recovery of seabed biota after bottom trawling disturbance, Hiddink et al (2017) summarise bottom trawling as '*the most widespread source of physical disturbance to the world's seabed'*. The key impacts of trawling include:

- Abrasion/penetration/disturbance of sea bed, altering structure and removing and damaging sessile species.
- Abrasion/penetration/disturbance of substrate below surface of the sea bed.
- Changes in suspended solids/siltation rate changes.
- Bycatch and removal of non-target species.

4.10.2 Ecosystem Services Transfer Toolkit evidence

Oceans are critical for biodiversity and ecosystem services. Our marine environment supports our economy with crucial jobs, seafood and raw materials. Damage from bottom towed gears can prevent key habitats from providing essential ecosystem services. These ecosystem services include the provision of functional habitats for breeding fish and as nursery grounds for their juveniles, giving food and shelter (see section 4.4.3 for further details).

Natural England's Ecosystem Services Transfer Toolkit (NECR159), reviews the available evidence linking management of habitats with the ecosystem services they provide - see http://publications.naturalengland.org.uk/publication/5890643062685696. The marine no-take zones toolkit reviews the published peer-reviewed literature relevant to establishing areas where certain types of fisheries are prohibited or restricted.

Food

For the provisioning ecosystem service of food, supporting evidence was categorised as strong in the toolkit, with the review of temporary or permanent closure of some areas to fisheries showing a generally positive outcome for fish stocks (Horwood et al., 1998). The exclusion of towed demersal fishing from Lyme Bay, an MPA within the nearshore area, resulted in increases in species richness and total abundance within three years, including a range of economically important species (Sheehan et al., 2013).

Voluntary fishing agreements, such as the Inshore Potting Agreement located off South Devon, where there is zonal management of fishing were analysed with respect to their effect on commercial fisheries (Blyth et al., 2004). The study found that where towed gear was prohibited and there was a use of static gear only, there was a significantly higher species richness and biomass of benthic communities.

The case of the opening of the three nautical mile exclusion to trawling in the Clyde Sea in 1984 clearly illustrates the deleterious impact of trawling within the nearshore area. A rapid decline in most commercial species was seen and a concomitant reduction in the diversity, amount and quality of catch for hundreds of local businesses (Thurstan & Roberts, 2010). Now there is limited opportunity to fish for anything other than prawns (Nephrops) and scallops (Thurstan & Roberts, 2010). This gradual shift to targeting species at lower trophic levels in response to decreasing catches is an observed global pattern termed 'fishing down marine foodwebs' (Pauly et al., 1998). Studies indicate that much of the North Sea is trawled too frequently to recover back to pristine levels of biomass and production, with recovery times estimated to be between two and a half and six years (Hiddink et al., 2006).

Biodiversity

For the ecosystem service of biodiversity, the NE toolkit concluded that there is a strong evidence base supporting the assertion that there is a detrimental impact of demersal fishing. Following the exclusion of demersal fishing gear from the Lyme Bay MPA, the protected reef was found to extend beyond the normal expected boundaries, showing that species assemblages previously associated with rocky reef habitat extended into sediment areas with benefits for biodiversity of the site (Sheehan et al., 2013). This is a key finding in light of current proposals to restrict trawling in the nearshore area over the range of habitat types, from rocky reef to sediments areas. The exclusion area also had a highly positive effect on biodiversity with the net export of species to the adjacent fished area (Sheehan et al., 2013).

Recreation and tourism

A strong supporting evidence base for the impact of fisheries closures on the cultural ecosystem service of recreation and tourism was cited in NE's toolkit. A study on the monetary value of tourism in Lyme Bay shows a clear benefit for those areas with the potential for the creation of protected areas as they show

higher levels of diversity for tourism. This could lead to a significant increase of economic value for the area (Rees et al., 2010).

Sediment areas impacts

In addition to findings on sediment areas recovery in Lyme Bay cited above, physical impacts of trawling on subtidal sand have been documented by the National Federation of Fishermen's Organisations (NFFO) within the Dogger Bank SAC (Lart, 2012). Both lethal and sub-lethal effects on epifauna and infauna were documented, along with changes in seabed structure. All damage caused occurs when the gear is being towed with ploughing, sweeping and compaction being the three main causal factors of damage (Lart, 2012).

Non-target species impacts

Bottom towed fishing gear can cause the mortality of non-target species through direct physical damage inflicted by the passage of the trawl or indirectly through immediate non-lethal damage to the individual, and consequent mortality through exposure and predation (Lart, 2012). Decreases in species biomass, species richness, production, diversity and alterations to species composition and community structure may lead to long-term changes in the benthic community structure (Tuck et al., 1998, Roberts et al., 2010)). Overall reductions in benthic productivity have been reported in areas where intense bottom trawling takes place (Jennings et al., 2001).

Studies of areas of the seabed that have experienced different levels of fishing activity demonstrate that continued fishing disturbance leads to the removal of high-biomass species and a shift to a benthic community dominated by a high abundance of small-sized organisms (Collie et al., 2000). Productivity is lowered as fishing intensity increases and high-biomass species are removed from the benthic habitat. These organisms also increase the complexity of the seabed which has been shown to provide shelter for juvenile fishes, reducing their vulnerability to predation (Kaiser et al., 2002). Disturbance from repeated trawling incidences can select for certain species, with communities becoming dominated by smaller-bodied infaunal species with short life histories, juvenile stages, mobile species and rapid colonists (Jennings et al., 2001, Kaiser et al., 2000, Kaiser et al., 2002).

Anecdotal reports of bottom towed fishing gears in the District over harder ground, mosaic habitats and thin veneers has resulted in damage to kelp beds and other benthic species such as ross corals, sponges and corals. This has a deleterious impact on the amount and quality of juvenile fish habitat and other ecosystem services (Smale et al., 2013; Bertocci et al., 2015).

Fishing affects seabed habitats globally but the effects are not uniform, varying with the habitat type and environment where they take place (Nelson and Burnside, 2019). Demersal trawl fisheries are especially problematic regarding their wider environmental impacts (Innes and Pascoe, 2010). Structurally complex habitats (e.g. seagrass meadows, biogenic reefs or kelp forests) are more highly impacted by fishing than sediment habitats in shallow coastal waters and also have the longest recovery times to recover from damage.

Target species impacts

Research on areas protected from mobile fishing gears in the US Gulf of Maine (Stone et al., 2004), Emerald Bank Canada (Fisher & Frank, 2002) and Icelandic continental shelf (Jaworksi et al., 2006) have shown strong positive effects of such closures on spawning stock biomass of several species including haddock, flounders, cod and scallops.

Trawling is a relatively unselective method of fishing (compared to gill netting, for example), and this can result in considerable discarding of undersized target species, non-target fish and other benthos. The results of this study suggest that all trawl fisheries around the English coast catch undersized bass, and that mesh size and, perhaps more importantly, fishing area have an influence on the size composition of the catch and therefore on the levels of undersized bass subsequently discarded (Walmsley & Pawson, 2006). Trawlers in the eastern English Channel in particular catch an extremely narrow size range and, as a result, catch a high proportion of bass <36 cm and a very high proportion of bass < 40 cm. See section 4.9.2.4 for an assessment of pair-trawl bycatch in Sussex.

Sussex sea users reports

The 'Brighton Fisheries Bill' proposed in 1835 by Captain Perchell to prohibit the use of seine nets from the beach to protect the breeding populations of certain fish species also sought to prohibit trawling within the inshore region as it was believed to be *'causing significant damage to the marine environment and local fish populations'*. It was eventually passed in 1836, although by this time an amendment had removed the prohibition of seine netting from the beach (Sussex IFCA, Centuries of Sussex Seas 2019)

Community feedback around the impacts of trawling, importance of the nearshore area and historic kelp forests are detailed within key Sussex IFCA reports, including:

- Centuries of Sussex Seas (2019) (https://secure.toolkitfiles.co.uk/clients/34087/sitedata/files/Research/Centuries-of-Sussex-Seas.pdf) - In 2018-19 Sussex IFCA undertook an investigation to find out information on the historic fisheries along the Sussex coast. Museums and historic documents were searched and local fishers were interviewed. The aim was to document this historic information and capture that which is still within living memory to help inform management decisions. It is important to not only protect the environment in its current day condition but to consider what it used to be like or what it might be in a future enhanced state. This is known as shifting baselines where the condition of the environment is measured against a particular point which may itself be degraded from a previous point. Information from this report helped inform the IFCAs understanding around the demise of historic dense kelp bed areas – refer to section 4.3.3.
- Community Voice Method report: In 2013-14 Sussex IFCA worked with the Marine Conservation Society (MCS) and an independent consultant on an innovative project which utilises a film-based technique called Community Voice Method, intended to help support management of MCZs in Sussex inshore waters. A total of 41 interviews were conducted. Numerous interviewees highlighted the demise of the kelp beds off of Worthing. The associated reduction in species caught and importance of protecting these areas was stressed. Responses indicated a strong community feeling that trawlers were responsible for the destruction of this habitat:

  Comment from a commercial fisher; *'Because of the gear they (trawlers) use it harvests the kelp (off Worthing) every day so that it doesn't get a chance to grow.'*

  Comment from a commercial fisher; *'When I was fishing before…I was catching hundreds of tons… of spiders (spider crabs) off to the west of Shoreham. They're not there anymore. I am sure that the removal of the kelp has removed a home for the spiders.*

  Many interviewees voiced concern about the impact of trawls on wider seabed habitats, in particular rocky reef, and the associated impact on fish stocks. A number of interviewees raised the importance of prohibiting trawling within nearshore waters, with strong support from commercial fishers evident as well as conservationists. Several commercial fishers raised the importance of protecting the inshore marine environment as their livelihoods depended on it, with current environmental degradation forcing people to buy bigger boats and fish further offshore. Conversely a number of interviewees opposed the view that trawlers impact kelp beds, rocky reef or wider habitats, with the impact of natural forces raised. Some interviewees also expressed the opinion that there has been no change to the seabed.

Static gear impacts

NE's ecosystem services transfer toolkit summarises that closures to mobile fishing gear are better studied than those to static gear. However, it highlights that a study from Lundy looked at the effect on benthic assemblages of a ban on all fishing (Coleman et al., 2013). It found that there was no net change in the benthic communities following the ban.

In terms of overall sustainability, rated against a range of measures including ecological, economic and social measures, pot based fisheries have been considered most sustainable, whereas otter trawl, beam trawl and dredge fisheries were ranked lowest (Stanford and Pitcher, 2004 in Mangi 2012).

A PhD study on shellfisheries, seabed habitats and interactions in Northumberland (Stephenson, 2016), concluded among its findings that 'current levels of potting are unlikely to have a direct physical impact on epibenthos in faunal and algal crust, and *Laminaria* spp. dominated habitats in Northumberland.'

4.11 Community engagement

Informal consultation

A comprehensive informal public consultation phase was carried out throughout June 2018, including web-based promotion, an online survey, a hard copy questionnaire, seven public drop in sessions and targeted emails and mailing. Numerous communications from stakeholders were received by letter and email contributing to the consultation. Report documents have been produced detailing the informal consultation responses and including representative quotes from stakeholders. These reports are archived and available for future reference.

Formal consultation

The formal consultation for trawling was launched on the 12th September 2019 and closed on 10th October, as per Defra byelaw guidance. Information was provided to stakeholders via the IFCA website, by post upon request and at all of the drop in sessions, which were run at seven locations along the coast including Rye, Hastings, Eastbourne, Newhaven, Shoreham by Sea, Littlehampton and Selsey. A total of 89 stakeholders attended the drop in sessions. The vast majority were from the commercial fishing sector. Two types of objections were received, the first that the proposed measures are too strong, and the second that the proposed measures are too weak.

The key themes that emerged from the consultation period with regard to byelaw content were:

- The proposed prohibition area was either too large or too small.
- Objections to the requirement for a 'vessel information and monitoring system; when fishing within 0.93km (0.5 nautical miles) of the prohibition area.
- Objections to the requirement to have trawls inboard, lashed and stowed when transiting the prohibition area.

As a result of this the IFCA has amended the proposals as follows:

Distance from shore

In considering what action to take, further regard was taken of:

- The evidence used in developing the management proposals, with reference to habitat data.
- The objectives of management e.g. the restoration of kelp habitats in the western part of the District and the associated ecosystem services.
- The future requirement for the Sussex IFCA to introduce fisheries management within Beachy Head East MCZ in accordance with conservation advice.
- The implications of using charted MHWS as opposed to lowest astronomical tide (LAT) as the landward reference for the measurement of distances from the shore.

Following these considerations, the IFCA has amended the byelaw so that from Beachy Head (eastern end of Beachy Head West MCZ) to a position north east of Fairlight, Hastings (Stone Walls 50º53.20 N, 00º 41.00 E), the prohibited area for trawling is reduced from 1km to 0.75km from MHWS, as this addresses concerns raised in the consultation from trawler operators fishing nearshore in the eastern part of the District in the vicinity of Hastings and Pevensey Bay, and does not undermine the intention of the byelaw. It was also recognised that much of this reduced 'eastern nearshore area' lay within the new Beachy Head East MCZ; management for which has yet to be defined. Thus, additional trawling management may still be introduced as part of a pending wider MCZ management process.

As a result of this amendment to the proposed management in respect to distance from the shore, the total area in which trawling is prohibited reduced from 313km^2 to 304km^2, a reduction of 9km^2 (in a 250 metre wide strip) representing 2.96% of the total area originally proposed.

Area that requires a vessel information and monitoring system.

Responses were concerned that the area requiring remote vessel monitoring would unfairly exclude vessels or burden operators. There is also a proposed national inshore vessel monitoring system scheme (iVMS) to consider. This was considered in the light of the environmental risk to the nearshore habitats, the number of operators/vessels which it would impact upon and the pending introduction of national requirements.

Following these considerations, the requirement that a person must not fish with towed gear in any sea area within 0.93km (0.5 nautical miles) of the nearshore prohibition area unless a vessel information and monitoring system is fitted to the vessel has been removed from the byelaw. This will allow the fishery to continue without any significant impact on the benthic habitats in the prohibition area.

Trawl on board, stowed and lashed.

In some areas, fishers tow gear behind the vessel on the surface with the cod end open, to clean/wash nets and to provide more deck space. For enforcement purposes, it is essential that there is clarity on determining when a vessel is in the act of 'fishing' by the location of trawl equipment. The proposed provisions are used as standard definitions in both byelaw, National and EU fisheries regulations. The provisions mitigate against the risk of illegal deployment or recovery of gears in prohibited areas. Nets can still be towed and washed in areas outside of the prohibited area.

Following these considerations, the IFCA has concluded that this requirement should remain in the byelaw to ensure that it is effective and enforceable.

4.12 IFCA Committee input

Consultation responses have been presented to the Technical Subcommittee and Principal Committee as part of the review process, and management options developed and agreed. See Annex 13 for a timetable of the nearshore trawling review and respective committee meetings.

5.0 Options

Management Options are derived from considering the best available evidence, committee discussions and consultation with stakeholders.

5.1 Option 0: Do nothing

A do nothing approach would entail leaving trawling management to current regulation under the existing trawling exclusion, Marine Protected Area and fishing instruments byelaws. As such Sussex IFCA would not fulfil their statutory duties under the Marine and Coastal Access Act 2009 to ensure the exploitation of sea fishery resources is carried out in a sustainable way.

5.2 Option 1: Voluntary agreement

A voluntary scheme to manage the trawling fishery is deemed to be incapable of creating compliance.

We have chosen to pursue a byelaw approach, as opposed to a voluntary approach, because it is the most effective way of ensuring compliance to management decisions. In broad terms, without the identification of any specific vessels, the compliance history of the pair trawling fishery can be considered as very poor. Past illegal activities have included multiple infringements of SFC and IFCA boundaries, including that of a recent MCZ designation. The characteristics of public goods, being available to all but belonging to no-one, mean that individuals do not necessarily have an incentive to voluntarily ensure the continued existence of these goods which can lead to their over exploitation. Market forces are unlikely to drive adherence to any voluntary measures which leaves a regulatory approach as the best option, as detailed within the Impact Assessment. The Authority has existing experience in managing spatial restrictions defined in existing Byelaw such as those protecting existing Marine Conservation Zones.

5.3 Option 2: Proposed management

The proposed nearshore trawling management will protect a range of sensitive and valuable habitats predominantly outside of MPAs and the limited areas of the Sussex IFC District which are currently afforded some seasonal protection from the documented impacts of trawl fisheries. It aims to allow the natural capital of valuable sensitive sites within the nearshore area to reach their full potential, and so deliver ecosystem services.

The following section details the proposed management measures, as derived from considering the best available evidence, committee discussions and the informal and formal consultation responses. After the initial informal consultation the authority agreed a set of themes to consider management options for, as follows;

- Maintain sustainable trawling activity on appropriate grounds.
- Extend the existing nearshore trawling exclusion spatially along the coast and temporally.
- Protect the historic kelp bed sites off Shoreham to Bognor Regis and geological sites.
- Treat different gears appropriately.
- Protection of specific isolated sites, e.g. mSNCIs and Chichester Harbour.

5.3.1 Maintain sustainable trawling activity on appropriate grounds

Outside of the proposed nearshore exclusion area and restrictions within MPAs trawling will be able to continue in 83% of the District, a total of 1442km^2.

5.3.2 Extending the current exclusion

The nearshore trawling exclusion is to extend spatially along the entire coast and will be in place for the entire year. The prohibition area reflects the habitat distribution and needs of the fisheries which utilise essential fish habitats. The trawling prohibition along the nearshore area is at varying distances from the shoreline, whilst allowing other activities (such as static gear fishing, scuba diving and sea angling) to continue.

The current Trawling Exclusion Byelaw will be made redundant by the proposed Nearshore Trawling Byelaw when the byelaw is confirmed by the Secretary of State and so will be revoked.

5.3.3 The area approach to exclusion

The preferred option based on the balance of evidence is presented below and illustrated in Figure 23. Under the proposed option, the area between Chichester and Selsey Bill and the Hounds MCZ, Shoreham to Beachy Head, and Rye Bay will have a prohibition of trawling from MHWS out to 1km. The area between Beachy Head and Fairlight will have a prohibition of trawling from MHWS to 0.75km. The area from Selsey Bill to Shoreham by Sea will have a prohibition from MHWS out to 4km, and the area from Selsey Bill to the western end of Selsey Bill and The Hounds MCZ follows the seaward boundary of the MCZ. The MCZ has a recover to favourable condition management objective for its rock features (see Annex 2 for list of features) due to their potential sensitivity to trawling pressure.

5.3.4 Protection of Chichester Harbour is to be included in prohibition area. Note that the portion of Chichester Harbour that falls within Southern IFCA's District will be included within this byelaw.

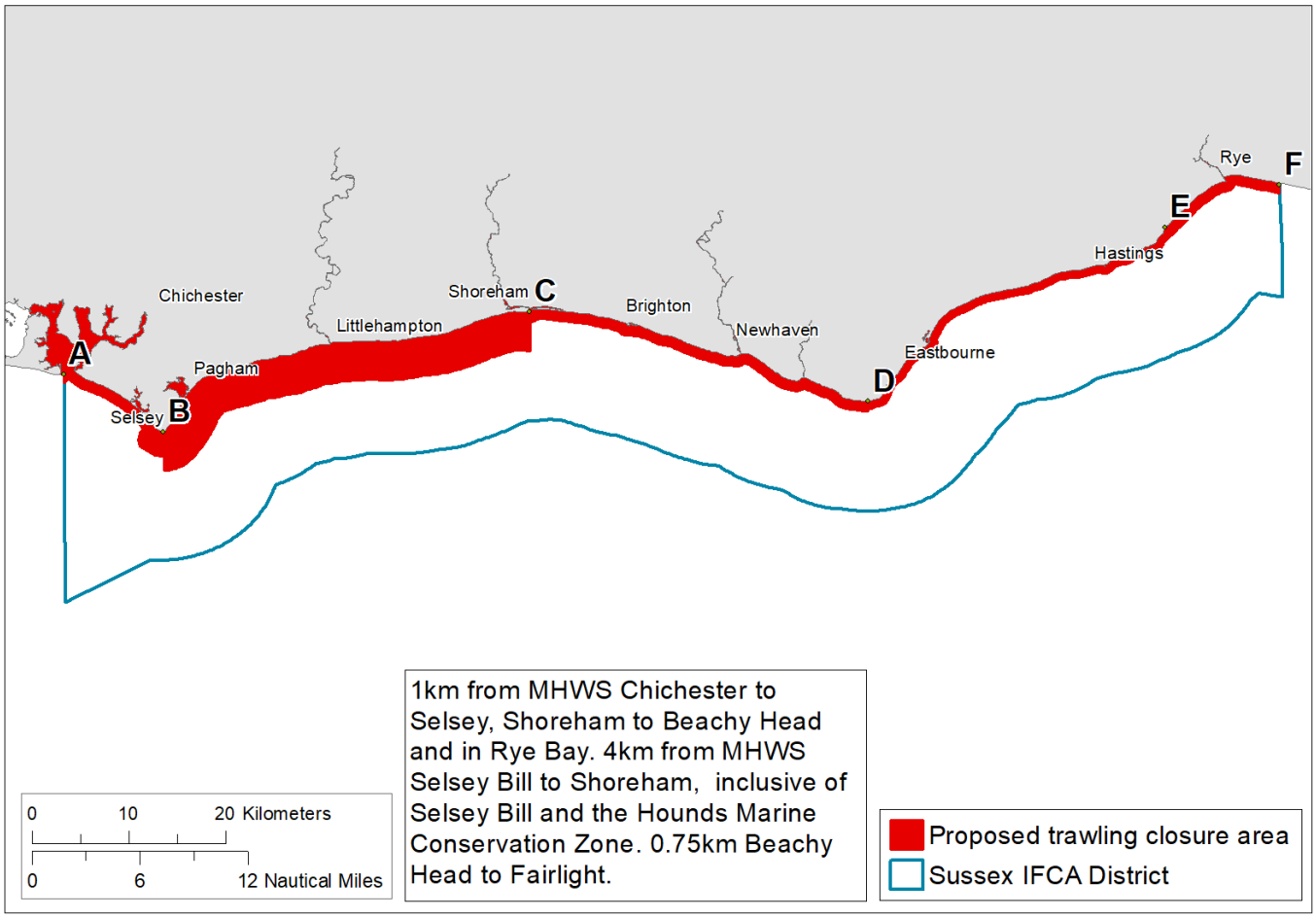

Figure 23. The proposed general prohibition area across the Sussex IFC District.

5.4 Option 3: Complete prohibition on trawling

A complete prohibition on trawling in Sussex District would protect all vulnerable spawning aggregations of marine species, valuable habitats and associated ecosystem service benefits. This option would be less resource intensive for the public sector in terms of implementation and compliance. This option has been rejected as it would have a profound effect on all elements of the inshore trawling fishery businesses. This option also means that inshore vessels would need to fish beyond the six nautical mile limit in order to catch allocated quota. This is not a viable option for much of the fleet.

