Subordinate legislation - The Sea Fish (Prohibition on Fishing) (Firth of Clyde) Order 2024

Correspondence from Robert Younger, 27 February 2024

Dear Sir or Madam

I write with respect to the discussion by the Rural Affairs Committee of the Sea Fish (Prohibition on Fishing) (Firth of Clyde) Order 2024 which is to be debated by the committee tomorrow 28 February 2024.

The Order bans all forms of fishing (including both Nephrops creel and Nephrops trawl) within a prescribed area, is aimed at the recovery of Firth of Clyde whitefish populations.

In considering this matter we would urge the committee to bear in mind the following:

1. The best available scientific research carried out by via Clyde 2020 Research Advisory shows a link between the Clyde Nephrops trawl fishery and Clyde whitefish populations. The clear advice given by Professor Heath based on work of PhD student Ana Adao is that bycatch mortality resulting from the Nephrops trawl Fishery is a significant factor in the lack of recovery of the whitefish stocks in the Firth of Clyde (see enclosed abstract of Current status of whitefish stocks in the Firth of Clyde (West coast of Scotland) Ana Adao, Robin Cook, Tanja Meithe, Liz Clarke and Michael Heath.
2. Professor Heath advises that the current ‘cod box’ is “necessary [but] it is by no means sufficient to promote recovery of the cod stock”. In other words, the spatial extent of the existing closure of the Nephrops trawl under the existing order is insufficient to allow cod stocks to recover. (see p18 of Mike’s presentation to the Clyde 2020 group which I believe is similar to a presentation he made to the Rural Affairs committee.
3. There is no evidence to suggest that creel fishing has any impact whatsoever on cod stocks and this method of fishing should never have been included in the closure. For interest I enclose a recent work done by Bangor University comparing the impacts of Nephrops trawl and Nephrops creel fishery.
4. If it is agreed that there is no evidence that Nephrops creel impacts on white fish populations then it should also be agreed that any loss of fishing opportunity resulting from spatial restrictions on Nephrops trawl could be replaced by Nephrops creel.

I hope this is of interest.

With thanks

Your faithfully

Robert Younger

Clyde 2020 Member

Director Scottish Creel Fishermen’s Federation

Clerk Argyll District Salmon Fishery Board

Director Fisheries Management Scotland

Member FMAC Inshore Committee

Solicitor Fish Legal

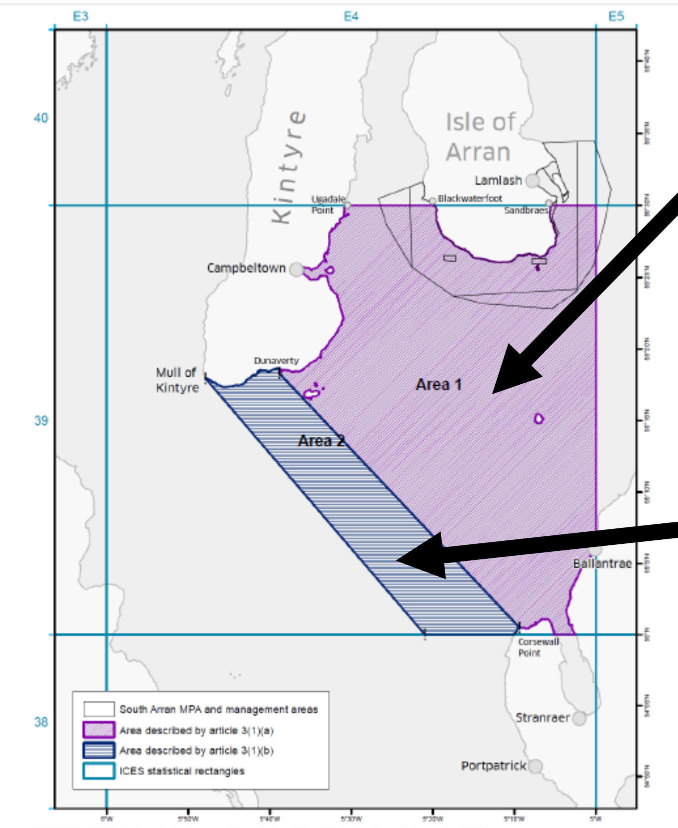
C2020 - 7th April 2022

Clyde Cod Box Closure

update on recent events

Mike Heath, University of Strathclyde

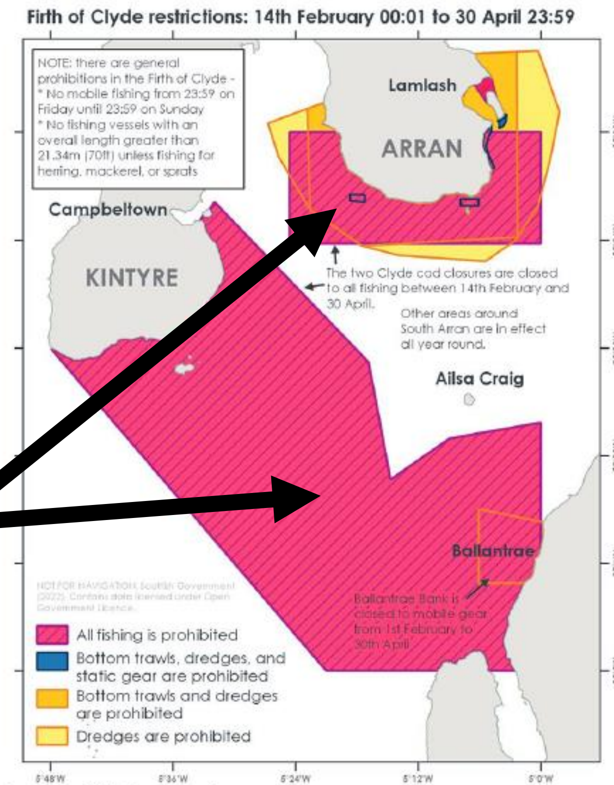
Clyde cod spawning closure 2001-2022



Fishing prohibited 14th Feb – 30th April, **EXCEPT** Nephrops trawls, Scallop dredges and creels

All fishing prohibited 14th Feb – 30th April

2001-2021



Source: Scottish Government

2022

Cabinet Secretary **Mairi Gougeon**

- “I accept that the process around the closure has been far from ideal, and I sincerely apologise for that.”
- “On this occasion, our approach has fallen short of our co-management principles and practice. It has been a really complex issue to balance, and we will ensure that we learn the lessons from the way in which this closure has been managed.”
- “Nevertheless, I believe that we have made the right call in adapting the closure this year and that the measures that we have put in place offer better protection for spawning cod.”

Issues covered in this talk

- Why was the cod box implemented in 2001?
- Background to the change in 2022?
- Is the cod box sufficient to promote recovery of the cod stock?
- What research needs arise from the cod box drama?

Science behind fish spawning closures

Key article:

van Overzee, H.M.J & Rijnsdorp, A.D. (2014). Effects of fishing during the spawning period: implications for sustainable management. Reviews in Fish Biology and Fisheries 19pp. DOI 10.1007/s11160-014-9370-x

Spawning closures may be of benefit it they:

1. Reduce the overall fishing mortality of the large and older spawners;
2. Avoid negative effects on spawning activity;
3. Avoid negative effects on spawning habitats;

- The contribution of spawning closures differs among species.
- Role of closures depends on the complexity of the spawning system, the level of aggregation during spawning, and the vulnerability of the spawning habitat.

What do we know about cod spawning in the Clyde?

- The Clyde sill is (or at least was) a regionally significant area where cod congregate each year to spawn;
- The sill area is not the only known spawning area inside the Clyde – other areas are in Loch Fyne, Heads of Ayr, south-west of Lady Isle, Girvan Bay, west of Pladda, and Ailsa Craig;
- The fish are particularly vulnerable to fishing during the spawning period – high CPUE is attainable even as the stock is declining;
- Tagging data show that the Clyde cod 'stock' is a self-contained unit;
- During 1960s-80s, very few cod tagged in the Clyde were ever been recaptured outside the Clyde;
- Tagged cod recaptured on the Clyde sill had been earlier released throughout the Clyde.

Big-picture story: cod gather from 'far and wide' to spawn on the Clyde sill, certainly from within the Clyde and maybe also from further afield in the Irish Sea.

Cod spawning aggregation on the Clyde sill

Catches of mature cod during 2005 and 2006 spawning season surveys conducted by the Northern Ireland Fisheries Laboratory

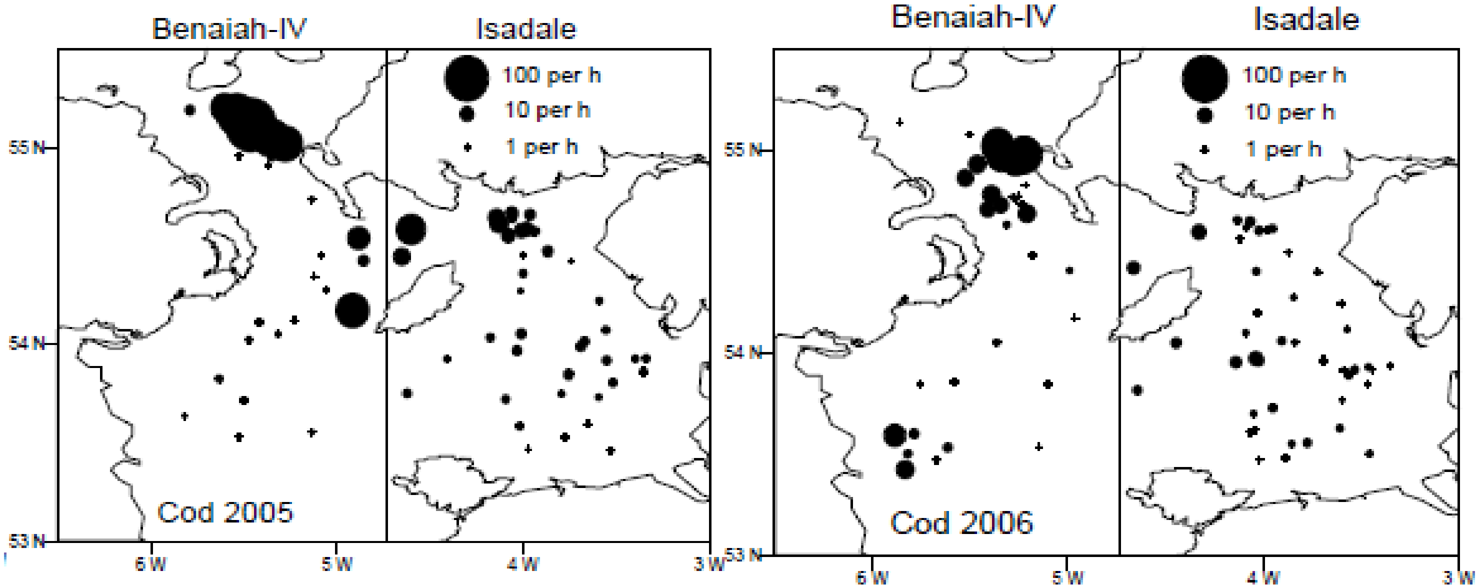


Figure 16.2. Catches of cod per hour of trawling during the spawning season; symbols marked at mid-tow positions with height proportional to catch per hour (Armstrong *et al.*, 2006).

The case for a Clyde cod spawning closure

- During 1986-2000 the majority of cod landings from the Northern Irish Sea and Clyde were taken from ICES rectangle 39E4 (The “cod box”, covering the Clyde sill) during March and April. Very high densities of spawning cod were found in this area;
- Closure of the Irish Sea to cod fishing in 2000 led to seasonal displacement of trawlers to the Clyde to target cod;
- Clear evidence of declining cod abundance;
- The original purpose of the spawning closure was explicitly to constrain overall fishing mortality on mature cod

EU STECF report 2007

COMMISSION OF THE EUROPEAN COMMUNITIES

Ispra, xxxxx.2007
SEC(2007)

COMMISSION STAFF WORKING DOCUMENT

EVALUATION OF CLOSED AREA SCHEMES (SGMOS-07-03)

SUBGROUP ON MANAGEMENT OF STOCKS (SGMOS), OF THE SCIENTIFIC, TECHNICAL AND ECONOMIC COMMITTEE FOR FISHERIES (STECF)

STECF OPINION EXPRESSED DURING THE PLENARY MEETING

OF 5-9 NOVEMBER 2007 IN ISPRA

This report does not necessarily reflect the view of the European Commission and in no way anticipates the Commission's future policy in this area

Table 16.1. Goals and objectives – Clyde cod closure

Goals	Specific objectives	Indices of success	Success criteria	Monitoring
Protection of adult cod during the spawning period	None explicit	None explicit *Required indices would be: fishing mortality on cod associated with catches inside and outside closure.*	*Extent of reduction in fishing mortality on mature cod attributable to closure.* *Local increase in SSB*	Research vessel derived indices of local SSB and Z.

The legislation which implemented the original cod spawning closure

- The 2001 Scottish Statutory Instrument (SSI) was limited to demersal trawl, seine or similar towed net, any gill net, trammel net, tangle net or similar static net or any fishing gear incorporating hooks between 14 February to 30 April
- Derogations were provided for fishing with gears appropriate for the capture of pelagic fish, molluscs and crustaceans.

What happened in 2022?

- Draft SSI (13 Jan 2022) removed all gear derogations in the cod box;
- The justification was that all forms of fishing up to 10m above the seabed cause disturbance to cod spawning behaviour and potentially reduce egg production;
- Amended SSI (1 February) revoked all restriction in a sub-area of the original cod box deemed to be unsuitable for cod spawning (but important for Nephrops fishing) based on seabed sediment types;
- The Rural Affairs and Natural Environment Committee called for evidence to conduct a review;
- Members of the Clyde2020 RAG and MASTS Fisheries Forum jointly submitted written evidence;
- Public oral evidence sessions held on 2nd March (industry, academic and NGO witnesses), 9th March (Cabinet Secretary and Marine Scotland witnesses).
- Official records at: https://archive2021.parliament.scot/parliamentarybusiness/ReportSelectPage.aspx?type=committee&year=2022&page=0&meeting=317

Cabinet Secretary **Mairi Gougeon**

- “We initially intended to continue those exemptions for 2022 and 2023, and we laid an SSI to that effect.”
- “However, on further reflection, we considered that the approach should be adapted and the exemptions removed. The stock has shown little sign of recovery under the present measures and there is evidence that any activity within 10m of the sea bed has the potential to disturb spawning cod. “
- “Moreover, removing exemptions brings the Clyde cod closure into line with other management measures in Scottish waters, including the national cod avoidance plan and measures in the Inner Sound.”
- “We therefore decided to remove the exemptions to increase the chances of boosting the west of Scotland cod stock …… “

Cabinet Secretary **Mairi Gougeon**

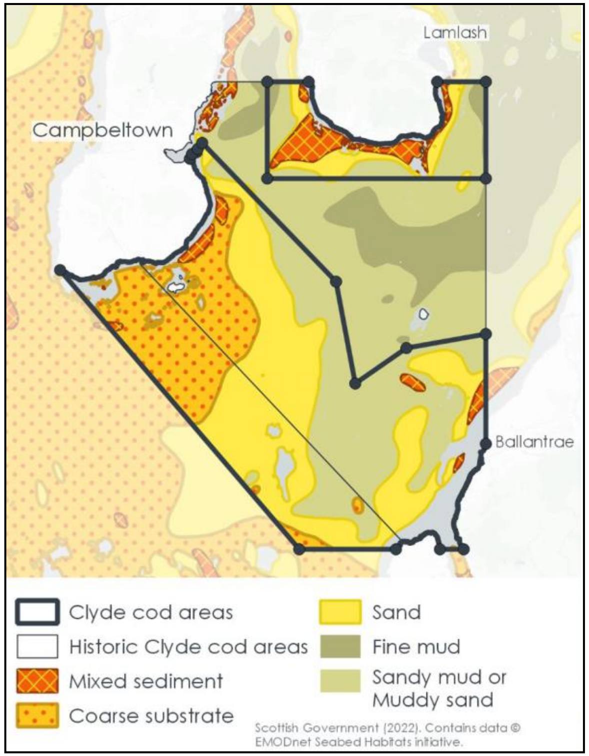
- "… on the basis of scientific evidence, we have made the closure more targeted, reducing its overall size by 28 per cent compared with previous years while providing comprehensive protection to the cod in areas where they are most likely to be spawning."
- "The revised closure areas are a pragmatic and evidence-based solution that reflects our commitment to protecting the spawning cod while, at the same time, mitigating potential socioeconomic impacts on our vulnerable coastal communities."

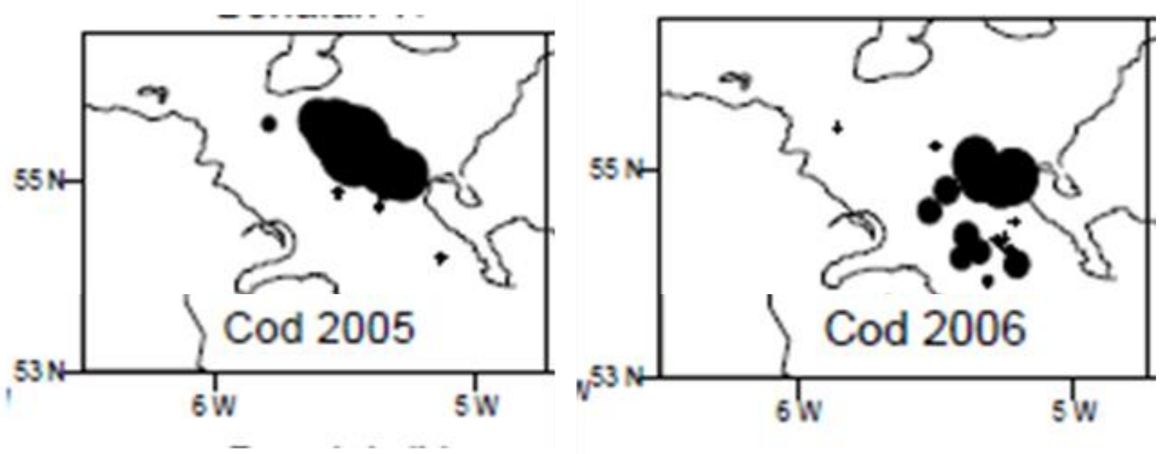
Science evidence used to justify the decisions

- **The mating behaviour of cod is easily disturbed, and if disturbed they may flee and not re-join the mating congregation;**
- **Atlantic cod mating activity occurs over coarse-grained seabed sediments, and not over mud.**

- These evidence strands are generic for Atlantic cod. They have been used here to justify a precautionary action. There has not been any local assessment of the evidence.
- Regarding creels, the case for disturbance of cod spawning seems particularly tenuous. No literature evidence specific to creels is cited.
- Maybe the deciding issue was that "*removing exemptions brings the Clyde cod closure into line with other management measures in Scottish waters, including the national cod avoidance plan and measures in the Inner Sound*."

What is the association between spawning cod and seabed sediments in the Clyde?





- ***Left*** *– Distribution of sediments relative to the original and revised closure box*
- ***Right*** *- Distributions of spawning cod in the 2005 and 2006 Irish surveys.*
- *Be interesting to eventually see the results from the 2016-2018 SOI/CFA surveys. How do they compare to 2005 and 2006 and what is the association between spawning fish, bathymetry and seabed sediments?*

Is the cod box sufficient to promote recovery of the cod stock?

- **Beatrice Wishart (Shetland Islands) (LD):** We have heard about the lack of historical data on and observation of Clyde cod. However, the Clyde box has been in place for 20 years now. Given that we seem to have got to this position today because of a lack of evidence and support, what has been happening for the past 20 years?

- **Mairi Gougeon:** I can probably answer for the activities that we are undertaking now and that we are looking to undertake. The policy objective that we are pursuing is the protection of spawning cod and, ultimately, boosting the numbers of cod in the Clyde. That is the objective that we are pursuing.

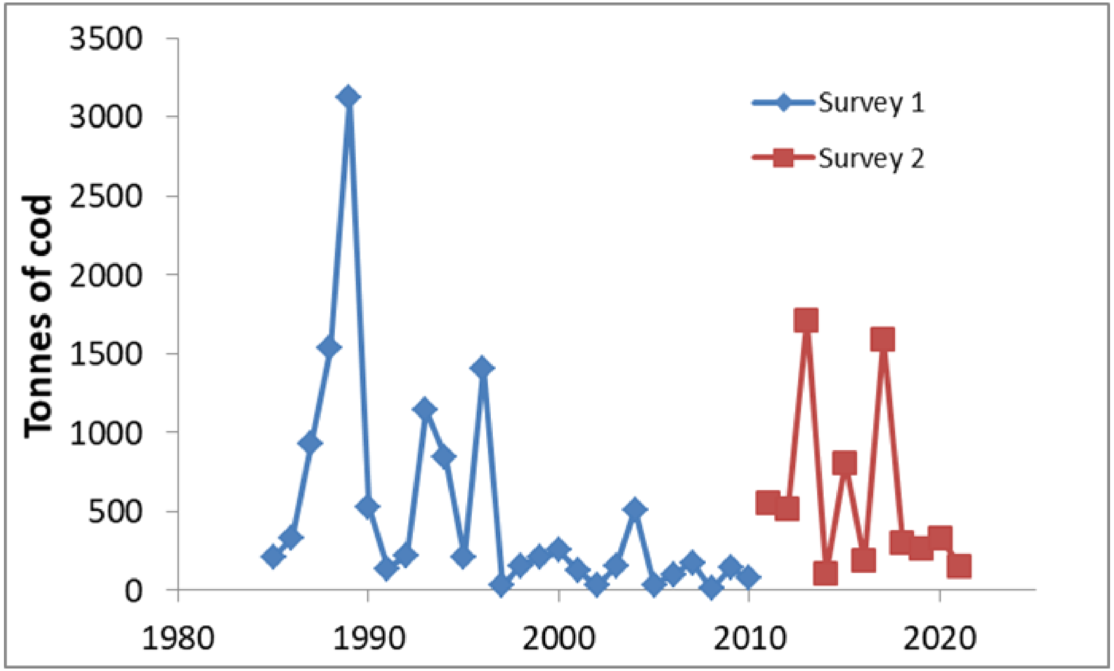
Is the cod box sufficient to promote recovery of the cod stock?

- **Beatrice Wishart**: "… We have all heard the evidence. We have also heard that, in the past 20 years, the cod stocks have not recovered. There is therefore an imbalance in the understanding of how the new approach will make any difference. I have to say that I am finding this issue extremely difficult."

Is the cod box sufficient to promote recovery of the cod stock?

- There is no evidence that 20 years of the cod box have led to recovery of the stock.
- The 2022 changes seem too trivial (biologically) to give any material prospect of greater impact
- But, removing the spawning closure would clearly be a terrible idea.
- The situation can be summarized as - ***"while the spawning closure is necessary it is by no means sufficient to promote recovery of the cod stock"***.

Raised swept-area estimates of Clyde cod biomass from the Marine Scotland west of Scotland Q1 survey



- *Direct biomass estimates from the survey are extremely uncertain;*
- ***The survey series is broken at 2011 due to a change in the survey design** (duration of each haul, and locations of sample hauls).*

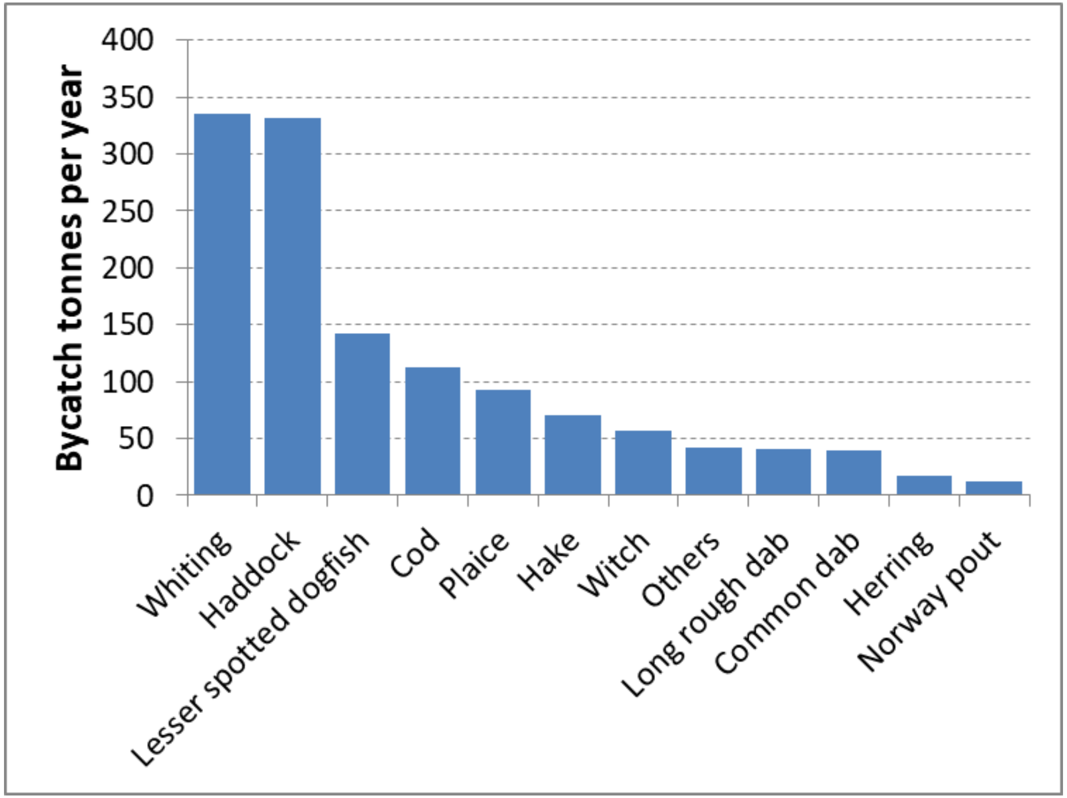
Current (total) stock is flat-lined at somewhere around 250 tonnes

Since there is no directed cod fishery in the Clyde, what other factors might be preventing stock recovery?