6.0 Costs and Benefits of Preferred Option

6.1 Natural capital approach: Assessment of trade-offs

Natural capital accounts provide a means of monitoring change in natural capital over time within a framework that is comparable to economic accounts, providing a broader measure of progress. Two types of accounts: physical accounts, consider the extent and quality of natural capital, and quantities of ecosystem services, while economic accounts consider monetary values (Defra et al., 2019). A focus on the monetary valuation of the natural capital approach may be less appropriate for marine areas in the absence of a sufficient number of robust monetary values' (Defra et al., 2019).

The natural capital approach is appropriate for the assessment of trade-offs, as it provides a structured approach to the evaluation of a wide range of benefits and the potential impacts upon them. The natural capital approach adopted with current proposals allows a holistic view of fisheries options to be taken, considering the food provision and economic return of the sector in terms of the costs to other natural capital assets and ecosystem services affected by different fishing strategies.

6.2 Key monetised and non-monetised costs

6.2.1 Fisheries impacts

6.2.1.1 Lost revenue for fishers

Element of the fishery no longer available

It should be noted that the following losses are in the context of long term recovery, sustainability and environmental protection.

The proposed nearshore trawling management would prohibit trawlers from an area of 304km^2 along the District's coastline. This encompasses 17% of the total District area of 1746km^2, when including Chichester Harbour in its entirety. It should be noted that a proportion of this area is not trawlable, given the nearshore shallow bathymetry and natural harbours.

The proposed nearshore exclusion areas overlap with existing trawling restrictions out to 1/4nm in specified areas of the District between May and October under Sussex IFCA's Trawling Exclusion Byelaw. As such, in reality proposals equate to an additional 246km^2 of ground from which trawlers would be excluded, albeit year-round (Figure 1). At present a total of 1603km^2 of ground within the District remains open to trawlers, taking into account exclusions under current MPA management, some of which are seasonal.

Reduced landings and profit

All Trawling vessels

Vessels which utilised the proposed trawling prohibition area between 2014 and 2018 were derived from Sussex IFCA sightings data. A bespoke economic analysis of these vessels was subsequently conducted by Seafish (2019). Inactive and low activity vessels were excluded from the analysis, and vessels were grouped according to Seafish segments, allocated based on the main gear used (by number of days at sea). Vessels can use other gears during the year in addition to the main gear – see Annex 10 for detailed methods and caveats.

The total combined value of landings (£) for each species targeted by these vessels is illustrated in Figure 24. Between 2014 and 2017 sole consistently generated the highest total landings value, with plaice overtaking in 2018. Over the same period, every year plaice comprised the highest total combined weight of landings by all trawling vessels in the group.

In 2018, a total of nine trawling vessels were sighted in the area, decreasing from 12 in 2014. The average value landed by these vessels in 2018 was £134,196 with an average net profit of £32,638. These can be used as maximum landings and profit values which may be affected by the proposed management. The value attributed to potential management should be treated with caution. It is associated with a high degree of uncertainty and is an overestimate as:

- the vessels known to trawl within the proposed management areas may also utilise other gear types. The Seafish economic analyses is based on the main gear used (by number of days at sea) and incudes all landings from these vessels, thus providing overestimates in the value of the fishery which will be impacted;
- the vessels operate in a wider area than the exclusion area. Indeed, we are confident that vessels will utilise the proposed prohibition area at a minimal level (the most effort being applied by pair trawlers). Economic analyses for the area of interest alone cannot be extracted from the data, again resulting in an overestimate of costs;
- vessels utilising the proposed restricted area in the east of the District are already subject to Sussex IFCA's seasonal 1/4nm exclusion zone, thus the proposed management will not represent great change to their ability to access certain grounds.

There has been an overall decrease in average (mean) value landed from trawling vessels sighted in the proposed prohibition area between 2014 and 2018 of £9,381. Average net profit increased over the same period by £18,247, from £14,391 in 2014 to £32,638 in 2018.

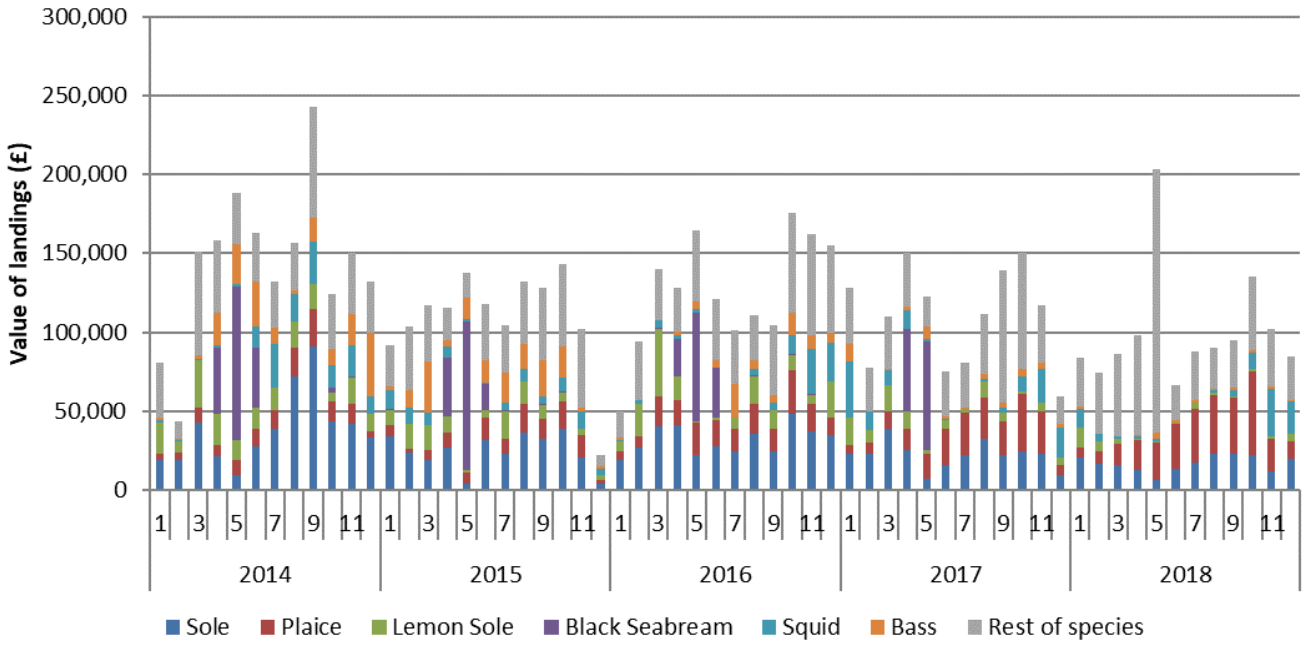

Figure 24. Combined value of landings (£) for each species targeted by trawling vessels which utilise the proposed exclusion area.

Pair Trawling Vessels

Our Sussex IFCA sightings data shows us that the vast majority of the impact of the proposed byelaw prohibition area will impact the pair trawling activity in the area between Selsey and Shoreham by Sea. Our sightings data shows that approximately 50% of pair trawling activity occurs in the prohibition area. This activity is seasonal around the black seabream nesting season, April to June. MMO landing data for the pair trawlers landing into Sussex ports is presented in Table 18 below. Data shows landing values for species as well as total tonnage landed. The period from 2015 is selected because prior to that, bass were not subject to European Union regulation. Values before 2015, therefore, were disproportionately greater and not comparable to post 2014 figures.

From this data it can be estimated that exclusion from the prohibition are will represent an annual cost to the pair trawling fleet of £93,400. Note that the benefits section will reflect on this calculation as it represents fish still available to the Sussex fleet, as well as additional availability of bass bycatch mortality.

Table 15. Values for fish species from MMO landings data for pair trawling in Sussex ports 2015 to 2018. Note the outlier 'other' category for 2018. Total tonnage of catch is also given

Species	2015	2016	2017	2018	Mean
Black Seabream	£142,730	£116,565	£133,480	£149,822	£135,649
Bass	£17,062	£16,005	£10,315	£5,678	£12,265
Grey mullet	£5,189	£15,857	£4,604	£7,270	£8,230
Squid	£2,52	£1,636	£1,333	£10,079	£3,893
Smoothhound	£2,396	£3,886	£3,139	£8,338	£4,440
Other species	£3,048	£12,154	£3,368	£70,811	£22,345
Total	**£172,950**	**£166,106**	**£156,242**	**£251,999**	**£186,824**
Metric Tonnes	75.950	80.280	65.844	133.090	88.79

All data

The pair trawl data is incorporated in the Seafish data above. To avoid double counting it is deemed appropriate to use the pair trawling data only. It is not possible to extract from the Seafish data how much effort is expended in the proposed prohibition area as compared to the entire District. As stated

above it is the pair trawl activity that will be impacted the most, with the other trawl methods having minimal effort within the proposed prohibition area (see Figure 15).

6.2.1.2 Displacement

The proposed management could cause limited displacement of trawlers to new grounds with subsequent increased conflicts with fishers who traditionally use the grounds, as well as associated environmental harm in these areas. There could also be increased costs for trawlermen who use the proposed exclusion areas due to increased travel time and fishing duration through being forced to look for other fishing grounds further offshore. There would be potential associated declines in fishing income and possible increased carbon dioxide emissions with increased journey distances.

A maximum of nine vessels for which trawls are the main gear used (assessed by number of days at sea by Seafish) have been sighted in the proposed exclusion area and may be displaced. It is important to note that most vessels in the Sussex IFC District engage in several different fishing methods throughout the year, sometimes concurrently and sometimes moving into different Districts, so this may not be the only method on which these vessels rely.

6.2.1.3 Gear changes

As outlined above, most vessels in Sussex already engage in several different fishing methods throughout the year. In a report by Mangi et al., (2012) results of their socio-economic assessment of Lyme Bay 4 years after closure showed that 84% of fishermen surveyed were still using the same gear types as they did before the closure.

6.2.1.4 Familiarisation costs to fishers

Fishers may need to take some time to become accustomed to the new regulations and to consider alternative fishing practices. This IA assumes that each fisherman takes two hours in the first year of operation to familiarise themselves with the new regulations and to take any adaptive actions.

The mean average hourly wage for marine fishers (agriculture, forestry and fishing) in 2018 was £9.97 per hour (Office of national Statistics figures Employee earnings in the UK: 2018). This IA uses a 30% allowance for non-wage costs to calculate an hourly cost to businesses of £12.96. In 2018 there were nine fishers using trawls in the proposed exclusion area, meaning that the estimated one-off familiarisation cost is £233.28 in total.

There are no additional expected costs for fishers to implement the measure, beyond the revenue they no longer receive due to not being able to access the fishery, which are covered in section 6.2.1.1.

6.2.1.5 Increased static gear activity

With the potential exclusion of trawling from the nearshore area there is an associated potential for an increase in static gear activity. Controls to manage this include the management currently being formulated for netters within the District as part of the Authority's historic byelaw review, and the management already in place to manage effort within the potting fisheries under Sussex IFCA's Shellfish Permit Scheme.

6.2.2 Cost of Implementation to Government

Sussex IFCA will regulate and monitor exclusion area through the use of:

- Education/communication strategies – provide advice and information on management. This can be done via information packages, public events, community groups, festivals, signage that can be delivered through specific meetings or whilst conducting routine land or sea patrols. This cost will be incorporated into current budgets. It is estimated that materials will cost £2000 and will take 20 days work, equating to £4000, this is an additional cost that the IFCA will incorporate into its current budget.
- Land based patrols – Land patrols conducting inspections on landings, premises, vehicles and persons will be required. Intelligence gathering, sightings and analysis will be required. Sussex IFCA conducts between 65 and 100 patrols per year at a cost of £500 per patrol. This is an additional cost that will be incorporated into the IFCAs current budget. This cost will be incorporated into current budgets.

- Sea based patrols – Sea patrols conducting boarding inspections, intelligence gathering, vessel sightings and key communication messages delivery to the fishing community will be required. Sussex IFCA conducts between 70 and 80 sea patrols per annum at a cost of £2000 per patrol. This is an additional cost that will be incorporated into the IFCAs current budget. This cost will be incorporated into current budgets. It is estimated that five additional patrols will focus on the prohibition zone at a cost of £10,000.

- Joint agency working – working with joint agency partners in order to conduct land or sea mobile patrols utilising effective use of resources to achieve common objectives and deliver key communication messages under the National Intelligence Model. This is an additional cost that will be incorporated into the IFCAs current budget. This cost will be incorporated into current budgets.

- Additional work will be required to remote monitor vessels during, for example the black seabream season, estimated at five days of work per year at £200 per day, totalling an annual cost to the Authority of £1000.

- Monitoring/research – conducting regular research and gathering data to support the enforcement efforts within the site. This cost will use existing budget and project bids with third party organisations. An initial estimates of additional monitoring costs is £10,000 per annum.

Through regular compliance patrols (land and sea) and remote monitoring systems (current VMS and iVMS when available) the Authority will monitor fishing activity and develop a thorough understanding of permissible activities following the introduction of management.

Compliance with the proposed management will be met within the current budget and wherever feasible will be incorporated into existing business and patrol commitments. Whenever possible Sussex IFCA will work with joint agency partners to conduct land or sea patrols making effective use of resources to achieve common objectives and further reduce estimated costs. In Lyme Bay MPA, enforcement agencies reported an initial increase in enforcement costs, then a drop in costs back to levels prior to the closure (Attrill et al, 2012).

Table 19 details the estimated administrative costs breakdown. It should be noted that these are top end, standalone costs. Efficiencies will be made as above.

Table 16. Administrative and enforcement costs estimate

	Costs (£k/year)		
	Low	High	Best
Compliance – sea patrols	0	150	10
Compliance– land patrols	0	0	0
Vessel tracking monitoring	0	1	1
Monitoring/research	0	10	10
Communication	0	0	0
Totals	0	161	21

*Costs are based on the following daily rates: Sea patrol including crew at £2000; Individual enforcement officers at £200; Road patrol at £500.

Table 17. Summary of costs

Cost	One off cost	Average annual recurring cost	Total cost
Cost to business			
Familiarisation Costs	£200	£0	£200
Lost revenue from fishery	£0	£94,000	£94,000
Total cost to business	£200	£94,000	£94,200
Cost to government			
Implementation Costs	£6,000	£0	£6,000
Total Costs to Government	£0	£21,000	£21,000
Total Costs	£6,000	£21,000	£27,000

It is important to note that low community support and resulting poor compliance will incur greater costs, thus Sussex IFCA has strived through pre-consultation and work with the community to develop proposed measures to generate good support for management.

6.2.3 Fisheries relative costs and benefits assessment

In the study by Nelson (2017), the impacts and benefits of the 37 main Sussex fisheries identified were assessed under nine criteria, three economic, three environmental and three social criteria, and scored from 1 (most desirable) to 5 (least desirable) - see Table 21 and section 4.9.1. The scores for each criterion were averaged to calculate the overall score for each fishery (Table 22). This method has been used successfully in several studies (NEF, 2011; Williams and Carpenter, 2015; MRAG, 2014; Williams and Carpenter, 2016). The score for each fishery was averaged to calculate the score for each of five main fishing methods; angling, dredging, netting, potting and trawling (Figure 25).

Table 18. The nine economic, environmental and social criteria used to assess each of the Sussex fisheries' impacts and benefits. (Full time equivalent (FTE) is the hours worked by one employee on a full-time basis)

Theme	Criterion	Units	Data source	Data scope
Economic	Value per tonne	£ per tonne	MMO landings data	Annual average 2012-2016, Sussex ports, per fishery
Economic	Final economic output	£ per tonne	MMO landings data and Seafish multiplier	Annual average 2012-2016, Sussex ports, per fishery, multiplier per sector
Economic	Gross profit	Thousand euros	European Commission	2014, UK, per fleet, <12m vessels
Environmental	Fuel use	Litres per tonne	European Commission	2014, UK, per fleet, <12m vessels
Environmental	Ecosystem damage	Descriptive	Seafish RASS	UK stock areas, per fishery
Environmental	Bycatch	Descriptive	Seafish RASS	UK stock areas, per fishery
Social	Port dependency	% of total landings	MMO landings data	Annual average 2012-2016, Sussex ports, per fishery
Social	Employment	Number of FTE	European Commission	2014, UK, per fleet, <12m vessels
Social	Wage	Average wage (thousand €) per FTE	European Commission	2014, UK, per fleet, <12m vessels

Table 19. The impacts and benefits for 37 Sussex fisheries. Scored from 0.1 pale blue most desirable to 5.0 dark blue least desirable. Assessment made using data from STECF (2016). Seafish RASS (no date), Seafish (2007) and MMO landings data.

Method	Species	Value (per tonne) rank	Final economic output rank	Gross profit rank	Fuel use rank	Ecosystem damage rank	Bycatch rank	Port dependency rank	Employment rank	Wage rank	Average
Angling	Bass	0.27	0.27	5	5	1	1	1.49	1	5	2.23
Dredging	Scallops	2.57	2.16	4	3	4	4	0.14	5	1	2.87
Netting	Bass	0.54	0.54	3	1	1	3	0.68	4	3	1.86
Netting	Brill	1.35	1.35	3	1	1	3	3.78	4	3	2.39
Netting	Cod	2.30	2.70	3	1	2	3	1.89	4	3	2.54
Netting	Cuttlefish	1.89	1.76	3	1	1	3	2.43	4	3	2.34
Netting	Lesser Spotted Dogfish	4.73	4.73	3	1	1	3	4.05	4	3	3.17
Netting	Mackerel	2.70	2.84	3	1	1	3	4.32	4	3	2.76
Netting	Plaice	3.51	3.51	3	1	1	3	1.35	4	3	2.60
Netting	Smoothhound	4.05	4.05	3	1	1	3	3.24	4	3	2.93
Netting	Sole	0.95	0.95	3	1	2	3	0.41	4	3	2.03
Netting	Thornback Ray	2.97	3.11	3	1	1	3	2.84	4	3	2.66
Netting	Turbot	0.41	0.41	3	1	2	3	3.11	4	3	2.21
Potting	Cuttlefish	2.43	2.03	1	2	2	2	1.22	3	4	2.19
Potting	Edible crab	3.11	2.97	1	2	2	2	0.81	3	4	2.32
Potting	Lobsters	0.14	0.14	1	2	2	2	1.08	3	4	1.71
Potting	Whelks	3.78	3.65	1	2	2	2	0.27	3	4	2.41
Trawling	Bass	0.81	0.81	2	4	4	4	1.76	2	2	2.38
Trawling	Black Seabream	2.03	2.30	2	4	4	3	1.62	2	2	2.55
Trawling	Blond ray	3.24	3.24	2	4	3	4	4.86	2	2	3.15
Trawling	Brill	1.49	1.49	2	4	4	5	3.78	2	2	2.86
Trawling	Cod	2.16	2.57	2	4	4	4	3.38	2	2	2.90
Trawling	Cuttlefish	2.84	2.43	2	4	4	4	2.30	2	2	2.84
Trawling	Dabs	4.46	4.46	2	4	4	4	4.86	2	2	3.53
Trawling	Flounder	4.59	4.59	2	4	4	5	4.73	2	2	3.66
Trawling	Gurnards	3.92	3.92	2	4	4	4	2.57	2	2	3.16
Trawling	Lemon Sole	1.62	1.62	2	4	4	3	2.03	2	2	2.47
Trawling	Lesser Spotted Dogfish	4.86	4.86	2	4	4	4	2.16	2	2	3.32
Trawling	Monks/anglers	1.76	1.89	2	4	4	4	4.32	2	2	2.89

Method	Species	Value (per tonne) rank	Final economic output rank	Gross profit rank	Fuel use rank	Ecosystem damage rank	Bycatch rank	Port dependency rank	Employment rank	Wage rank	Average
Trawling	Plaice	3.65	3.78	2	4	4	5	0.95	2	2	3.04
Trawling	Pouting Bib	5.00	5.00	2	4	4	4	4.59	2	2	3.62
Trawling	Smoothhound	4.32	4.32	2	4	3	4	3.65	2	2	3.26
Trawling	Sole	1.08	1.22	2	4	4	5	0.54	2	2	2.43
Trawling	Squid	1.22	1.08	2	4	3	3	3.51	2	2	2.42
Trawling	Thornback Ray	3.38	3.38	2	4	4	5	2.70	2	2	3.16
Trawling	Turbot	0.68	0.68	2	4	4	5	2.97	2	2	2.59
Trawling	Whiting	4.19	4.19	2	4	4	3	4.19	2	2	3.29

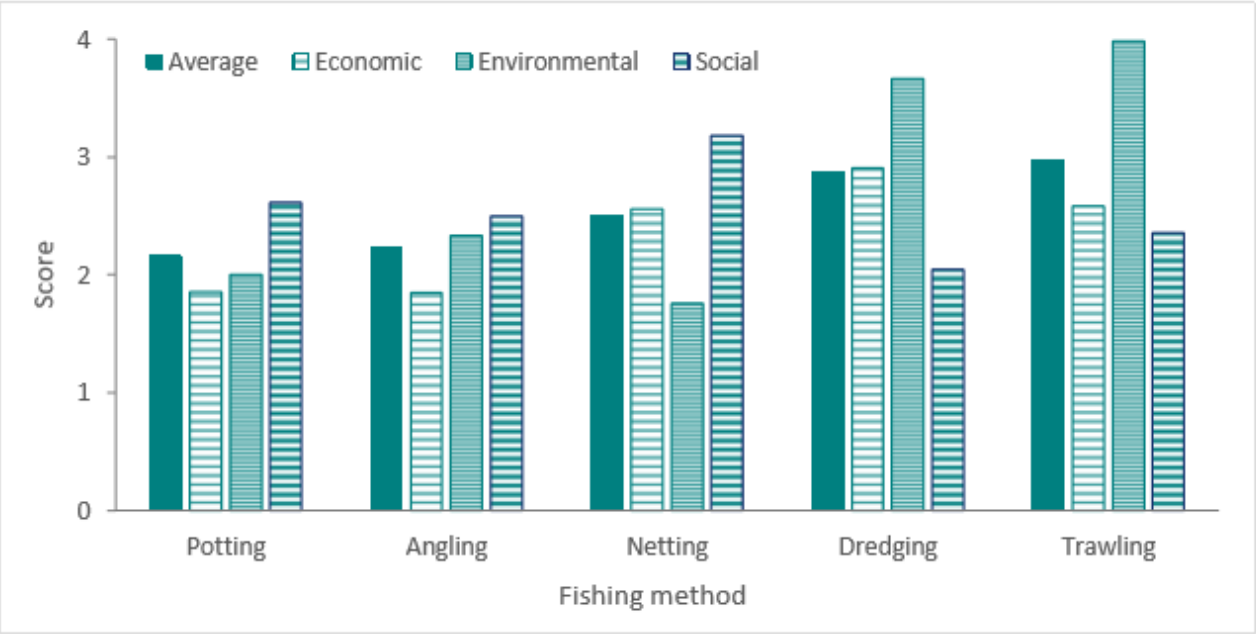

Figure 25. The average scores for the economic, environmental and social criteria, as well as the overall average score for each fishing method 0 – 5 most desirable to least desirable (least impacts and most benefits to most impacts and least benefits). Assessment made using data from STECF (2016), Seafish RASS (no date), Seafish (2007) and MMO landings data.