- Outward migration (but tagging data says not)
- Predation mortality (dogfish, seals..)
- Degradation of juvenile habitat (inshore ‘complex’ seabeds)
- Changes in growth conditions due to warming, nutrient conditions…
- Bycatch in the Nephrops trawl fishery

Of these, the only factor we can have any control over is the bycatch issue

What is the scale of the cod by-catch?



- MSS data for Clyde Nephrops trawl fleet bycatch derived from observer data

- 66 sampling trips during 2011-2017
- Annual average fish bycatch = 1292 tonnes (167kg/fishing trip)
- Annual average cod bycatch = 112 tonnes (14kg/fishing trip)
- Cod = approx 2% of Nephrops landings

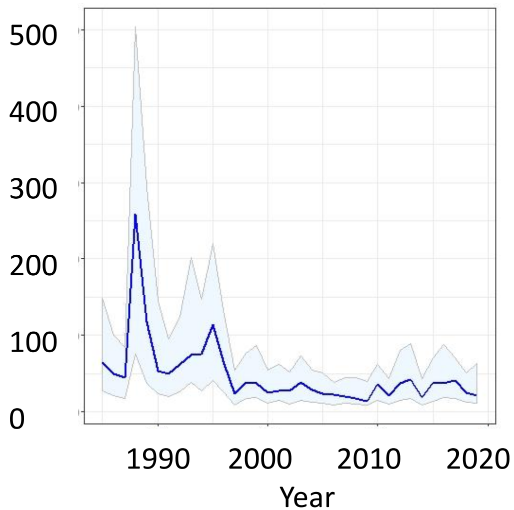
Back-of-the-envelope estimate of the proportion of the cod stock that is taken as bycatch

- The cod bycatch is mostly 1 & 2 year old fish;
- Assuming a typical length of 15-20cm, 100 tonnes corresponds to 1.5 - 2 million fish;
- Assuming a stock size of 250 tonnes, the stock is between 3.5 and 4.0 million fish;
- On face value, the bycatch is taking about 50% of the stock numbers per year;

- We need to do better than these rough calculation…

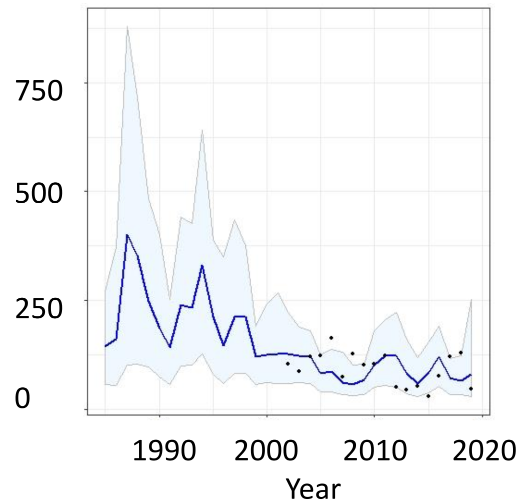
First draft Clyde cod stock assessment (Strathclyde & MSS – Phd studentship, Ana Adao)

Spawning stock biomass (tonnes)



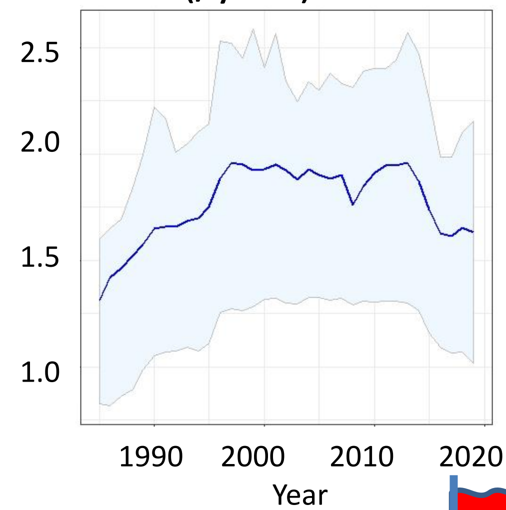
Post-2010 SSB = around 50 tonnes

Catch (tonnes)



Catch = all gears, not just Nephrops trawls (dots = recent observed bycatch data)

Fishing mortality rate (/year)

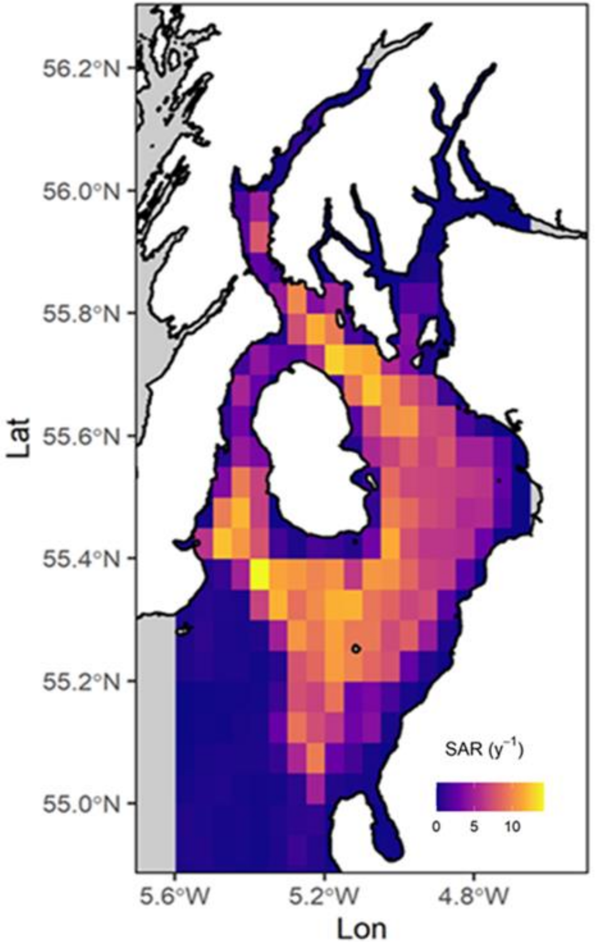


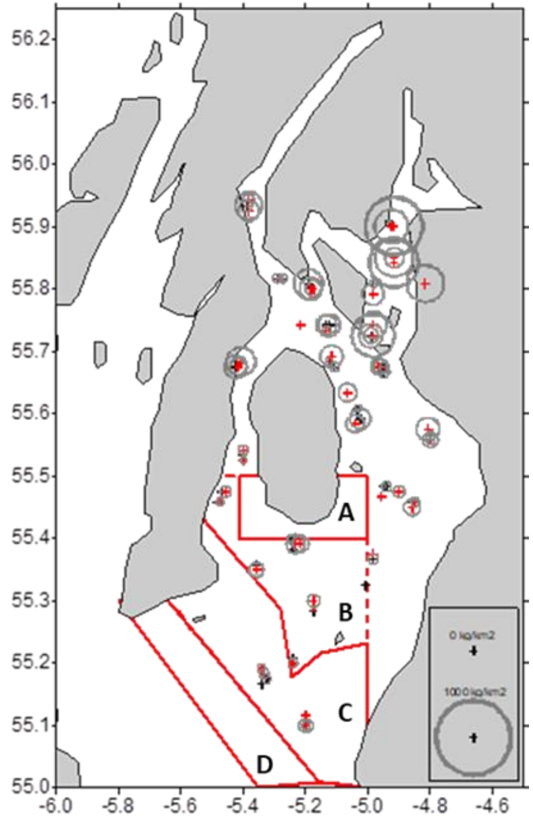
Fishing mortality >1 = 🚩

F_{MSY} would be around 0.3

These high F rates need checking .. Depend on natural mortality and survey size selectivity assumptions.

What could be done to alleviate cod bycatch?





- **Left**: 2009 – 2016 fishing swept area ratio
- **Right**: Immature cod distribution 1989-1990
- Scope for spatial management measures to minimise cod bycatch?

Research needs

- What proportion of cod spawning relevant to the Clyde is occurring in the closure area? A planktonic egg survey?
- Can we use acoustic data to get an impression of the distribution of cod spawning in the North Channel and Clyde (in collaboration with the Northern Irish Lab efforts)?
- Is there scope for some additional hauls in the Clyde during the MSS Q1 and/or Q4 surveys ?
- Can we get a comprehensive trawl survey of the Clyde to see what fish species and age classes are where, and to compare with the 1989/1990 surveys by RV Clupea?
- Spatial maps of byctach rates – compare with distributions of cod age classes
- Finalise the new stock assessment model and input data (Q1 and Q4 surveys, landings, bycatch by age classes) and apply to the main Clyde species (haddock, whiting, cod) (MASTS/SUPER PhD project – Ana Adao, supervised by Strathclyde & MSS)
- What can be done about the bycatch issue?

Smartrawl: a system to eliminate discards and bycatch in fisheries

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Abstract

Discards and bycatch (Fernandes *et al.*, 2011) are one of the main threats to fisheries sustainability. According to the most recent estimates (Pérez Roda, 2019), around 46% of total global annual discards (4.2 million tonnes), were from bottom trawls. In Europe, the practice is banned through the Landings Obligation, but there is no effective means of preventing it, so it continues more or less unabated (EFCA, 2019).

This presentation describes the Smartrawl, a technological solution to the problems of discards and bycatch. The system consists of a stereo camera, a computer, and an innovative gate, all of which are inserted into the trawl extension - the part of the trawl just before the cod-end (where fish are caught). The stereo camera takes images of fish passing by, and the computer, employing artificial intelligence algorithms, will then size these and identify them. Based on user selected preferences of species and size, the computer then sends a message to the gate to either close, thus catching the fish, or open, releasing the fish (or other animal) into the water, unharmed.

Crucial to the function of the system is an understanding of how quickly fish pass by. Trials have been conducted which have generated over 200,000 images which have been analysed. Fish passage rates ranged from 1 fish every 0.5 s to more typical rates of one fish every several seconds. Faster rates were associated with patches of small haddock, which are the most numerous demersal fish in the North Sea. The gate was, therefore, designed with a response time of 0.5 seconds. However, the provisional AI algorithms, by virtue of being run on the local, small PC, can take longer than that to run. The algorithms also need large numbers (several thousand per species) of high-quality images to be trained, and we also report how image quality has been improved.

The system is still in development, but most of the components have been built and tested. The presentation highlights the next steps and plans for further trials to test the system in the field.

Acknowledgements

The Smartrawl project has been funded by Fisheries Innovation Scotland, through their membership organisations, chief amongst which was Marine Scotland: all of their support is gratefully acknowledged. The system was designed with the assistance of Vivek Chacko (University of Aberdeen) and Richard Nielson (University of Aberdeen). John Polanski (Aberdeen) and Shaun Fraser (UHI) are thanked for running field trials.

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EFCA. 2019. Evaluation of Compliance with the Landing Obligation North Sea Demersal Species 2016-2017 Executive Summary. https://www.efca.europa.eu/sites/default/files/atoms/files/Executive%20Summary%20NS%20LO%20Compliance%20Evaluation%20Report%202016-2017%20August%202019.pdf (Accessed 5 August 2022).

Fernandes, P. G., Coull, K., Davis, C., Clark, P., Catarino, R., Bailey, N., Fryer, R., *et al.* 2011. Observations of discards in the Scottish mixed demersal trawl fishery. ICES Journal of Marine Science, 68: 1734–1742.

Pérez Roda, M. A. (ed). 2019. A third assessment of global marine fisheries discards. FAO Fisheries and Aquaculture Technical Paper. FAO, Rome, Italy. 79 pp. https://www.fao.org/publications/card/en/c/CA2905EN (Accessed 5 August 2022).

Current status of whitefish stocks in the Firth of Clyde (West coast of Scotland)

Ana Adao[1], Robin Cook[1], Tanja Miethe[2], Liz Clarke[2] and Michael Heath[1]

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[2] *Marine Scotland Science, Marine Laboratory, 375 Victoria Road, Aberdeen AB11 9DB, UK.*

The Firth of Clyde is one of the main grounds of the Scottish Nephrops (*Nephrops norvegicus*, or Norway lobster) trawl fishery. However, this fishery also catches demersal fish species such as cod, haddock and whiting. Almost 100% of fish bycaught is discarded due to trawlers not possessing licenses to land whitefish and the fish caught being below the minimum conservation reference sizes. Even though targeted fishing for whitefish ended in early 2000s [1], there are still no signs of cod and whiting recovery in the Clyde. One hypothesis is that fish discards in the trawl fishery for prawns is sufficient to maintain a high mortality rate on the stocks, thus hindering their recovery.
This study examines this hypothesis by estimating the quantities of cod, haddock and whiting discarded in the Nephrops fishery, and assessing the fishing mortality and current abundance of fish biomass.
We developed an age-structured stock assessment model that tracks annual cohorts of fish through time and uses the survey index information (as annual indices of relative abundance) and commercial catch data. The model can account for the high proportion of zero values in the data and was implemented using Bayesian inference through Markov Chain Monte Carlo algorithms for parameter estimation. The model was applied to the three main species of whitefish in the Firth of Clyde.
Results show high levels of mean fishing mortality (mean F>1) for all three stocks and low levels of spawning biomass (less than half of estimated catches), with a range of sensitivity tests all supporting this finding. The scale of the estimated mean fishing mortality might be unrealistically high because of migration effects out of the Clyde not accounted for in the model. Nevertheless, mean fishing mortality has decreased substantially for the three stocks within the last 10-15 years (up to 50% decrease), and is correlated, albeit weakly, with mean fishing mortality estimated by ICES [2] for adjacent stocks of the west coast of Scotland and the Irish sea. Despite this decline, it appears likely that mortality resulting from the Nephrops fishery is a significant factor in the lack of recovery of the whitefish stocks in the Firth of Clyde.

References

[1] Thurstan, R. H. and C. M. Roberts (2010). Ecological meltdown in the Firth of Clyde, Scotland: two centuries of change in a coastal marine ecosystem. PLoS One 5(7): e11767.
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Outer Hebrides Early Adopters and Creel Limitation Pilot Trials – A case study in inshore fisheries co-management

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In November 2020 Marine Scotland, in collaboration with the Western Isles Fishermen's Association and the Outer Hebrides Regional Inshore Fisheries Group, initiated two pilot projects to run in parallel for two years to:

1. Assess the potential to role out a low cost tracking system on 10m and under vessels (Early Adopters Pilot – EAP)
2. Introduce creel limits to reduce the increase in creeling effort (Creel Limitation Pilot – CLP)

These initiatives were linked as the 40 vessels involved in the EAP were also party to the CLP involving ~140 vessels.

The development of CLP was founded on calls from fishers in the Western Isles for limits to be set on the maximum number of creels that could be deployed by a vessel of given size. The fishers recognized the significant increase in creeling effort that had been taking place and needed to formalize with Scottish Government a mechanism to limit creeling effort.

The EAP was designed to further inform Marine Scotland's intention to introduce tracking of all commercial fishing vessels of 10m and under operating in Scottish coastal waters. The objectives of the EAP were to assess the operational challenges of equipping and monitoring the fishing activities of a subset of vessels involved in the CLP, including the development of novel processes to identify fishing activity and estimate creel numbers deployed. An App was also developed to encourage reporting of catch and landings that could be linked to fishing track.

The EAP and CLP have taken place against the backdrop of major political, economic and social challenge including EU Exit, the COVID-19 pandemic and now the cost of living crisis. Teasing out the, impacts, costs and benefits of the EAP and CLP within the context of such perturbations is challenging. The need to inform future policy in this area requires that we do so.

We will report on the progress of the EAP and CLP which is due to end in November 2022 and explore some of the lessons learned with respect to the development of co-management approaches in the context of the inshore fishery.

Acknowledgements

We gratefully acknowledge the support of Duncan Mckinnes and all members of the Western Isles Fishermen's Association and Outer Hebrides Regional Inshore Fisheries Group. Marine Scotland staff; Stuart Bell, Chloe Aird, Linda Blackadder, Kay Barclay and Jim Watson have provided invaluable support and guidance throughout. This work has been funded by Scottish Government.

Essential spawning grounds of Scottish herring: current knowledge, challenges and ongoing research

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Atlantic herring (*Clupea harengus*) helped to generate local income, identity, and societal change in Scotland for centuries. Their numbers on the west coast of Scotland have been in steady decline since the 1980s, but in spring 2018/2019, large herring shoals were observed on the west coast for the first time in decades, at a formerly important spawning ground. This highlighted the importance of maintaining suitable benthic spawning grounds, which these fish rely upon for egg deposition. However, information on exact location, characteristics, and status of historic and contemporary spawning grounds, if existing, is not easily accessible. We therefore performed an exhaustive literature search, dating as far back as 1884, using scientific databases, grey literature, a query for automated search of comprehensive historical reports, and fisher interviews (Frost and Diele 2022). We present current knowledge on Scottish herring spawning grounds and discuss challenges arising from methods currently used to recognize these grounds. Knowledge gaps regarding spawning season, as well as the location and environmental status of spawning grounds, particularly relevant for Scotland's west coast, are also identified.

Based on the importance of specific environmental variables for herring reproductive success, protection of herring spawning grounds should be, but currently is not, incorporated into marine management plans. This would require additional data on spawning grounds, including local ecological knowledge rarely considered. These knowledge gaps are now being addressed through the collaborative Edinburgh Napier University-led "West of Scotland Herring Hunt" (WOSHH) project, which seeks to identify and produce evidence for the conservation and potential restoration of herring spawning habitat on the west coast of Scotland. In addition to conducting interviews and collaborative field work along the Scottish west coast, WOSHH will shortly provide a new citizen-science 'herring hunt' web-app to help collect signs of spawning herring and aid the identification (and evaluation) of spawning grounds.

Healthy (and abundant) spawning grounds would increase the chance for herring to rebuild inshore populations (where and when possible), with potential positive social and economic impacts, as well as improve general biodiversity. A more inclusive and ecosystem-based approach to herring management, encompassing targeted actions to protect essential spawning habitat, would contribute towards Scotland's Blue Economy vision and Nature Positive commitments.

Acknowledgements

We thank all collaborators/ contributors. WOSHH is funded by the William Grant Foundation.

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Biomass and the Large Fish Indicator in a changing North Sea Ecosystem

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Recently, fish species richness in the North Sea has increased, driven by increased occurrence of species with an affinity for warmer waters (Lusitanian). This process is known as tropicalization, an increase in richness caused by movement of species from warmer and more diverse waters into historically cooler, less diverse waters. Evidence for this in coastal regions and in the North Sea is strong, though trends in abundance of Lusitanian species at the haul level has not been published previously. Therefore, it is important to investigate whether abundance of Lusitanian species has also increased alongside richness as this will likely have a greater impact on the ecosystem. Equally, little research has focused on how these changes may affect ecosystem health and current quality objectives. One such quality objective is the Large Fish Indicator (LFI). This is the proportion of fish above a specific length (50cm in the North Sea) within the total community. This has declined from historic baselines in the North Sea but has been recovering in recent years. Lusitanian species often grow faster, mature earlier, and reach smaller sizes compared with species from cooler waters. Since typically the North Sea was dominated by species from cooler waters (Boreal) the increase in occurrence of Lusitanian species has the potential to negatively impact LFI recovery and may mask recovery seen in Boreal species.

This paper looks to further investigate whether the recent increases in Lusitanian richness have also led to an increase in abundance (using biomass) and what impact, if any, this may have on the LFI. Data was taken from the International Bottom Trawl Survey for the North Sea between 1983 and 2020. Haul data was converted from number at length data into using weight-length relationships as reported in Fung et al. 2012. Biomass density was then calculated by dividing the calculated biomass by the reported swept-area (downloaded from ICES-DATRAS) as per the method used by OSPAR. Boreal (cold water) and Lusitanian (warm water) species were analysed separately to investigate how shifts in thermal affinity may impact these measures as the ecosystem changes.

Though biomass of both Lusitanian and Boreal species fluctuated between years, there was no clear increase in Lusitanian biomass over the study period. A slight declining trend was observed in Boreal biomass, though this is difficult to state definitively due to the fluctuating nature of the data. These fluctuations were largely driven by key commercial species such as whiting (Lusitanian) and haddock (Boreal). The beginnings of a recovery in the LFI was reported by OSPAR in 2017. Interestingly, this increase in the LFI after 2000 was seen in both Lusitanian and Boreal species. However, Lusitanian LFI was much lower overall than Boreal LFI (0.1 compared to 0.2 for Boreal).

This study suggests that increases in Lusitanian biomass have not been observed despite the increases seen in Lusitanian richness. However, the difference in the LFI between Boreal and Lusitanian species highlights the potential impact an increase in Lusitanian biomass could have on the overall LFI in the North Sea if this is observed in the future. The general utility of the LFI as a measure for fish community health in a changing North Sea is also discussed.

Acknowledgements

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Integrated system to improve inference of fishing activity from geospatial data

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Geospatial data obtained from vessel tracks is an important source of information with fisheries management and marine planning applications. These analyses can provide information on fishing grounds (Mendo et al., 2019) as well important measures of fishing effort. These data can improve the resilience of fishing industry by providing objective metrics by which to assess the impacts of management measures and spatial squeeze resulting from offshore renewable energy developments for example. Whilst (Mendo et al., 2019) use spatial data to reliably identify hauling events, identifying when gear is shot is more problematic as vessel spatial data provides few characteristics synonymous with this event. This makes it more difficult to calculate, for example, the time that the gear was in the water, which is important to understand fishing effort (Lifentseva, 2022).
In order to improve the prediction of the exact location of both hauling and shooting events an integrated system has been designed and is currently being tested on an inshore vessel deploying pots. The integrated system for inferring fishing activity consists of a tracking device, an Inertial Movement Unit (IMU) and two active Radio Frequency Identification (aRFID) tags. The tracking device provides GNSS position, speed and track. The IMU records the movement of the vessel in the 6 Degrees Of Freedom (DOF: linear surge, sway and heave; rotational roll, pitch and yaw) by measuring the acceleration with an accelerometer, the rotation speed with a gyroscope and the true heading with respect to magnetic north. The aRFID tags are placed inside the first and last creels in a string and communicate with the tracking device via Bluetooth indicating their presence whilst on board the vessel. Details are summarized in Table 1.

Table 1. Description of the elements within the ISIFA

Unit	Sensor	Data
Tracker	GNSS+GSM	Lat-Lon + speed ($m \cdot s^{-1}$)
	Accelerometer	ms^{-2}
IMU	GNSS+GSM	Lat-Lon
	Magnetometer	nanotesla
	Accelerometer	$m \cdot s^{-2}$
	Gyroscope	$rad \cdot s^{-1}$
aRFID	Bluetooth	Presence/Absence

As an example, Figure 1 plots the georeferenced points obtained during a fishing trip with the tracker (orange stars), and the IMU (black circles). Based on previous work, (Mujal-Colilles et al., 2022), tracker position reporting for these static gear vessels has been optimized to record location every 30 seconds which explains the differences in point density within Figure 1. Nevertheless, both the IMU and the Tracker yield similar geo-positional data.

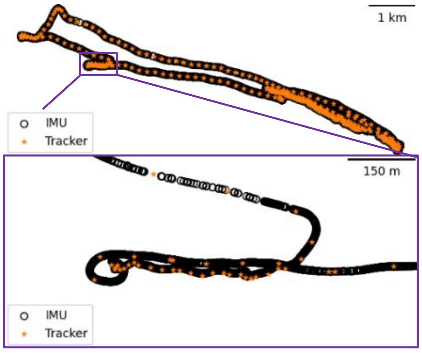

Figure 1. Comparison of the lat-lon points obtained by the two devices fixed at the vessel

Figure 2 is an analysis of the associated IMU data showing high resolution movement data. The grey section shows data associated with the fishing trip. During the hauling process, the magnetometer data has a specific pattern. By analyzing a combination of track and IMU data, with the time and position of hauling and shooting being validated through the aRFID tags, we hope to detect signatures in vessel movement that can be more reliably used to infer the deployment of fishing gear.

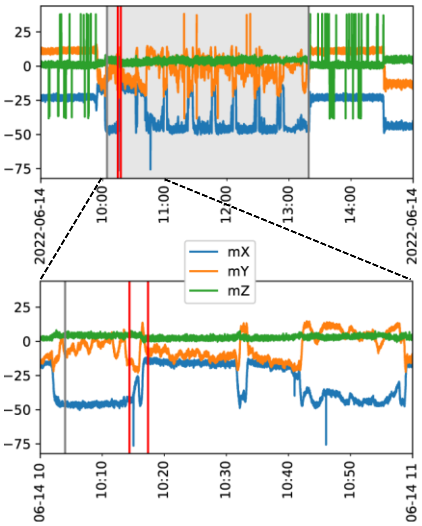

Figure 2. Three-component magnetometer data. Red lines indicate the presence of the aRFID onboard.