Key findings from this assessment pertinent to the environmental cost of trawling include:

- Trawling was shown to have the highest average score for the economic, environmental and social criteria out of all Sussex fisheries, meaning it was identified as the least desirable fishing method, having the most impacts and least benefits. In contrast, potting was the method with the most desirable average score.

- For environmental criteria (fuel use, ecosystem damage rank and bycatch rank) trawling again had the least desirable score i.e. the highest impacts. In contrast, netting had the most desirable score.

- For economic criteria (value per tonne rank, final economic output rank and gross profit rank) potting and angling had the most desirable scores (least impact and most benefit).

6.3 Benefits

6.3.1 Overview

Studies that attempt to compare the total value of global ecosystems demonstrate the high relative value of marine, coastal and transitional environments (de Groot e al., 2012). The range of habitats across the nearshore area support a valuable flow of ecosystem services that underpin human wellbeing. Many of the uses of the marine environment are dependent on healthy natural capital. The removal of the abrasive pressure of trawling on sensitive and valuable nearshore habitats, as well as the reduction in bycatch of juveniles and non-target species, will benefit the range of ecosystem services these natural capital assets provide.

6.3.2 Food provision and sustainable fisheries

Management proposals will help to ensure that we have healthy fish stocks that are exploited sustainably, and support long-term viability of the local fishing sector (HM Government, 2018). Fishing in a sustainable way within these sensitive nearshore areas will also help protect the coastal ecosystems that support the fish species we rely on. Protecting and enhancing essential fish habitats in the nearshore marine environment, including functional habitats for breeding fish and nursery grounds for their juveniles, providing food and shelter, will support food provision.

The economic benefits associated with protecting essential fish habitats would be felt across local commercial and recreational fisheries. Specific benefits will include predicted increased breeding success of exploited fish species. Benefits to more sustainable lower-impact fishing operations such as set-net fishing, line fishing, angling and pot and trap fishing are envisaged.

Protection of the nearshore marine environment is vital for local, smaller-scale fishers who are tied to their local environment, being unable to exploit areas further offshore if the nearshore environment becomes degraded and juvenile stocks are impacted. Proposals aim to support numerous lower impact fishers and associated businesses through the prohibition of a smaller number of higher impact fishers. Trawling can move further offshore where the habitat vulnerability is generally lower.

The socio-economic changes resulting from the Lyme Bay closed area inside which scallop dredging and bottom trawling were banned in July 2008 were assessed by Mangi et al (2012). This found static gear fishermen who fished inside the closed area were able to increase the number of crab and whelk pots they could deploy. They have experienced improved fishing conditions, are reporting gear safety and less conflict, and increased fishing income as a result.

Sussex static gear fisheries benefits

As well as costs for trawl fisheries there are likely to be improved long-term economic prospects for static gear fisheries using the proposed exclusion area. The netting and potting vessels which utilise the proposed overall closure area were identified from Sussex IFCA sightings data 2014-2018 and a bespoke economic analysis of these vessels was also conducted by Seafish. As outlined for the trawling assessment, inactive and low activity vessels excluded from the analysis and vessels were grouped according to Seafish segments, allocated based on the main gear used (by number of days at sea).

A far higher number of static gear operators than trawlers were found to utilise the proposed trawling exclusion area, with 82 netting and potting vessels operating in 2018 compared to nine trawlers. Combined average net profit from netting and potting vessels utilising the proposed exclusion area was 1.7 times greater than that made by the trawling fleet using the area in 2018, at £55,919 compared to £32,638. The combined average value of netting and potting landings from vessels using the proposed exclusion area was £189,405 in 2018, compared to £134,196 for trawling, 1.4 times more.

Any costs associated with a reduction in pair trawling catch (as calculated above) can be assumed to be a benefit to the rest of the fishing fleet, i.e. the fish are still available for the netting fleet (subject to quota

allocations for quota species). Thus we can assume that the £93.4k cost to the pair trawlers will translate to approximately £93.4k benefit to the rest of the fleet and predominantly the netting fleet.

This data supports the current proposal of managing a few higher environmental impact fishers with benefits for many lower impact fishers. With these lower impact fishers also providing greater economic benefits for society, employing more people, having higher landings value and producing higher profits.

Anecdotal evidence form fishers encapsulated in the Centuries of Sussex Sea Report (Sussex IFCA, 2019) indicates that when the kelp beds were present, for example, a fisher could set eight to ten trammel net fleets for two and a half hours and catch over 16 stones (100kg) of fish, but after the loss of the kelp 11 trammel net fleets set for 48 hours would return two and a half stones (16kg) of fish. This is a sixty-fold difference in catch per unit effort. Although far from scientific, this evidence is indicative of the potential gains of habitat restoration.

Bass

Bass are a valuable fish stock. Sussex IFCA evidence from 2019 inspections at sea indicate that the pair trawlers catch a significant bycatch of bass that is subsequently discarded with an associated mortality. Table 23 below shows back projected calculations for bass bycatch 2015 to 2018 based on 'a' average bass catch weight from 2019 to 2014 and 'b' the more contemporary figures obtained from 2019 pair trawl inspections at sea (see Figure 20).

Table 20. Assessment of estimated bass discards from the pair trawl fishery. Where 'a' are values estimated from 2009 to 2014 landings and 'b' is estimated from 2019 inspections at sea.

Table a, Figures based on bass representing 8.94% of catch prior to 2015 when no restrictions of % in trawls applied					
	2015	**2016**	**2017**	**2018**	**mean**
All Species Landed Metric Tonnes (MT)	75.950	80.280	65.844	133.090	88.79
Estimate Bass >36cm MT	6.790	7.177	5.886	11.898	7.93
Value per MT	£7,510	£9,563	£9,267	£10,493	£9,208
Total Value Bass	£50,996	£68,634	£54,553	£124,857	£74,760
Value of Bass retained	£17,062	£16,005	£10,315	£5,678	£12,265
Value of Bass Discarded	£33,934	£52,628	£44,237	£119,178	**£62,494**

Table b, Figures based on bass discard samples taken during at sea inspections in 2019 (when restrictions of 1% bass in trawls applied) mean value of bycatch was at 42.1%, where F is fishing mortality					
	2015	**2016**	**2017**	**2018**	**mean**
All Species Landed MT	75.950	80.280	65.844	133.090	88.79
Estimate Bass MT all sizes	31.975	33.798	27.720	56.031	37.38
Value per MT (assuming (F) is 0 for bass below 42 cm)	£7,510	£9,563	£9,267	£10,493	£9,208
Total Value Bass (all sizes)	£240,153	£323,209	£256,903	£587,973	£352,060
Value of Bass retained	£17,062.72	£16,005.69	£10,315.90	£5,678	£12,266
Value of Bass Discarded	£223,090	£307,204	£246,587	£582,295	**£339,794**

As such we can see that there is a potential mortality (using a 10% survival rate for returned fish) of discarded Bass valued at £305,000 per annum from pair trawl bycatch. This fish represents a potential lost benefit to the wider fishery. From the costs section above we know that 50% of the pair trawl fishery would be affected by the proposed prohibition area, thus 50% of the £305,000 figure would be available for the wider fishery, which is £152,500 per annum.

Note that discarded undersize fish that survive would be available to the fishery after it had obtained breeding size (MCRS).

Important habitats

As outlined in section 4.4.3, a range of habitats were found to support food provision (fisheries) in Sussex. These include biogenic and rocky reefs and kelp communities which provide shelter for juvenile stages of commercially targeted fishes, crustaceans and bivalve molluscs, as well as sediment habitats which provide food resources for fish. Different life stages of commercial species are reliant on different habitats it is therefore important to protect examples of the range of habitats which support these species.

Importance of kelp

The presence of macroalgae is considered an ecosystem component critical to ecosystem services delivery, its removal or alteration would result in a decline or cessation in ecosystem service provision (Alexander et al., 2016). Such critical components should be given special attention when considering management. Macroalgae and other critical components are likely to be negatively affected by degradation in the overall state of the environment, ultimately affecting the capacity of the ecosystem to generate such services. Current nearshore trawling prohibition proposals aim to help protect and restore such critical components for ecosystem services delivery. Noting the extent and condition of the historic kelp forest and taking evidence from peer reviewed articles which document the benefits that kelp can provide, it is considered that the restoration of the Sussex kelp would be beneficial for commercial fisheries specifically, and for the marine environment more broadly.

Specific ecosystem services provided by kelp are highlighted in the relevant sections. In relation to sustainable fisheries, kelp contributes to the supply of juvenile nursery ground, providing shelter for juvenile stages of commercially targeted fishes, crustaceans and bivalve molluscs. Kelp holdfasts and their associated communities provide food resources for flatfish, sea bass and gadoid species. In a review of existing literature on the potential effects of kelp species on local fisheries, Bertocci et al (2015) found:

- Positive association between the abundance of lobsters and other decapod crustaceans and kelp beds – which is of particular importance due to the large market value and existing local fisheries of these animals;
- A positive relationship between the amount and structural complexity of kelp species and the amount of their associated commercially valuable species due to the role of kelp as a foundation species able to provide space, food and protection to a number of organisms;
- Generally positive association of juvenile stages of fish species to kelp beds, although abundance of adult fish and its relationship with kelp density was very dependent on fish species.

The reported positive relationship between the presence and density of kelp forests and fisheries has important management implications. It supports the current ecosystem-based approach to kelp-fisheries systems. There is evidence that the restoration of kelp forests has the potential to drastically increase the production of local fisheries, representing a valuable tool for ecosystem-based management (Claisee et al., 2013 in Bertocci et al., 2015). The socio-economic implications of kelp bed protection area clear and huge as kelp forests provide an essential habitat for adults (e.g. European lobster) and juveniles (e.g. Atlantic cod) of extremely valuable animals.

6.3.3 Increased Biodiversity

The proposed nearshore trawling management aims to allow the natural capital of valuable sensitive sites to reach its full potential, including chalk reef habitats and seaweed communities, and so deliver ecosystem services. A diverse range of habitats in the nearshore area will be protected under current

proposals, with associated increases in biodiversity predicted. Biodiversity is an important factor in the functioning and resilience of ecosystems.

There is often more diversity when the habitat is more heterogeneous and structurally complex, such as the mosaics of habitats identified within the District. As outlined in the MSFD, high levels of biodiversity can be said to be a reflection of good environmental quality. Conversely, a decline in environmental quality is likely to result in a loss of biodiversity and the ecosystem services associated with this component.

Through direct provision of food and structural habitat, kelp forests support higher levels of biodiversity and biomass than simple, unstructured habitats. Reef features provides surfaces for epibiota such as corals and sponges to attach. Biodiversity associated with these areas supports fishing activities and recreational diving / nature watching.

6.3.4 Healthy climate

Marine ecosystems are important for climate regulation, sequestering and storing more than half (55%) of the world's carbon. The Government's Office for Science, Foresight Future of the Sea report 2018, estimates that climate regulation / carbon dioxide sequestration in the coastal shelf provides £7 billion to the UK Gross Value Added (GVA) per year.

Both seagrass beds and kelp beds sequester carbon and are important carbon sinks. These habitats are critically important to protect due to the fact that both of these habitats are known to be currently decreasing within the District and because of their important contribution to the ecosystem service of climate regulation in terms of mitigating climate change.

For seagrass carbon sequestration figures see https://www.weforum.org/agenda/2018/11/we-desperately-need-to-store-more-carbon-seagrass-could-be-the-answer

Carbon sequestration values for kelp are outlined in the NDMP project report by Rees et al (2019) (Table 24).

Table 21. Carbon sequestration values tonnes/carbon/square kilometre/year (t/C/km^2/yr) presented in literature reviewed for each habitat asset presented in NDMP. Confidence in the assessment based on review by Howard et al. 2017 and corresponding carbon value pounds/tonne (£/t) (Rees et al., 2019).

Habitat		Area	Carbon sequestered t/C/km^2/yr	Confidence (1=poor, 2=moderate, 3=high)	Reference	Benefit (Flow) (adjustred for presence of required L4 habitat) carbon sequestered (t)	Carbon value (£/t CO_2e) value given to the cost of mitigating emissions (central)	Carbon value (£/t CO_2e) value given to measure the long term damage by a tonne of carbon
Saltmarsh	A2.5: Saltmarsh	2.80	206.68	2 (likely underestimate (Howard et al. 2017))	(Scott et al. 2013; Chumara et al. 2003) (Mcleod et al. 2011; Duarte et al. 2013; Howard et al. 2017)	549.77	2270.55	12672.17
Intertidal rock	A1: Littoral rock and other hard substrata **(with seaweed and plant communities)**	11.31	393.68	1	(Trevathan-Tackett et al. 2015; Gevaert et al. 2008; Alonso et al. 2012)	445.15	1838.49	10260.80
Intertidal sediments	A2.2: Littoral sand and muddy sand	14.99				0.00	0.00	0.00
	A2.3: Littoral mud	9.98	16.00	1	(Andrews et al. 2006; Alonso et al. 2012)	159.68	659.47	3680.60
Biogenic reef	A2.7: Littoral biogenic reefs	0.01				0.00	0.00	0.00
Subtidal reef	A3: Infralittoral rock and other hard substrata **(with seaweed and particularly kelp communities)**	17.27	393.68	1 Must Contain Kelp communties (A3.11, A3.12) (Sequestration less likely as no root system in soft substratum (Howard et al. 2017))	(Gevaert et al. 2008; Alonso et al. 2012)	680.05	2808.59	15675.06
	A4: Circalittoral rock and other hard substrata	875.90	unknown / 0			0.00	0.00	0.00
Subtidal sediment to 50m	A5.1: Sublittoral coarse sediment	2,845.22	9.84	1	(Painting et al. 2010; Alonso et al. 2012)	26597.08	109845.92	613062.59
	A5.2: Sublittoral sand	1,690.03	9.84	1	(Painting et al. 2010; Alonso et al. 2012)	15798.43	65247.50	364153.72
	A5.3: Sublittoral mud	10.85	9.84	1	(Painting et al. 2010; Alonso et al. 2012)	101.45	419.00	2338.48
	A5.4: Sublittoral mixed sediments	48.56	9.84	1	(Painting et al. 2010; Alonso et al. 2012)	453.97	1874.92	10464.12
Subtidal sediment >50m to <200m	A5.1: Sublittoral coarse sediment	2,845.22	0.00	1	Thomas et al. 2005	0.00	0.00	0.01
	A5.2: Sublittoral sand	1,690.03	0.00	1	Thomas et al. 2005	0.00	0.00	0.01
	A5.3: Sublittoral mud	10.85	0.00	1	Thomas et al. 2005	0.00	0.00	0.00
	A5.4: Sublittoral mixed sediments	48.56	0.00	1	Thomas et al. 2005	0.00	0.00	0.00
Phytoplankton	Water column	5526.93	0.004	1	(Falkowski 2012; Howard et al. 2017)	19.90	82.17	458.62
TOTAL						44805.47	185046.61	1032766.19

Based on carbon sequestration values suggested in the above report and a suggested historic kelp bed extent of 177 km^2 in the District, a potential 70,000 tonnes of carbon could be sequestered if the local kelp forest is restored to historic extents.

The value of the ecosystem service benefits of kelp bed recovery off West Sussex

As part of the evidence collection for this byelaw Sussex IFCA commissioned the New Economics Foundation (NEF) to evaluate the ecosystem service benefits of kelp bed recovery off West Sussex (Williams and Davies 2019). A model was developed that incorporates the economic valuation for seven ecosystem services (fishery resources, harvesting e.g. materials (alginates) for pharmaceutical and industrial use, water quality maintenance, protection of coastlines from storm surge waves/reduction in shoreline erosion, carbon sequestration, nursery habitats for commercial fish species and tourism and recreation (e.g. diving), which were chosen as they represent the key ecosystem functions of kelp bed habitat and reflect where it was possible to obtain secondary data to estimate unit area valuations for these services.

Three scenarios for kelp bed restoration were developed using the model: the current scenario (6.28km^2), the past extent as recorded in the 1987 Worthing Council report (177km^2) and a hypothetical maximum (167km^2). For the hypothetical maximum scenario, estimates were determined by bathymetry and substrate that were possible for the growth of kelp. This is slightly less than the 1987 past extent, which points to potential inaccuracies of past data.

Table 25 presents the ecosystem services valuation for the current kelp habit off the West Sussex coastline, estimated at £79,170 per annum. Table 26 presents the ecosystem services valuation of the hypothetical maximum kelp habitat off the West Sussex coastline, estimated at £3,243,886 per annum.

Table 22. Ecosystem services valuation per annum for the current kelp bed off the West Sussex coastline

	Value per km2 (£)	Area by kelp bed density (%)				Value of areas of kelp bed density (£)				Total value (£)
		Low	Medium	High	Very High	Low	Medium	High	Very High	
Fishery resources	£2,066	90%	10%	0%	0%	£2,920	£649	£-	£-	£3,569
Harvesting e.g. materials (alginates) for pharmaceutical and industrial use	£10,288	90%	10%	0%	0%	£-	£-	£-	£-	£-
Water quality maintenance	£5,703	90%	10%	0%	0%	£8,059	£1,791	£-	£-	£9,849
Protection of coastlines from storm surges waves/ reduction in shoreline erosion	£17,870	90%	10%	0%	0%	£25,250	£5,611	£-	£-	£30,861
Carbon sequestration	£9,046	90%	10%	0%	0%	£12,782	£2,840	£-	£-	£15,623
Nursery habitats for commercial fish species	£7,099	90%	10%	0%	0%	£10,031	£2,229	£-	£-	£12,260
Tourism and recreation	£4,058	90%	10%	0%	0%	£5,734	£1,274	£-	£-	£7,008
									Total ecosystem services value per annum	£79,170

Table 23. Ecosystem services valuation per annum for kelp habitat for hypothetical maximum scenario

	Value per km2 (£)	Area by kelp bed density (%)				Value of areas of kelp bed density (£)				Total value (£)
		Low	Med.	High	Very High	Low	Medium	High	Very High	
Fishery resources	£2,066	50%	40%	5%	5%	£43,137	£69,019	£12,941	£17,255	£142,351
Harvesting e.g. materials (alginates) for pharmaceutical and industrial use	£10,288	50%	40%	5%	5%	£-	£-	£-	£85,904	£85,904
Water quality maintenance	£5,703	50%	40%	5%	5%	119,053	£190,486	£35,716	£47,621	£392,877
Protection of coastlines from storm surges waves/ reduction in shoreline erosion	£17,870	50%	40%	5%	5%	£373,034	£596,855	£111,910	£149,214	£1,231,013
Carbon sequestration	£9,046	50%	40%	5%	5%	£188,839	£302,142	£56,652	£75,536	£623,168
Nursery habitats for commercial fish species	£7,099	50%	40%	5%	5%	£148,188	£237,100	£44,456	£59,275	£489,019
Tourism and recreation	£4,058	50%	40%	5%	5%	£84,714	£135,542	£25,414	£33,885	£279,555
									Total ecosystem services value per annum	£3,243,886

This evidence was made available as part of the formal consultation.

6.3.5 Natural Hazard regulation

Marine habitats play a valuable role in the defence of the coastal area, including the dampening of wave energy from storms and tidal surges by physical structures such as reefs, floodwater storage and attenuation wave of water currents and wave energy by habitats such as saltmarsh and kelp forests, and dissipation of wave energy by sediment habitats (Rees et al., 2019). By altering water flow, physical disturbance and sedimentation rates, algae communities such as kelp *Laminaria digitata* communities modify the local environment for other organisms and provide natural hazard protection ecosystem service benefits.

Restoring extents of intertidal habitat in unfavourable condition such as saltmarsh and maintaining habitat extents of this, intertidal sand and coarse sediments will ensure that ecosystem service provision is maximised (Rees et al., 2019). Proposed work on restoring our nearshore kelp beds will also help improve the ecosystem service of natural hazard regulation.

The Government's Office for Science Foresight Future of the Sea report, estimates coastal protection (provided by intertidal habitats of sand dunes and saltmarsh) to be in the range of £3.1 to £33.2 billion to UK GVA.

6.3.6 Tourism and recreation

Improved recreational experience

It is anticipated that there will be benefits to other users associated with the proposed nearshore trawling restrictions and associated habitat recovery, such as the restoration of kelp beds. These include local residents and visitors, whether this is for angling, scuba diving, boat charter or other activities resulting in visits to the area. The proposed trawling closure would benefit most of these activities since they depend in part on healthy ecosystems. There is also the likelihood that habitats in the nearshore area and the ecosystem services they provide would recover over time which could increase the benefits from such activities. An improved recreational experience due to habitat quality and potential restoration of key habitats such as kelp forest is anticipated. The Sussex coast is a popular location for recreational scuba diving and offers sites for wreck, reef and drift diving with multiple launch points and harbours accessible within the Sussex District.

In their assessment of socio-economic changes after four years resulting from the Lyme Bay closed area inside which scallop dredging and bottom trawling were banned in July 2008, Mangi et al (2012) found divers were being attracted to Lyme Bay to dive within the closed area and local divers reported an improvement to the diving experience within it. Anglers were also actively choosing to spend time in Lyme Bay and within the closed area. Charter boat operators who are closer to the closed area were beginning to take more anglers to fishing sites within it and are reporting an improvement in the angling experience. Improvements in recreational experiences were reported, with better fishing, visibility and a greater variety of things to see.

Fisheries economic and societal benefits versus recreational sectors

In the Natural Capital Committee's report on Marine and the 25 year plan (2019), it highlights that fisheries have a comparatively small economic, social, health and wellbeing impact on UK people compared to leisure, recreation and tourism. The Government's Office for Science Foresight Future of the Sea report provides values of benefits from ecosystem services in the UK, indicating aquaculture, fisheries and processing provides £1.1 billion GVA, compared to £4.5 billion GVA from marine tourism and recreation. The UK National Ecosystem Assessment (NEA) suggested that coastal margin habitats provided 3.5% of the UK's gross national income, from 0.6% of its land area (Jones, 2014).

Some of the recreational sectors, such as sea angling and wildlife watching, are directly or indirectly in competition for the same natural capital resources. These trade-offs need to be considered to ensure the aspiration of the 25 Year Environment Plan can be met: to improve the environment, protecting and growing its natural capital.