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Determining the impact of fishing on seabed habitats for *Nephrops* with trawls and creels around the United Kingdom

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Photo: a seabed image taken on the Fladen Ground in 2004, showing *Nephrops* burrows and a seapen *Virgularia mirabilis.* Photo credit: School of Ocean Sciences, Bangor University

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Abstract

The benthic impact and recovery of trawling and creel fishing was assessed for the *Nephrops norvegicus* fishery around the United Kingdom using the MSC Benthic Impact Tool (BIT). The BIT calculates the relative benthic status and recovery of habitats with an indicative MSC score calculated based on the time to recovery. The assessment was conducted for four regional assessment areas (Celtic, West of Scotland, northern North Sea, and North Sea) on commonly encountered habitats and Vulnerable Marine Ecosystem habitats (VMEs). Despite high impact on areas of the main *Nephrops* habitat (circalittoral mud) under TR2 and TR1 trawling, recovery is predicted to be rapid and no commonly encountered habitats scored below a suggested SG100 in the impact assessment as determined by the indicative MSC scoring. Creel fishing swept area ratio was estimated by combing several data sets, and was estimated to be no greater anywhere than 0.017 (i.e. less than 1% of the seabed disturbed) and resulted in no relative benthic status values lower than 0.99, and all commonly encountered habitats passing the impact assessment as determined by the indicative MSC scoring. The VME habitats assessment used two depletion scenarios which could be considered as low (0.06 and 0.14 for trawling and creel fishing respectively) and high (0.5) to account of a lack of direct estimates of depletion caused by passive gears. No VMEs scored a 'fail' MSC score for the creel fishing assessment. However, for TR2 trawling 'Sea-pen and burrowing megafauna communities' and '*Modiolus modiolus* horse mussel beds' did have assessment with suggested scores not reaching SG60 under different combinations of VME data layer and depletion values for the Celtic and West of Scotland assessment areas. This showed that the VME assessment is sensitive to the habitat layer and the depletion values used, both of which have uncertainty in the assessments conducted and merit future refinement and quantification.

Contents

1. Introduction

The Norway lobster, *Nephrops norvegicus*, is an important target species in UK and other European fisheries. Annual UK landings are between 20-30 thousand tons with a value of £116m (Seafood Scotland, 2021). *Nephrops* is primarily fished using bottom trawls and traps (known as creels).

Nephrops trawling is carried out using otter trawls. Otter trawls are towed over the seabed, and kept open by two heavy otter doors. There are two types of trawl being assessed in the is report. The TR1 trawl gear (BENTHIS gear grouping OT_MIX_CRU_DMF) (ICES Technical Service, 2018) has a mesh size greater than or equal to 100 mm and targets *Nephrops* but also whitefish. The second type is TR2 (BENTHIS gear grouping OT_CRU) (ICES Technical Service, 2018)and is the primary trawl gear targeting *Nephrops* around the UK. TR2 trawl gear has mesh size greater than or equal to 70 mm and less than 100 mm.

Bottom trawling is widely known to have a detrimental effect on the benthic marine invertebrate organisms and habitats that can be found in areas that experience direct contact with fishing gear. By removing and/or damaging infauna assemblages and sessile organisms, these activities reduce the habitat complexity and alter the community composition (Kefalas et al., 2003). The impact of trawling varies, depending upon the sensitivity of the species it interacts with. Most sensitive are organisms which are slow growing and long-lived, and those which form biogenic structures such as reefs. These structures enhance the biodiversity of the surrounding area and provide a functionally important role in the ecological and biological processes. Generally, longer living species have slow reproductive rates and thus future recruitment to their populations is reduced (Pianka, 1970). The type of seabed will also determine the level of impact fishing has on the habitat found in areas that are fished, as well as the intensity of fishing over such areas in short periods of time that prevent recovery (Auster et al., 1996; Hiddink et al., 2017).

The impact of creel fishing for seabed living target species has not been studied in much detail. There are several studies that have attempted to quantify the seabed impacts of traps, pots and creels, and these studies suggest that although there may be some impacts on the seabed, the magnitude of these impacts are likely to be smaller that those of mobile bottom gears (Eno et al., 2001; Gall et al., 2020; Lewis et al., 2009; Rees et al., 2021; Stephenson et al., 2017)

Here we assess the impact and quantify the interaction that *Nephrops* fishing has on the marine benthic habitats and some of the sensitive species which are present within four assessment areas. In order to obtain an MSC sustainability certification certificate, the MSC requirement is that habitats which are subject to fishing activity are not impacted beyond the point at which they could not recover to 80% (or more) of their unimpacted level within 5-20 years (Marine Stewardship Council, 2018).

The aim of the work that outlined in this report was to estimate the state and recovery times of commonly encountered habitats and VMEs in response to *Nephrops* fisheries using creels and trawls in Scotland and other UK *Nephrops* fishery areas, and provide an indicative MSC recovery score for each habitat and VME. The primary means of doing is using the Benthic Impacts Tool (BIT) developed by Bangor University for the Marine Stewardship Council. The BIT provides an indicative score by habitat type that can be used to inform the scoring of P2.4.1 in MSC assessments.

The scoring within the MSC Fisheries Standard is based on the probability that the state of each habitat in the assessed area will not recover to 80% of its unfished value within 20 years if fishing were to stop. The highest score, SG100, is awarded when the probability of the habitat failing to recover is <20%. SG80, is awarded when the probability is <30%. SG60, is awarded when the probability is <40%.

If the probability of the habitat failing to recover to 80% of its unimpacted level is >40%, the Unit of Assessment will fail on PI 2.3.1 (Table 2). These scoring guideposts provide a minimum recovery trajectory, and the indicative score generated by the tool should be considered in combination with other available information and to inform the scoring of a Unit of Assessment.

The BIT is based on a wealth of scientific information, which has been published in peer-reviewed journals (Hiddink et al., 2017, 2019; Pitcher et al., 2017; Rijnsdorp et al., 2018). The method incorporated in the tool has a relatively low demand for data layers, and combines insights based on ecological theory with the most robust available parameter estimates. The relative benthic status (RBS) is defined as the biomass B relative to the carrying capacity of the community K. RBS is derived by solving the logistic population growth equation for the equilibrium state (Pitcher et al., 2017). The effect of trawling depends on both the trawl mortality (depletion *d*) of a gear and the recovery rates (r) of the benthic community. The strength of the method used in this study are that the habitat impact is calculated spatially incorporating empirical data on the sensitivity and recovery times of the habitats impacted from spatially explicit fishing data.

Although the BIT was developed for mobile bottom gears, we also apply it here to assess the benthic impacts of the creel fisheries here by making several assumptions. This outcome of the assessment of the creel fisheries is therefore much more uncertain than the assessment of the trawl fishery, and we therefore made sure that the assumptions we made would result in a conservative assessment.

2. Methods

2.1. Benthic Impact Tool (BIT)

This tool uses a model that estimates Relative Benthic State (RBS) and its recovery. This model provides an opportunity for quantifying the impacts of bottom-towed gear on sedimentary environments. The approach has a low demand for data, and only requires maps of fishing effort and habitat type and their sensitivity. Data on the spatial distribution of fishing activity and benthic habitats are used to predict the relative benthic status (RBS) of habitats, and a predicted recovery trajectory over time if fishing were to cease. The tool, a manual and example datasets are available from the MSC website https://www.msc.org/what-we-are-doing/science-and-research/habitat-impacts-tool#:~:text=The%20MSC%20Habitat%20Impacts%20Tool,being%20objective%20and%20data%2Ddriven. Here we describe some of the key information about the application of the tool, but for further details we refer to the manual.

The RBS model parameters quantify the interaction between the gear and seabed biota and the recovery dynamics of this biota. The depletion rates have been quantified by meta-analysis for typical gear types (i.e., otter trawls, beam trawls and dredges) and broadscale sediment types (i.e., mud, sand and gravel), while recovery rates have been estimated in relation to the longevity of benthic biota. Therefore, the RBS of impacted habitats depends on the impact rate (depletion by gear), the recovery rate (of species within habitat) and the exposure to trawling (Pitcher et al., 2017). The outcome of the Benthic Impacts Tool provides an estimate of benthic status relative to an unimpacted habitat baseline.

An RBS score is calculated per habitat type per grid cell and the distribution of RBS and the mean value per habitat is generated for the assessment. Finally, the recovery trajectories for each habitat if fishing were to cease were estimated, leading to an indicative MSC score.

2.2. Data inputs

Some of the datasets for this work were readily available such as trawl swept area (SA) and benthic habitats. However, other data needed such as the distribution and SA of the creel fishery and biomass of benthic fauna were not readily available and needed to be calculated from multiple data sources.

2.2.1.Assessment Areas

The creation of assessment areas (AAs) for the benthic impact assessment is needed to both constrain the spatial extent of data layers to ensure the BIT can run, but also large enough to ensure the fishing activity and relevant habitats are included as required by the MSC standard. The size of the assessment area can influence outcomes of the mean RBS for a habitat and the associated recovery times, mainly through how much of a habitat that is commonly fished is included that extends beyond the extent of the fishing activity. In this study four assessment areas were made in consultation with MSC. The four assessment areas were based on ICES rectangles VIIa, VIa, IVa and IVb out to the UK EEZ, but extended to include *Nephrops* Functional Units 'Irish Sea West' and 'Botney Cut & Silver Pit' (Figure 1).

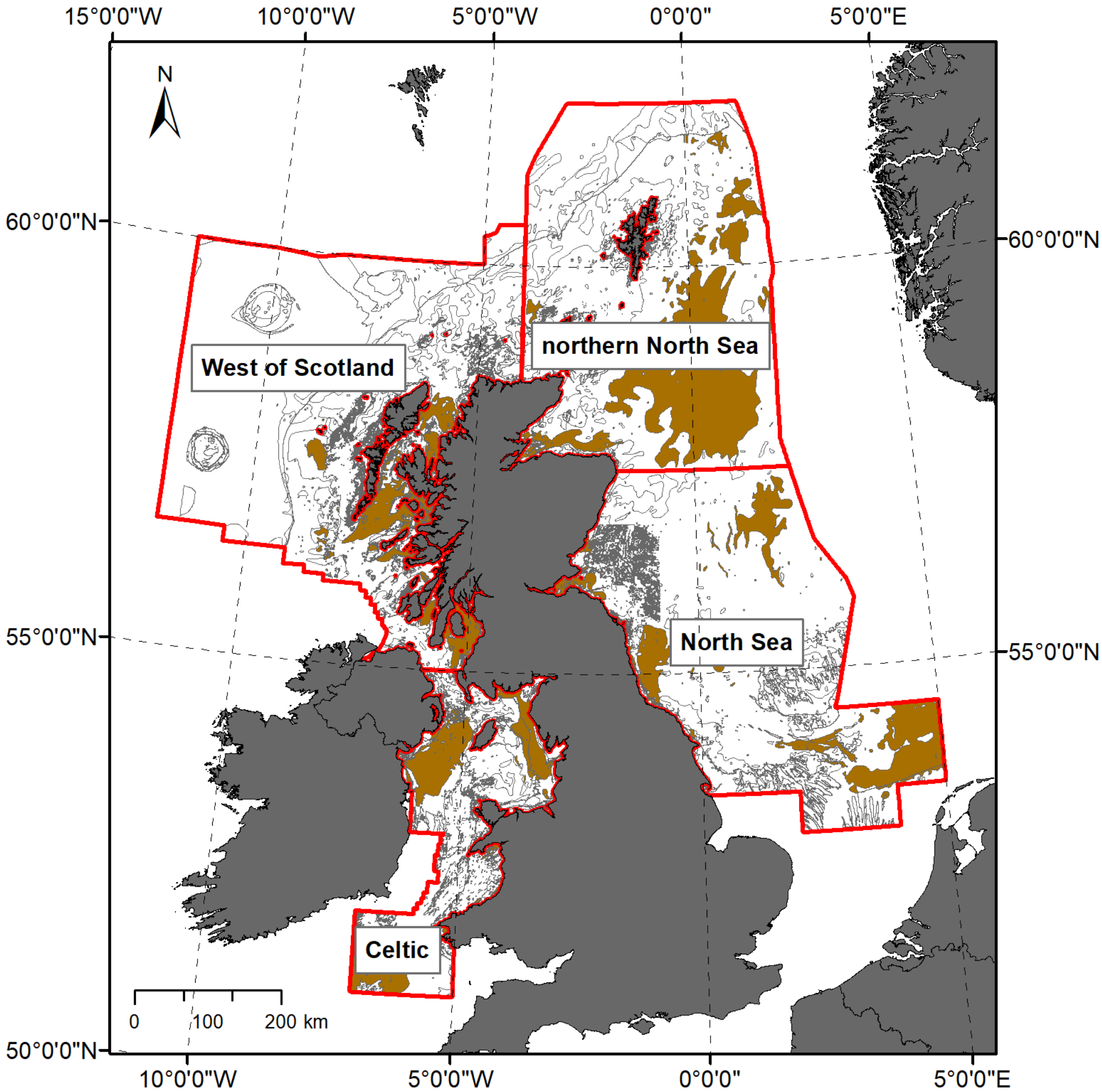

Figure 1. The four assessment areas (AAs) used to run the benthic impact assessments. The main *Nephrops* habitat of EUNIS A5.3 circalittoral mud is shown in brown, with outlines of other habitats shown in grey.

2.2.2.Commonly encountered habitats

Benthic habitat data (EUSeaMap 2021: EMODnet broad-scale seabed habitat map for Europe) was downloaded from EMODnet. This data provides EUNIS habitat classifications suitable for use in the BIT. Coverage of the habitat layer was almost complete for the assessment areas. The exception being some of the very nearshore areas and sea lochs, which is most limiting for the creel fishery assessment which occurs more inshore where no data exists. In addition, many sea loch and close inshore areas are area categorised as 'NA', as there is no EUNIS habitat classification but some other physical environment classification within the dataset. This 'NA' habitat was kept in the assessment as an RBS and recovery can still be calculated and is referred to as 'undefined' habitat in this report, with the caveat that 'undefined' habitat is likely to represent several actual habitat types.

The analysis used EUNIS level 4 where available (i.e., 'A5.37 Deep circalittoral mud'). This level is appropriate for P2.3.1, which requires an assessment at the level of 'commonly encountered habitat' (Marine Stewardship Council, 2018).

The main habitat that the *Nephrops* fishery occurs on is 'A5.37 Deep circalittoral mud' but fishing also occurs on other sublittoral mud (EUNIS A5.3) habitats and sublittoral sand (EUNIS A5.23 through to A5.27) where it borders deep circalittoral mud (Figure 2).

The EMODnet habitat data shapefile for the assessment areas contains a large number of polygons (> 200,000), which makes working with and processing the data slow and unreliable. During initial trials of using the BIT with the chosen assessment areas (AAs) it was realised that the data contained large amounts of very small polygons, with a large proportion of these polygons likely to be due to processing errors of the data during its creation. The habitat data in its 'raw' format would not work in the BIT and cause it to run out of memory because the habitat layer was >10Gb. Therefore, some simplification of the habitat data was needed and the method used can be found in section 15 of the BIT manual. The simplification does slightly reduce the total areas of some habitats, but for the habitats relevant to the *Nephrops* fishery this change was less than 0.5% compared to the unmanipulated habitat layer and so a necessary and deemed acceptable processing step.

2.2.3. Swept Area (SA)

The BIT needs swept area for each fishing gear (SA, in km^2) data for the fishing activity to run the benthic impact assessment. As part of the assessment the Swept Area Ratio (SAR) is calculated, which is the SA per year divided by the area of the assessment grid cell (0.05 x 0.05 degree cells). Therefore, a SAR of 2 would indicate that the area of the cell has been fished twice in a year.

2.2.3.1. Trawl swept area

Data on the swept area (cumulative area contacted by a fishing gear within a grid cell over one year) of trawl gear was obtained from ICES for the years 2012 – 2017 (ICES Technical Service, 2018) to a resolution of 0.05 x 0.05 degree cells. Data for both TR2 (OT_CRU Otter trawl for *Nephrops* or shrimp) and TR1 (OT_MIX_CRU_DMF Otter trawl for *Nephrops* and mixed fish) trawls were processed with BIT assessments run separately for each gear type as required by the MSC standard. TR2 trawling occurs throughout the assessment areas on most sublittoral mud areas (Figure 2) reaching higher SAR values than TR1 trawling, with TR1 trawling mostly occurring in the eastern North Sea and the Celtic assessment area (Figure 3). Following the recommendation of (WGFBIT, 2021) 6 years of fishing data was used covering 2014 -2017, which was then averaged to give one layer of swept area for each gear type. The year 2017 was the most recent year with available effort data. The spatial pattern of fishing activity is known to be relatively stable over time, in particular for fisheries targeting habitat specialists like *Nephrops*. The total amount of fishing effort for *Nephrops* is likely to have reduced since 2017, because the fishing mortality has dropped substantially for some of the stocks between 2017 and 2021, suggesting that our results are likely to be precautionary.

Some data for TR2 trawl gear and considerably more so in TR1 trawl gear data for the North Sea had been given swept area values of -9 by ICES to anonymise the data as three or less vessels had fished there. These -9 values were replaced with the median for each gear type of the swept area values > 0. This is likely to overestimate the fishing effort in most of these cells. The BIT calculates the swept area ratio (SAR) by dividing the swept area values provided in the data by the area of 0.05 x 0.05 degrees cells.

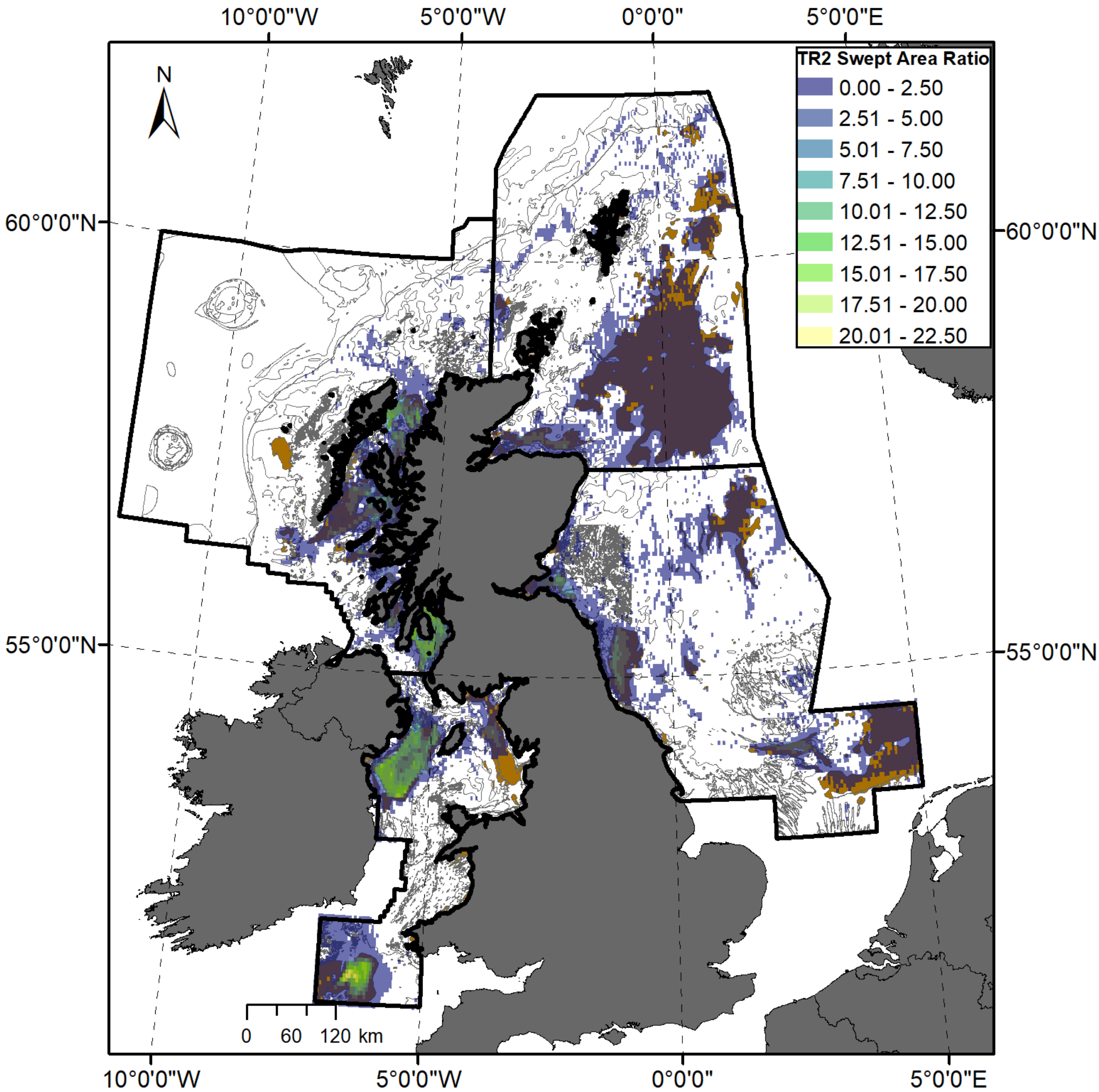

Figure 2. Swept Area Ratio (SAR) for TR2 *Nephrops* trawling calculated from the mean of ICES data from 2012 to 2017 clipped by the four assessment areas. SAR values are the mean of 2012 to 2017 data, provided and plotted at a resolution of 0.05 x 0.05 degree grid cells. SAR is shown with transparency over EMODnet habitat data with only A5.3 EUNIS sublittoral mud habitats shown in colour as brown areas.

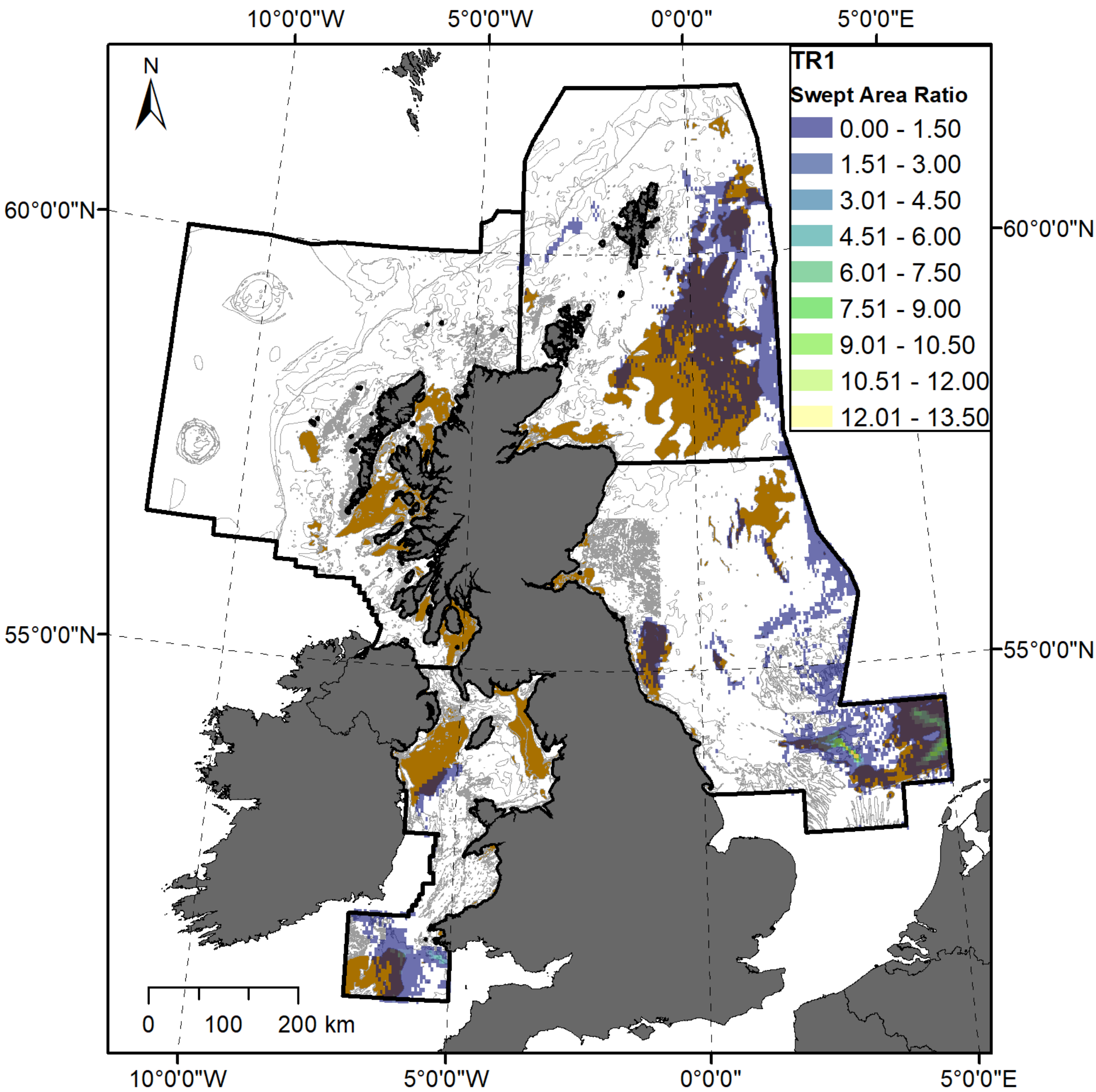

Figure 3. Swept Area Ratio (SAR) for TR1 *Nephrops* trawling calculated from the mean of ICES data from 2012 to 2017, clipped by the four assessment areas. SAR values are the mean of 2012 to 2017 data, provided and plotted at a resolution of 0.05 x 0.05 degree grid cells. SAR is shown with transparency over EMODnet habitat data with only A5.3 sublittoral mud EUNIS habitats shown in colour as brown areas.

2.2.3.2. Creel swept area

Unlike trawl fisheries no data layer of creel swept area (SA) exist for NW European *Nephrops* fisheries (or any other static gears). Difficulties with creating such data is the lack of AIS and VMS on most of the creel fishing fleet due most vessel being under 10m in length (Russell, 2017), and the nature of creel fishing where the gear fishes when the vessel is not present. There is also large variation in the number of creels and creel strings/ fleets deployed across the creel fishery among vessels and locations (Northridge et al., 2010) along with variations in creel sizes, anchor use and deployment and recovery techniques, all making calculating the swept area of creel fishing sensitive to many parameters (Hornborg et al., 2017).

We therefore had to create a swept area layer using several available datasets. This process required many assumptions, and the resulting data layer therefore also has large uncertainties associated with it, and the outcomes of the analyses should be interpreted with caution.

To create a dataset of *Nephrops* creel swept area (Figure 4) four different data sets on creel fishing distribution and effort were used along with technical details of the gear from the literature and feedback from fishermen to estimate the SA. Due to many uncertainties in and spatial variations creel fishing it is recognised the estimate of creel SA is likely to be an overestimation in distribution and effort in some areas.

Some key values needed to be set for converting the reported effort to a SA in several of the datasets. The first value to estimate was the swept area per creel fleet (a string of creels). Where possible we used the total area of creels (footprint on the bottom) in the fleet plus total area of anchors in a creel fleet. Both these values were based on feedback from creel fishermen with a creel size used of 56 x 40 cm (0.224 m^2) and an anchor size of 37 x 21 cm. We know that in many areas' anchors are not used because they are not needed, or that heavy creels at each of the string are used instead. The area of anchors could in be included in one of the data sets (HWDT data) and it was decided to include the anchor area in that data set to make sure that the footprint was not underestimated. Any SA from ropes use in the creel strings was not included as fishermen feedback and Northridge et al. (2010) report that floating lines are used and therefore are likely not in contact with the seabed.

The next parameter that was estimated, again with feedback from creel fishermen included, was the number of creels per string. The number of creels on a fleet varies by based on many factors including location and vessel size, but a single value was needed to be applied in this analysis. A value of 64 creels per fleet was used based on the figure of 30-100 creels per fleet in (Mendo et al., 2019) on Scottish *Nephrops* creel fishing, and a mean of 63 creels per fleet (although not specific to *Nephrops*) given in Northridge et al. (2010), with creel fishermen feedback also considered.

Creel effort dataset 1. Hebridean Whale and Dolphin Trust (HWDT)

The Hebridean Whale and Dolphin Trust (https://hwdt.org/) conduct annual surveys around the west coast of Scotland to record the distribution of cetacean species (MacLennan et al., 2021; Northridge et al., 2010). They record sightings of creel fleets by observing the marker buoys present at both ends of a creel fleet. Data from 2014 – 2019 (Appendix P) was analysed and filtered by search status (visual surveys), sea state (<= 3) and 'sightability' ('too poor to survey' removed). As the creel fleet sightings cannot identify the species being targeted, and fishing for brown crab and lobster is also widespread in the West of Scotland, the sighting and effort data was clipped by the possible *Nephrops* habitats as all of EUNIS A5.3 (sublittoral mud), A6.5 (Deep-sea mud) and A6.3 or A6.4 (Deep-sea sand or Deep-sea muddy sand). For each 0.05 x 0.05 degree cell and year, the creel sightings were divided by the survey effort, with the 6 years of data averaged for each cell. The output produced based on the search area of 1km either side of the vessel was creel sightings per km^2. Where the search area was less than 6 km^2 in a 0.05 x 0.05 degree cell (mean cell area of 17 km^2) the data was not included, as small search areas could result near the coast and artificially inflate the creel fleet sightings per km^2.

To estimate the swept area of the creels from the HWDT derived creel fleet sightings per km^2,the following formula was used.

HWDT creel SA = creel fleet sightings per km^2/ days surveyed x (0.05 x 0.05 degree grid cell area (km^2) x ((number of creels in a fleet x area of a creel + area of two anchors) x 365)) (Equation 1)

The value of '365' represents is to produce an annual figure, with the assumption that the number of creels in a cell is constant throughout a year.

Creel effort dataset 2. Global Fishing Watch (GFW)

Global Fishing Watch (https://globalfishingwatch.org/) provides estimation of fishing hours of AIS transmitting vessels for different fishing gear types. Most creel vessels will not be transmitting AIS due to their size and not being required to, however small number large vessels and smaller vessel that have AIS fitted in the fleet may be in AIS derived data. Annual total fishing hours for 2014 to 2019 (6 years of pre-covid restrictions data) of 'pots and traps' fishing were downloaded for our assessment areas by 0.05 x 0.05 cells and divided by six to get the average annual fishing hours per cell.

To convert the total number of fishing hours into swept area we first estimated how long an individual vessel would spend deploying and recovering creels (defined as apparent fishing hours by Global Fishing Watch). We selected two vessels from the data set that were fishing in *Nephrops* habitat areas (Sealgair_Mara_SY132 and RESTLESS WAVE II) and calculated the mean number of apparent fishing hours a day for 2017 to 2019. This gave a value of 4.3 hours which we then divided by the number of creels deployed by similar size vessels, which was 805.5 creels (Marine Analytical Unit, 2017) to give an estimation of the number of creels deployed per hour. We assume that a vessel is recovering and redeploying all its creels during a trip. which is likely an overestimation. The total number of fishing hours in cell was divided by the number creels deployed per hour to give the number of creels per cell deployed, with the area of a single creel (0.224 m^2) was then multiplied by to give the SA of creels per cell for one year.

GFW creel SA = (Annual fishing hours/(4.3/805.5))creel area km^2 (Equation 2)

Due to the Global fishing Watch data not discriminating which species is being targeted, we clipped the SA layer by the most common *Nephrops* habitats being defined as EUNIS A5.3 sublittoral mud habitats. This has left some areas in the Celtic, northern North Sea and North Sea assessment areas as having *Nephrops* creel fishing in them in our analysis while they are likely to be brown crab creel fishing.

Marine Scotland Science: Creel Fishing Effort Study (CFES)

The Creel Fishing Effort Study (Marine Analytical Unit, 2017) provides *Nephrops* specific average creel hauls per day per 4 km^2 for two regions in the west of Scotland. The hauls per day were converted from 4km^2 to 1km^2, and then used to multiply the area of a creel giving creel area per 1 km^2. This area was then multiplied by the area of the analysis grid cell (0.05 x 0.05 degree) and multiplied by 365 to produce the annual SA of creels.

CFES creel SA = ((Hauls per day per km^2 x Creel area km^2)grid cell area km^2)365 (Equation 3)

ScotMap

The HWDT, GFW and CFES creel SA data sets were combined, with the highest SA value retained where cells overlapped from the three SA layers. The maximum SA of this combined SA data set (0.28 km^2, rounded to two decimal places) was then applied to the ScotMap (Kafas et al., 2017) distribution of *Nephrops* creel fishing activity, in effect assuming that all areas fished in this effort layer were very intensely fished (Figure 4). We know these values are very likely too high for almost all areas and that some areas may not be fished regularly, but we are accounting for the maximum likely swept area that may occur based on the data available.

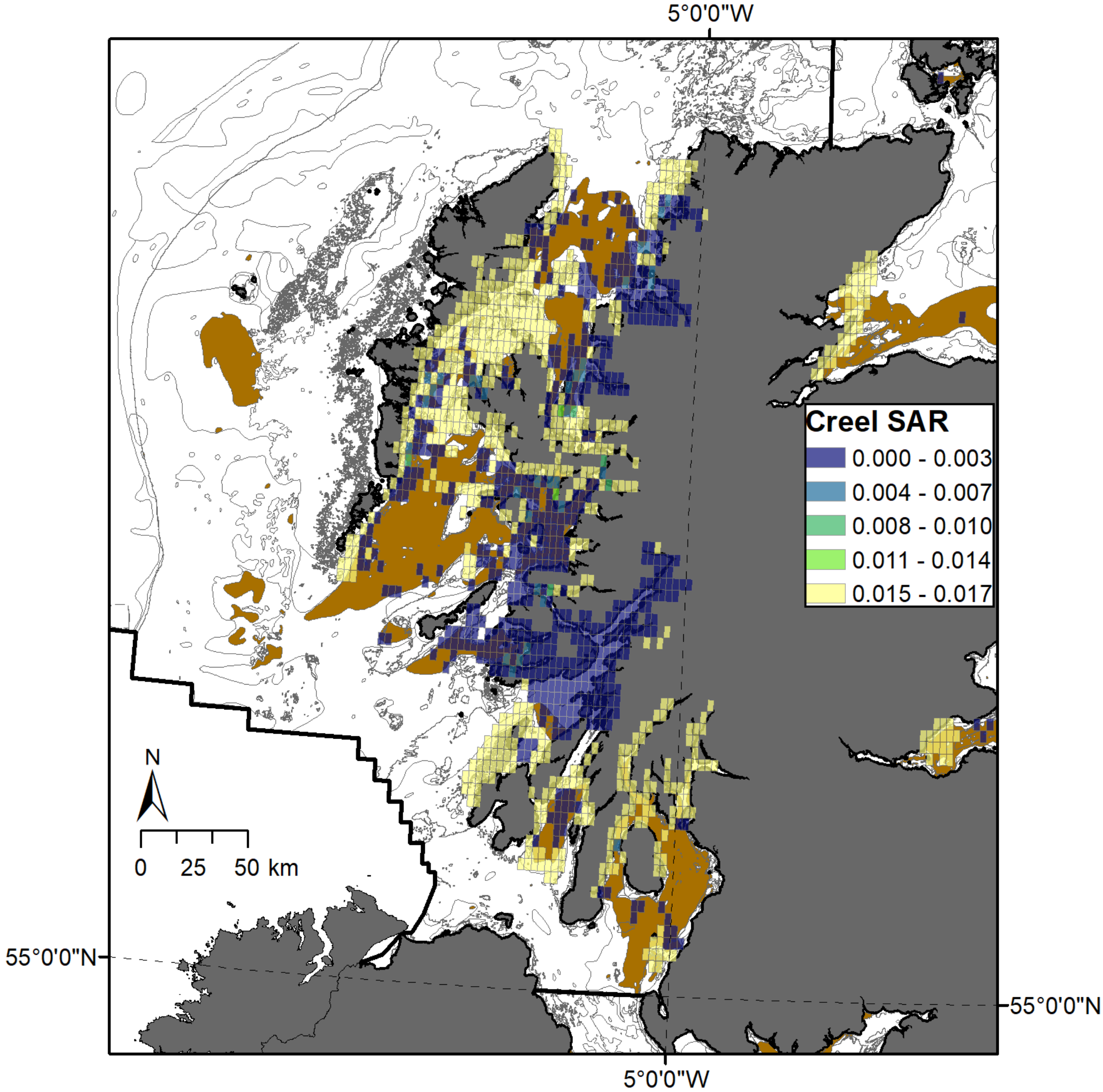

Figure 4. Swept Area Ratio (SAR) for *Nephrops* creel fishing calculated from all data sources combined plotted at a resolution of 0.05 x 0.05 degree grid cells. SAR is shown with transparency over EMODnet habitat data with only sublittoral mud A5.3 EUNIS habitats shown in colour as brown areas.

2.2.4.Depletion of fauna

For the commonly encountered habitat assessments the sediment specific depletion rates that are provided in the BIT were used for otter trawls for the TR1 and TR2 assessments, and for beam trawl for the creel assessments. Without data on the depletion of infauna from creels it was determined that a beam trawl was the closest equivalent gear to the hard structures present in a creel.

For VME assessments the BIT tool does not have specific depletion values for the VME habitats under the trawl and creel fishing gear. Therefore, we ran the assessments using both the default gear depletion rate for the gear, but also a much higher depletion rate of 0.5 to show a high depletion outcome of 50% of the VME being killed, as a way of testing the sensitivity of the outcomes to the uncertainty in this depletion rate.

2.2.5. Longevity of fauna

For the commonly encountered habitat assessments, modelled longevity distributions for un-trawled conditions for each habitat in the assessment area were used. To estimate these distributions infauna biomass samples (1258 samples) collected from 2007 -2020 was used (no more than 6 years before the earliest trawl SA data used) (Figure 5) along with longevity distributions of the fauna (Clare et al., 2022) in linear mixed models to estimate the slope and intercept that can be inputted into the BIT. The data allowed the slope and intercept estimation for EUNIS habitats A5.15, A5.27, A5.35, A5.36 and A5.37 due to a suitable number (greater than 50 samples for a habitat) of samples for those habitats. For all other habitats the estimated parameters were used when habitat was not included in the linear mixed model as a variable.

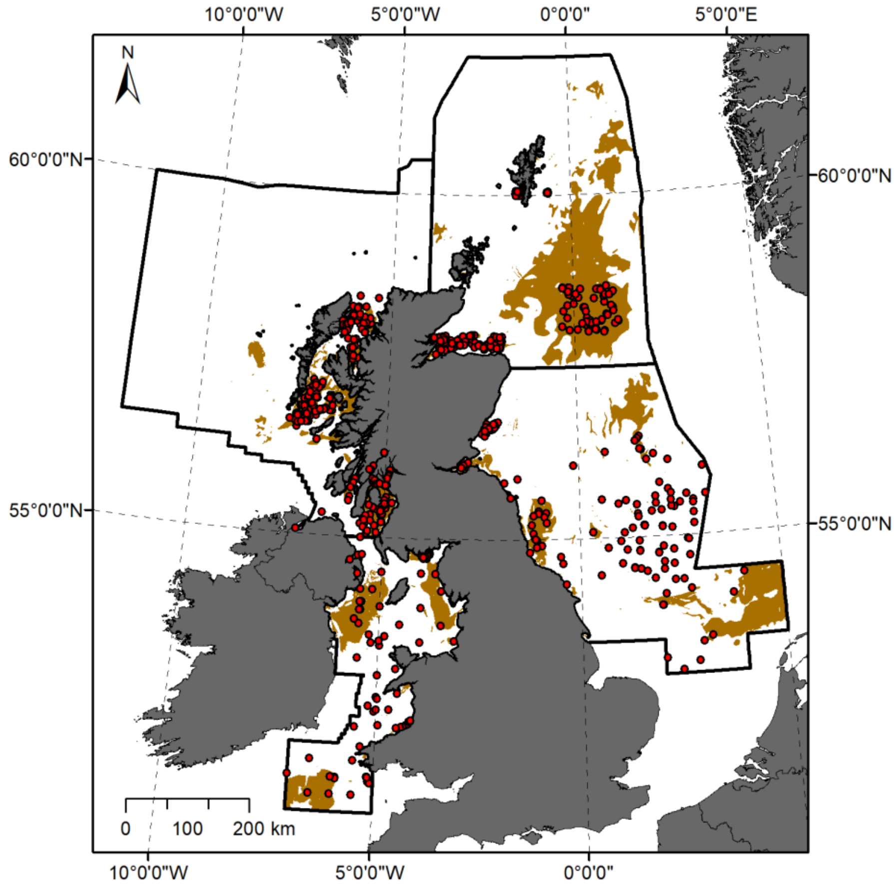

Figure 5. Infauna biomass samples used in the longevity estimation model for commonly encountered habitats. Sublittoral mud A5.3 EUNIS habitats are shown as brown areas.

For the VME assessments the maximum longevity of the indicator species of that VME was used and inputted into the BIT (Appendix Q).

2.2.6. Vulnerable Marine Ecosystems (VMEs)

The true extent of subtidal VMEs is likely poorly understood, and many data sets of VMEs state that they should not be considered as an absolute record of VME extent, but rather a record of occurrence where data is available. In addition, many VME data sets are in the format of points which are not directly applicable to use in the BIT which requires polygon data. We used the OSPAR habitat polygon data in addition to polygons for 'fan mussel aggregations' and 'flame shell beds' from the Geodatabase of Marine features adjacent to Scotland (GeMS) in our VME assessments (Appendix P) as these polygons are not included in the OSPAR data and were available in the GeMS dataset. We used two data layers for each VME assessment of 1) a 'certain VME' layer which comprised of the OSPAR habitat polygon data with only 'certain' polygons included (Figure 6) and 2) an 'all VME' layer which included all the OSPAR habitat polygon data and the GeMS fan mussel aggregations and flame shell beds (Figure 7).

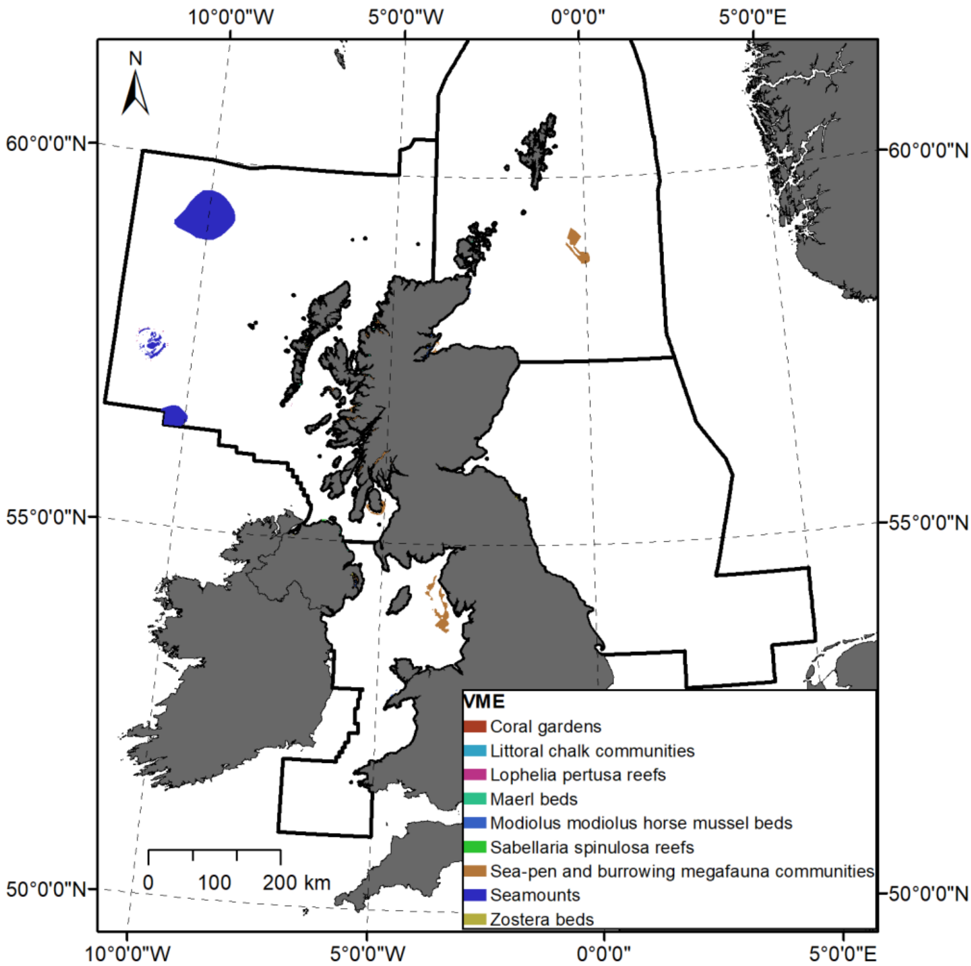

Figure 6. OSPAR habitat polygon data with certain records only included within the assessment areas used in the 'certain VME' BIT assessment. Intertidal VMEs were not included in the analysis.

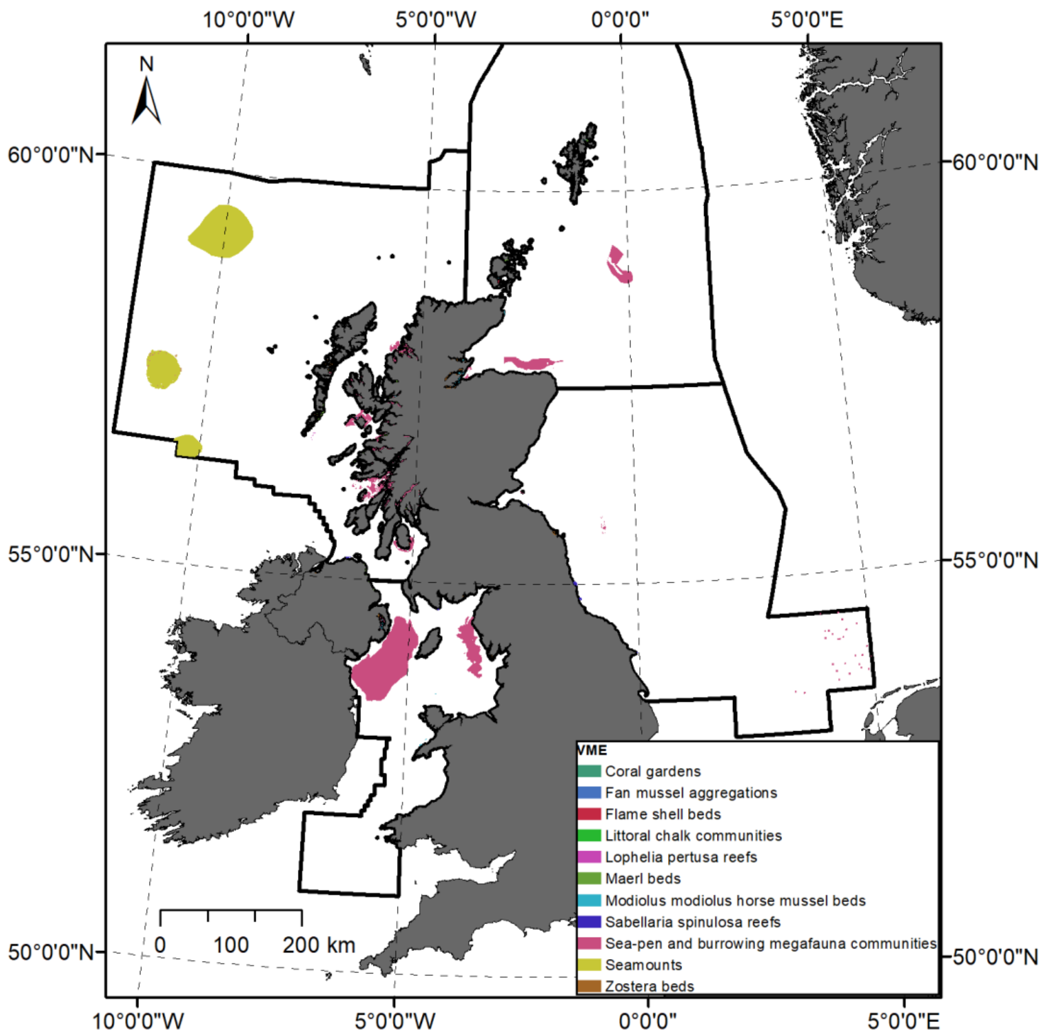

Figure 7. All (excluding intertidal VMEs) OSPAR habitat polygon data and some polygons for fan mussel aggregations and flame shell beds from the Geodatabase of Marine features adjacent to Scotland (GeMS) that are within the assessment areas used in the 'all VME' BIT assessments.

3. Results

3.1. Commonly encountered habitats assessments

3.1.1.TR2 trawling

All commonly encountered habitats within the TR2 trawl fishery assessment recovered to RBS>0.8 within 20 years with a high probability, and therefore achieved suggested scores of SG100 (Appendices

Appendix A). The lowest two mean RBS values of 0.43 and 0.61 were for the A5.37 'deep circalittoral mud' in the Celtic and West of Scotland assessment areas respectively (Appendices

Appendix A). In the Celtic assessment area, large areas have extremely low RBS scores between 0 to 0.1, such as the Dublin Bay area fishery and a large portion of functional unit 22 off the southwest coast of Wales in the Celtic Sea (Figure 8), indicating that the seabed is currently greatly degraded as a result of trawling activity. However, large areas also have RBS values > 0.91, including off Cumbria and the western portion of the mud habitats in the Celtic Sea. Areas of low RBS can be seen for the West of Scotland assessment area around Arran and between the Isle of Lewis and the mainland (Figure 8). The maximum mean time to recovery for a habitat in the assessment under TR2 trawling ending was 5 years in the Celtic assessment area A5.37 deep circalittoral mud (Appendices

Appendix A).