Natural England's ecosystem services toolkit highlights that the economic value of fisheries often dominates the decisions on marine management plans and also cites a review which suggests that other non-extractive uses such as tourism (diving, kayaking, seabird watching) have the same potential value and should be considered as such when planning marine management (Ruiz-Frau et al., 2013). A business model for marine reserves in tropical and temperate waters also shows that the net benefits of protected areas in terms of enhanced adjacent fisheries and tourism exceed the pre-reserve value and that economic benefit can be seen within five years (Sala et al., 2013). In a study of a large temperate towed fishing gear exclusion area the size of trophy fish was found to have increased (Blyth-Skyrme et al., 2006), which could potentially benefit a sport fishing industry.

Sea angling cost benefits

Sea angling from the shore, charter vessels and from recreational vessels along the Sussex coast is a highly popular pastime. Recreational fishing activity supports a range of businesses including tackle shops, bait shops and charter boat companies. In addition, due to its relative proximity to the city of London, a large number of anglers visit the Sussex coastline and thus also support the local accommodation sector. According to the research commissioned by the Blue Marine Foundation from the Marine Resources' Assessment Group (MRAG), anglers spent £37.6 million on tackle, charter vessels and accommodation in 2012.

Sea Angling 2012 reports the findings of the Government national survey of sea angling in England in 2011 (Armstrong et al., 2013). It assessed the number of people sea angling, catch data and the economic and social value of sea angling. The surveys estimated there are 884,000 sea anglers in England who in 2012 spent £1.23 billion on the sport, equivalent to £831 million direct spend once imports and taxes had been excluded. Taking indirect and induced effects into account, sea angling supported £2.1 billion of total spending, a total of over 23,600 jobs, and almost £980 million of GVA. As George Eustice, the Fishing Minister in post when the report was published, said: "Looking after our sea

is just as much and economic issue as it is an environmental one. It's in everybody's interest to manage fish stocks sensibly so people can continue to enjoy the sport and support local businesses" (in Ares, 2016).

Bass recreational fishing

In terms of potential sea bass protection benefits specifically, this is an important species for sport fishermen in the UK. The Bass Anglers' Sportfishing Society (BASS) claimed that fishing of the species was worth £100 million in 2004 (ICES, 2012). Angling groups argue that this spending makes the species more valuable as a sport quarry than as a commercial food-fish (Ares, 2016).

According to the research commissioned by the Blue Marine Foundation from MRAG, for recreational bass fisheries alone, the estimated economic and employment impacts in Sussex in 2012 is £31.3 million and 353 full time jobs, compared to £9.25 million and 111 jobs generated from the commercial bass fisheries.

SCHIP 1 project results

The value of Sussex's coastal waters to society was explored as part of the Sussex Coastal Habitats Inshore Pilot (SCHIP1) project, run by Sussex IFCA and Sussex Wildlife Trust (SWT) for the Environment Agency. SWT undertook the community engagement aspects of the project and reported the following indication of feelings around the value of the resource to the community (n=56):

- Uses of Sussex's coastal waters were grouped into 10 broad categories. Results indicated that angling, 'multiple recreation activities' and diving were the key uses within the area, in the order of the number of mentions.
- Throughout the Sussex coastal water body the majority of respondents valued the area for its wildlife value, ranging from 55% of responses for section A to 40% for section C.
- Tackling pollution and managing fisheries were selected by the majority of stakeholder respondents as the priorities for action (each with 31% of the votes)

6.3.8 Cognitive and feel good value

As outlined in the Government's Fisheries 2027 report on sustainable fisheries benefits 'all members of society will enjoy the non-use benefits of the marine environment, including the value that people place on a healthy marine environment, abundant fish stocks and the protection of rare, vulnerable and valued species and habitats – even if they do not use the marine environment directly themselves'.

Associated human wellbeing benefits of management include nutrition, health and enjoyment. Cultural benefits in terms of recreational opportunities as outlined above and cognitive value will also be felt. Financially, proposals represent good value for money for taxpayers who fund public investments and contribute to the overall vision for environmental improvement that underpins the Government's 25 Year Environmental Plan.

6.3.9 Adding value to the UK MPA network

The proposed ecosystem-based management approach also seeks to support sustainable management of marine resources outside of Marine Protected Areas. MPAs and the associated management measures cover a relatively small proportion of the Sussex IFC District. Fisheries management outside of these areas is a vital component of effective marine environmental protection, supporting ecosystem service flows and providing ecological connectivity benefits. The size of the proposed area to be protected from identified higher impact gear, compared to the relatively small size of the majority of MPAs within the District means it's a large enough area to contain viable populations of a range of mobile and sedentary species during most of their life cycle and allow larval transfer across all protected zones in the nearshore area proposed across the District. As stressed in the NDMP report (Rees et al., 2019) an overriding feature of the NDMP risk register was the contribution of the range of habitats to the provision of ecosystem service benefits. Whilst MPAs may play a significant role in achieving this, the NDMP risk register demonstrated that this is a limited assumption. Ecosystem service benefits are linked to habitats and species with and without conservation designations for management'.

Rees et al (2019) also suggest that a 'net gain' for natural capital may be achieved via MPA management, through a more ambitious approach to marine biodiversity conservation that considers the wider ecological structures and processes that have the potential for 'recovery' and 'renewal' beyond the

delineated boundaries of features of conservation interest within an MPA (the whole site approach). Ecosystem service benefits may be linked to management that seeks a reduction in pressures across the 'whole site' along with the identification of thresholds for sustainable use. For instance, the reduction of pressures on intertidal saltmarsh extents and reduction of pressures negatively impacting sublittoral rock and soft substratum habitats further offshore (e.g. abrasion related to demersal fishing), will benefit fish and shellfish populations that utilise multiple habitats as nursery areas or across different life stages.

6.3.10 Bass protection benefits

Management proposals to restrict trawling close inshore along the Sussex coast could have concomitant benefits for bass stocks. Concerns about declining bass stocks since 2005 prompted Europe-wide restrictions on bass fishing from 2015. Bass take four to eight years to reach reproductive maturity at around 42cm length. The juveniles use estuaries and the nearshore environment for shelter and feeding. The juveniles are vulnerable to the effects of habitat damage and fishing pressure. Although the minimum conservation reference size and exemption from the landings obligation mean that any fish less than 42cm long will be discarded, discard survival rates are estimated to be as low as 10% (although work is ongoing to elucidate further information on this). The proposed regulation will prevent this additional mortality on bass and make this valuable catch available for the wider fishery.

6.4 One in Three Out (OI3O**)**

OITO is not applicable for byelaws implemented by the IFCAs for their respective districts as they are local government byelaws introducing local regulation and therefore not subject to central government processes.

6.5 Small firms impact test and competition assessment

No firms are exempt from this byelaw as it applies to all firms who use the area, therefore it does not have a disproportionate impact on small firms. It also has no impact on competition as it applies equally to all businesses that utilise the area.

6.6 Risks and assumptions

Estimates for the impacts on fishers of a loss of landing has involved making several simplifying assumptions, which were tested and proven to be robust during consultation:

- Assumption of full compliance with existing legislation.
- Assumption of the part of the fleet that will be impacted.
- Assumption that data used is applied across the full ten year appraisal period.
- Assumptions of stock boundaries.
- Assumptions that habitat maps are a good reflection of actuality.

Reputational risks are a potential hazard with the proposed management introduction, for example:

- Negative perception by the fishing community and wider stakeholders due to restrictive measures.
- Negative perception by stakeholders for not protecting the nearshore area.
- Negative perception by government for not implanting legislation and statutory failure of duty.

For the Seafish economic assessments outlined in section 6, see Annex 10 for the associated methods and caveats.

7.0 Conclusion

Regulation is required to update existing byelaws in the light of updated evidence. The proposed regulation protects important habitats and fish in sensitive locations, whilst also protecting existing fisheries important to the community.

Based on the evidence presented, it is considered that the environmental, societal and economic benefits of introducing the proposed management outweigh the potential monitoring, administrative and enforcement burden and costs to industry.

This work contributes to the fulfilment of Sussex IFCA's responsibility to ensure the sustainable management of inshore fisheries balancing environmental, social and economic costs and benefits. The ecosystem approach to fisheries management adopted responds to a clear steer from Government.

In summary, a byelaw is proposed to deliver the proposed management measures which include:

- Maintain sustainable trawling activity on appropriate grounds.
- Extend the existing nearshore trawling exclusion spatially along the coast and temporally to 12 months of the year.
- Protect, to restore, the historic kelp bed sites off Shoreham to Bognor Regis.
- Protection of specific (designated) sites including Chichester Harbour and Selsey Bill and the Hounds MCZ.

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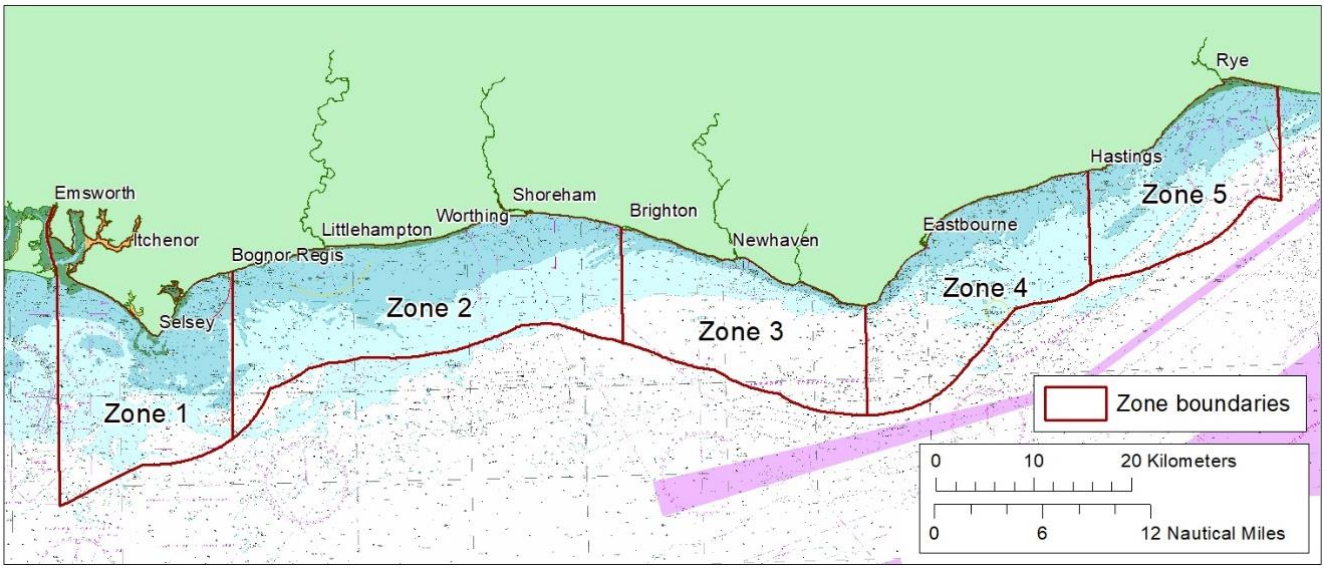
Annexes

Annex 1. Chart of initial trawling management zones for the informal consultation



Annex 2. Description of MPAs in the Sussex IFC District

MPA name	Feature	Sub-feature	EUNIS	Condition	Management
Kingmere MCZ	Moderate energy infralittoral rock and thin mixed sediments			Recover	Sussex IFCA byelaw: towed gear prohibited in all zones, all year, except zone 3 July-March. Netting prohibited in all zones April-June. Potting, lining and dive gathering prohibited in zones 1 & 2 April-June. Angling prohibited in zone 1 April-June and 4 black seabream per person per day all year.
	Subtidal chalk			Recover	
	Black seabream (*Spondyliosoma cantharus*)			Recover	
Beachy Head West MCZ	Intertidal coarse sediment		A2.1	Maintain	Sussex IFCA byelaw: prohibition of the removal of the native oyster, piddock, seahorse and the blue mussel. Prohibition of set nets and lining gear from the shore. Prohibition of all towed gear. Prohibition of all intertidal gathering within the Educational Conservation Areas. Outside of ECAs, prohibited to remove from the shore more than 2 European lobsters, 5 edible crabs, 20 crabs of other species, 1kg mollusc shellfish, 1kg shrimps/prawns, 1kg marine worms or 2kg seaweed per person per day.
	Subtidal mixed sediments		A5.4	Maintain	
	Subtidal mud		A5.3	Maintain	
	Subtidal sand		A5.2	Maintain	
	Infralittoral muddy sand		A5.24	Maintain	
	Infralittoral sandy mud		A5.33	Maintain	
	Low energy infralittoral rock and thin sandy sediment			Maintain	
	Blue mussel (*Mytilus edulis*) beds		A5.62	Maintain	
	Subtidal chalk			Recover	
	Littoral chalk communities			Maintain	
	Native oyster (*Ostrea edulis*)			Maintain	
	Short-snouted seahorse (*Hippocampus hippocampus*)			Maintain	
	Moderate energy circalittoral rock		A4.2	Recover	
	High energy circalittoral rock		A4.1	Recover	
Pagham Harbour MCZ	Seagrass beds		A5.53	Maintain	Sussex IFCA byelaw: Prohibition of towed gear, netting, potting or lining. Prohibition of intentionally removing or damaging seagrass. Prohibited to remove from the shore more than 2 European lobsters, 5 edible crabs, 20 crabs of other species, 1kg mollusc shellfish, 1kg shrimps/prawns, 1kg
	Defolin's lagoon snail (*Caecum armoricum*)			Maintain	
	Lagoon sand shrimp (*Gammarus insensibilis*)			Maintain	

MPA name	Feature	Sub-feature	EUNIS	Condition	Management
					marine worms or 2kg seaweed per person per day. In the Bird Conservation Areas, April to August, no angling or intertidal gathering.
Utopia MCZ	High energy circalittoral rock		A4.1	Recover	Sussex IFCA byelaw: prohibition of the use of towed gear.
	Moderate energy circalittoral rock		A4.2	Recover	
	Subtidal coarse sediment		A5.1	Recover	
	Subtidal mixed sediments		A5.4	Recover	
	Subtidal sand		A5.2	Recover	
	Fragile sponge and anthozoan communities on subtidal rocky habitats		A4.12	Recover	
Selsey Bill and the Hounds MCZ	Bracklesham Bay geological feature			Maintain	Designated May 2019. Management measures in development.
	Short-snouted seahorse (*Hippocampus hippocampus*)			Maintain	
	Subtidal mixed sediments		A5.4	Maintain	
	Subtidal sand		A5.2	Maintain	
	High energy infralittoral rock		A3.1	Recover	
	Low energy infralittoral rock		A3.3	Recover	
	Moderate energy infralittoral rock		A3.2	Recover	
	Moderate energy circalittoral rock		A4.2	Recover	
	Peat and clay exposures			Recover	
Beachy Head East MCZ	Littoral chalk communities			Maintain	Designated May 2019. Management measures in development.
	Short-snouted seahorse (*Hippocampus hippocampus*)			Maintain	
	Subtidal coarse sediment		A5.1	Maintain	
	Subtidal sand		A5.2	Maintain	
	High energy circalittoral rock		A4.1	Recover	
	Moderate energy circalittoral rock		A4.2	Recover	
	Peat and clay exposures			Recover	
	Ross worm reefs			Recover	

MPA name	Feature	Sub-feature	EUNIS	Condition	Management
	(*Saballeria spinulosa*)				
	Subtidal chalk			Recover	
Chichester & Langstone Harbours SPA	Bird species or assemblage	Seagrass	A5.53		Sussex IFCA byelaw: all fishing activity prohibited within the seagrass closure areas.
		Mixed sediment shores; Sand & shingle	A2.42		
		Intertidal mudflats & sandflats	A2.3		
		Shallow coastal waters Saltmarsh			
	Interest feature	Sandwich tern, Common tern, Little tern			
	Interest feature	Grey Plover, Sanderling, Dunlin, Redshank, Dark-bellied			
Solent Maritime SAC (includes Chichester Harbour)	Subtidal Sandbanks	Subtidal gravelly sand and sand	A5.2	Unfavourable/ no change	Sussex IFCA Oyster Permit byelaw: An annual permit is required to fish for oysters. 70mm minimum landing size. Maximum dredge width 1.2m, minimum ladder gap of 60mm, no diving blade, no teeth, maximum weight of 50kg. Fishing only in the specified areas. Fishing only 0800-1400, Monday to Friday. Fishing prohibited March-October. The fishery closes at the end of the day on which the fleet average catch per unit effort falls below the harvest control threshold.
		Subtidal muddy sand communities		Unfavourable/ no change	
		Subtidal eelgrass Zostera marina beds	A5.53	Unfavourable/ no change	
	Estuaries	Subtidal sediment communities		Unfavourable/ no change	
	Mudflats and sandflats not covered by sea at low tide	Intertidal mud communities	A2.3	Unfavourable/ no change	
		Intertidal muddy sand communities	A2.2	Unfavourable/ no change	
		Intertidal zostera beds (structural component of intertidal	A2.5	Unfavourable/ no change	
		Intertidal mixed sediment communities	A2.4	Unfavourable/ no change	
	Atlantic Saltmeadows	Atlantic salt meadows (Interest Feature), Salicornia	A2.5315		
	Annual vegetation of driftlines	Annual vegetation of driftlines (Interest feature)			
	Coastal Lagoons			Favourable	
Pagham Harbour SPA	Bird species or assemblage	Shingle	A2.11		Sussex IFCA byelaw: Prohibition of towed gear, netting, potting or lining. Prohibition of intentionally removing or damaging seagrass. Prohibited to remove from the shore more than 2 European lobsters, 5 edible crabs, 20 crabs of other species, 1kg mollusc shellfish, 1kg shrimps/prawns, 1kg marine worms or 2kg seaweed per person per day. In the Bird Conservation Areas,
		Intertidal mudflats and sandflats			
		Shallow coastal waters			
		Saltmarsh	A2.5		
		Shallow coastal waters (Brent goose roosting areas)			
	Interest feature	Surface feeding birds			
	Interest feature	Estuarine birds			

MPA name	Feature	Sub-feature	EUNIS	Condition	Management
					April to August, no angling or intertidal gathering.
Dungeness to Pett Level SAC	Annual vegetation of driftlines	Annual vegetation of driftlines			
Dungeness, Romney Marshes and Rye Bay SPA	Bird species or assemblage	Shingle	A2.11		Sussex IFCA trawling exclusion byelaw: No trawling between 1st May and 30th October within an area extending a quarter of a nautical mile seaward from the mark of lowest astronomical tide except between Hollywell, Eastbourne and Cuckmere Haven, and to the west of western breakwater of Shoreham Harbour.
		Intertidal mudflats and sandflats			
		Saltmarsh	A2.5		
		Shallow coastal waters			
	Interest feature	Surface feeding birds			
	Interest feature	Estuarine birds			

Name of area and designation	***Brief Description***
European Marine Sites	
Solent Maritime Special Area of Conservation (SAC)	This area includes areas of sea grass and also encompasses important estuarine and salt marsh habitats.
Dungeness, Romney Marsh and Rye Bay Special Protection Area (SPA)	This large area encompasses a range of coastal and marine habitats and sits on the border of East Sussex and Kent. The shingle beach at Rye Harbour supports breeding gulls and terns; the SPA also includes areas of salt marsh, sand flats and mud flats, as well a diverse range of broadscale habitats within the marine environment which support a variety of prey species for the foraging seabirds. These habitats include subtidal and intertidal sand and muddy sand, subtidal biogenic reef, intertidal stony reef, coarse and mixed sediments, and moderate energy infralittoral and circalittoral rock.
Dungeness to Pett Levels SAC	Annual vegetation of drift lines and perennial vegetation of stony banks are habitats giving the primary reason for selection of this site as an SAC.
Chichester and Langstone Harbours Special Protection Area (SPA)	This area has been designated for a number of breeding, wintering and migratory birds, including the Little Tern, Sandwich Tern, Redshank, Fringed Plover and Dark-bellied Brent Goose. The area incorporates extensive mud-flats and sea grass beds, as well as a wide range of other coastal habitats which support important animals and plants.
Pagham Harbour Special Protection Area	The harbour includes a number of coastal habitats, including salt marsh, mud flats, lagoons and shingle which support breeding and wintering birds. The designation covers the Little Tern, Ruff and Pintail.
Marine Conservation Zones[1] (MCZs)	
Utopia MCZ	In Utopia, a rocky reef rises from the surrounding seabed to create beautiful, intricate and diverse communities of corals, sponges and anemones. Over 15 species of sponge have been recorded here, with many more yet to be identified. Corals, such as dead man's fingers, and white striped anemones are also common within the area. Utopia has been designated as an MCZ on the grounds that it hosts one of only two regional examples of these fragile sponge, coral and anemone communities.

[1] Information taken from https://www.wildlifetrusts.org/marine-protected-areas/england/eastern-channel#paghamharbour

	Utopia's idyllic name actually refers to the tope shark, as it partly makes up an important pupping ground for this UK species. The surrounding seabed is largely covered in deep deposits of sand and gravel. Utopia is close to an aggregate extraction area, where the sand and gravel is dredged for use in the construction industry.
Offshore Overfalls MCZ	This area is diverse and species-rich, with a variety of habitats including sandstone reefs. It also encompasses the Overfalls, an unusual area of mixed sediment, sands and gravels that form sandwaves, which are particularly important for bony fish and elasmobranchs like thornback rays, undulate rays and tope. Commercially and ecologically important species have been recorded here: bass, cod, sandeels, and *Molgula* sea squirts to name a few. Ross worm beds and the invasive American slipper limpet are present at several locations, while blue mussel beds are also thought to occur here. This site hosts the geomorphological remains of an ancient river valley that once flowed through the Channel before it flooded to separate England from the mainland continent.
Kingmere MCZ	This site has been designated for the rock and chalk habitats found here, as well as to protect the black seabream. Kingmere MCZ is the most important regional location for breeding black seabream, which build their nests on hard bedrock overlain with thin sands and gravels. The area contains excellent examples of rocky habitats, which support abundant marine life. Nooks and crannies provide shelter and a solid foundation for species to cling to. Kingmere Rocks, 10km south east of Littlehampton, includes a large area of sandstone and mudstone reef where fan worms protrude from cracks between boulders and edible crabs shelter under overhangs. Worthing Lumps, 8km south-west of Worthing sea front represents the best exposures of underwater chalk cliffs in Sussex. Red algae dominate the top of the cliff with hydroids, bryozoans, tube worms and sponges covering the vertical face. Molluscs, including blue mussels and piddocks, are present. Tompot blennies and catsharks make use of the shelter as do lobsters and spider crabs. The seabed at the base of the cliff is home to anemones, whelks and topshells which live in the gravel and chalk pebbles.
Pagham Harbour MCZ	This site has been designated to protect the seagrass beds found in the area, as well as for the lagoon sand shrimp and Defolin's lagoon snail. This small area is one of just three places in the UK where the exceptionally rare Defolin’s lagoon snail occurs. This snail’s rarity makes it very vulnerable. Any changes to the lagoons in which it lives could result in its complete disappearance. This minute (up to just 2mm long!) snail lives in the spaces between small pebbles in the site's shingle spit at the harbour mouth. Pagham Harbour is renowned for its rich marine life. Species include the lagoon sand shrimp, found in Ferry Pool on the west side of the harbour, the beautiful starlet sea anemone, native oysters, and adult eels and elvers, the juvenile eels that swim up rivers to mature, after which they return to the sea.
Beachy Head West MCZ	This site has been designated to protect a range of habitats including sand and mud habitats, blue mussel beds and chalk communities. It will also provide protection for the native oyster and short-snouted seahorse. The chalk we see on land, most impressively at the iconic Seven Sisters, extends some 500m out to sea as a wave-cut platform. The gullies, crevices and ledges are home to a fascinating array of marine life. The surface of the chalk is pitted with holes, mostly caused by burrowing piddocks and boring worms. Ross coral, sponges, sea squirts, anemones, bryozoans and hydroids all cloak the chalk reefs. Forests of kelp occupy shallow areas whilst ridges and gully sides are covered with tightly packed blue mussels mixed with native oysters. Species such as lobsters, spider crabs and hermit crabs are often spotted on the move in search of food.

	Populations of both long-snouted and short-snouted seahorses are found here, with other fish including the long-spined sea scorpion and ballan wrasse. European eel elvers also migrate along the coastline into the estuaries.
Offshore Brighton Marine Conservation Zone	Situated south of Brighton and extending out to the median line with France, this large area is situated in deeper offshore waters within the English Channel. These deeper waters are less influenced by natural disturbance than those which are inshore, allowing a wide range of species to colonise the gravel undisturbed. Such diverse gravel communities provide rich hunting grounds, supporting a range of other species, such as rays. The area is also important for rarer deep-water rocky habitats. Ross worm 'reefs', known as biogenic reefs, are present here. Formed out of consolidated tubes of ross worms, these structures add additional complexity to the seafloor and encourage other marine species to live there.
Beachy Head East Marine Conservation Zone	Beachy Head East MCZ is an inshore site that covers an area of 195 km2 and is located along the coast near Eastbourne in East Sussex, in the Eastern Channel region. Beachy Head East has a sandstone / chalk reef system which provides a home for a wide range of species. Between Beachy Head point and Holywell a chalk reef extends from the subtidal area up to the coast and white cliffs forming sheltered rockpools at low tide. The soft chalk is pitted by holes created by rock-boring piddocks, a type of bivalve mollusc (an invertebrate with a hard external shell). Once empty, these holes can also house crabs, sponges, anemones and worms. Chalk extending above the high water mark supports rich littoral chalk communities, namely unique communities of seaweeds in the areas where the chalk cliffs and sea caves are splashed by waves. Marine chalk is a globally rare habitat, a large proportion of which is contained in the UK. The largest underwater chalk seascapes are predominantly found in Kent and Sussex, including within the Beachy Head East site. Short-snouted seahorses and Ross worm reefs are also found within this site. Ross worms build tubes from sand and shell fragments. Large colonies can form reefs, stabilising the seabed, providing shelter for other creatures and boosting the number and types of species in the area. The site is also considered an important nursery area for herring, plaice and Dover sole. Plaice and Dover sole survive by camouflaging themselves in subtidal sand allowing them to avoid predators, whilst subtidal sand and coarse sediments provide a habitat for invertebrate species on which adult fish prey. High and moderate energy circalittoral rock features provide habitats for a wide variety of animals due to the varying conditions that can be found in these areas.
Selsey Bill and the Hounds Marne Conservation Zone	Selsey Bill and the Hounds Marine Conservation Zone (MCZ) is an inshore site which covers an area of approximately 16 km2 and is located by the town of Selsey in West Sussex on the south coast of England. The landward boundary is at Mean Low Water and the site adjoins the Bracklesham Bay Site of Special Scientific Interest. The site lies within the Eastern Channel region of English waters. Selsey Bill and the Hounds is well known for its high biodiversity and species richness, supported by a variety of different habitats ranging from rocky habitats to soft sandy sediments. The site provides additional protection for a series of geological interest features that are exposed on, and underlie, the foreshore within Bracklesham Bay. These rock features, known locally as "The Hounds", consist of outcrops of limestone and clay exposures and are representative of a coherent rock system stretching across the MCZ from the northwest corner to the southeast. These rock features provide a range of habitats that support a wide variety of species, with deeper or vertical rock faces dominated by animals such as anemones, sponges, and sea squirts. The site also protects one of the best examples of peat and clay exposures on the southeast coast. Within the southeast of the site is the Mixon Hole, a dramatic 20 m drop in the seafloor exposing clay cliffs capped with limestone. This feature supports a rich diversity of habitats and species and has been classed as a marine Site of Nature Conservation Importance by West Sussex County Council.

Annex 3. Habitat data confidence maps

In terms of confidence in the seabed habitat data, the greater the number of survey points (i.e. actual surveyed data) then the greater the confidence in the accuracy of the data produced by the model. To ascertain the confidence, point kernel density estimation was used to assess the density of the data points. This has been used successfully in other studies (Tomline & Burnside, 2015).

The highest confidence in the data was in the area south west of Selsey and south east of Littlehampton which coincides with Utopia and Kingmere MCZs respectively (where there have been extensive surveys to verify protected features). The lowest confidence in the data is found in the area between Shoreham and Eastbourne and east of Hastings as this had the least dense data points. This is perhaps due the distance from shore and the lack of Marine Protected Areas or features of interest such as wrecks, which are often the focus of research and incentives for divers. Future survey of these areas would help to improve confidence levels in the data for this area.

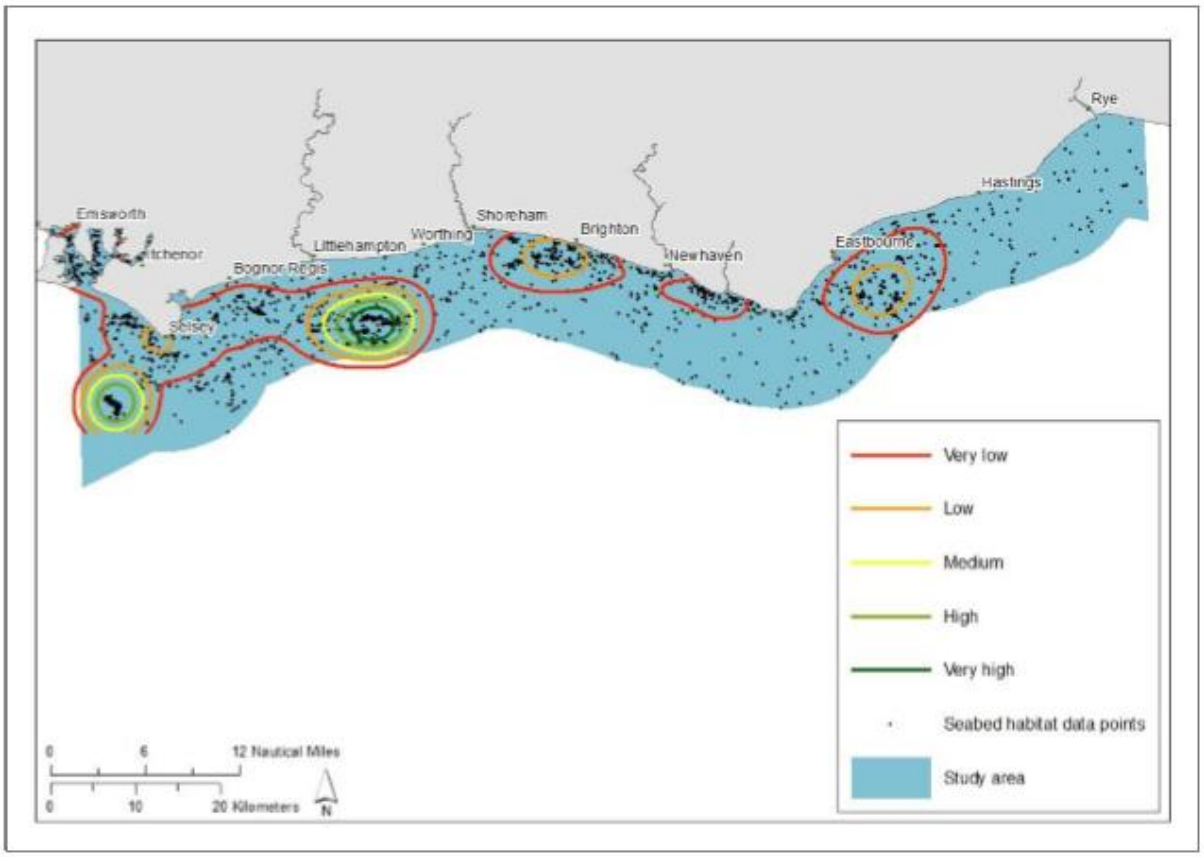


Figure 26. The confidence contours based on the density of the seabed habitat data points, where a greater density of points suggested a greater relative confidence.

Annex 4. Sensitivity assessment

Table 24 summary of the resistance, resilience and sensitivity of the three main broadscale habitat types. Based on information provided by the Marine Life Information Network (MarLIN, 2017a).

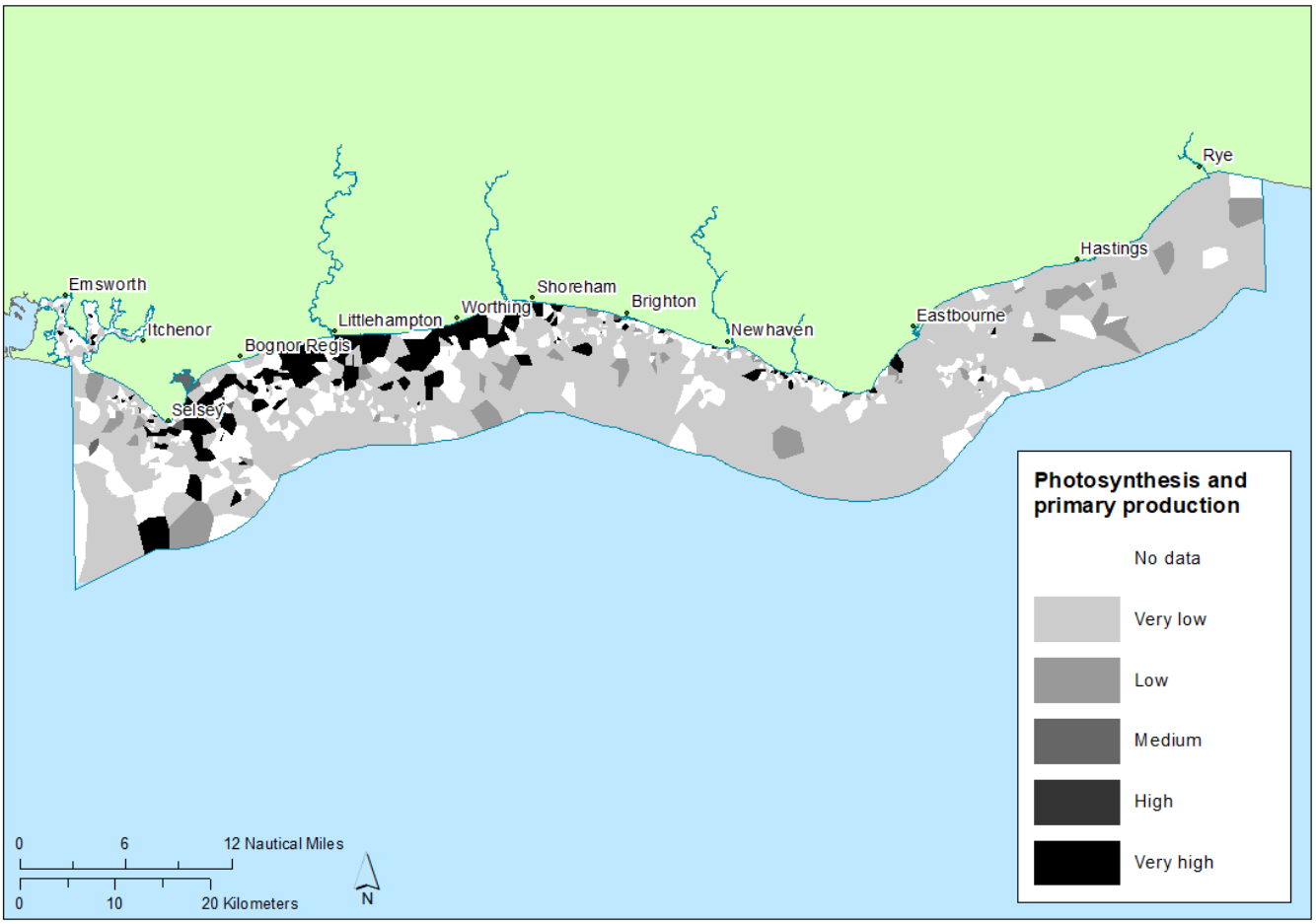
Habitat	Resistance	Resilience	Sensitivity
Mobile coarse sediment	Very few species present due to very mobile substrate, those present are robust	Very few species present due to very mobile substrate, those present have rapid recolonisation or are mobile and also inhabit other habitats	Low as habitat is subject to high levels of natural disturbance
Mud or sand with burrowing fauna	Generally soft bodied fragile fauna, low resistance for species near the surface but medium to high for those in deeper burrows	Generally short-lived species with high fecundity so rapid recolonisation	Low to medium as habitat and species could be damaged but likely to recover quickly
Fauna or algae on rock	Generally fragile erect species and spatially complex habitats which can be damaged by abrasion or disturbance	Generally quick to recolonise through larval dispersion, can take longer to reach full recovery, repair and asexual reproduction can support recolonisation	Medium to high as biotope could be damaged but likely to recover quickly for most species

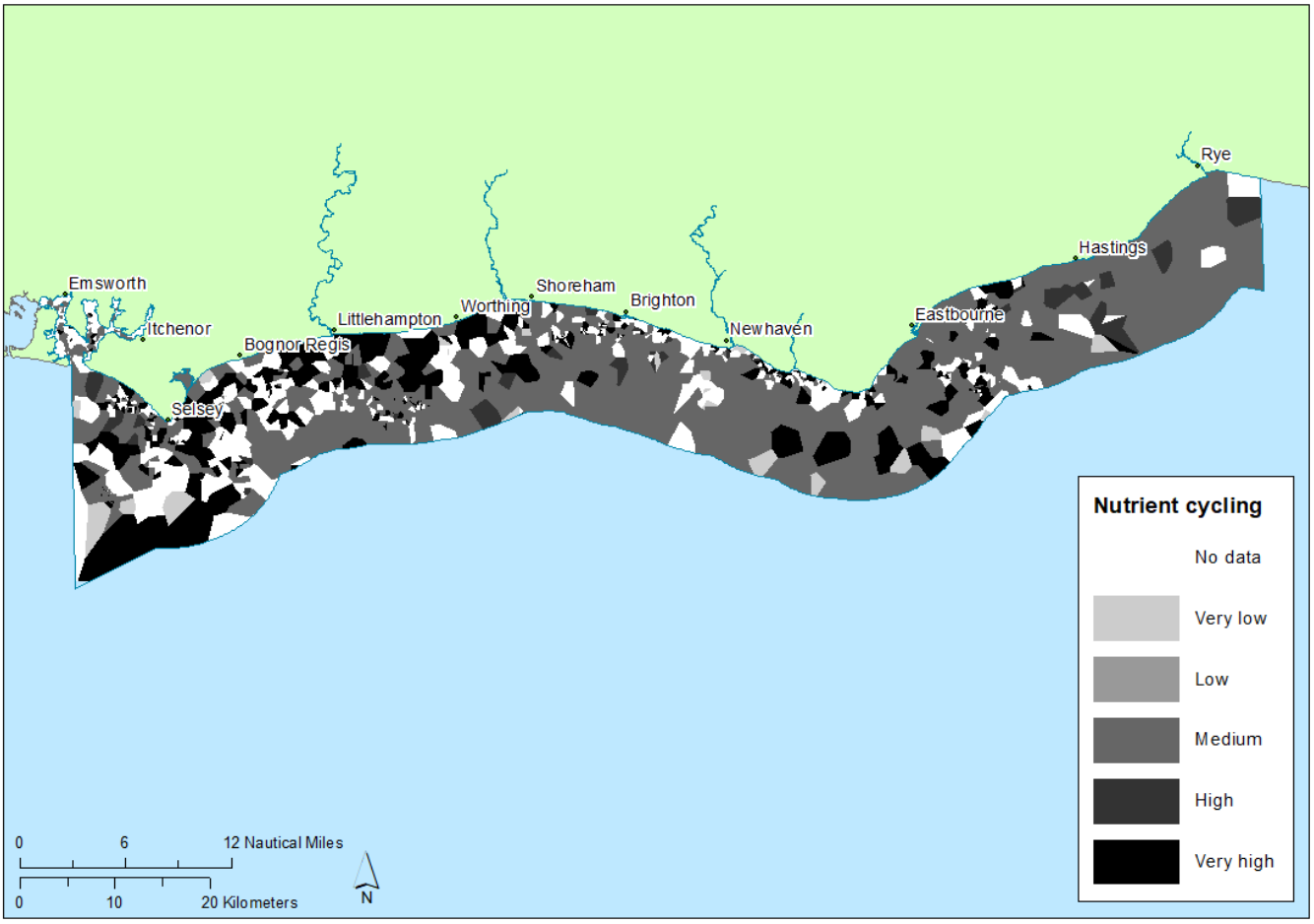
Table 25. Summarising the sensitivity of 26 seabed habitats at EUNIS level 2,3 and 4 where appropriate to provide further details of the sensitivity analysis. In EUNIS code numerical order. Based on information provided by the Marine Life Information Network (MarLIN, 2017a).

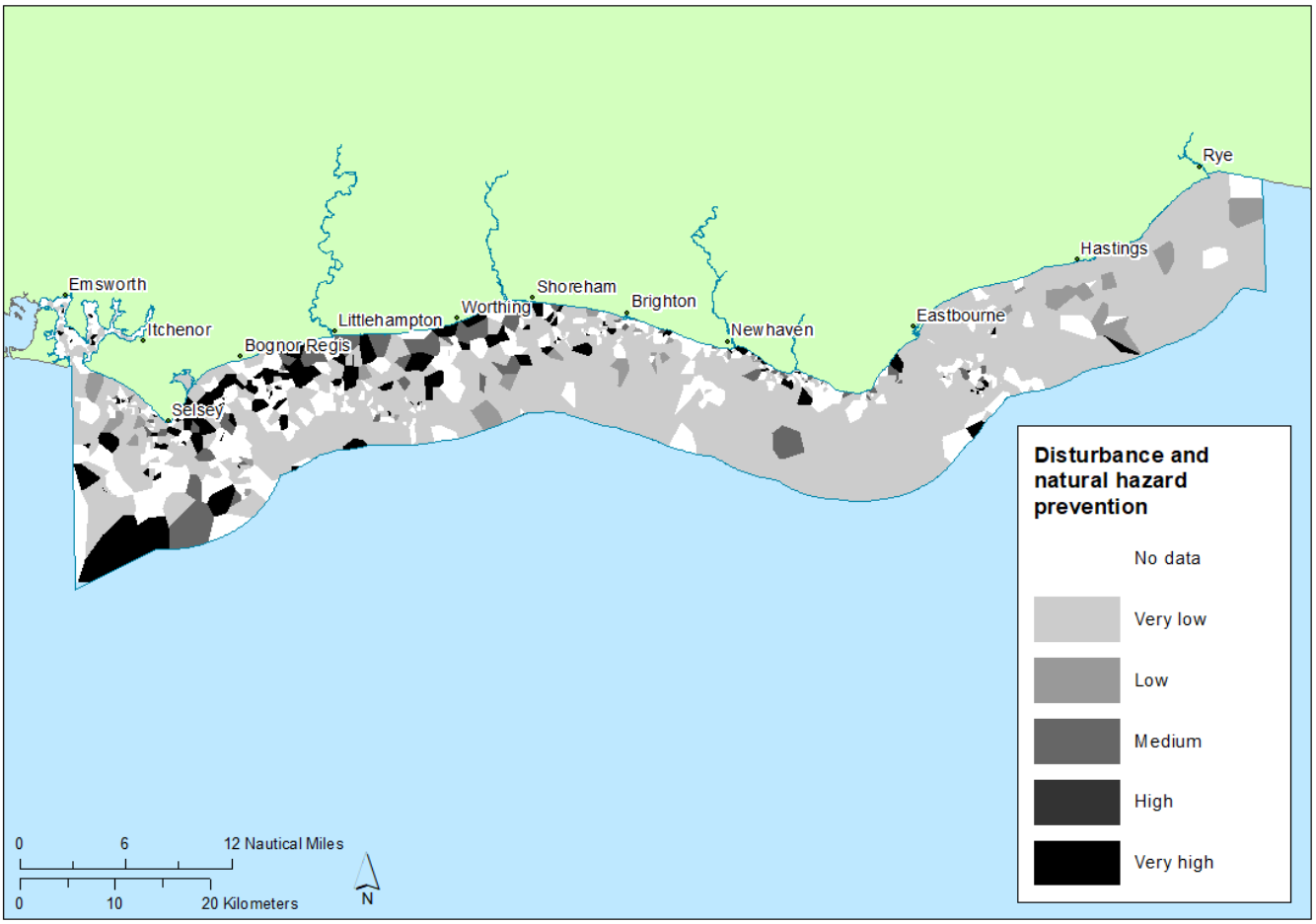
Habitat	EUNIS code	Description of sensitivity	Resistance	Resilience	Sensitivity
Intertidal rock (and other hard substrata)	A1	Erect epifauna will be damaged by abrasion but other species have some resistance, recovery is likely to be rapid especially if some adults left nearby	Low	High	3
Intertidal coarse sediment	A2.1	These tend to have high natural disturbance and low abundance	High	High	1
Intertidal mud	A2.3	Generally burrowing fauna with some resistance to abrasion, generally rapid recovery	Med	High	2
Intertidal mixed sediment	A2.4	These tend to have high natural disturbance and low abundance but with some erect fauna	Med	High	2
Saltmarsh	A2.5	Some tolerance to trampling, can recover within 2 years	Med	High	2
Intertidal sediments dominated by aquatic angiosperms (seagrass)	A2.6	Not robust, roots near surface, annual regrowth but abrasion can induce negative feedback, could take long time to fully recover	Low	Low	5
Intertidal biogenic reefs - Sabellaria	A2.71	Some resistance to abrasion of tube dwelling species and they can repair damage, recolonisation can be rapid	Med	High	2
Intertidal biogenic reefs - Blue mussel	A2.72	Vulnerable to damage from abrasion, can take over 2 years to fully recover due to large interannual variation in recruitment	Low	Med	4
Infralittoral rock (and other hard substrata dominated by algae)	A3	Erect epifauna will be damaged by abrasion, but recovery is likely to be rapid	Low	High	3
High energy infralittoral rock	A3.1	There will be high natural disturbance, but erect epifauna will be damaged by abrasion, recovery is likely to be rapid	Low	High	3
Moderate energy infralittoral rock	A3.2	Erect epifauna will be damaged by abrasion, but recovery is likely to be rapid	Low	High	3
Low energy infralittoral rock	A3.3	Erect epifauna will be damaged by abrasion, but recovery is likely to be rapid	Low	High	3
Features of infralittoral rock	A3.7	Erect fauna vulnerable to abrasion but rapid recovery, especially if some adults left nearby	Low	High	3