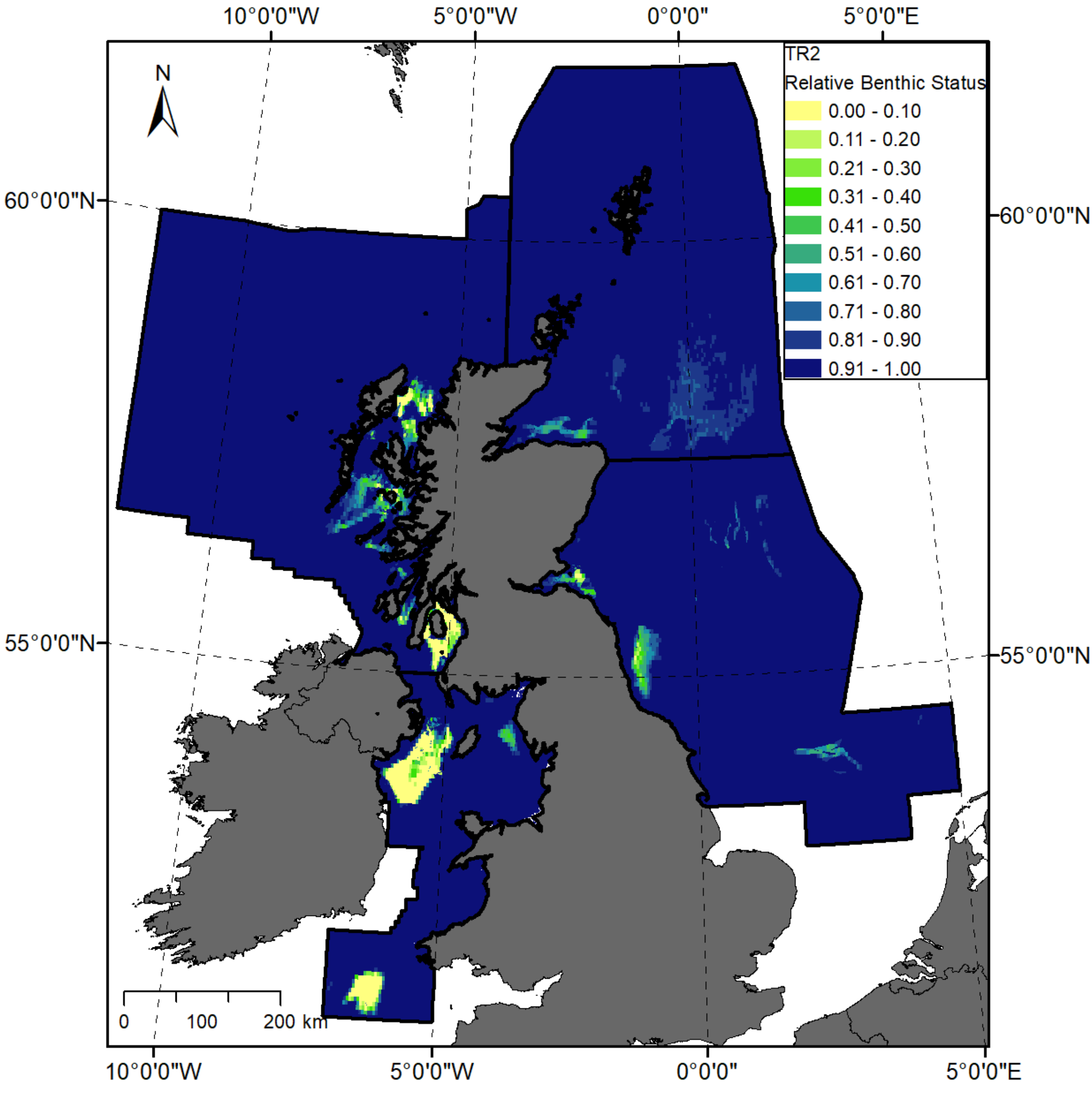

Figure 8. The calculated Relative Benthic Status of TR2 *Nephrops* trawling for the four assessment areas.

3.1.2.TR1 trawling

All habitats in the TR1 trawl habitat assessment achieved a suggested MSC score of SG100 and are predicted to be recovered within one year of trawling ending (Appendix B). 'Deep circalittoral mud' A5.37 was the only habitat that had a mean RBS below 0.99 across the four assessment areas

(Appendix B), with the low RBS cell values occurring in the Botney Gut-Silver Pit functional unit in the south east of the North Sea assessment area (Figure 9).

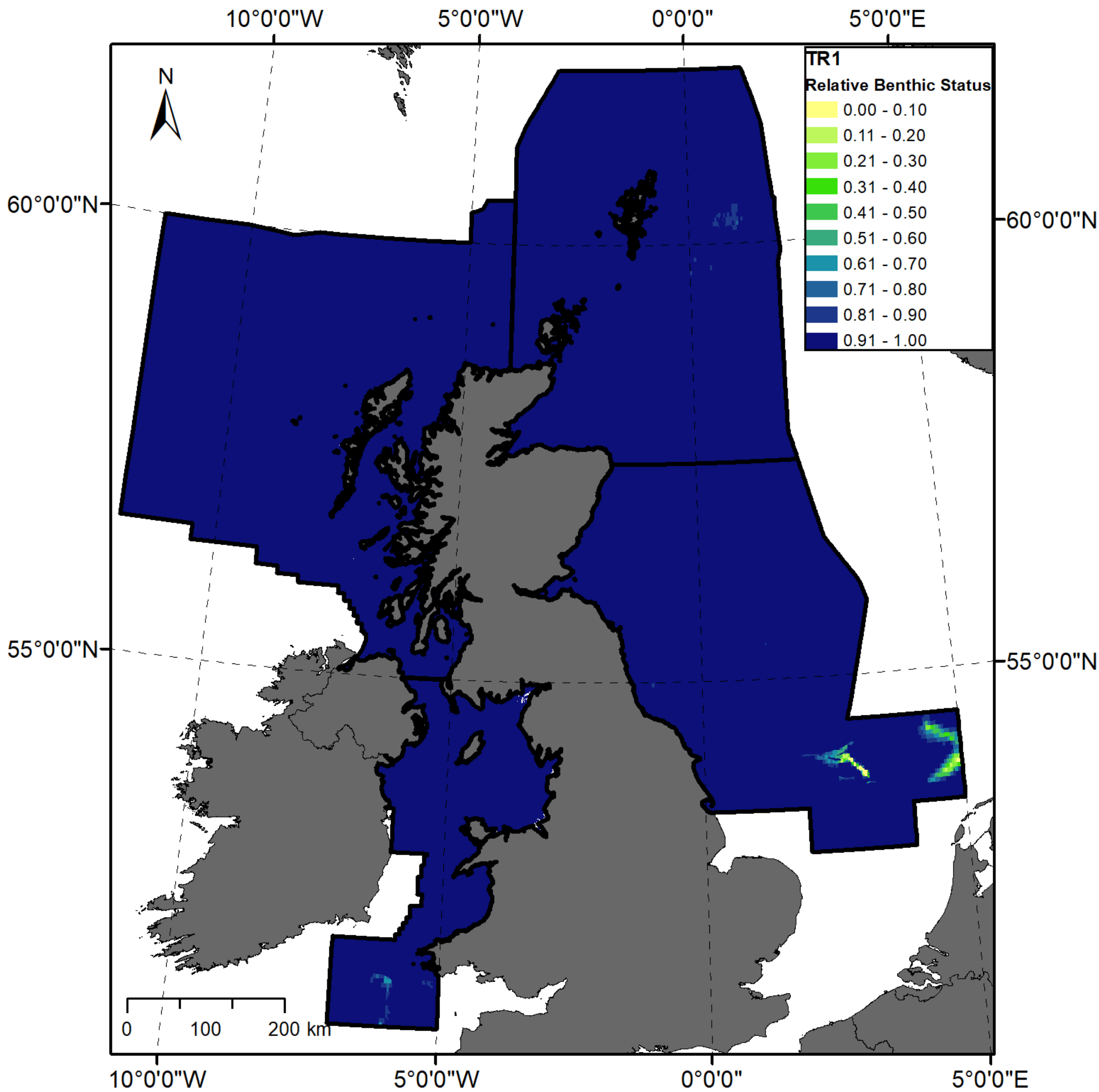

Figure 9. The calculated Relative Benthic Status of TR1 *Nephrops* trawling for the four assessment areas.

3.1.3.Creel fishery commonly encountered habitats assessments

Because of the very low swept-areas by creel fishing, all the habitats in the creel fishery assessment achieved a suggested MCS score of SG100, with recovery occurring within a year in all cases (Appendix C). No area in the creel assessment had an RBS below 0.99 (Figure 10 and Appendix C).

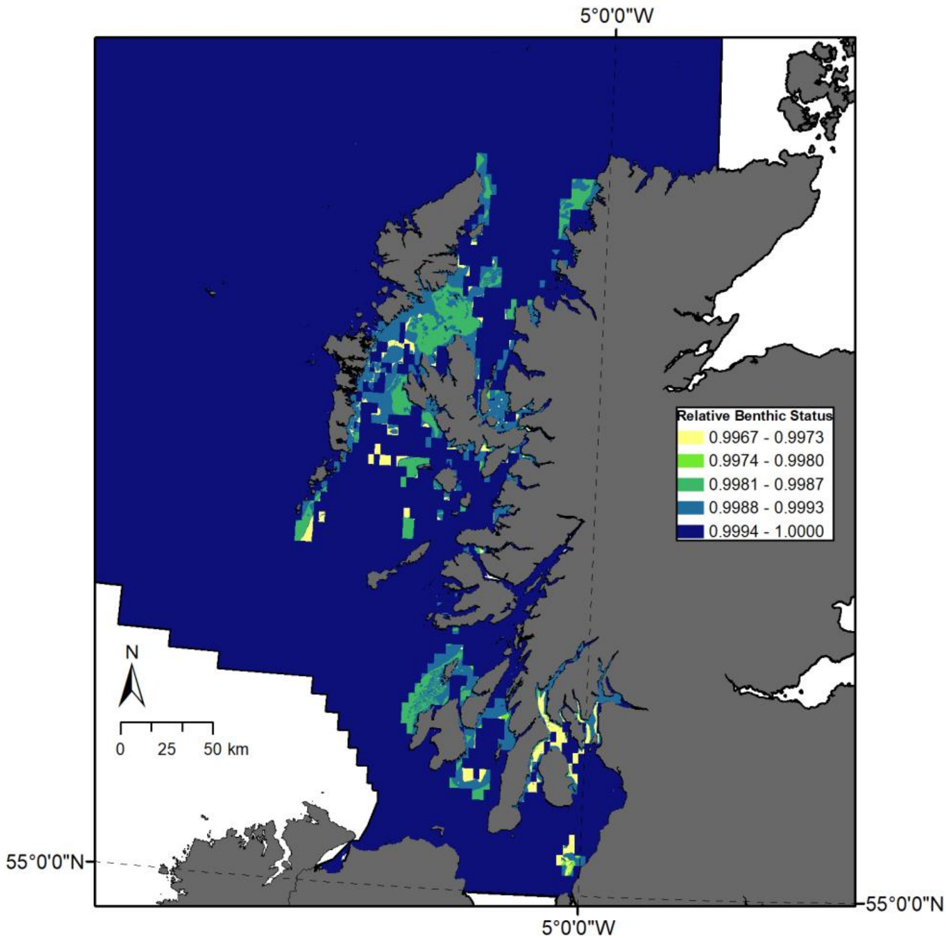

Figure 10. The calculated Relative Benthic Status of *Nephrops* Creel fishing focused on the West of Scotland where *Nephrops* creel fishing occurs. Note the Relative Benthic Status scale used is different to *Figure 8* and *Figure 9*.

3.2. VMEs assessment results

3.2.1.TR2 trawling VME assessments

TR2 trawling assessed with the 'all VME' layer with depletion of 0.06 resulted in an indicative 'fail' score for the Celtic assessment area 'Sea-pen and burrowing megafauna communities' VME and SG60 indicative MSC score for West of Scotland 'Sea-pen and burrowing megafauna communities' (Appendix D). Using a depletion of 0.5 for the same VME layer produced an indicative 'fail' score for 'Sea-pen and burrowing megafauna communities' in the Celtic and West of Scotland assessment areas, and an indicative MSC score of SG60 for 'Sea-pen and burrowing megafauna communities' in the northern North Sea area (Appendix E).

The assessment using the certain OSPAR records using a depletion of 0.06 resulted in an assessment pass for all VMEs, with an indicative MSC score of SG60 for 'Sea-pen and burrowing megafauna communities' taking 16.5 years (50% probability estimate) to achieve for the West of Scotland (Appendix F). With depletion of 0.5 both 'Sea-pen and burrowing megafauna communities' and '*Modiolus modiolus* horse mussel beds' obtained an indicative 'fail' score in the assessment in the West of Scotland assessment area (Appendix G).

3.2.2. TR1 trawling VME assessments

All but one VME assessments under TR1 trawling achieved an indicative MSC score SG100 (Appendix H - Appendix K), the exception was 'Sea-pen and burrowing megafauna communities' in the North Sea assessment area with the 'all VME' layer using a depletion of 0.5 (Appendix I). The indicative MSC score for that scenario was SG60 with 19 years to reach recovery that score.

3.2.3. Creel VME assessments

All creel VME assessments passed with indicative MSC scores of SG100 (Appendix L - Appendix O).

4. Discussion

Commonly encountered habitats, including those that the *Nephrops* fishery is focused on, all recovered to a relative benthic status of 0.8 within 20 years. Despite significant areas having very low RBS values and zero RBS values, the fast recovery for the deep circalittoral mud meant that depletion of significant areas of habitat can easily result in an assessment pass under MSC scoring. In the northern North Sea and North Sea assessment areas most of the 'deep circalittoral mud' experienced TR2 fishing, but with much lower SAR values than areas in of the Celtic and West of Scotland assessment areas.

The TR1 trawl assessment showed a far more limited spatial distribution of effort than TR2 trawling, but also occurred on habitats beyond sublittoral mud. The high SAR values were limited to the Botney Gut-Silver Pit functional unit 5 in the North Sea and the Celtic Sea, Bristol Channel functional unit 5 off South Wales, with the Botney Gut-Silver Pit functional unit the only area with low RBS values. Due to large areas of mud habitat having no fishing occurring on it, the recovery within 20 years for each assessment areas were easily achieved.

The creel fishery was estimated to have very low SAR values (max SAR = 0.017, comparing to a max SAR >22 for TR2 and >12 for TR1), and where it almost exclusively occurred in the West of Scotland assessment area, there were large areas of unfished habitat. This meant that an MSC indicative score of SG100 was easily achieved for all habitats.

Due to the slow recovery of VME habitats the same fishing effort can results in greater impacts compared to commonly encountered habitats. However, due to uncertainty of the depletion of VMEs under the trawl and creel gear, we used a low and high depletion scenario in the assessments to help constrain which VMEs may be most vulnerable despite the uncertainty. The VME assessments did result in some suggested fails under the MSC scoring, but only under TR2 trawling. When using the 'all VME' layer the 'Sea-pen and burrowing megafauna communities' Celtic assessment area would appear most vulnerable as it scored a 'fail' under both a depletion of 0.06 and 0.5. This would indicate that the VME depletion uncertainty is less significant for this assessment as a depletion of 0.06 is likely an underestimate of VME depletion rate. This can be explained by the Dublin Bay mud ground in the Celtic region, that is a focus of *Nephrops* fishing having high SAR values, being included as a VME in the 'all VME' layer. However, the 'certain VME' layer did not result in any 'fail' MSC scores VME assessments for the Celtic assessment area due to the Dublin Bay mud ground not being included. This indicates that the operational distinction between what constitutes a common habitat type vs. a VME is very important in for the 'burrowed mud' that Nephrops fisheries target. In the West of Scotland assessment area, the 'Sea-pen and burrowing megafauna communities' VME scored Fail only under the higher TR2 trawling depletion of 0.5 under with 'all VME' and the 'certain VME' data layers, but with an indicative MSC core of SG60 taking 18.3 and 18.8 years respectively to achieve this under a depletion of 0.06. This indicates that the uncertainty in depletion is likely very important for the assessment of this VME off the West of Scotland for TR2 trawling, and may also be considered vulnerable. This uncertainty may feed into the MSC score for the uncertainty of the information on habitats impacts (P2.4.3). The only other VME fail was for ‘*Modiolus modiolus* horse mussel beds’ in the West of Scotland under the higher depletion of 0.5 with the ‘certain VME’ layer, which again shows the assessment outcome sensitivity to what records are included and the depletion uncertainty. The addition of more ‘*Modiolus modiolus* horse mussel beds’ in the ‘all VME’ layer is likely to have diluted the impact seen under the ‘certain VME’ layer due to the addition of unfished or low SAR impacted horse mussel beds.

The different scenarios assessed show that the uncertainty in depletion for VME habitats and the variation between different data layers can have significant influence on assessment outcomes.

4.1. Limitations and future recommendations

There are limitations with the data sets and methods used which should be considered when evaluating the assessment outcomes.

The 0.05 x 0.05 degree resolution of the fishing data used means that there will be some overlap between areas that are actually fished and some areas adjacent to them which in reality are not fished. This is likely only relevant to the VME assessments where the VME habitat areas are often small and the recovery slow. For example, a single *Modiolus* bed between Rùm and the Isle of Canna that is directly surround by trawled mud habitat is driving the results under TR2 trawling for the ‘certain VME’ assessment, and in reality, no fishing effort may occur over the *Modiolus* bed. Higher resolution fishing effort data would reduce this type of overlap effect, but such data was not available for this assessment. The time periods we had fishing and habitat data available for was variable. The creel SA was based on four data sets that were produced over different periods, and the latest trawl data we had was up to 2017. The extent of the fishing is likely to be more stable than the effort, which is why 6-year averages, and the latest data were used where possible.

The BIT model recovery rate for common habitats was estimated based on the infauna grab samples that we could obtain. More biomass data from unfished areas, and inclusion of trawl samples would be preferable, and might have resulted in slightly different recovery rates and resulting impacts (ICES, 2020). It is believed that biomass data will now be more routinely collected from grab samples within collected within Scottish waters which may benefit future work.

The creel assessments all passed based on the MSC indicative scoring, but limitations in the creel fishing data should be considered regardless. Quantifying creel swept area required many assumptions, so should be considered as highly uncertain. However, the outcomes show that this uncertainty is extremely unlikely to affect the MSC scores, as the SAR values were very low and the RBS predictions were all greater than 0.99. We could not quantify the creel swept area for Strangford Loch and any creel fishing off the Cumbria coast, and so it was not included in the assessment. For the same reasons outlined above, the inclusion of these missing SAR data sets, if they could be estimated, on the indicative MSC scores would likely be negligible. In addition, the BIT model was developed for mobile gears and common habitats, so the outcomes for creels and VMEs should also be considered with some caution.

In future the introduction of iVMS on smaller vessels may greatly help the estimation of creel SA, although due to the nature of creel fishing additional information on creel numbers and deployment and recovery of creel strings using technologies such as gear-in–gear-out sensors (Emmerson et al., 2022) would be beneficial. Higher resolution fishing effort data would help reduce spill over into unfished areas, particularly for VME assessments. The discrepancy in format and content between

VME data sets available can have implications on assessment outcomes, particularly for the *Nephrops* fishery in the allocation of 'Sea-pen and burrowing megafauna communities' as defined by OSPAR or similar sea-pen and other mud habitat VMEs or Priority Marine Features. Consolidating these various data VME sets, integrating VME point data and clearly defining mud VME habitat extents would be a significant undertaking were beyond this assessment. There are several areas (over 5400 km^2 for the West of Scotland assessment area) which are classed as NA in the EMODnet habitat data or as referred to in this report 'undefined' in the commonly encountered habitats layer. These 'undefined' habitat areas are often inshore and did include sea loch and would benefit from having a EUNIS habitat allocated to them. However, these areas are most relevant to the creel fishery which had negligible impact in this assessment, and the 'undefined' habitat areas were included in the assessments with default values had showed little impact all scoring SG100. This means that making allocating these 'undefined' habitats a EUNIS habitat would likely have minor implications to any future *Nephrops* creel assessment.

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7. Appendices

Appendix A. Benthic Impact Tool results for commonly encountered habitats for TR2 trawl gear in the four assessment areas. Recovery times are in years and blanks cells indicate the habitat is not present to assess. The main *Nephrops* habitat is highlighted in grey.

		TR2 Celtic assessment area							TR2 West of Scotland assessment area							TR2 northern North Sea assessment area							TR2 North Sea assessment area						
EUNIS code	**EUNIS habitat me**	**Mean RBS**	**Habitat area km²**	**Mean recovery time**	**SG60 recovery time**	**SG80 recovery time**	**SG100 recovery time**	**Indicative MSC Score**	**Mean RBS**	**Habitat area km²**	**Mean recovery time**	**SG60 recovery time**	**SG80 recovery time**	**SG100 recovery time**	**Indicative MSC Score**	**Mean RBS**	**Habitat area km²**	**Mean recovery time**	**SG60 recovery time**	**SG80 recovery time**	**SG100 recovery time**	**Indicative MSC Score**	**Mean RBS**	**Habitat area km²**	**Mean recovery time**	**SG60 recovery time**	**SG80 recovery time**	**SG100 recovery time**	**Indicative MSC Score**
A3	Infralittoral rock and other hard substrata	1.00	5.49	0.0	0.0	0.0	0.0	SG100	0.99	6.03	0.0	0.0	0.0	0.0	SG100	1.00	8.87	0.0	0.0	0.0	0.0	SG100	1.00	1.32	0.0	0.0	0.0	0.0	SG100
A3.1	Atlantic and Mediterranean high energy infralittoral rock	1.00	86.23	0.0	0.0	0.0	0.0	SG100	1.00	309.24	0.0	0.0	0.0	0.0	SG100	1.00	423.46	0.0	0.0	0.0	0.0	SG100	1.00	75.52	0.0	0.0	0.0	0.0	SG100
A3.2	Atlantic and Mediterranean moderate energy infralittoral rock	1.00	17.22	0.0	0.0	0.0	0.0	SG100	0.99	74.29	0.0	0.0	0.0	0.0	SG100	1.00	256.88	0.0	0.0	0.0	0.0	SG100	1.00	27.70	0.0	0.0	0.0	0.0	SG100
A3.3	Atlantic and Mediterranean low energy infralittoral rock	1.00	9.89	0.0	0.0	0.0	0.0	SG100	0.99	134.87	0.0	0.0	0.0	0.0	SG100	1.00	108.77	0.0	0.0	0.0	0.0	SG100	1.00	16.32	0.0	0.0	0.0	0.0	SG100
A4	Circalittoral rock and other hard substrata	1.00	1.59	0.0	0.0	0.0	0.0	SG100	0.97	0.38	0.0	0.0	0.0	0.0	SG100	1.00	0.18	0.0	0.0	0.0	0.0	SG100	1.00	0.79	0.0	0.0	0.0	0.0	SG100
A4.1	Atlantic and Mediterranean high energy circalittoral rock	1.00	241.18	0.0	0.0	0.0	0.0	SG100	1.00	2130.99	0.0	0.0	0.0	0.0	SG100	1.00	808.01	0.0	0.0	0.0	0.0	SG100	1.00	70.44	0.0	0.0	0.0	0.0	SG100
A4.12	Sponge communities on deep circalittoral rock	1.00	19.08	0.0	0.0	0.0	0.0	SG100	1.00	331.32	0.0	0.0	0.0	0.0	SG100	1.00	60.38	0.0	0.0	0.0	0.0	SG100							
A4.12 or A4.27 or A4.33	NA	1.00	0.34	0.0	0.0	0.0	0.0	SG100																					
A4.2	Atlantic and Mediterranean moderate energy circalittoral rock	1.00	93.33	0.0	0.0	0.0	0.0	SG100	0.99	310.99	0.0	0.0	0.0	0.0	SG100	1.00	497.14	0.0	0.0	0.0	0.0	SG100	1.00	258.67	0.0	0.0	0.0	0.0	SG100
A4.27	Faul communities on deep moderate energy circalittoral rock	1.00	568.95	0.0	0.0	0.0	0.0	SG100	1.00	471.33	0.0	0.0	0.0	0.0	SG100	1.00	193.93	0.0	0.0	0.0	0.0	SG100	1.00	46.16	0.0	0.0	0.0	0.0	SG100
A4.3	Atlantic and Mediterranean low energy circalittoral rock	1.00	6.53	0.0	0.0	0.0	0.0	SG100	0.98	243.93	0.0	0.0	0.0	0.0	SG100	1.00	57.40	0.0	0.0	0.0	0.0	SG100	0.99	25.46	0.0	0.0	0.0	0.0	SG100
A4.33	Faul communities on deep low energy circalittoral rock	0.93	64.88	0.0	0.0	0.0	0.0	SG100	0.98	486.19	0.0	0.0	0.0	0.0	SG100	1.00	118.34	0.0	0.0	0.0	0.0	SG100	0.98	113.33	0.0	0.0	0.0	0.0	SG100
A5	Sublittoral sediment	0.99	364.92	0.0	0.0	0.0	0.0	SG100	1.00	4959.77	0.0	0.0	0.0	0.0	SG100	1.00	427.43	0.0	0.0	0.0	0.0	SG100	0.99	121.74	0.0	0.0	0.0	0.0	SG100
A5.13	Infralittoral coarse sediment	1.00	482.16	0.0	0.0	0.0	0.0	SG100	1.00	210.63	0.0	0.0	0.0	0.0	SG100	1.00	173.60	0.0	0.0	0.0	0.0	SG100	1.00	946.77	0.0	0.0	0.0	0.0	SG100
A5.14	Circalittoral coarse sediment	1.00	5108.32	0.0	0.0	0.0	0.0	SG100	0.99	4563.64	0.0	0.0	0.0	0.0	SG100	1.00	1316.36	0.0	0.0	0.0	0.0	SG100	1.00	5272.10	0.0	0.0	0.0	0.0	SG100
A5.15	Deep circalittoral coarse sediment	1.00	16242.79	0.0	0.0	0.0	0.0	SG100	1.00	30014.69	0.0	0.0	0.0	0.0	SG100	1.00	24018.11	0.0	0.0	0.0	0.0	SG100	1.00	15806.50	0.0	0.0	0.0	0.0	SG100
A5.23 or A5.24	NA	1.00	887.52	0.0	0.0	0.0	0.0	SG100	0.99	93.57	0.0	0.0	0.0	0.0	SG100	1.00	231.02	0.0	0.0	0.0	0.0	SG100	1.00	3244.27	0.0	0.0	0.0	0.0	SG100
A5.25 or A5.26	NA	1.00	3751.31	0.0	0.0	0.0	0.0	SG100	0.99	1970.90	0.0	0.0	0.0	0.0	SG100	1.00	772.23	0.0	0.0	0.0	0.0	SG100	1.00	11926.78	0.0	0.0	0.0	0.0	SG100
A5.27	Deep circalittoral sand	1.00	11764.17	0.0	0.0	0.0	0.0	SG100	1.00	22786.83	0.0	0.0	0.0	0.0	SG100	1.00	63892.21	0.0	0.0	0.0	0.0	SG100	1.00	87598.86	0.0	0.0	0.0	0.0	SG100
A5.33	Infralittoral sandy mud	1.00	132.26	0.0	0.0	0.0	0.0	SG100	0.97	32.20	0.0	0.0	0.0	0.0	SG100	1.00	77.82	0.0	0.0	0.0	0.0	SG100	1.00	29.15	0.0	0.0	0.0	0.0	SG100
A5.34	Infralittoral fine mud	1.00	37.98	0.0	0.0	0.0	0.0	SG100	1.00	5.40	0.0	0.0	0.0	0.0	SG100								1.00	0.32	0.0	0.0	0.0	0.0	SG100
A5.35	Circalittoral sandy mud	0.97	2702.42	0.0	0.0	0.0	0.0	SG100	0.78	884.17	0.3	0.5	0.8	1.3	SG100	0.98	287.51	0.0	0.0	0.0	0.0	SG100	0.98	985.10	0.0	0.0	0.0	0.0	SG100
A5.36	Circalittoral fine mud	0.99	40.56	0.0	0.0	0.0	0.0	SG100	0.78	30.58	0.3	0.5	1.0	1.5	SG100								0.94	2.02	0.0	0.0	0.0	0.0	SG100
A5.37	Deep circalittoral mud	0.43	10089.15	5.0	5.8	6.8	7.8	SG100	0.61	10514.39	2.3	3.3	4.0	5.5	SG100	0.94	36528.08	0.0	0.0	0.0	0.0	SG100	0.89	18347.41	0.0	0.0	0.0	0.0	SG100
A5.43	Infralittoral mixed sediments	1.00	36.58	0.0	0.0	0.0	0.0	SG100	0.99	38.35	0.0	0.0	0.0	0.0	SG100	1.00	57.89	0.0	0.0	0.0	0.0	SG100	1.00	49.76	0.0	0.0	0.0	0.0	SG100
A5.434	[Limaria hians] beds in tide-swept sublittoral muddy mixed sediment								1.00	3.59	0.0	0.0	0.0	0.0	SG100	1.00	5.24	0.0	0.0	0.0	0.0	SG100							
A5.44	Circalittoral mixed sediments	1.00	386.29	0.0	0.0	0.0	0.0	SG100	0.97	235.13	0.0	0.0	0.0	0.0	SG100	1.00	81.64	0.0	0.0	0.0	0.0	SG100	1.00	315.52	0.0	0.0	0.0	0.0	SG100
A5.45	Deep circalittoral mixed sediments	1.00	2329.88	0.0	0.0	0.0	0.0	SG100	0.96	1482.50	0.0	0.0	0.0	0.0	SG100	1.00	774.22	0.0	0.0	0.0	0.0	SG100	0.99	1019.79	0.0	0.0	0.0	0.0	SG100
A5.6	Sublittoral biogenic reefs	1.00	2.88	0.0	0.0	0.0	0.0	SG100	1.00	15.17	0.0	0.0	0.0	0.0	SG100	1.00	0.51	0.0	0.0	0.0	0.0	SG100	0.98	1.82	0.0	0.0	0.0	0.0	SG100
A5.61	Sublittoral polychaete worm reefs on sediment	1.00	0.23	0.0	0.0	0.0	0.0	SG100															1.00	0.38	0.0	0.0	0.0	0.0	SG100
A5.611	[Sabellaria spinulosa] on stable circalittoral mixed sediment	1.00	6.06	0.0	0.0	0.0	0.0	SG100	1.00	0.16	0.0	0.0	0.0	0.0	SG100								1.00	36.18	0.0	0.0	0.0	0.0	SG100
A5.612	[Sabellaria alveolata] on variable salinity sublittoral mixed sediment	1.00	0.71	0.0	0.0	0.0	0.0	SG100																					
A5.613	[Serpula vermicularis] reefs on very sheltered circalittoral muddy sand								1.00	0.15	0.0	0.0	0.0	0.0	SG100														
A5.62	Sublittoral mussel beds on sediment	1.00	27.16	0.0	0.0	0.0	0.0	SG100	1.00	0.74	0.0	0.0	0.0	0.0	SG100	1.00	28.06	0.0	0.0	0.0	0.0	SG100	1.00	5.91	0.0	0.0	0.0	0.0	SG100
A5.625	[Mytilus edulis] beds on sublittoral sediment																						1.00	3.46	0.0	0.0	0.0	0.0	SG100
A5.631	Circalittoral [Lophelia pertusa] reefs								1.00	6.57	0.0	0.0	0.0	0.0	SG100														
A6	Deep-sea bed								1.00	9035.66	0.0	0.0	0.0	0.0	SG100	1.00	2655.45	0.0	0.0	0.0	0.0	SG100							
A6.11	Deep-sea bedrock								1.00	1033.01	0.0	0.0	0.0	0.0	SG100														
A6.2	Deep-sea mixed substrata								1.00	4093.56	0.0	0.0	0.0	0.0	SG100	1.00	6357.68	0.0	0.0	0.0	0.0	SG100							
A6.3 or A6.4	NA								1.00	11693.59	0.0	0.0	0.0	0.0	SG100	1.00	4485.41	0.0	0.0	0.0	0.0	SG100							
A6.5	Deep-sea mud								1.00	66080.52	0.0	0.0	0.0	0.0	SG100	1.00	11286.73	0.0	0.0	0.0	0.0	SG100							
A6.61	Communities of deep-sea corals								1.00	18.96	0.0	0.0	0.0	0.0	SG100														
Undefined	NA	1.00	1452.55	0.0	0.0	0.0	0.0	SG100	0.99	5461.00	0.0	0.0	0.0	0.0	SG100	1.00	962.81	0.0	0.0	0.0	0.0	SG100	1.00	519.17	0.0	0.0	0.0	0.0	SG100