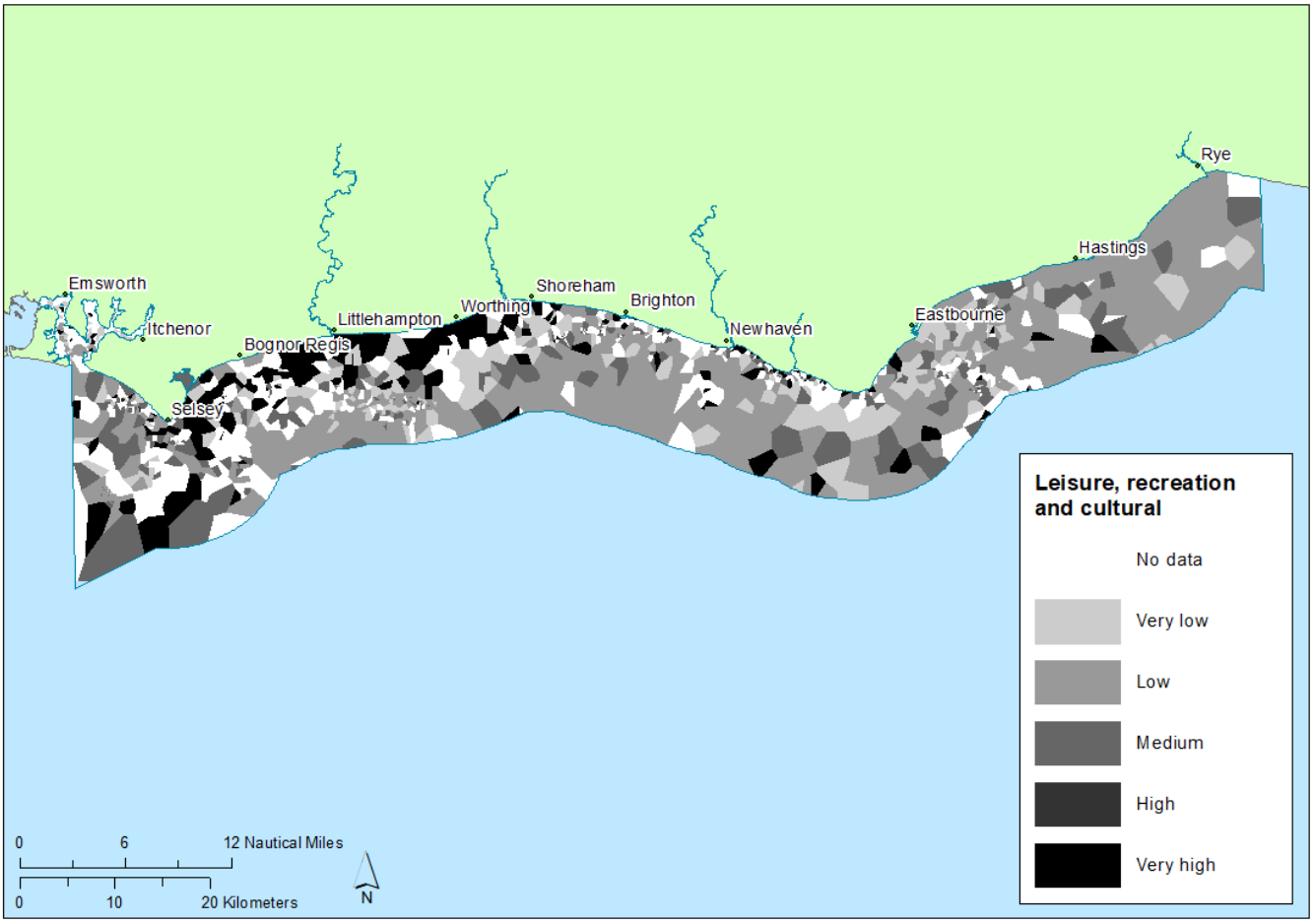
Circalittoral rock (and other hard substrata dominated by fauna)	A4	Erect epifauna will be damaged by abrasion, but recovery is likely to be rapid	Low	High	3
High energy circalittoral rock	A4.1	There will be high natural disturbance, but erect epifauna will be damaged by abrasion, recovery is likely to be rapid	Low	High	3
Moderate energy circalittoral rock	A4.2	Erect epifauna will be damaged by abrasion, but recovery is likely to be rapid	Low	High	3
Low energy circalittoral rock	A4.3	Erect epifauna will be damaged by abrasion, but recovery is likely to be rapid	Low	High	3
Circalittoral caves and overhangs	A4.71	Some rare species, little interaction between species, slow recovery up to 25 years, some sponges elastic but others damaged by abrasion	Low	Low	5
Circalittoral fouling faunal communities	A4.72	Sponges, and ascidians to a lesser degree, are likely to be damaged by abrasion, sponges and hydroids are fast growing and recovery likely to be rapid	Low	High	3
Sublittoral sediment	A5	These tend to have high natural disturbance and low abundance but with some erect fauna	High	High	1
Sublittoral coarse sediment	A5.1	These tend to have high natural disturbance and low abundance	Med	High	2
Sublittoral sand	A5.2	Species poor mobile habitat with burrowing or mobile species, some burrows may be damaged by abrasion but there is rapid recovery, within weeks or months	Med	High	2
Sublittoral cohesive mud and sandy mud communities	A5.3	Generally burrowing fauna with some resistance to abrasion, generally rapid recovery	Med	High	2
Sublittoral mixed sediment	A5.4	These tend to have high natural disturbance and low abundance but with some erect fauna	Med	High	2
Sublittoral macrophyte-dominated communities on sediments	A5.5	Erect fauna vulnerable to abrasion but rapid recovery, especially if some adults left nearby	Low	High	3
Sublittoral biogenic reefs on sediment	A5.6	Vulnerable to damage from abrasion, can take over 2 years to fully recover due to large interannual variation in recruitment	Low	Med	4

Annex 5. Maps of each of the 12 ecosystem services assessed

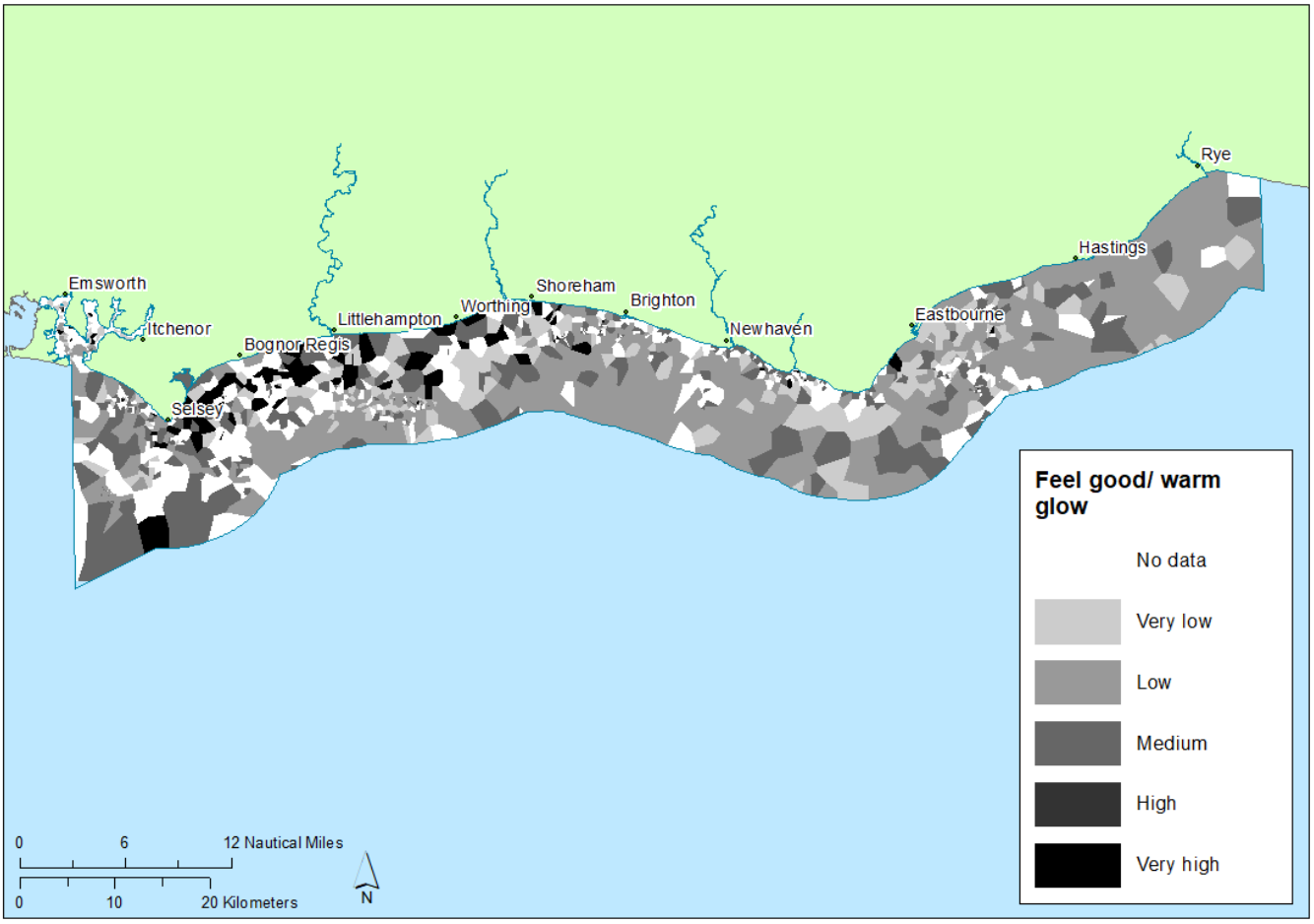

Rye
Hastings
Emsworth
Shoreham
Brighton
Worthing
Littlehampton
Eastbourne
Itchenor
Newhaven
Bognor Regis
Selsey
Photosynthesis and primary production
No data
Very low
Low
Medium
High
Very high
0
6
12 Nautical Miles
0
10
20 Kilometers
N

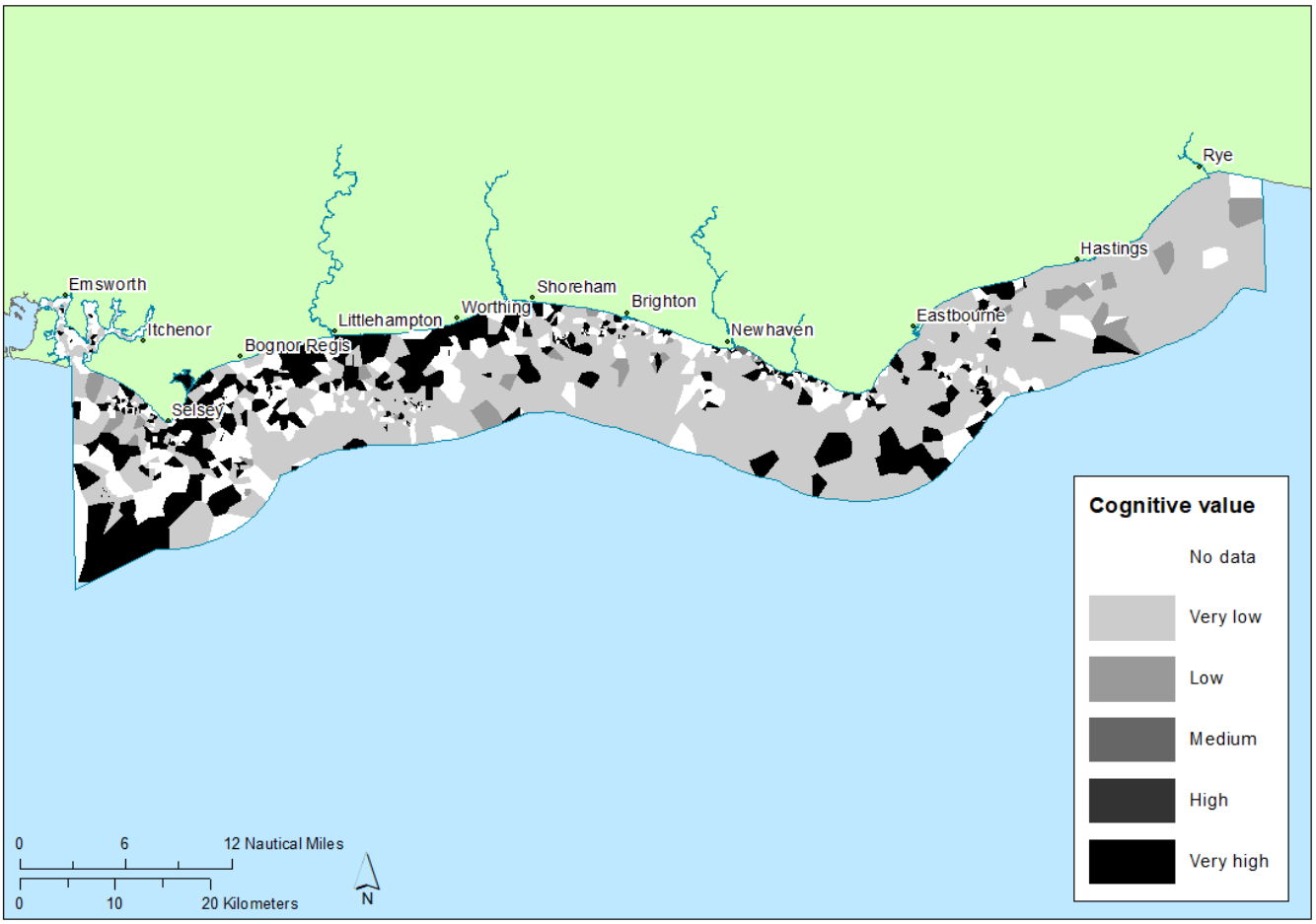

Rye
Hastings
Emsworth
Shoreham
Brighton
Worthing
Littlehampton
Eastbourne
Itchenor
Newhaven
Bognor Regis
Selsey
Nutrient cycling
No data
Very low
Low
Medium
High
Very high
0
6
12 Nautical Miles
0
10
20 Kilometers
N

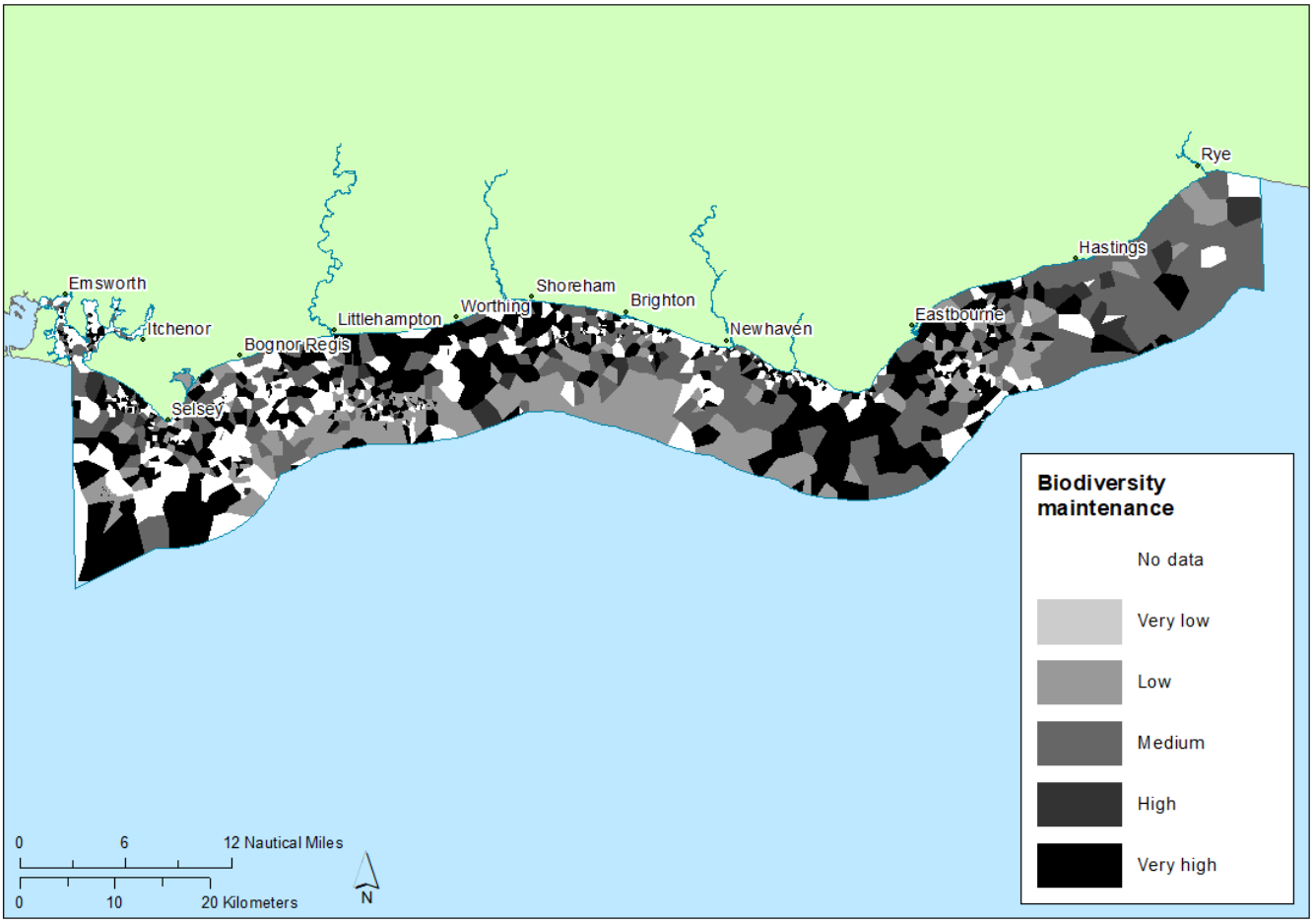

Rye
Hastings
Emsworth
Shoreham
Worthing
Brighton
Littlehampton
Eastbourne
Itchenor
Newhaven
Bognor Regis
Selsey
Disturbance and natural hazard prevention
No data
Very low
Low
Medium
High
Very high
0
6
12 Nautical Miles
0
10
20 Kilometers
N

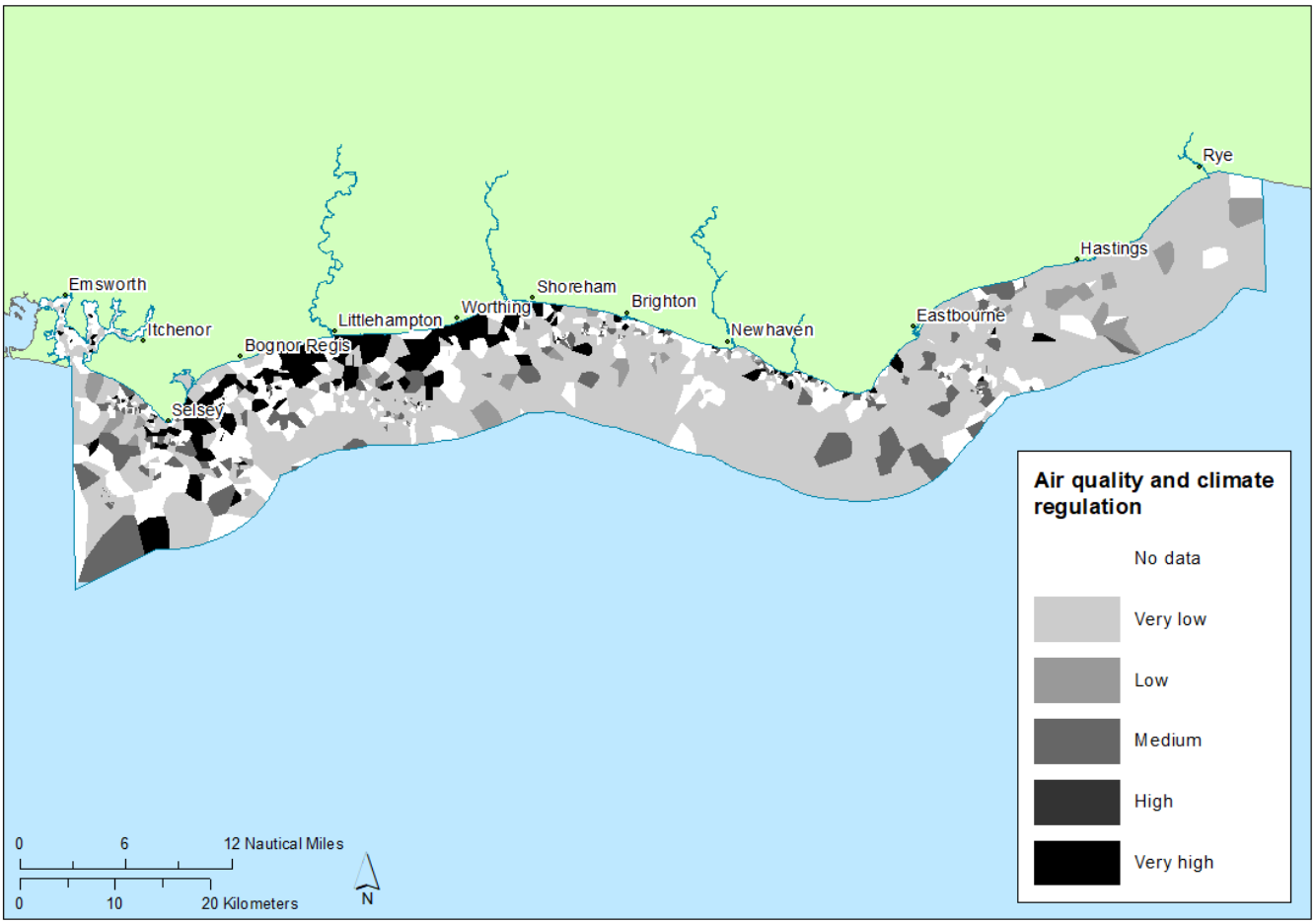

Rye
Hastings
Emsworth
Shoreham
Worthing
Brighton
Littlehampton
Eastbourne
Itchenor
Newhaven
Bognor Regis
Selsey
Leisure, recreation and cultural
No data
Very low
Low
Medium
High
Very high
0
6
12 Nautical Miles
0
10
20 Kilometers
N