Appendix B. Benthic Impact Tool results for commonly encountered habitats for TR1 trawl gear in the four assessment areas. Recovery times are in years and blanks cells indicate the habitat is not present to assess. The main *Nephrops* habitat is highlighted in grey.

		TR1 Celtic assessment area							TR1 West of Scotland assessment area						
EUNIS code	EUNIS habitat me	Mean RBS	Habitat area km^2	Mean recovery time	SG60 recovery time	SG80 recovery time	SG100 recovery time	Indicative MSC Score	Mean RBS	Habitat area km^2	Mean recovery time	SG60 recovery time	SG80 recovery time	SG100 recovery time	Indicative MSC Score
A3	Infralittoral rock and other hard substrata	1.00	5.49	0.0	0.0	0.0	0.0	SG100	1.00	6.03	0.0	0.0	0.0	0.0	SG100
A3.1	Atlantic and Mediterranean high energy infralittoral rock	1.00	86.23	0.0	0.0	0.0	0.0	SG100	1.00	309.24	0.0	0.0	0.0	0.0	SG100
A3.2	Atlantic and Mediterranean moderate energy infralittoral rock	1.00	17.22	0.0	0.0	0.0	0.0	SG100	1.00	74.29	0.0	0.0	0.0	0.0	SG100
A3.3	Atlantic and Mediterranean low energy infralittoral rock	1.00	9.89	0.0	0.0	0.0	0.0	SG100	1.00	134.87	0.0	0.0	0.0	0.0	SG100
A4	Circalittoral rock and other hard substrata	1.00	1.59	0.0	0.0	0.0	0.0	SG100	1.00	0.38	0.0	0.0	0.0	0.0	SG100
A4.1	Atlantic and Mediterranean high energy circalittoral rock	1.00	241.18	0.0	0.0	0.0	0.0	SG100	1.00	2130.99	0.0	0.0	0.0	0.0	SG100
A4.12	Sponge communities on deep circalittoral rock	1.00	19.08	0.0	0.0	0.0	0.0	SG100	1.00	331.32	0.0	0.0	0.0	0.0	SG100
A4.12 or A4.27 or A4.33	NA	1.00	0.34	0.0	0.0	0.0	0.0	SG100							
A4.2	Atlantic and Mediterranean moderate energy circalittoral rock	1.00	93.33	0.0	0.0	0.0	0.0	SG100	1.00	310.99	0.0	0.0	0.0	0.0	SG100
A4.27	Faunal communities on deep moderate energy circalittoral rock	1.00	568.95	0.0	0.0	0.0	0.0	SG100	1.00	471.33	0.0	0.0	0.0	0.0	SG100
A4.3	Atlantic and Mediterranean low energy circalittoral rock	1.00	6.53	0.0	0.0	0.0	0.0	SG100	1.00	243.93	0.0	0.0	0.0	0.0	SG100
A4.33	Faunal communities on deep low energy circalittoral rock	1.00	64.88	0.0	0.0	0.0	0.0	SG100	1.00	486.19	0.0	0.0	0.0	0.0	SG100
A5	Sublittoral sediment	1.00	364.92	0.0	0.0	0.0	0.0	SG100	1.00	4959.77	0.0	0.0	0.0	0.0	SG100
A5.13	Infralittoral coarse sediment	1.00	482.16	0.0	0.0	0.0	0.0	SG100	1.00	210.63	0.0	0.0	0.0	0.0	SG100
A5.14	Circalittoral coarse sediment	1.00	5108.32	0.0	0.0	0.0	0.0	SG100	1.00	4563.64	0.0	0.0	0.0	0.0	SG100
A5.15	Deep circalittoral coarse sediment	1.00	16242.79	0.0	0.0	0.0	0.0	SG100	1.00	30014.69	0.0	0.0	0.0	0.0	SG100
A5.23 or A5.24	NA	1.00	887.52	0.0	0.0	0.0	0.0	SG100	1.00	93.57	0.0	0.0	0.0	0.0	SG100
A5.25 or A5.26	NA	1.00	3751.31	0.0	0.0	0.0	0.0	SG100	1.00	1970.90	0.0	0.0	0.0	0.0	SG100
A5.27	Deep circalittoral sand	1.00	11764.17	0.0	0.0	0.0	0.0	SG100	1.00	22786.83	0.0	0.0	0.0	0.0	SG100
A5.33	Infralittoral sandy mud	1.00	132.26	0.0	0.0	0.0	0.0	SG100	1.00	32.20	0.0	0.0	0.0	0.0	SG100
A5.34	Infralittoral fine mud	1.00	37.98	0.0	0.0	0.0	0.0	SG100	1.00	5.40	0.0	0.0	0.0	0.0	SG100
A5.35	Circalittoral sandy mud	1.00	2702.42	0.0	0.0	0.0	0.0	SG100	1.00	884.17	0.0	0.0	0.0	0.0	SG100
A5.36	Circalittoral fine mud	1.00	40.56	0.0	0.0	0.0	0.0	SG100	1.00	30.58	0.0	0.0	0.0	0.0	SG100
A5.37	Deep circalittoral mud	0.99	10089.15	0.0	0.0	0.0	0.0	SG100	1.00	10514.39	0.0	0.0	0.0	0.0	SG100
A5.43	Infralittoral mixed sediments	1.00	36.58	0.0	0.0	0.0	0.0	SG100	1.00	38.35	0.0	0.0	0.0	0.0	SG100
A5.434	[Limaria hians] beds in tide-swept sublittoral muddy mixed sediment								1.00	3.59	0.0	0.0	0.0	0.0	SG100
A5.44	Circalittoral mixed sediments	1.00	386.29	0.0	0.0	0.0	0.0	SG100	1.00	235.13	0.0	0.0	0.0	0.0	SG100
A5.45	Deep circalittoral mixed sediments	1.00	2329.88	0.0	0.0	0.0	0.0	SG100	1.00	1482.50	0.0	0.0	0.0	0.0	SG100
A5.6	Sublittoral biogenic reefs	1.00	2.88	0.0	0.0	0.0	0.0	SG100	1.00	15.17	0.0	0.0	0.0	0.0	SG100
A5.61	Sublittoral polychaete worm reefs on sediment	1.00	0.23	0.0	0.0	0.0	0.0	SG100							
A5.611	[Sabellaria spinulosa] on stable circalittoral mixed sediment	1.00	6.06	0.0	0.0	0.0	0.0	SG100	1.00	0.16	0.0	0.0	0.0	0.0	SG100
A5.612	[Sabellaria alveolata] on variable salinity sublittoral mixed sediment	1.00	0.71	0.0	0.0	0.0	0.0	SG100							
A5.613	[Serpula vermicularis] reefs on very sheltered circalittoral muddy sand								1.00	0.15	0.0	0.0	0.0	0.0	SG100
A5.62	Sublittoral mussel beds on sediment	1.00	27.16	0.0	0.0	0.0	0.0	SG100	1.00	0.74	0.0	0.0	0.0	0.0	SG100
A5.625	[Mytilus edulis] beds on sublittoral sediment														
A5.631	Circalittoral [Lophelia pertusa] reefs								1.00	6.57	0.0	0.0	0.0	0.0	SG100
A6	Deep-sea bed								1.00	9035.66	0.0	0.0	0.0	0.0	SG100
A6.11	Deep-sea bedrock								1.00	1033.01	0.0	0.0	0.0	0.0	SG100
A6.2	Deep-sea mixed substrata								1.00	4093.56	0.0	0.0	0.0	0.0	SG100
A6.3 or A6.4	NA								1.00	11693.59	0.0	0.0	0.0	0.0	SG100
A6.5	Deep-sea mud								1.00	66080.52	0.0	0.0	0.0	0.0	SG100
A6.61	Communities of deep-sea corals								1.00	18.96	0.0	0.0	0.0	0.0	SG100
Undefined	NA	1.00	1452.55	0.0	0.0	0.0	0.0	SG100	1.00	5461.00	0.0	0.0	0.0	0.0	SG100

		TR1 northern North Sea assessment area							TR1 North Sea assessment area						
EUNIS code	EUNIS habitat me	Mean RBS	Habitat area km^2	Mean recovery time	SG60 recovery time	SG80 recovery time	SG100 recovery time	Indicative MSC Score	Mean RBS	Habitat area km^2	Mean recovery time	SG60 recovery time	SG80 recovery time	SG100 recovery time	Indicative MSC Score
A3	Infralittoral rock and other hard substrata	1.00	8.87	0.0	0.0	0.0	0.0	SG100	1.00	1.32	0.0	0.0	0.0	0.0	SG100
A3.1	Atlantic and Mediterranean high energy infralittoral rock	1.00	423.46	0.0	0.0	0.0	0.0	SG100	1.00	75.52	0.0	0.0	0.0	0.0	SG100
A3.2	Atlantic and Mediterranean moderate energy infralittoral rock	1.00	256.88	0.0	0.0	0.0	0.0	SG100	1.00	27.70	0.0	0.0	0.0	0.0	SG100
A3.3	Atlantic and Mediterranean low energy infralittoral rock	1.00	108.77	0.0	0.0	0.0	0.0	SG100	1.00	16.32	0.0	0.0	0.0	0.0	SG100
A4	Circalittoral rock and other hard substrata	1.00	0.18	0.0	0.0	0.0	0.0	SG100	1.00	0.79	0.0	0.0	0.0	0.0	SG100
A4.1	Atlantic and Mediterranean high energy circalittoral rock	1.00	808.01	0.0	0.0	0.0	0.0	SG100	1.00	70.44	0.0	0.0	0.0	0.0	SG100
A4.12	Sponge communities on deep circalittoral rock	1.00	60.38	0.0	0.0	0.0	0.0	SG100							
A4.12 or A4.27 or A4.33	NA														
A4.2	Atlantic and Mediterranean moderate energy circalittoral rock	1.00	497.14	0.0	0.0	0.0	0.0	SG100	1.00	258.67	0.0	0.0	0.0	0.0	SG100
A4.27	Faunal communities on deep moderate energy circalittoral rock	1.00	193.93	0.0	0.0	0.0	0.0	SG100	1.00	46.16	0.0	0.0	0.0	0.0	SG100
A4.3	Atlantic and Mediterranean low energy circalittoral rock	1.00	57.40	0.0	0.0	0.0	0.0	SG100	1.00	25.46	0.0	0.0	0.0	0.0	SG100
A4.33	Faunal communities on deep low energy circalittoral rock	1.00	118.34	0.0	0.0	0.0	0.0	SG100	1.00	113.33	0.0	0.0	0.0	0.0	SG100
A5	Sublittoral sediment	1.00	427.43	0.0	0.0	0.0	0.0	SG100	1.00	121.74	0.0	0.0	0.0	0.0	SG100
A5.13	Infralittoral coarse sediment	1.00	173.60	0.0	0.0	0.0	0.0	SG100	1.00	946.77	0.0	0.0	0.0	0.0	SG100
A5.14	Circalittoral coarse sediment	1.00	1316.36	0.0	0.0	0.0	0.0	SG100	1.00	5272.10	0.0	0.0	0.0	0.0	SG100
A5.15	Deep circalittoral coarse sediment	1.00	24018.11	0.0	0.0	0.0	0.0	SG100	1.00	15806.50	0.0	0.0	0.0	0.0	SG100
A5.23 or A5.24	NA	1.00	231.02	0.0	0.0	0.0	0.0	SG100	1.00	3244.27	0.0	0.0	0.0	0.0	SG100
A5.25 or A5.26	NA	1.00	772.23	0.0	0.0	0.0	0.0	SG100	1.00	11926.78	0.0	0.0	0.0	0.0	SG100
A5.27	Deep circalittoral sand	1.00	63892.21	0.0	0.0	0.0	0.0	SG100	1.00	87598.86	0.0	0.0	0.0	0.0	SG100
A5.33	Infralittoral sandy mud	1.00	77.82	0.0	0.0	0.0	0.0	SG100	1.00	29.15	0.0	0.0	0.0	0.0	SG100
A5.34	Infralittoral fine mud								1.00	0.32	0.0	0.0	0.0	0.0	SG100
A5.35	Circalittoral sandy mud	1.00	287.51	0.0	0.0	0.0	0.0	SG100	1.00	985.10	0.0	0.0	0.0	0.0	SG100
A5.36	Circalittoral fine mud								1.00	2.02	0.0	0.0	0.0	0.0	SG100
A5.37	Deep circalittoral mud	0.98	36528.08	0.0	0.0	0.0	0.0	SG100	0.92	18347.41	0.0	0.0	0.0	0.0	SG100
A5.43	Infralittoral mixed sediments	1.00	57.89	0.0	0.0	0.0	0.0	SG100	1.00	49.76	0.0	0.0	0.0	0.0	SG100
A5.434	[Limaria hians] beds in tide-swept sublittoral muddy mixed sediment	1.00	5.24	0.0	0.0	0.0	0.0	SG100							
A5.44	Circalittoral mixed sediments	1.00	81.64	0.0	0.0	0.0	0.0	SG100	1.00	315.52	0.0	0.0	0.0	0.0	SG100
A5.45	Deep circalittoral mixed sediments	1.00	774.22	0.0	0.0	0.0	0.0	SG100	1.00	1019.79	0.0	0.0	0.0	0.0	SG100
A5.6	Sublittoral biogenic reefs	1.00	0.51	0.0	0.0	0.0	0.0	SG100	1.00	1.82	0.0	0.0	0.0	0.0	SG100
A5.61	Sublittoral polychaete worm reefs on sediment								1.00	0.38	0.0	0.0	0.0	0.0	SG100
A5.611	[Sabellaria spinulosa] on stable circalittoral mixed sediment								1.00	36.18	0.0	0.0	0.0	0.0	SG100
A5.612	[Sabellaria alveolata] on variable salinity sublittoral mixed sediment														
A5.613	[Serpula vermicularis] reefs on very sheltered circalittoral muddy sand														
A5.62	Sublittoral mussel beds on sediment	1.00	28.06	0.0	0.0	0.0	0.0	SG100	1.00	5.91	0.0	0.0	0.0	0.0	SG100
A5.625	[Mytilus edulis] beds on sublittoral sediment								1.00	3.46	0.0	0.0	0.0	0.0	SG100
A5.631	Circalittoral [Lophelia pertusa] reefs														
A6	Deep-sea bed	1.00	2655.45	0.0	0.0	0.0	0.0	SG100							
A6.11	Deep-sea bedrock														
A6.2	Deep-sea mixed substrata	1.00	6357.68	0.0	0.0	0.0	0.0	SG100							
A6.3 or A6.4	NA	1.00	4485.41	0.0	0.0	0.0	0.0	SG100							
A6.5	Deep-sea mud	1.00	11286.73	0.0	0.0	0.0	0.0	SG100							
A6.61	Communities of deep-sea corals														
Undefined	NA	1.00	962.81	0.0	0.0	0.0	0.0	SG100	1.00	519.17	0.0	0.0	0.0	0.0	SG100

Appendix C. Benthic Impact Tool results for commonly encountered habitats for creel gear in the four assessment areas. Recovery times are in years and blanks cells indicate the habitat is not present to assess. The main *Nephrops* habitat is highlighted in grey.

		Creel Celtic assessment area							Creel West of Scotland assessment area						
EUNIS code	EUNIS habitat name	Mean RBS	Habitat area km^2	Mean recovery time	SG60 recovery time	SG80 recovery time	SG100 recovery time	Indicative MSC Score	Mean RBS	Habitat area km^2	Mean recovery time	SG60 recovery time	SG80 recovery time	SG100 recovery time	Indicative MSC Score
A3	Infralittoral rock and other hard substrata	1.00	5.49	0.0	0.0	0.0	0.0	SG100	1.00	6.03	0.0	0.0	0.0	0.0	SG100
A3.1	Atlantic and Mediterranean high energy infralittoral rock	1.00	86.23	0.0	0.0	0.0	0.0	SG100	1.00	309.24	0.0	0.0	0.0	0.0	SG100
A3.2	Atlantic and Mediterranean moderate energy infralittoral rock	1.00	17.22	0.0	0.0	0.0	0.0	SG100	1.00	74.29	0.0	0.0	0.0	0.0	SG100
A3.3	Atlantic and Mediterranean low energy infralittoral rock	1.00	9.89	0.0	0.0	0.0	0.0	SG100	1.00	134.87	0.0	0.0	0.0	0.0	SG100
A4	Circalittoral rock and other hard substrata	1.00	1.59	0.0	0.0	0.0	0.0	SG100	1.00	0.38	0.0	0.0	0.0	0.0	SG100
A4.1	Atlantic and Mediterranean high energy circalittoral rock	1.00	241.18	0.0	0.0	0.0	0.0	SG100	1.00	2130.99	0.0	0.0	0.0	0.0	SG100
A4.12	Sponge communities on deep circalittoral rock	1.00	19.08	0.0	0.0	0.0	0.0	SG100	1.00	331.32	0.0	0.0	0.0	0.0	SG100
A4.12 or A4.27 or A4.33	NA	1.00	0.34	0.0	0.0	0.0	0.0	SG100			0.0	0.0	0.0	0.0	SG100
A4.2	Atlantic and Mediterranean moderate energy circalittoral rock	1.00	93.33	0.0	0.0	0.0	0.0	SG100	1.00	310.99	0.0	0.0	0.0	0.0	SG100
A4.27	Faunal communities on deep moderate energy circalittoral rock	1.00	568.95	0.0	0.0	0.0	0.0	SG100	1.00	471.33	0.0	0.0	0.0	0.0	SG100
A4.3	Atlantic and Mediterranean low energy circalittoral rock	1.00	6.53	0.0	0.0	0.0	0.0	SG100	1.00	243.93	0.0	0.0	0.0	0.0	SG100
A4.33	Faunal communities on deep low energy circalittoral rock	1.00	64.88	0.0	0.0	0.0	0.0	SG100	1.00	486.19	0.0	0.0	0.0	0.0	SG100
A5	Sublittoral sediment	1.00	364.92	0.0	0.0	0.0	0.0	SG100	1.00	4959.77	0.0	0.0	0.0	0.0	SG100
A5.13	Infralittoral coarse sediment	1.00	482.16	0.0	0.0	0.0	0.0	SG100	1.00	210.63	0.0	0.0	0.0	0.0	SG100
A5.14	Circalittoral coarse sediment	1.00	5108.32	0.0	0.0	0.0	0.0	SG100	1.00	4563.64	0.0	0.0	0.0	0.0	SG100
A5.15	Deep circalittoral coarse sediment	1.00	16242.79	0.0	0.0	0.0	0.0	SG100	1.00	30014.69	0.0	0.0	0.0	0.0	SG100
A5.23 or A5.24	NA	1.00	887.52	0.0	0.0	0.0	0.0	SG100	1.00	93.57	0.0	0.0	0.0	0.0	SG100
A5.25 or A5.26	NA	1.00	3751.31	0.0	0.0	0.0	0.0	SG100	1.00	1970.90	0.0	0.0	0.0	0.0	SG100
A5.27	Deep circalittoral sand	1.00	11764.17	0.0	0.0	0.0	0.0	SG100	1.00	22786.83	0.0	0.0	0.0	0.0	SG100
A5.33	Infralittoral sandy mud	1.00	132.26	0.0	0.0	0.0	0.0	SG100	1.00	32.20	0.0	0.0	0.0	0.0	SG100
A5.34	Infralittoral fine mud	1.00	37.98	0.0	0.0	0.0	0.0	SG100	1.00	5.40	0.0	0.0	0.0	0.0	SG100
A5.35	Circalittoral sandy mud	1.00	2702.42	0.0	0.0	0.0	0.0	SG100	1.00	884.17	0.0	0.0	0.0	0.0	SG100
A5.36	Circalittoral fine mud	1.00	40.56	0.0	0.0	0.0	0.0	SG100	1.00	30.58	0.0	0.0	0.0	0.0	SG100
A5.37	Deep circalittoral mud	1.00	10089.15	0.0	0.0	0.0	0.0	SG100	1.00	10514.39	0.0	0.0	0.0	0.0	SG100
A5.43	Infralittoral mixed sediments	1.00	36.58	0.0	0.0	0.0	0.0	SG100	1.00	38.35	0.0	0.0	0.0	0.0	SG100
A5.434	[Limaria hians] beds in tide-swept sublittoral muddy mixed sediment								1.00	3.59					
A5.44	Circalittoral mixed sediments	1.00	386.29	0.0	0.0	0.0	0.0	SG100	1.00	235.13	0.0	0.0	0.0	0.0	SG100
A5.45	Deep circalittoral mixed sediments	1.00	2329.88	0.0	0.0	0.0	0.0	SG100	1.00	1482.50	0.0	0.0	0.0	0.0	SG100
A5.6	Sublittoral biogenic reefs	1.00	2.88	0.0	0.0	0.0	0.0	SG100	1.00	15.17	0.0	0.0	0.0	0.0	SG100
A5.61	Sublittoral polychaete worm reefs on sediment	1.00	0.23	0.0	0.0	0.0	0.0	SG100			0.0	0.0	0.0	0.0	SG100
A5.611	[Sabellaria spinulosa] on stable circalittoral mixed sediment	1.00	6.06	0.0	0.0	0.0	0.0	SG100	1.00	0.16	0.0	0.0	0.0	0.0	SG100
A5.612	[Sabellaria alveolata] on variable salinity sublittoral mixed sediment	1.00	0.71	0.0	0.0	0.0	0.0	SG100			0.0	0.0	0.0	0.0	SG100
A5.613	[Serpula vermicularis] reefs on very sheltered circalittoral muddy sand								1.00	0.15					
A5.62	Sublittoral mussel beds on sediment	1.00	27.16	0.0	0.0	0.0	0.0	SG100	1.00	0.74	0.0	0.0	0.0	0.0	SG100
A5.625	[Mytilus edulis] beds on sublittoral sediment														
A5.631	Circalittoral [Lophelia pertusa] reefs								1.00	6.57					
A6	Deep-sea bed								1.00	9035.66					
A6.11	Deep-sea bedrock								1.00	1033.01					
A6.2	Deep-sea mixed substrata								1.00	4093.56					
A6.3 or A6.4	NA								1.00	11693.59					
A6.5	Deep-sea mud								1.00	66080.52					
A6.61	Communities of deep-sea corals								1.00	18.96					
Undefined	NA	1.00	1452.55	0.0	0.0	0.0	0.0	SG100	1.00	5461.00	0.0	0.0	0.0	0.0	SG100

		Creel northern North Sea assessment area							Creel North Sea assessment area						
EUNIS code	EUNIS habitat name	Mean RBS	Habitat area km^2	Mean recovery time	SG60 recovery time	SG80 recovery time	SG100 recovery time	Indicative MSC Score	Mean RBS	Habitat area km^2	Mean recovery time	SG60 recovery time	SG80 recovery time	SG100 recovery time	Indicative MSC Score
A3	Infralittoral rock and other hard substrata	1.00	8.87	0.0	0.0	0.0	0.0	SG100	1.00	1.32	0.0	0.0	0.0	0.0	SG100
A3.1	Atlantic and Mediterranean high energy infralittoral rock	1.00	423.46	0.0	0.0	0.0	0.0	SG100	1.00	75.52	0.0	0.0	0.0	0.0	SG100
A3.2	Atlantic and Mediterranean moderate energy infralittoral rock	1.00	256.88	0.0	0.0	0.0	0.0	SG100	1.00	27.70	0.0	0.0	0.0	0.0	SG100
A3.3	Atlantic and Mediterranean low energy infralittoral rock	1.00	108.77	0.0	0.0	0.0	0.0	SG100	1.00	16.32	0.0	0.0	0.0	0.0	SG100
A4	Circalittoral rock and other hard substrata	1.00	0.18	0.0	0.0	0.0	0.0	SG100	1.00	0.79	0.0	0.0	0.0	0.0	SG100
A4.1	Atlantic and Mediterranean high energy circalittoral rock	1.00	808.01	0.0	0.0	0.0	0.0	SG100	1.00	70.44	0.0	0.0	0.0	0.0	SG100
A4.12	Sponge communities on deep circalittoral rock	1.00	60.38	0.0	0.0	0.0	0.0	SG100							
A4.12 or A4.27 or A4.33	NA														
A4.2	Atlantic and Mediterranean moderate energy circalittoral rock	1.00	497.14	0.0	0.0	0.0	0.0	SG100	1.00	258.67	0.0	0.0	0.0	0.0	SG100
A4.27	Faunal communities on deep moderate energy circalittoral rock	1.00	193.93	0.0	0.0	0.0	0.0	SG100	1.00	46.16	0.0	0.0	0.0	0.0	SG100
A4.3	Atlantic and Mediterranean low energy circalittoral rock	1.00	57.40	0.0	0.0	0.0	0.0	SG100	1.00	25.46	0.0	0.0	0.0	0.0	SG100
A4.33	Faunal communities on deep low energy circalittoral rock	1.00	118.34	0.0	0.0	0.0	0.0	SG100	1.00	113.33	0.0	0.0	0.0	0.0	SG100
A5	Sublittoral sediment	1.00	427.43	0.0	0.0	0.0	0.0	SG100	1.00	121.74	0.0	0.0	0.0	0.0	SG100
A5.13	Infralittoral coarse sediment	1.00	173.60	0.0	0.0	0.0	0.0	SG100	1.00	946.77	0.0	0.0	0.0	0.0	SG100
A5.14	Circalittoral coarse sediment	1.00	1316.36	0.0	0.0	0.0	0.0	SG100	1.00	5272.10	0.0	0.0	0.0	0.0	SG100
A5.15	Deep circalittoral coarse sediment	1.00	24018.11	0.0	0.0	0.0	0.0	SG100	1.00	15806.50	0.0	0.0	0.0	0.0	SG100
A5.23 or A5.24	NA	1.00	231.02	0.0	0.0	0.0	0.0	SG100	1.00	3244.27	0.0	0.0	0.0	0.0	SG100
A5.25 or A5.26	NA	1.00	772.23	0.0	0.0	0.0	0.0	SG100	1.00	11926.78	0.0	0.0	0.0	0.0	SG100
A5.27	Deep circalittoral sand	1.00	63892.21	0.0	0.0	0.0	0.0	SG100	1.00	87598.86	0.0	0.0	0.0	0.0	SG100
A5.33	Infralittoral sandy mud	1.00	77.82	0.0	0.0	0.0	0.0	SG100	1.00	29.15	0.0	0.0	0.0	0.0	SG100
A5.34	Infralittoral fine mud								1.00	0.32	0.0	0.0	0.0	0.0	SG100
A5.35	Circalittoral sandy mud	1.00	287.51	0.0	0.0	0.0	0.0	SG100	1.00	985.10	0.0	0.0	0.0	0.0	SG100
A5.36	Circalittoral fine mud								1.00	2.02	0.0	0.0	0.0	0.0	SG100
A5.37	Deep circalittoral mud	1.00	36528.08	0.0	0.0	0.0	0.0	SG100	1.00	18347.41	0.0	0.0	0.0	0.0	SG100
A5.43	Infralittoral mixed sediments	1.00	57.89	0.0	0.0	0.0	0.0	SG100	1.00	49.76	0.0	0.0	0.0	0.0	SG100
A5.434	[Limaria hians] beds in tide-swept sublittoral muddy mixed sediment	1.00	5.24	0.0	0.0	0.0	0.0	SG100							
A5.44	Circalittoral mixed sediments	1.00	81.64	0.0	0.0	0.0	0.0	SG100	1.00	315.52	0.0	0.0	0.0	0.0	SG100
A5.45	Deep circalittoral mixed sediments	1.00	774.22	0.0	0.0	0.0	0.0	SG100	1.00	1019.79	0.0	0.0	0.0	0.0	SG100
A5.6	Sublittoral biogenic reefs	1.00	0.51	0.0	0.0	0.0	0.0	SG100	1.00	1.82	0.0	0.0	0.0	0.0	SG100
A5.61	Sublittoral polychaete worm reefs on sediment								1.00	0.38	0.0	0.0	0.0	0.0	SG100
A5.611	[Sabellaria spinulosa] on stable circalittoral mixed sediment								1.00	36.18	0.0	0.0	0.0	0.0	SG100
A5.612	[Sabellaria alveolata] on variable salinity sublittoral mixed sediment														
A5.613	[Serpula vermicularis] reefs on very sheltered circalittoral muddy sand														
A5.62	Sublittoral mussel beds on sediment	1.00	28.06	0.0	0.0	0.0	0.0	SG100	1.00	5.91	0.0	0.0	0.0	0.0	SG100
A5.625	[Mytilus edulis] beds on sublittoral sediment								1.00	3.46	0.0	0.0	0.0	0.0	SG100
A5.631	Circalittoral [Lophelia pertusa] reefs														
A6	Deep-sea bed	1.00	2655.45	0.0	0.0	0.0	0.0	SG100							
A6.11	Deep-sea bedrock														
A6.2	Deep-sea mixed substrata	1.00	6357.68	0.0	0.0	0.0	0.0	SG100							
A6.3 or A6.4	NA	1.00	4485.41	0.0	0.0	0.0	0.0	SG100							
A6.5	Deep-sea mud	1.00	11286.73	0.0	0.0	0.0	0.0	SG100							
A6.61	Communities of deep-sea corals														
Undefined	NA	1.00	962.81	0.0	0.0	0.0	0.0	SG100	1.00	519.17	0.0	0.0	0.0	0.0	SG100

Appendix D. Benthic Impact Tool assessment results for TR2 trawl gear and all OSPAR VME habitat polygons and Priority Marine Feature fan mussel aggregations and flame shell bed polygons with depletion of 0.06. Recovery times are in years and blanks cells indicate the habitat is not present to assess.

	TR2 all VME d= 0.06 Celtic assessment area							TR2 all VME d= 0.06 West of Scotland assessment area							TR2 all VME d= 0.06 northern North Sea assessment area							TR2 all VME d= 0.06 North Sea assessment area						
VME habitat	**Mean RBS**	**Habitat area km²**	**Mean recovery time**	**SG60 recovery time**	**SG80 recovery time**	**SG100 recovery time**	**Indicative MSC Score**	**Mean RBS**	**Habitat area km²**	**Mean recovery time**	**SG60 recovery time**	**SG80 recovery time**	**SG100 recovery time**	**Indicative MSC Score**	**Mean RBS**	**Habitat area km²**	**Mean recovery time**	**SG60 recovery time**	**SG80 recovery time**	**SG100 recovery time**	**Indicative MSC Score**	**Mean RBS**	**Habitat area km²**	**Mean recovery time**	**SG60 recovery time**	**SG80 recovery time**	**SG100 recovery time**	**Indicative MSC Score**
Coral gardens								1.00	2.50	0.0	0.0	0.0	0.0	SG100														
Fan mussel aggregations								0.47	1.77	3.8	5.0	7.0	13.0	SG100														
Flame shell beds								1.00	4.62	0.0	0.0	0.0	0.0	SG100														
Littoral chalk communities	1.00	0.00	0.0	0.0	0.0	0.0	SG100															1.00	0.04	0.0	0.0	0.0	0.0	SG100
Lophelia pertusa reefs								0.97	29.66	0.0	0.0	0.0	0.0	SG100														
Maerl beds	1.00	3.89	0.0	0.0	0.0	0.0	SG100	0.89	39.18	0.0	0.0	0.0	0.0	SG100	1.00	12.98	0.0	0.0	0.0	0.0	SG100							
Modiolus modiolus horse mussel beds	1.00	17.57	0.0	0.0	0.0	0.0	SG100	0.95	4.06	0.0	0.0	0.0	0.0	SG100	1.00	28.77	0.0	0.0	0.0	0.0	SG100							
Sabellaria spinulosa reefs	1.00	7.14	0.0	0.0	0.0	0.0	SG100	1.00	13.44	0.0	0.0	0.0	0.0	SG100								0.99	47.68	0.0	0.0	0.0	0.0	SG100
Sea-pen and burrowing megafauna communities	0.28	7225.31	20.0	20+ years	20+ years	20+ years	Fail	0.51	1711.67	16.5	18.8	20+ years	20+ years	SG60	0.74	1664.48	2.8	4.5	7.0	11.0	SG100	0.95	196.00	0.0	0.0	0.0	0.0	SG100
Seamounts								1.00	7702.13	0.0	0.0	0.0	0.0	SG100														
Zostera beds	1.00	16.44	0.0	0.0	0.0	0.0	SG100	0.97	14.99	0.0	0.0	0.0	0.0	SG100	1.00	36.30	0.0	0.0	0.0	0.0	SG100	1.00	8.89	0.0	0.0	0.0	0.0	SG100

Appendix E. Benthic Impact Tool assessment results for TR2 trawl gear and all OSPAR VME habitat polygons and Priority Marine Feature fan mussel aggregations and flame shell bed polygons with depletion of 0.5. Recovery times are in years and blanks cells indicate the habitat is not present to assess.

	TR2 all VME d= 0.5 Celtic assessment area							TR2 all VME d= 0.5 West of Scotland assessment area							TR2 all VME d= 0.5 northern North Sea assessment area							TR2 all VME d= 0.5 North Sea assessment area						
VME habitat	**Mean RBS**	**Habitat area km²**	**Mean recovery time**	**SG60 recovery time**	**SG80 recovery time**	**SG100 recovery time**	**Indicative MSC Score**	**Mean RBS**	**Habitat area km²**	**Mean recovery time**	**SG60 recovery time**	**SG80 recovery time**	**SG100 recovery time**	**Indicative MSC Score**	**Mean RBS**	**Habitat area km²**	**Mean recovery time**	**SG60 recovery time**	**SG80 recovery time**	**SG100 recovery time**	**Indicative MSC Score**	**Mean RBS**	**Habitat area km²**	**Mean recovery time**	**SG60 recovery time**	**SG80 recovery time**	**SG100 recovery time**	**Indicative MSC Score**
Coral gardens								1.00	2.50	0.0	0.0	0.0	0.0	SG100														
Fan mussel aggregations								0.15	1.77	12.0	13.3	14.8	16.8	SG100														
Flame shell beds								0.99	4.62	0.0	0.0	0.0	0.0	SG100														
Littoral chalk communities	1.00	0.00	0.0	0.0	0.0	0.0	SG100															1.00	0.04	0.0	0.0	0.0	0.0	SG100
Lophelia pertusa reefs								0.83	29.66	0.0	0.0	0.0	20+ years	SG80														
Maerl beds	1.00	3.89	0.0	0.0	0.0	0.0	SG100	0.81	39.18	0.0	0.0	0.0	0.0	SG100	1.00	12.98	0.0	0.0	0.0	0.0	SG100							
Modiolus modiolus horse mussel beds	1.00	17.57	0.0	0.0	0.0	0.0	SG100	0.87	4.06	0.0	0.0	0.0	0.0	SG100	1.00	28.77	0.0	0.0	0.0	0.0	SG100							
Sabellaria spinulosa reefs	1.00	7.14	0.0	0.0	0.0	0.0	SG100	1.00	13.44	0.0	0.0	0.0	0.0	SG100								0.90	47.68	0.0	0.0	0.0	0.0	SG100
Sea-pen and burrowing megafauna communities	0.14	7225.31	20+ years	20+ years	20+ years	20+ years	Fail	0.32	1711.67	20+ years	20+ years	20+ years	20+ years	Fail	0.43	1664.48	18.0	20.0	20+ years	20+ years	SG60	0.71	196.00	6.3	7.8	10.3	14.3	SG100
Seamounts								1.00	7702.13	0.0	0.0	0.0	0.0	SG100														
Zostera beds	1.00	16.44	0.0	0.0	0.0	0.0	SG100	0.90	14.99	0.0	0.0	0.0	0.0	SG100	1.00	36.30	0.0	0.0	0.0	0.0	SG100	1.00	8.89	0.0	0.0	0.0	0.0	SG100

Appendix F. Benthic Impact Tool assessment results for TR2 trawl gear and certain OSPAR VME habitat polygons with depletion of 0.06. Recovery times are in years and blanks cells indicate the habitat is not present to assess.

	TR2 VME certain d= 0.06 Celtic assessment area							TR2 VME certain d= 0.06 West of Scotland assessment area							TR2 VME certain d= 0.06 northern North Sea assessment area							TR2 VME certain d= 0.06 North Sea assessment area						
VME habitat	**Mean RBS**	**Habitat area km^2**	**Mean recovery time**	**SG60 recovery time**	**SG80 recovery time**	**SG100 recovery time**	**Indicative MSC Score**	**Mean RBS**	**Habitat area km^2**	**Mean recovery time**	**SG60 recovery time**	**SG80 recovery time**	**SG100 recovery time**	**Indicative MSC Score**	**Mean RBS**	**Habitat area km^2**	**Mean recovery time**	**SG60 recovery time**	**SG80 recovery time**	**SG100 recovery time**	**Indicative MSC Score**	**Mean RBS**	**Habitat area km^2**	**Mean recovery time**	**SG60 recovery time**	**SG80 recovery time**	**SG100 recovery time**	**Indicative MSC Score**
Coral gardens								1.00	0.48	0.0	0.0	0.0	0.0	SG100														
Lophelia pertusa reefs								1.00	22.11	0.0	0.0	0.0	0.0	SG100														
Maerl beds	1.00	2.57	0.0	0.0	0.0	0.0	SG100	0.88	23.56	0.0	0.0	0.0	0.0	SG100	1.00	4.20	0.0	0.0	0.0	0.0	SG100							
Modiolus modiolus horse mussel beds	1.00	14.40	0.0	0.0	0.0	0.0	SG100	0.83	1.28	0.0	0.0	1.3	4.8	SG100	1.00	26.48	0.0	0.0	0.0	0.0	SG100							
Sabellaria spinulosa reefs								1.00	13.43	0.0	0.0	0.0	0.0	SG100														
Sea-pen and burrowing megafauna communities	0.90	785.80	0.0	0.0	0.0	0.0	SG100	0.61	380.95	16.5	18.3	20+ years	20+ years	SG60	0.96	748.33	0.0	0.0	0.0	0.0	SG100							
Seamounts								1.00	6161.32	0.0	0.0	0.0	0.0	SG100														
Zostera beds	1.00	11.93	0.0	0.0	0.0	0.0	SG100	0.96	3.82	0.0	0.0	0.0	0.0	SG100	1.00	3.27	0.0	0.0	0.0	0.0	SG100	1.00	5.55	0.0	0.0	0.0	0.0	SG100

Appendix G. Benthic Impact Tool assessment results for TR2 trawl gear and certain OSPAR VME habitat polygons with depletion of 0.5. Recovery times are in years and blanks cells indicate the habitat is not present to assess.

	TR2 VME certain d= 0.5 Celtic assessment area							TR2 VME certain d= 0.5 West of Scotland assessment area							TR2 VME certain d= 0.5 northern North Sea assessment area							TR2 VME certain d= 0.5 North Sea assessment area						
VME habitat	**Mean RBS**	**Habitat area km^2**	**Mean recovery time**	**SG60 recovery time**	**SG80 recovery time**	**SG100 recovery time**	**Indicative MSC Score**	**Mean RBS**	**Habitat area km^2**	**Mean recovery time**	**SG60 recovery time**	**SG80 recovery time**	**SG100 recovery time**	**Indicative MSC Score**	**Mean RBS**	**Habitat area km^2**	**Mean recovery time**	**SG60 recovery time**	**SG80 recovery time**	**SG100 recovery time**	**Indicative MSC Score**	**Mean RBS**	**Habitat area km^2**	**Mean recovery time**	**SG60 recovery time**	**SG80 recovery time**	**SG100 recovery time**	**Indicative MSC Score**
Coral gardens								1.00	0.48	0.0	0.0	0.0	0.0	SG100														
Lophelia pertusa reefs								0.96	22.11	0.0	0.0	0.0	0.0	SG100														
Maerl beds	1.00	2.57	0.0	0.0	0.0	0.0	SG100	0.81	23.56	0.0	0.0	0.0	0.0	SG100	1.00	4.20	0.0	0.0	0.0	0.0	SG100							
Modiolus modiolus horse mussel beds	1.00	14.40	0.0	0.0	0.0	0.0	SG100	0.58	1.28	20+ years	20+ years	20+ years	20+ years	Fail	1.00	26.48	0.0	0.0	0.0	0.0	SG100							
Sabellaria spinulosa reefs								1.00	13.43	0.0	0.0	0.0	0.0	SG100														
Sea-pen and burrowing megafauna communities	0.90	785.80	4.0	5.3	6.8	9.5	SG100	0.53	380.95	18.3	20+ years	20+ years	20+ years	Fail	0.69	748.33	4.0	5.3	6.8	9.0	SG100							
Seamounts								1.00	6161.32	0.0	0.0	0.0	0.0	SG100														
Zostera beds	1.00	11.93	0.0	0.0	0.0	0.0	SG100	0.81	3.82	0.0	0.0	0.0	0.0	SG100	1.00	3.27	0.0	0.0	0.0	0.0	SG100	1.00	5.55	0.0	0.0	0.0	0.0	SG100

Appendix H. Benthic Impact Tool assessment results for TR1 trawl gear and all OSPAR VME habitat polygons and Priority Marine Feature fan mussel aggregations and flame shell bed polygons with depletion of 0.06. Recovery times are in years and blanks cells indicate the habitat is not present to assess.

	TR1 all VME d=0.06 Celtic assessment area							TR1 all VME d=0.06 West of Scotland assessment area						
VME habitat	**Mean RBS**	**Habitat area km^2**	**Mean recovery time**	**SG60 recovery time**	**SG80 recovery time**	**SG100 recovery time**	**Indicative MSC Score**	**Mean RBS**	**Habitat area km^2**	**Mean recovery time**	**SG60 recovery time**	**SG80 recovery time**	**SG100 recovery time**	**Indicative MSC Score**
Coral gardens								1.00	2.50	0.0	0.0	0.0	0.0	SG100
Fan mussel aggregations								1.00	1.77	0.0	0.0	0.0	0.0	SG100
Flame shell beds								1.00	4.62	0.0	0.0	0.0	0.0	SG100
Littoral chalk communities	1.00	0.00	0.0	0.0	0.0	0.0	SG100							
Lophelia pertusa reefs								1.00	29.66	0.0	0.0	0.0	0.0	SG100
Maerl beds	1.00	3.89	0.0	0.0	0.0	0.0	SG100	1.00	39.18	0.0	0.0	0.0	0.0	SG100
Modiolus modiolus horse mussel beds	1.00	17.57	0.0	0.0	0.0	0.0	SG100	1.00	4.06	0.0	0.0	0.0	0.0	SG100
Sabellaria spinulosa reefs	1.00	7.14	0.0	0.0	0.0	0.0	SG100	1.00	13.44	0.0	0.0	0.0	0.0	SG100
Sea-pen and burrowing megafauna communities	1.00	7225.31	0.0	0.0	0.0	0.0	SG100	1.00	1711.67	0.0	0.0	0.0	0.0	SG100
Seamounts								1.00	7702.13	0.0	0.0	0.0	0.0	SG100
Zostera beds	1.00	16.44	0.0	0.0	0.0	0.0	SG100	1.00	14.99	0.0	0.0	0.0	0.0	SG100

	TR1 all VME d=0.06 northern North Sea assessment area							TR1 all VME d=0.06 North Sea assessment area						
VME habitat	**Mean RBS**	**Habitat area km^2**	**Mean recovery time**	**SG60 recovery time**	**SG80 recovery time**	**SG100 recovery time**	**Indicative MSC Score**	**Mean RBS**	**Habitat area km^2**	**Mean recovery time**	**SG60 recovery time**	**SG80 recovery time**	**SG100 recovery time**	**Indicative MSC Score**
Coral gardens														
Fan mussel aggregations														
Flame shell beds	1.00	5.08	0.0	0.0	0.0	0.0	SG100							
Littoral chalk communities								1.00	0.04	0.0	0.0	0.0	0.0	SG100
Lophelia pertusa reefs														
Maerl beds	1.00	12.98	0.0	0.0	0.0	0.0	SG100							
Modiolus modiolus horse mussel beds	1.00	28.77	0.0	0.0	0.0	0.0	SG100							
Sabellaria spinulosa reefs								1.00	47.68	0.0	0.0	0.0	0.0	SG100
Sea-pen and burrowing megafauna communities	0.99	1664.14	0.0	0.0	0.0	0.0	SG100	0.79	196.00	1.0	2.0	3.3	5.5	SG100
Seamounts														
Zostera beds	1.00	36.30	0.0	0.0	0.0	0.0	SG100	1.00	8.89	0.0	0.0	0.0	0.0	SG100

Appendix I. Benthic Impact Tool assessment results for TR1 trawl gear and all OSPAR VME habitat polygons and Priority Marine Feature fan mussel aggregations and flame shell bed polygons with depletion of 0.5. Recovery times are in years and blanks cells indicate the habitat is not present to assess.