Rye
Hastings
Emsworth
Shoreham
Brighton
Worthing
Littlehampton
Eastbourne
Itchenor
Newhaven
Bognor Regis
Selsey
Food
No data
Very low
Low
Medium
High
Very high
0
6
12 Nautical Miles
0
10
20 Kilometers
N

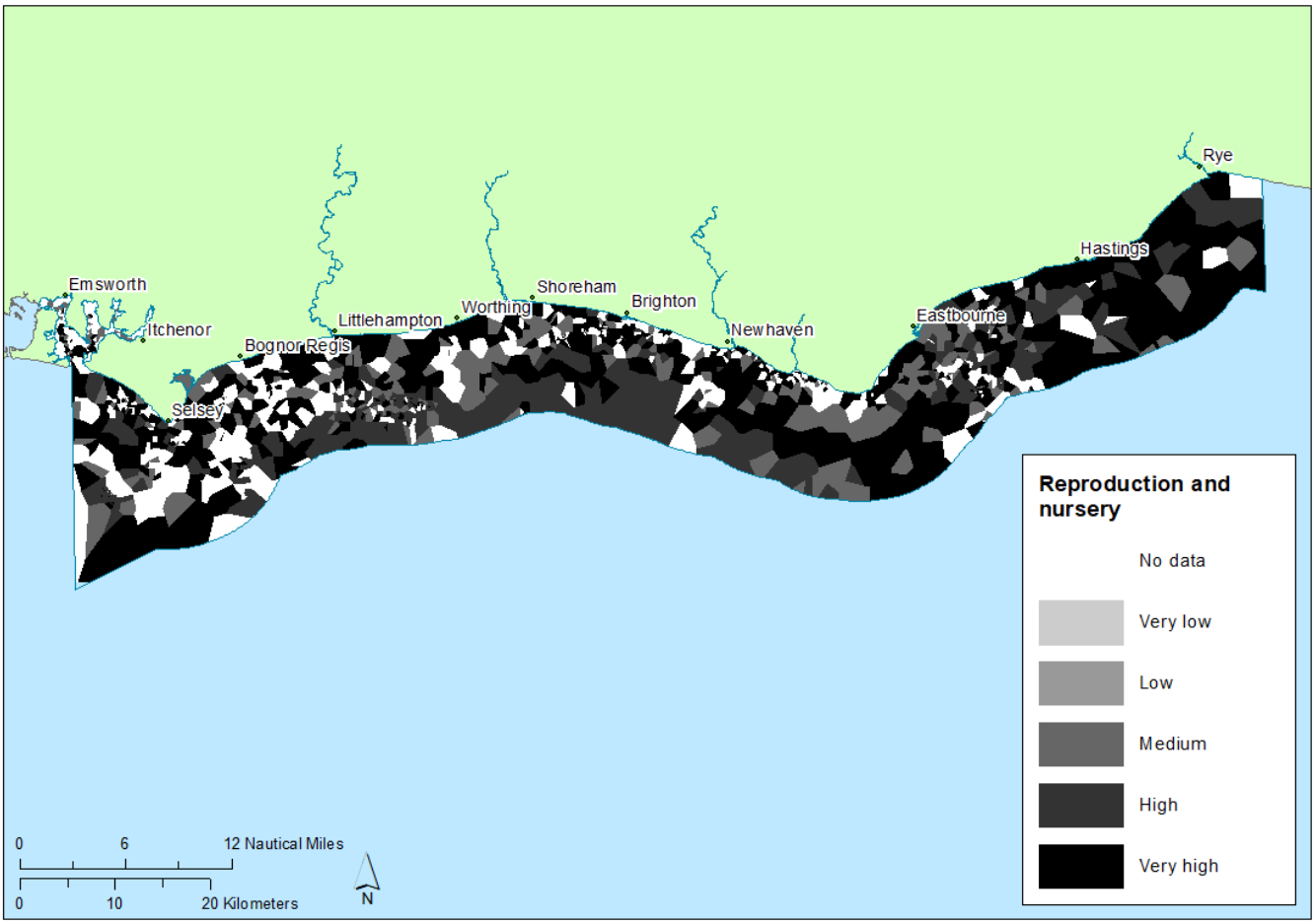

Rye
Hastings
Emsworth
Shoreham
Brighton
Worthing
Littlehampton
Eastbourne
Itchenor
Newhaven
Bognor Regis
Selsey
Feel good/ warm glow
No data
Very low
Low
Medium
High
Very high
0
6
12 Nautical Miles
0
10
20 Kilometers
N


Rye
Hastings
Emsworth
Shoreham
Brighton
Worthing
Littlehampton
Eastbourne
Itchenor
Newhaven
Bognor Regis
Selsey
Cognitive value
No data
Very low
Low
Medium
High
Very high
0
6
12 Nautical Miles
0
10
20 Kilometers
N


Rye
Hastings
Emsworth
Shoreham
Brighton
Worthing
Littlehampton
Eastbourne
Itchenor
Newhaven
Bognor Regis
Selsey
Biodiversity maintenance
No data
Very low
Low
Medium
High
Very high
0
6
12 Nautical Miles
0
10
20 Kilometers
N


Rye
Hastings
Emsworth
Shoreham
Brighton
Worthing
Littlehampton
Eastbourne
Itchenor
Newhaven
Bognor Regis
Selsey
Air quality and climate regulation
No data
Very low
Low
Medium
High
Very high
0
6
12 Nautical Miles
0
10
20 Kilometers
N


Rye
Hastings
Emsworth
Shoreham
Brighton
Worthing
Littlehampton
Eastbourne
Itchenor
Newhaven
Bognor Regis
Selsey
Water quality
No data
Very low
Low
Medium
High
Very high
0
6
12 Nautical Miles
0
10
20 Kilometers
N


Rye
Hastings
Emsworth
Shoreham
Brighton
Worthing
Littlehampton
Eastbourne
Itchenor
Newhaven
Bognor Regis
Selsey
Reproduction and nursery
No data
Very low
Low
Medium
High
Very high
0
6
12 Nautical Miles
0
10
20 Kilometers
N


Rye
Hastings
Emsworth
Shoreham
Brighton
Worthing
Littlehampton
Eastbourne
Itchenor
Newhaven
Bognor Regis
Selsey
Raw materials
No data
Very low
Low
Medium
High
Very high
0
6
12 Nautical Miles
0
10
20 Kilometers
N

Annex 6. Main Sussex Fisheries

In its assessment of Sussex fisheries, the masters by Nelson (2017) defined a fishery as a combination of the species and the method used to catch it (Dapling et al, 2010). A total of 872 fisheries were identified in Sussex, which included 104 species and 22 fishing methods. As some of the fishing methods were recorded differently to the Authority's fishing effort dataset and to simplify analysis, the fishing methods were aggregated to five classes; angling, dredging, netting, potting and trawling. A major fishery was defined by a mean annual landings weight of greater than ten tonnes and that the fishing method accounted for greater than 10% of the landings weight for that species. Under these parameters, 37 fisheries were selected for further analysis in the study, the combination of five fishing methods and 25 species.

Table 26. The category, common name, scientific name and brief description of the 25 species included in the study, as well as the fishing methods used to catch them.

Species category	Description	Species	Fishing method
Flat fish	Flat fish live on sandy or gravelly seabeds where they are well camouflaged. They hatch as tiny round fish which swim near the surface for several weeks before moving to the bottom and metamorphosing into flat fish.	Brill (*Scophthalmus rhombus*)	Netting & trawling
		Dab (*Limanda limanda*)	Trawling
		Flounder (*Platichthys flesus*)	Trawling
		Lemon sole (*Microstomus kitt*)	Trawling
		Plaice (*Pleuronectes platessa*)	Netting & trawling
		Sole (*Solea solea*)	Netting & trawling
		Turbot (*Scophthalmus maximus*)	Netting & trawling

Species category	Description	Species	Fishing method
Pelagic fish	Pelagic fish swim in the water column from mid-water to the surface. Mackerel are a summer visitor to Sussex.	Mackerel (*Scomber scombrus*)	Netting
Demersal fish	Demersal fish swim in the water column, on or near the seabed, feeding on crustaceans, algae and other fish.	Bass (*Dicentrarchus labrax*)	Angling, netting & trawling
		Black seabream (*Spondyliosoma cantharus*)	Trawling
		Cod (*Gadus morhua*)	Netting & trawling
		Gurnards (*Chelidonichthys* spp.)	Trawling
		Monkfish/anglerfish (*Lophius* spp.)	Trawling
		Pouting bib (*Trisopterus luscus*)	Trawling
		Whiting (*Merlangius merlangus*)	Trawling
Shellfish	Shellfish all have hard shells, internalised in the cuttlefish and squid. Some have low mobility and spend their entire lifecycle in Sussex waters, others are seasonal visitors for specific life stages.	Cuttlefish (*Sepia officinalis*)	Netting, potting & trawling
		Edible crab (*Cancer pagurus*)	Potting
		Lobster (*Homarus gammarus*)	Potting
		Scallops (*Pecten maximus*)	Dredging
		Squid (*Loligo* spp.)	Trawling
		Whelks (*Buccinum undatum*)	Potting
Elasmobranchs	Sharks and rays have cartilaginous skeletons. They are long-lived, slow to mature and either give birth to live young or young hatch from egg cases.	Blond ray (*Raja brachyura*)	Trawling
		Lesser spotted dogfish (*Scyliorhinus canicula*)	Netting & trawling
		Smoothhound (*Mustelus* spp.)	Netting & trawling
		Thornback ray (*Raja clavata*)	Netting & trawling

Annex 7. Fishing activity data confidence

Mapping of fishing intensity was based on observations of fishing activity made by Sussex IFCA fisheries officers. There were fishing vessels observed across the study area with an average spacing of 425m but with significant clustering (p value: <0.01, average nearest neighbour analysis). Where no fishing vessels were observed, it cannot be assumed that no fishing took place, only that the activity was not observed. Despite this limitation, this dataset was the best available at the time of the study and the annual average effort 2012-2016 was considered to be suitable for the assessment of relative fishing effort.

To assess the confidence in this data, kernel density was used to assess the density of the data points (as in section 3.2.6). The density surface was converted to contour lines, outlining areas of relative confidence in five classes from very low to very high. In addition, the annual average patrol effort (km^2 of the sea patrolled) was calculated. This highlighted areas where there was greatest confidence that the observed fishing effort was representative of the true effort.

The fishing vessel observations were significantly clustered (Z score: -40.95, p value: <0.01). Where there were more data points, there was more confidence that the observations reflected the actual and total fishing activity. There was highest confidence inshore from Shoreham to Newhaven. This was expected as the fisheries patrol vessel's home berth was in Shoreham and the area around Shoreham was most frequently patrolled (Figure 27).

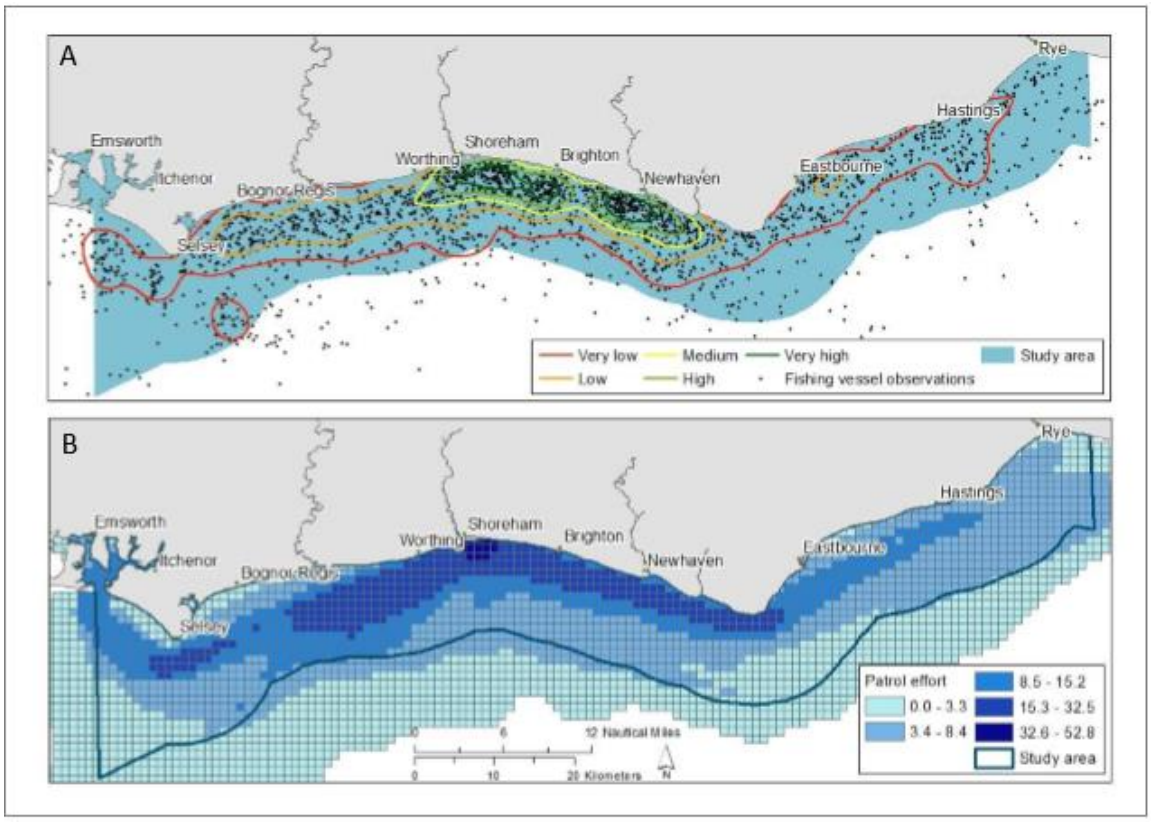


Figure 27. A) The fishing vessel observation data points and relative confidence contours. B) The annual average patrol effort (km2 of sea patrolled) 2012-2016. Five classes, Jenks natural breaks.

Annex 8. Historic sightings maps 2001 - 2018

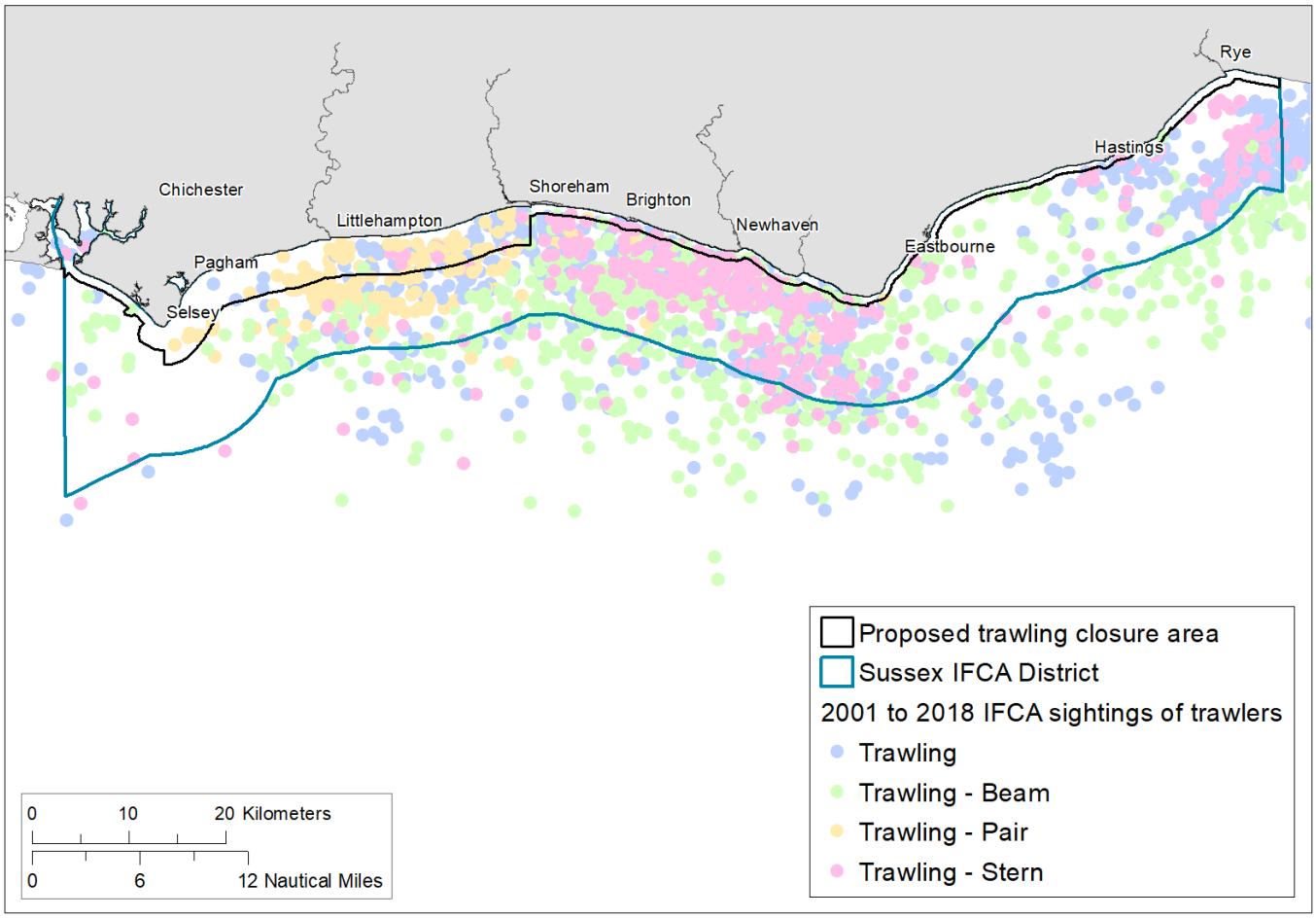


Figure 28. Trawling sightings by type in the Sussex IFC District 2001 - 2018

Annex 9. Water body asset condition

Bathing Waters

Water quality at designated bathing water sites in England is assessed by the Environment Agency. Annual ratings classify each site as excellent, good, sufficient or poor based on measurements taken over a period of up to four years. The following water quality classifications for the bathing waters in Sussex are taken from this Environment Agency online information[1].

East Sussex	
Bathing Water	Condition classification
Bexhill	Sufficient
Camber	Excellent
Hastings Pelham Beach	Sufficient
Pevensey Bay	Good
St Leonards	Excellent
Birling Gap	Excellent
Eastbourne	Good
Norman's Bay	Good
Seaford	Excellent
Winchelsea	Excellent

West Sussex	
Bathing Water	Condition classification
Bognor Regis (Aldwick)	Sufficient
Bracklesham Bay, Chichester	Excellent
Lancing, Beach Green	Good
Middleton-on-sea	Excellent
Selsey	Excellent
Bognor Regis (east)	Good
Felpham	Good
Littlehampton	Good
Pagham	Good
Shoreham Beach	Good
Southwick	Excellent
West Wittering	Excellent
Worthing	Sufficient

Brighton and Hove	
Bathing Water	Condition classification
Saltdean	Excellent
Brighton Kemptown	Excellent
Brighton Central	Excellent
Hove	Excellent

The classifications are:

- excellent – the highest cleanest seas
- good – generally good water quality
- sufficient – the water meets minimum standards
- poor – the water has not met the new minimum standards

[1] Environment Agency https://environment.data.gov.uk/bwq/profiles/

Water bodies monitored under WFD

The following information comes from reporting under the Water Framework Directive (WFD) – using data accessed in 2016[2].

Table 27. Status of water bodies in Sussex listed under WFD (Estuary and Coastal)

Estuarine Water Bodies

Water Body	Area (ha)	Overall status	Ecological Status	Chemical Status	Target status	Hydromorph status	Heavily modified (HM) (Y/N)	Use (reason for designation as HM)
Chichester Harbour	3012.66	Moderate	Moderate	Good	Good	Supports Good	Y	Coastal Protection Navigation, Ports & Harbours
Cuckmere	36.48	Moderate	Moderate	Good	Good	Supports Good	Y	Flood Protection
Ouse - estuarine	139.31	Moderate	Moderate	Good	Moderate	Supports Good	Y	Flood Protection Navigation, ports & harbours
Pagham Harbour	257.24	Moderate	Moderate	Good	Moderate	Supports Good	Y	Flood Protection
Pagham lagoon	9.52	Good	Good	Good	Good	Not assessed	N	
Rother	38.64	Moderate	Moderate	Good	Moderate	Supports Good	Y	Flood protection

Coastal Water Bodies (monitored under the WFD)

Water Body	Area (ha)	Overall status	Ecological Status	Chemical Status	Target status	Hydromorph status	Heavily modified (y/n)	Use (reason for designation as HM)
Sussex	19059.70	Moderate	Moderate	Good	Good	Not assessed	N	Coastal Protection
Sussex East	13059.21	Moderate	Moderate	Good	Good	Not assessed	N	Coastal Protection
Ternery Pool	5.18	Good	Good	Good	Good	Supports Good	N	

Shellfish waters

Chichester Harbour native oyster fishery

The following information has been taken from a study of the ecosystem services associated with the designated Chichester Harbour shellfish waters[3].

- The native oyster fishery in Chichester Harbour is in decline. In terms of attribution, it is impossible to blame this decline on a single factor. Continued fishing activity of stocks under pressure, the resulting and associated habitat loss, and disease can have the effect of reducing the density of oysters on the beds, which in turn can affect the reproductive processes of the population resulting in recruitment failure. The effects of poor water quality and disease combined with these other factors including siltation have all compounded that decline. Whatever the under lying cause(s), lack of recruitment to the population will be the eventual cause of stock collapse. Alongside the socio-economic impacts of the declining fishery, the reduction of the oyster stock has also meant a

[2] 2016 data.
https://assets.publishing.service.gov.uk/.../wfd_water_body_summary_table.xlsx

[3] Williams, C., Davies, W., and Kuyer, J. (2018). A valuation of the Chichester Harbour Provisioning Ecosystem Services provided by Shellfish. NEF Consulting.

reduction in the water filtration capacity and biogenic habitat (which can act as a nursery area) provided, alongside the array of other services which functional shellfish / oyster beds provide.