	TR1 all VME d=0.5 Celtic assessment area							TR1 all VME d=0.5 northern North Sea assessment area							TR1 all VME d=0.5 North Sea assessment area						
VME habitat	**Mean RBS**	**Habitat area km^2**	**Mean recovery time**	**SG60 recovery time**	**SG80 recovery time**	**SG100 recovery time**	**Indicative MSC Score**	**Mean RBS**	**Habitat area km^2**	**Mean recovery time**	**SG60 recovery time**	**SG80 recovery time**	**SG100 recovery time**	**Indicative MSC Score**	**Mean RBS**	**Habitat area km^2**	**Mean recovery time**	**SG60 recovery time**	**SG80 recovery time**	**SG100 recovery time**	**Indicative MSC Score**
Flame shell beds								1.00	5.08	0.0	0.0	0.0	0.0	SG100							
Littoral chalk communities	1.00	0.00	0.0	0.0	0.0	0.0	SG100								1.00	0.04	0.0	0.0	0.0	0.0	SG100
Maerl beds	1.00	3.89	0.0	0.0	0.0	0.0	SG100	1.00	12.98	0.0	0.0	0.0	0.0	SG100							
Modiolus modiolus horse mussel beds	1.00	17.57	0.0	0.0	0.0	0.0	SG100	1.00	28.77	0.0	0.0	0.0	0.0	SG100							
Sabellaria spinulosa reefs	1.00	7.14	0.0	0.0	0.0	0.0	SG100								1.00	47.68	0.0	0.0	0.0	0.0	SG100
Sea-pen and burrowing megafauna communities	0.97	7225.31	0.0	0.0	0.0	0.0	SG100	0.99	1664.14	0.0	0.0	0.0	0.0	SG100	0.50	196.00	17.0	19.0	20+ years	20+ years	SG60
Zostera beds	1.00	16.44	0.0	0.0	0.0	0.0	SG100	1.00	36.30	0.0	0.0	0.0	0.0	SG100	1.00	8.89	0.0	0.0	0.0	0.0	SG100

Appendix J. Benthic Impact Tool assessment results for TR1 trawl gear and certain OSPAR VME with depletion of 0.06. Recovery times are in years and blanks cells indicate the habitat is not present to assess. West of Scotland did not have any overlap of TR1 trawling and the VME data used.

	TR1 VME certain d= 0.06 Celtic assessment area							TR1 VME certain d= 0.06 northern North Sea assessment area							TR1 VME certain d= 0.06 North Sea assessment area						
VME habitat	**Mean RBS**	**Habitat area km^2**	**Mean recovery time**	**SG60 recovery time**	**SG80 recovery time**	**SG100 recovery time**	**Indicative MSC Score**	**Mean RBS**	**Habitat area km^2**	**Mean recovery time**	**SG60 recovery time**	**SG80 recovery time**	**SG100 recovery time**	**Indicative MSC Score**	**Mean RBS**	**Habitat area km^2**	**Mean recovery time**	**SG60 recovery time**	**SG80 recovery time**	**SG100 recovery time**	**Indicative MSC Score**
Maerl beds	1.00	2.57	0.0	0.0	0.0	0.0	SG100	1.00	4.20	0.0	0.0	0.0	0.0	SG100							
Modiolus modiolus horse mussel beds	1.00	14.40	0.0	0.0	0.0	0.0	SG100	1.00	26.48	0.0	0.0	0.0	0.0	SG100							
Sea-pen and burrowing megafauna communities	1.00	785.80	0.0	0.0	0.0	0.0	SG100	0.98	748.33	0.0	0.0	0.0	0.0	SG100							
Zostera beds	1.00	11.93	0.0	0.0	0.0	0.0	SG100	1.00	3.27	0.0	0.0	0.0	0.0	SG100	1.00	5.55	0.0	0.0	0.0	0.0	SG100

Appendix K. Benthic Impact Tool assessment results for TR1 trawl gear and certain OSPAR VME with depletion of 0.5. Recovery times are in years and blanks cells indicate the habitat is not present to assess. West of Scotland did not have any overlap of TR1 trawling and the VME data used.

	TR1 VME certain d= 0.5 Celtic assessment area							TR1 VME certain d= 0.5 northern North Sea assessment area							TR1 VME certain d= 0.5 North Sea assessment area						
VME habitat	**Mean RBS**	**Habitat area km^2**	**Mean recovery time**	**SG60 recovery time**	**SG80 recovery time**	**SG100 recovery time**	**Indicative MSC Score**	**Mean RBS**	**Habitat area km^2**	**Mean recovery time**	**SG60 recovery time**	**SG80 recovery time**	**SG100 recovery time**	**Indicative MSC Score**	**Mean RBS**	**Habitat area km^2**	**Mean recovery time**	**SG60 recovery time**	**SG80 recovery time**	**SG100 recovery time**	**Indicative MSC Score**
Maerl beds	1.00	2.57	0.0	0.0	0.0	0.0	SG100			0.0	0.0	0.0	0.0	SG100							
Modiolus modiolus horse mussel beds	1.00	14.40	0.0	0.0	0.0	0.0	SG100			0.0	0.0	0.0	0.0	SG100							
Sea-pen and burrowing megafauna communities	1.00	785.80	0.0	0.0	0.0	0.0	SG100			0.0	0.0	0.0	0.5	SG100							
Zostera beds	1.00	11.93	0.0	0.0	0.0	0.0	SG100	1.00	5.55	0.0	0.0	0.0	0.0	SG100	1.00	5.55	0.0	0.0	0.0	0.0	SG100

Appendix L. Benthic Impact Tool assessment results for creel gear and all OSPAR VME habitat polygons and Priority Marine Feature fan mussel aggregations and flame shell bed polygons with depletion of 0.14. Recovery times are in years and blanks cells indicate the habitat is not present to assess.

VME habitat	Creel VME all d=0.14 Celtic assessment area						
	Mean RBS	Habitat area km^2	Mean recovery time	SG60 recovery time	SG80 recovery time	SG100 recovery time	Indicative MSC Score
Coral gardens							
Fan mussel aggregations							
Flame shell beds							
Littoral chalk communities	1.00	0.00	0.0	0.0	0.0	0.0	SG100
Lophelia pertusa reefs							
Maerl beds	1.00	3.89	0.0	0.0	0.0	0.0	SG100
Modiolus modiolus horse mussel beds	1.00	17.57	0.0	0.0	0.0	0.0	SG100
Sabellaria spinulosa reefs	1.00	7.14	0.0	0.0	0.0	0.0	SG100
Sea-pen and burrowing megafauna communities	1.00	7225.31	0.0	0.0	0.0	0.0	SG100
Seamounts							
Zostera beds	1.00	16.44	0.0	0.0	0.0	0.0	SG100

VME habitat	Creel VME all d=0.14 West of Scotland assessment area						
	Mean RBS	Habitat area km^2	Mean recovery time	SG60 recovery time	SG80 recovery time	SG100 recovery time	Indicative MSC Score
Coral gardens	1.00	2.50	0.0	0.0	0.0	0.0	SG100
Fan mussel aggregations	1.00	1.77	0.0	0.0	0.0	0.0	SG100
Flame shell beds	1.00	4.62	0.0	0.0	0.0	0.0	SG100
Littoral chalk communities							
Lophelia pertusa reefs	0.98	29.66	0.0	0.0	0.0	0.0	SG100
Maerl beds	0.99	39.18	0.0	0.0	0.0	0.0	SG100
Modiolus modiolus horse mussel beds	0.99	4.06	0.0	0.0	0.0	0.0	SG100
Sabellaria spinulosa reefs	1.00	13.44	0.0	0.0	0.0	0.0	SG100
Sea-pen and burrowing megafauna communities	1.00	1711.67	0.0	0.0	0.0	0.0	SG100
Seamounts	1.00	7702.13	0.0	0.0	0.0	0.0	SG100
Zostera beds	1.00	14.99	0.0	0.0	0.0	0.0	SG100

VME habitat	Creel VME all d=0.14 northern North Sea assessment area						
	Mean RBS	Habitat area km^2	Mean recovery time	SG60 recovery time	SG80 recovery time	SG100 recovery time	Indicative MSC Score
Coral gardens							
Fan mussel aggregations							
Flame shell beds	1.00	5.08	0.0	0.0	0.0	0.0	SG100
Littoral chalk communities							
Lophelia pertusa reefs							
Maerl beds	1.00	12.98	0.0	0.0	0.0	0.0	SG100
Modiolus modiolus horse mussel beds	0.99	28.77	0.0	0.0	0.0	0.0	SG100
Sabellaria spinulosa reefs							
Sea-pen and burrowing megafauna communities	1.00	1664.14	0.0	0.0	0.0	0.0	SG100
Seamounts							
Zostera beds	1.00	36.30	0.0	0.0	0.0	0.0	SG100

VME habitat	Creel VME all d=0.14 North Sea assessment area						
	Mean RBS	Habitat area km^2	Mean recovery time	SG60 recovery time	SG80 recovery time	SG100 recovery time	Indicative MSC Score
Coral gardens							
Fan mussel aggregations							
Flame shell beds							
Littoral chalk communities	1.00	0.04	0.0	0.0	0.0	0.0	SG100
Lophelia pertusa reefs							
Maerl beds							
Modiolus modiolus horse mussel beds							
Sabellaria spinulosa reefs	1.00	47.68	0.0	0.0	0.0	0.0	SG100
Sea-pen and burrowing megafauna communities	1.00	196.00	0.0	0.0	0.0	0.0	SG100
Seamounts							
Zostera beds	1.00	8.89	0.0	0.0	0.0	0.0	SG100

Appendix M. Benthic Impact Tool assessment results for creel gear and all OSPAR VME habitat polygons and Priority Marine Feature fan mussel aggregations and flame shell bed polygons with depletion of 0.5. Recovery times are in years and blanks cells indicate the habitat is not present to assess.

VME habitat	Creel VME all d=0.5 Celtic assessment area						
	Mean RBS	Habitat area km^2	Mean recovery time	SG60 recovery time	SG80 recovery time	SG100 recovery time	Indicative MSC Score
Coral gardens							
Fan mussel aggregations							
Flame shell beds							
Littoral chalk communities	1.00	0.00	0.0	0.0	0.0	0.0	SG100
Lophelia pertusa reefs							
Maerl beds	1.00	3.89	0.0	0.0	0.0	0.0	SG100
Modiolus modiolus horse mussel beds	1.00	17.57	0.0	0.0	0.0	0.0	SG100
Sabellaria spinulosa reefs	1.00	7.14	0.0	0.0	0.0	0.0	SG100
Sea-pen and burrowing megafauna communities	1.00	7225.31	0.0	0.0	0.0	0.0	SG100
Seamounts							
Zostera beds	1.00	16.44	0.0	0.0	0.0	0.0	SG100

VME habitat	Creel VME all d=0.5 West of Scotland assessment area						
	Mean RBS	Habitat area km^2	Mean recovery time	SG60 recovery time	SG80 recovery time	SG100 recovery time	Indicative MSC Score
Coral gardens	1.00	2.50	0.0	0.0	0.0	0.0	SG100
Fan mussel aggregations	1.00	1.77	0.0	0.0	0.0	0.0	SG100
Flame shell beds	0.99	4.62	0.0	0.0	0.0	0.0	SG100
Littoral chalk communities							
Lophelia pertusa reefs	0.93	29.66	0.0	0.0	0.0	0.0	SG100
Maerl beds	0.96	39.18	0.0	0.0	0.0	0.0	SG100
Modiolus modiolus horse mussel beds	0.96	4.06	0.0	0.0	0.0	0.0	SG100
Sabellaria spinulosa reefs	1.00	13.44	0.0	0.0	0.0	0.0	SG100
Sea-pen and burrowing megafauna communities	0.99	1711.67	0.0	0.0	0.0	0.0	SG100
Seamounts	1.00	7702.13	0.0	0.0	0.0	0.0	SG100
Zostera beds	0.99	14.99	0.0	0.0	0.0	0.0	SG100

VME habitat	Creel VME all d=0.5 northern North Sea assessment area						
	Mean RBS	Habitat area km^2	Mean recovery time	SG60 recovery time	SG80 recovery time	SG100 recovery time	Indicative MSC Score
Coral gardens							
Fan mussel aggregations							
Flame shell beds							
Littoral chalk communities							
Lophelia pertusa reefs							
Maerl beds	1.00	4.20	0.0	0.0	0.0	0.0	SG100
Modiolus modiolus horse mussel beds	0.98	26.48	0.0	0.0	0.0	0.0	SG100
Sabellaria spinulosa reefs							
Sea-pen and burrowing megafauna communities	1.00	748.33	0.0	0.0	0.0	0.0	SG100
Seamounts							
Zostera beds	1.00	3.27	0.0	0.0	0.0	0.0	SG100

VME habitat	Creel VME all d=0.5 North Sea assessment area						
	Mean RBS	Habitat area km^2	Mean recovery time	SG60 recovery time	SG80 recovery time	SG100 recovery time	Indicative MSC Score
Coral gardens							
Fan mussel aggregations							
Flame shell beds							
Littoral chalk communities	1.00	0.04	0.0	0.0	0.0	0.0	SG100
Lophelia pertusa reefs							
Maerl beds							
Modiolus modiolus horse mussel beds							
Sabellaria spinulosa reefs	1.00	47.68	0.0	0.0	0.0	0.0	SG100
Sea-pen and burrowing megafauna communities	1.00	196.00	0.0	0.0	0.0	0.0	SG100
Seamounts							
Zostera beds	1.00	8.89	0.0	0.0	0.0	0.0	SG100

Appendix N. Benthic Impact Tool assessment results for creel gear and certain OSPAR VME with depletion of 0.14. Recovery times are in years and blanks cells indicate the habitat is not present to assess. West of Scotland did not have any overlap of TR1 trawling and the VME data used.

	Creel VME certain d=0.14 Celtic assessment area							Creel VME certain d=0.14 West of Scotland assessment area							Creel VME certain d=0.14 northern North Sea assessment							Creel VME certain d=0.14 North Sea assessment area						
VME habitat	**Mean RBS**	**Habitat area km^2**	**Mean recovery time**	**SG60 recovery time**	**SG80 recovery time**	**SG100 recovery time**	**Indicative MSC Score**	**Mean RBS**	**Habitat area km^2**	**Mean recovery time**	**SG60 recovery time**	**SG80 recovery time**	**SG100 recovery time**	**Indicative MSC Score**	**Mean RBS**	**Habitat area km^2**	**Mean recovery time**	**SG60 recovery time**	**SG80 recovery time**	**SG100 recovery time**	**Indicative MSC Score**	**Mean RBS**	**Habitat area km^2**	**Mean recovery time**	**SG60 recovery time**	**SG80 recovery time**	**SG100 recovery time**	**Indicative MSC Score**
Coral gardens								1.00	0.48	0.0	0.0	0.0	0.0	SG100														
Lophelia pertusa reefs								0.99	22.11	0.0	0.0	0.0	0.0	SG100														
Maerl beds	1.00	2.57	0.0	0.0	0.0	0.0	SG100	0.99	23.56	0.0	0.0	0.0	0.0	SG100	1.00	4.20	0.0	0.0	0.0	0.0	SG100							
Modiolus modiolus horse mussel beds	1.00	14.40	0.0	0.0	0.0	0.0	SG100	1.00	1.28	0.0	0.0	0.0	0.0	SG100	0.99	26.48	0.0	0.0	0.0	0.0	SG100							
Sabellaria spinulosa reefs								1.00	13.43	0.0	0.0	0.0	0.0	SG100														
Sea-pen and burrowing megafauna communities	1.00	785.80	0.0	0.0	0.0	0.0	SG100	1.00	380.95	0.0	0.0	0.0	0.0	SG100	1.00	748.33	0.0	0.0	0.0	0.0	SG100							
Seamounts								1.00	6161.32	0.0	0.0	0.0	0.0	SG100														
Zostera beds	1.00	11.93	0.0	0.0	0.0	0.0	SG100	1.00	3.82	0.0	0.0	0.0	0.0	SG100	1.00	3.27	0.0	0.0	0.0	0.0	SG100	1.00	5.55	0.0	0.0	0.0	0.0	SG100

Appendix O. Benthic Impact Tool assessment results for creel gear and certain OSPAR VME with depletion of 0.5. Recovery times are in years and blanks cells indicate the habitat is not present to assess. West of Scotland did not have any overlap of TR1 trawling and the VME data used.

	Creel VME certain d=0.5 Celtic assessment area							Creel VME certain d=0.5 West of Scotland assessment area							Creel VME certain d=0.5 northern North Sea assessment							Creel VME certain d=0.5 North Sea assessment area						
VME habitat	**Mean RBS**	**Habitat area km^2**	**Mean recovery time**	**SG60 recovery time**	**SG80 recovery time**	**SG100 recovery time**	**Indicative MSC Score**	**Mean RBS**	**Habitat area km^2**	**Mean recovery time**	**SG60 recovery time**	**SG80 recovery time**	**SG100 recovery time**	**Indicative MSC Score**	**Mean RBS**	**Habitat area km^2**	**Mean recovery time**	**SG60 recovery time**	**SG80 recovery time**	**SG100 recovery time**	**Indicative MSC Score**	**Mean RBS**	**Habitat area km^2**	**Mean recovery time**	**SG60 recovery time**	**SG80 recovery time**	**SG100 recovery time**	**Indicative MSC Score**
Coral gardens								1.00	0.48	0.0	0.0	0.0	0.0	SG100														
Lophelia pertusa reefs								0.98	22.11	0.0	0.0	0.0	0.0	SG100														
Maerl beds	1.00	2.57	0.0	0.0	0.0	0.0	SG100	0.96	23.56	0.0	0.0	0.0	0.0	SG100	1.00	4.20	0.0	0.0	0.0	0.0	SG100							
Modiolus modiolus horse mussel beds	1.00	14.40	0.0	0.0	0.0	0.0	SG100	1.00	1.28	0.0	0.0	0.0	0.0	SG100	0.98	26.48	0.0	0.0	0.0	0.0	SG100							
Sabellaria spinulosa reefs								1.00	13.43	0.0	0.0	0.0	0.0	SG100														
Sea-pen and burrowing megafauna communities	1.00	785.80	0.0	0.0	0.0	0.0	SG100	0.99	380.95	0.0	0.0	0.0	0.0	SG100	1.00	748.33	0.0	0.0	0.0	0.0	SG100							
Seamounts								1.00	6161.32	0.0	0.0	0.0	0.0	SG100														
Zostera beds	1.00	11.93	0.0	0.0	0.0	0.0	SG100	0.99	3.82	0.0	0.0	0.0	0.0	SG100	1.00	3.27	0.0	0.0	0.0	0.0	SG100	1.00	5.55	0.0	0.0	0.0	0.0	SG100

Appendix P. Data sets used in the benthic impact assessment for trawl and creel *Nephrops* fisheries around the United Kingdom in this report.

Data Use	Data name	Link to source	Aknowledgement or reference
Commonly encountered habitats	EUSeaMap 2021 Broad-Scale Predictive Habitat Map for Europe	http://gis.ices.dk/geonetwork/srv/eng/catalog.search#/metadata/10d3d35c-8f8e-40ff-898f-32e0b037356c	Information contained here has been derived from data that is made available under the European Marine Observation Data Network (EMODnet) Seabed Habitats initiative (www.emodnet-seabedhabitats.eu), financed by the European Union under Regulation (EU) No 508/2014 of the European Parliament and of the Council of 15 May 2014 on the European Maritime and Fisheries Fund.
Trawl swept area	ICES trawl swept area Data	http://doi.org/10.17895/ices.data.4686	ICES. 2018. Spatial data layers of fishing intensity/ pressure per gear type for surface and subsurface abrasion, for the years 2009 to 2017 in the OSPAR regions II and III (ver. 2, 22 January, 2019): ICES data product release, http://doi.org/10.17895/ices.data.4686
Creel swept area	Hebridean Whale and Dolphin Trust 2022	https://hwdt.org/	Hebridean Whale and Dolphin Trust 2022. Creel sightings and associated effort for the west coast of Scotland. Silurian Dataset 2014-2019. Accessed 06 May 2022 Made available under agreement on terms and conditions of use, and accessible via Hebridean Whale and Dolphin Trust (HWDT), Tobermory, United Kingdom
Creel swept area	ScotMap	https://marine.gov.scot/information/scotmap-inshore-fisheries-mapping-project-scotland	Kafas, A., McLay, A., Chimienti, M., Scott, B. E., Davies, I., & Gubbins, M. (2017). ScotMap: Participatory mapping of inshore fishing activity to inform marine spatial planning in Scotland. Marine Policy, 79, 8–18. https://doi.org/10.1016/j.marpol.2017.01.009
Creel swept area	Marine Scotland Science: Creel Fishing Effort Study (CFES)	https://www.gov.scot/publications/creel-fishing-effort-study/	Marine Analytical Unit. (2017). Marine Scotland Science: Creel Fishing Effort Study. https://www.gov.scot/publications/creel-fishing-effort-study/
Creel swept area	Global Fishing Watch	https://globalfishingwatch.org/map	Global Fishing Watch. 2022, updated daily. Vessel presence and apparent fishing effort v20201001, Jan 01 2014 - Dec 31 2019. Data set accessed 2022-08-11 at https://globalfishingwatch.org/map
Biomass data for longevity estimation	Marine Environment Monitoring and Assessment National database (MERMAN)	https://www.bodc.ac.uk/projects/data_management/uk/merman/	These data are a snapshot of the data held within MERMAN obtained on the 06/06/2022. The data were supplied by the British Oceanographic Data Centre on behalf of the Clean Safe Seas Evidence Group. Data were collected by the Agri-Food and Biosciences Institute, Centre for Environment, Fisheries and Aquaculture Science, Department of Agriculture, Environment and Rural Affairs, Environment Agency, Food Standards Scotland, Marine Scotland Science, Natural Resource Wales and Scottish Environment Protection Agency. The data were funded by Agri-Food Biosciences institute, Department of Agriculture, Environment and Rural Affairs, Department for Environment, Food and Rural Affairs and Scottish Government. These data contain public sector information licensed under the Open Government Licence v3.0.
Biomass data for longevity estimation	Clyde Sea biomass data	https://www.nature.scot/doc/naturescot-commissioned-report-539-infaunal-analysis-grab-samples-collected-clyde-sea-march-2012	Allen, J. H. (2013). Infaunal analysis of grab samples collected from the Clyde Sea , in March 2012. In Scottish Natural Heritage Commissioned Report No. 539. (Issue 5). https://www.nature.scot/doc/naturescot-commissioned-report-539-infaunal-analysis-grab-samples-collected-clyde-sea-march-2012
Biomass data for longevity estimation	CEFAS biomass data	https://doi.org/10.1016/j.seares.2010.02.003	Bolam, S. G., Barrio-Frojan, C. R. S., & Eggleton, J. D. (2010). Macrofaunal production along the UK continental shelf. *Journal of Sea Research* , *64*(3), 166–179. https://doi.org/10.1016/j.seares.2010.02.003
Biomass data for longevity estimation	Howarth et al. data	https://www.bodc.ac.uk/data/published_data_library/catalogue/10.5285/674d4224-7cc5-4080-e053-6c86abc0626e/	Howarth, L. M., Waggitt, J. J., Bolam, S. G., Eggleton, J., Somerfield, P. J., & Hiddink, J. G. (2018). Effects of bottom trawling and primary production on the composition of biological traits in benthic assemblages. Marine Ecology Progress Series, 602, 31–48. https://doi.org/10.3354/MEPS12690
VME habitats	OSPAR 2020: OSPAR Habitats in the North-East Atlantic Ocean	http://gis.ices.dk/geonetwork/srv/eng/catalog.search#/metadata/1e7ed77a-ced4-40f5-b0be-e907c0a8f29e	This is a compilation of OSPAR habitat polygon data for the northeast Atlantic submitted by OSPAR contracting parties. The compilation is coordinated by the UK's Joint Nature Conservation Committee, working with a representative from each of the OSPAR coastal contracting parties. This version (v2020) was published in June 2020.
VME habitats	Geodatabase of Marine features adjacent to Scotland (GeMS)	https://spatialdata.gov.scot/geonetwork/srv/api/records/c755b501-6731-4f8c-b726-cda5bdf731e7	Collation of species polygon records contributing to the Geodatabase of Marine features adjacent to Scotland (GeMS). Records are attributed as to their qualification as protected features of protected areas within the Scottish MPA network. Where appropriate typical record details will include: status as Scottish Priority Marine Features or Annex II Species, scientific name, abundance details, date, date range, year, status, accuracy, determiner and details of where the records are sourced from and intellectual property ownership.

Appendix Q. Details of the longevity estimates used for the VME habitat assessments. This longevity is used in the BIT to estimate the recovery rate of a habitat.

VME habitat name	**Species used for longevity**	**Longevity (years)**	**Source**
Zostera beds	*Zostera marina*	50	(Reusch et al., 1999)
Sea-pen and burrowing megafauna communities	*Funiculina quadrangularis*	20	(Neves et al., 2015)
Maerl beds	*Phymatolithon calcareum*	87	(Montero-Serra et al., 2018)
Sabellaria spinulosa reefs	*Sabellaria spinulosa*	10	(Clare et al., 2022)
Seamounts	*Lophelia pertusa*	451	(Montero-Serra et al., 2018)
Coral gardens	*Lophelia pertusa*	451	(Montero-Serra et al., 2018)
Lophelia pertusa reefs	*Lophelia pertusa*	451	(Montero-Serra et al., 2018)
Modiolus modiolus horse mussel beds	*Modiolus modiolus*	48	(Ridgway et al., 2011)
Fan mussel aggregations	*Atrina fragilis*	11	(Ridgway et al., 2011)
Flame shell beds	*Limaria hians*	10	(Clare et al., 2022)