- Water quality: faecal indicator microorganism levels: In 2009 the Chichester Channel designated Shellfish Water (SW) failed the Guideline (G) faecal coliform shellfish flesh standard. Thornham Channel SW only achieved the G standard for faecal coliforms in shellfish flesh in 2005 and 2008, although faecal coliform levels observed in the water column have been consistently low. Emsworth Channel SW achieved the G standard for faecal coliforms in shellfish flesh in 2004 and 2005. The level of treatment at Bosham STW and Chichester STW was upgraded to ultraviolet disinfection in March 2008 as part of a water company investment programme to improve water quality in the catchment and endeavour to ensure compliance with Shellfish Waters guideline standards.
- Water quality and impact on fishery and human consumption

There are three standard regimes, which have different drivers and metrics, but all impact on the **shellfish fishery and human consumption.** These include the WFD water quality assessments (EU), the Food Standards Agency shellfish waters rating (UK), and the Sussex IFCA fisheries management regimes (local).

The table below identifies the status of the three channels within the fishery under these regimes.

Water quality Assessment (WFD)
Emsworth – Failing (<300 e.*coli*/100g of flesh in 75 percentile of samples.)
Thorney - Failing (<300 e.*coli*/100g of flesh in 75 percentile of samples.)
Chichester - Failing (<300 e.*coli*/100g of flesh in 75 percentile of samples.)
FSA (food hygiene) Shellfish waters
Emsworth – B
Thorney – Prohibited / closed
Chichester - B
Sussex IFCA fisheries management
Emsworth – open - under oyster permit byelaw – onward sale permitted
Thorney – open – but due to FSA standard cannot be sold into human food chain
Chichester Channel – closed - not open to fishing due to IFCA management (native oyster brood stock for harbour)

Annex 10. Seafish methods, caveats and full results

Vessels included in the analysis

The original vessel lists were supplied by Sussex IFCA on April 2019, based on sightings of vessels working in the proposed exclusion areas.

It was noted the lists may not be comprehensive or represent a complete picture of the vessels that operate in the proposed exclusion areas.

Four lists were supplied, based on four different groups of vessels, which have been combined with Seafish segmentation to obtain the following groups:

Group 1 Netting vessels sighted in the trawling exclusion area belonging to the Seafish segments 'Under 10m drift and/or fixed nets' and 'Gill netters'

Group 2 Trawling vessels sighted in the trawling exclusion area belonging to the Seafish segments 'Under 10m demersal trawl/seine', Area 7B-K trawlers 10-24m' and 'South West beamers under 250kW'

Group 3 Potting vessels sighted in the trawling exclusion area belonging to the Seafish segments 'Under 10m pots and traps', 'Pots and traps 10-12m' and 'pots and traps over 12m'

Group 4 Vessels sighted in the netting exclusion area belonging to the Seafish segments 'Under 10m drift and/or fixed nets'

The year of sighting was not specified. Hence each group contains a list of vessels sighted in the corresponding exclusion area at least once in the period 2014-2018.

Seafish segments are allocated based on the main gear used (by number of days at sea). Vessels can use other gears during the year in addition to the main gear.

For a detailed description on how Seafish segments are defined, please refer to Table 7 of our 'Economics of the UK Fishing Fleet' report available at: https://www.seafish.org/article/fleet

The vessel names and PLNs supplied were cross-checked against the MMO vessel list.

A very small number of vessels changed name and/or PLN during the study period.

Inactive and low activity vessels have been excluded from the analysis.

- Inactive vessels are those which did not make any landings on the given year.
- Low activity vessels are those that landed under £10,000 on a given year. Many are part-time businesses for which Seafish does not hold complete financial information (only on the fishing side of the business).

Hence the number of **vessels in a group can vary from year to year** as a vessel can go inactive/low activity in a particular year, and return in a later year.

In addition, a vessel can move between groups on different years, if their main activity changes from one year to another. (for example, a vessel can belong to Group 1 on a given year, and to Group 3 the following year).

The tab 'Economic data' shows financial data for each group of vessels. For each year the table shows:

- Number of vessels in the group
- Average weight landed per vessel in the group (tonnes)
- Average value landed per vessel in the group (£)

- Average turnover per vessel (sum of fishing and non-fishing income such as tourist trips, etc) (£)
- Average operating costs per vessel (£)
- Average operating profit per vessel (turnover minus operating costs) (£)
- Average net profit per vessel (after depreciation) (£)

The above are annual figures. We are not able to estimate how much of annual income, costs and profit derives from their main gear used, or from the proposed exclusion zones.

Tabs 'Group 1 to 4_landings' show landings data for each group of vessels. For each year the table shows:

- Total combined weight of landings by all vessels in the group, by species (tonnes)
- Total combined value of landings by all vessels in the group, by species (£)

All monetary figures above are adjusted for inflation to the year 2018.

Adjusted values are calculated using Gross Domestic Product deflators consistent with DEFRA publications.

Further details on this method can be found on the HM Treasury website (https://www.gov.uk/government/collections/gdp-deflators-at-market-prices-and-money-gdp).

All values have been estimated based on MMO effort and landings data and economic sample data collected by Seafish.

2018 values are projections based on MMO landings and effort data in 2018, observed monthly fuel price in 2018 and Seafish economic sample survey for 2017.

Methodology

Seafish produces this dataset by combining costs and earnings information from vessel accounts provide by vessel owners to the annual Seafish UK Fleet Survey with official effort, landings and capacity data for all active UK fishing vessels provided by the UK Marine Management Organisation (MMO).

The outputs for all years are produced using a consistent methodology and fleet segmentation criteria so that trends in key indicators can be observed over time. Note that vessels can be in different segments in different years if they change their gear, area or target species.

First developed in 2008, the methodology was used to produce single year estimates that were reported in the 2008, 2009 and 2010 Seafish economic survey reports of the UK fishing fleet.

The methodology was again revised in February 2013. The revision involved changing the way that the sample cost structure for each fleet segment was calculated, resulting in a more robust approach when dealing with outlying (far from average) cost data.

This is a summary of the method we use to estimate the earnings, cost structure and profits of the UK fleet and fleet segments:

1. The UK fleet is stratified into approximately 30 relatively homogeneous fleet segments using MMO data on capacity, effort and landings for each vessel (see segmentation criteria worksheet)

2. Seafish uses a self-selecting stratified sampling approach to obtain an adequate sample size of vessel financial accounts for each fleet segment

3. Costs and earnings data from vessel accounts are allocated to particular fleet segments following the segmentation procedure, giving approximately 30 costs and earnings segment samples. Sample sizes for vessel

accounts in each fleet segment and each year can be found at the end of this workbook.

4. To estimate the cost structure of all vessels in each fleet segment, we:

a) add together the individual cost and earnings items from vessel accounts within each segment sample to create a 'combined segment sample cost structure'.

b) calculate the sum of each cost item in the 'combined segment sample cost structure' as a proportion of the sum of fishing income e.g. sum of gear cost is 10% of sum of fishing income, sum of commission is 3% of sum of fishing income etc.

c) calculate fuel costs and crew costs differently from the other costs. For crew share, we give a minimum £100 per day in instances where the actual observed amount within the 'combined segment sample cost structure' is lower. For fuel costs, the capacity (VCUs) and monthly fishing effort (days at sea) of each vessel are used to estimate monthly fuel consumption in litres, which is then combined with the average monthly red diesel price (excluding duty) to calculate the fuel cost estimates for each vessel. (Please note this method was updated March 2018)

d) Following calculation of fuel cost and crew share, we apply the proportions from all the other costs within the 'combined segment sample cost structure' to the official declared fishing income for each vessel within each fleet segment, which enables us to calculate Gross Value Added, operating profit and net profit for each vessel.

5. UK fleet totals and fleet segment totals and averages are then calculated from the estimates produced for each vessel.

Where we have low sample size for a particular segment in a particular year we take into account previous years' estimates along with the reference year fuel price data to estimate costs.

Annex 11. Extent and percentage of each habitat natural capital asset that falls within current demersal gear management areas and MPAs, and the additional extent of habitat within the proposed nearshore trawling exclusion area.

										Extent (kmsq) with management to reduce benthic impact in			Extent (kmsq) with management measures to reduce		
Natural capital asset - habitats		Extent (kmsq) of habitat in whole District	% of whole District	Extent (kmsq) of habitat within proposed management areas (1km from MHWS along coast, 4km Selsey to Shoreham) (309.8kmsq)	% of habitat area in whole District which is within proposed management area	Extent (kmsq) of habitat within proposed management areas (14threequarters1 + SBatH) (304kmsq)	% of habitat area in whole District which is within proposed management area	Extent (kmsq) in MPAs in proposed management areas	Extent (kmsq) in MPAs in whole District	Current trawling exclusion byelaw (extends to SFC boundary) (64.75 kmsq)	Scallop 3nm exclusion (958.80 kmsq)	Oyster dredging permit (30.44kmsq)	Current trawling exclusion byelaw (64.75 kmsq)	Scallop 3nm exclusion (958.80 kmsq)	Oyster dredging permit (30.44kmsq)
Littoral coarse sediment	A2.1	1.28	0.07%	1.28	99.97%	1.28	99.97%	0.51	0.51	0.83	1.28	0.00	0.83	0.78	0.00
Littoral sand	A2.2	1.54	0.09%	1.54	99.97%	1.54	99.97%	0.76	0.76	0.13	1.54	0.63	0.13	0.78	0.63
Littoral mud	A2.3	0.32	0.02%	0.32	100.00%	0.32	100.00%	0.32	0.32	0.00	0.32	0.32	0.00	0.14	0.32
Littoral mixed sediment	A2.4	0.03	0.00%	0.03	99.37%	0.03	99.37%	0.03	0.03	0.00	0.03	0.03	0.00	0.00	0.03
Infralittoral rock (and other hard substrata)	A3	4.80	0.28%	3.74	77.97%	3.45	71.90%	1.24	1.99	1.23	3.74	0.00	1.23	4.77	0.00
High energy infralittoral rock	A3.1	9.82	0.56%	5.02	51.08%	5.52	56.26%	1.55	1.84	0.80	5.02	0.05	0.80	9.66	0.05
Moderate energy infralittoral rock	A3.2	49.04	2.81%	35.77	72.94%	36.87	75.18%	3.71	4.00	1.79	35.77	0.00	1.79	44.94	0.00
Low energy infralittoral rock	A3.3	4.76	0.27%	4.55	95.56%	4.55	95.56%	0.17	0.17	0.15	4.55	0.00	0.15	4.49	0.00
Features of infralittoral rock	A3.7	4.62	0.26%	1.02	22.01%	1.02	22.01%	0.48	0.48	0.00	1.02	0.00	0.00	1.36	0.00
Circalittoral rock (and other hard substrata)	A4	12.92	0.74%	0.16	1.27%	0.16	1.27%	0.12	0.69	0.00	0.16	0.00	0.00	5.82	0.00
High energy circalittoral rock	A4.1	42.48	2.43%	1.27	2.99%	1.27	2.99%	0.81	4.90	0.77	1.27	0.00	0.77	8.34	0.00
Moderate energy circalittoral rock	A4.2	94.64	5.42%	11.57	12.22%	11.59	12.24%	7.07	25.74	3.73	11.57	0.00	3.73	54.39	0.00
Low energy circalittoral rock	A4.3	3.40	0.20%	0.54	15.76%	0.54	15.76%	0.10	1.50	0.40	0.54	0.07	0.40	1.93	0.07
Features of circalittoral rock	A4.7	46.47	2.66%	3.19	6.88%	3.20	6.88%	0.24	0.32	0.08	3.19	0.06	0.08	11.80	0.06
Sublittoral sediment	A5	65.79	3.77%	4.64	7.06%	4.60	6.98%	1.66	28.20	1.35	4.64	0.00	1.35	45.82	0.00
Sublittoral coarse sediment	A5.1	317.20	18.17%	10.39	3.28%	10.45	3.30%	5.77	96.89	4.50	10.39	0.08	4.50	92.65	0.08
Sublittoral sand	A5.2	455.08	26.06%	48.80	10.72%	43.50	9.56%	32.43	178.36	23.84	48.80	3.65	23.84	246.68	3.65
Sublittoral cohesive mud and sandy mud communities	A5.3	14.87	0.85%	2.77	18.62%	2.77	18.62%	2.70	9.66	0.00	2.77	2.73	0.00	6.41	2.73
Sublittoral mixed sediment	A5.4	206.63	11.83%	33.84	16.38%	33.29	16.11%	7.90	59.26	2.49	33.84	2.91	2.49	153.27	2.91
Sublittoral macrophyte-dominated communities on sediments	A5.5	65.27	3.74%	40.74	62.43%	40.75	62.44%	0.35	1.03	0.00	40.74	0.00	0.00	53.10	0.00
Sublittoral biogenic reefs on sediment	A5.6	33.60	1.92%	0.89	2.63%	0.59	1.77%	0.59	3.22	0.64	0.89	0.00	0.64	3.02	0.00
Mosaic	x	311.56	17.84%	94.94	30.47%	94.88	30.45%	46.16	82.66	15.24	94.94	19.91	15.24	200.58	19.91
	Total	1746.12		307.01		302.16		114.69	502.52	57.98	307.01	30.44	64.75	958.80	30.44
				18%											
												395.43			1053.99
															1556.51

Annex 12. Method underpinning condition proxy from sensitivity-pressure approach for abrasion impacts from demersal fishing, as adapted from the North Devon Marine Pioneer Project methodology and limitations of the approach.

Intersect habitat-ES-sensitivity layer with data on fishing intensity. Fishing effort/exposure levels were coded and combined spatially with the sensitivity information. Combinations of sensitivity and exposure levels were then used to indicate the likely impacts to benthic habitats, and their likely relative condition as a result.

Next steps could be to intersect the LRC layer with spatial boundaries of management measures (MPAs and fishery byelaws) and areas aggregated by broad ES classes to examine extent and condition under management, as conducted within the NDMP.

Lowest 3 categories classified as moderately degraded to poor i.e. impaired quality. In Sussex, no 'good' category currently as misleading, just equates to areas where no known trawling activity based on sightings data. No 'not sensitive' habitat identified in Sussex which would have also been assigned good category within the NDMP. Note that 1) other abrasive impacts within the area are not taken into account 2) sightings data does not provide a complete picture of the level of trawling activity, just what vessels sighted when enforcement vessel is out.

For the category splits a geometrical interval classification was used which is defined as: The class breaks are based on intervals which have a geometrical series. A constant coefficient multiplies each value in the series, e.g.: 0.3, 0.9, 2.7, 8.1 has a coefficient of 3. It is specifically designed for skewed data.

Table 28. Combination matrix for Impacts due to habitats sensitivity and pressure exposure, and inferred Likely Relative Condition (LRC) due to impacts.

Sensitivity	Exposure			
	None	Low	Moderate	High
NS	None	None	None	None
L	None	Low	Low	Moderate
M	None	Low	Moderate	High
H	None	Moderate	High	Very High

⇒

Sensitivity	Exposure			
	None	Low	Moderate	High
NS	Good	Good	Good	Good
L	Good			↓
M	Good			↓
H	Good	→	→	Poor

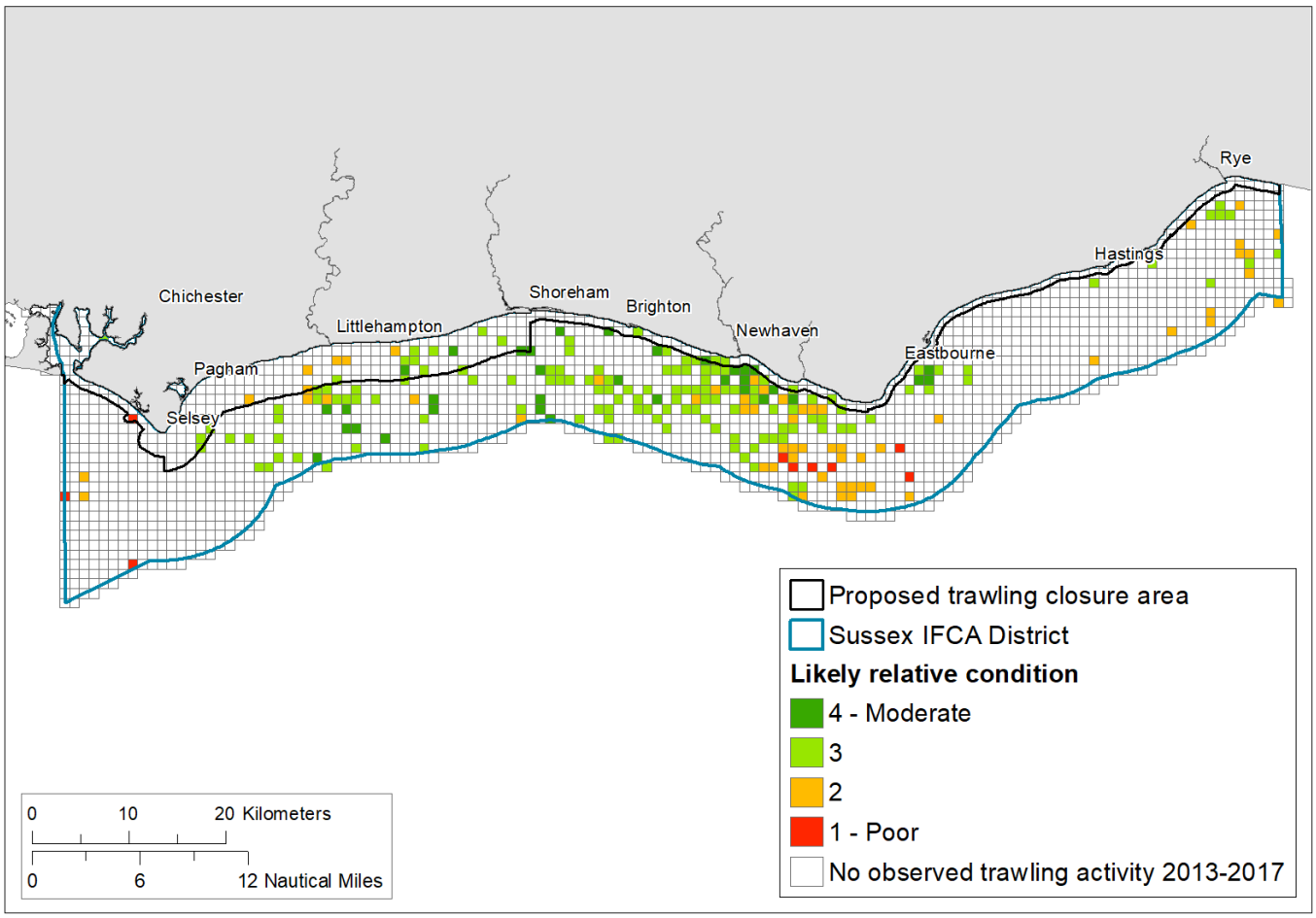


Figure 29 Likely Relative Condition (LRC) due to impacts from abrasion, as inferred and adapted from the sensitivity -pressure approach developed in Rees et al. (2019), based on sensitivity and trawling pressure alone.

*Note: Map only includes trawling abrasion pressure from those vessels sighting by IFCA within the District. It does not provide a complete picture of activity level or include other abrasive pressures, so represents an underestimate of degraded condition extent.

Limitations with the method, including those resulting in an underestimate of degraded condition extent:

- Does not include other fishing related abrasion impacts such as dredging, potting and anchoring.
- Excludes wider abrasive pressures such as aggregates and maintenance dredging.
- Fishing effort based on IFCA sightings data represents those vessels seen when the patrol vessel is out, it does not encompass all activity so will underestimate activity level.
- This is a work in progress and has been adapted from the NDMP, it only shows data for where there is known trawling activity based on sightings data.
- Temporal and spatial resolution of activity data. Mapping at a District-wide scale loses detail would see at a finer scale.
- Habitat extents are modelled thus areas of sensitive habitat may be under represented.
- Habitat types based on recent ground truth data and therefore on potentially already degraded habitats with associated lower sensitivity ratings.
- Combination of uncertainty measures across methods.
- Application of sensitivity assessments to broad scale habitat levels.

Annex 13. Timetable of Nearshore Trawling Review and Respective Committee Meetings

Date	action	comment
2013	Through consultation the Authority established its approach to reviewing existing management. Themes included trawling.	Review of management
7th December 2017	Scope and content of informal consultation presented.	Technical Subcommittee informal consultation phase
25th January 2018	Scope and content of informal consultation presented.	Quarterly Authority meeting informal consultation phase
21st March 2018	Informal consultation documents and consultation plan presented. Document included fishery background, IFCA review of management, sustainability issues, habitat evidence, rational for intervention, policy objectives and proposed management options.	Technical Subcommittee informal consultation phase
26th April 2018	Informal consultation documents and consultation plan presented.	Quarterly Authority meeting informal consultation phase
June 2018	Informal consultation with stakeholders including seven drop in sessions, online survey and paper & electronic questionnaires.	Informal consultation
9th July 2018	Analysis of the informal consultation responses presented. Other evidence sources presented. Draft management options presented.	Technical Subcommittee
26th July 2018	Analysis of the informal consultation responses presented. Draft management options presented.	Quarterly Authority meeting Management options phase
2nd October 2018	Final management options presented to quarterly committee, together with a summary of the consultation responses.	Technical Subcommittee
1st November 2018	Final management options presented to quarterly committee, together with a summary of the consultation responses.	Quarterly Authority meeting Management options phase
10th January 2019	Draft final management options presented including; a review of approach, habitat evidence, fishery evidence, essential fish habitats, environmental impact of trawling evidence, comprehensive supporting legislation, charts, rationale for intervention and policy objectives.	Technical Subcommittee
24th January 2019	Draft final management options presented to quarterly committee. Including a review of approach, habitat evidence, essential fish habitats, comprehensive supporting legislation, charts and proposed management measures.	Quarterly Authority meeting Management options phase
21st March 2019	Management option and draft byelaw text options presented to technical subcommittee, including summary matrix and charts.	Technical Subcommittee
25th April 2019	Management option and draft byelaw text options presented to quarterly committee. Including revisited option on light otter gear definition removal.	Quarterly Authority meeting Management options & byelaw phase. Commercial industry present as observers.

Date	action	comment
27th June 2019	Draft byelaw and options presented to technical subcommittee, including Tranche 3 MCZ information, bass information, charts, evidence summaries and working draft Impact Assessment.	Technical Subcommittee
27th June 2019	Draft byelaw presented to technical including Tranche 3 MCZ information, bass information, charts, evidence summaries and working draft Impact Assessment.	Quarterly Authority meeting To make the byelaw. Commercial industry present as observers.
25th July 2019	Byelaw text and draft Impact Assessment presented, including policy summary, charts, key concepts summary, kelp information, trawling fleet summary. Byelaw was made.	Quarterly Authority meeting Byelaw made
24th October	Initial formal consultation summary and next step plan for byelaw process presented along with consultation materials.	Quarterly Authority meeting