FIS014 – Fisheries management in the context of shared seas

A REPORT COMMISSIONED BY FIS
AND PREPARED BY

NAFC Marine Centre

Published by: Fisheries Innovation Scotland (FIS)

This report is available at: http://www.fiscot.org.

Dissemination Statement

Disclaimer

Suggested Citation: Shelmerdine. R, L. Shucksmith, R, J. Mouat. B. 2017. Fisheries management in the context of shared seas. A study commissioned by Fisheries Innovation Scotland (FIS) http://www.fiscot.org/ and supported by The European Maritime and Fisheries Fund and The Scottish Government

European Maritime and Fisheries Fund

The Scottish Government
Riaghaltas na h-Alba

Title: Fisheries management in the context of shared seas

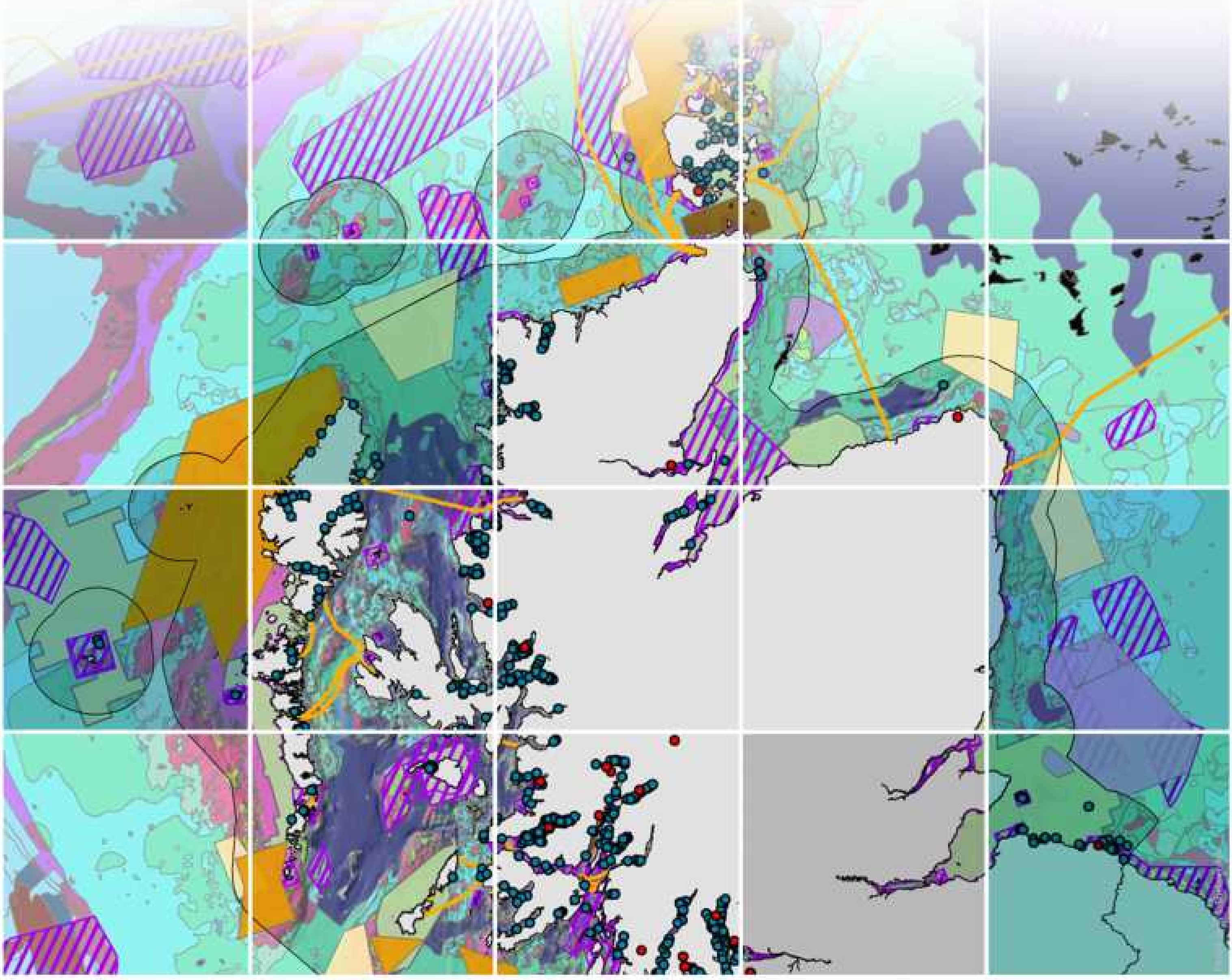
ISBN: 978-1-911123-13-2

First published: October 2017

NAFC Marine Centre
University of the Highlands and Islands

Fisheries management in the context of shared seas.

May 2017



Fisheries management in the context of shared seas.

Authors:
Dr Richard L. Shelmerdine, NAFC Marine Centre
richard.shelmerdine@uhi.ac.uk

Rachel J. Shucksmith, NAFC Marine Centre
rachel.shucksmith@uhi.ac.uk

Dr Beth Mouat, NAFC Marine Centre
beth.mouat@uhi.ac.uk

Project Team Members and Editors (alphabetically):
Luke Batts, NAFC Marine Centre

Dr Matthew Gubbins, Marine Scotland – Science

Andronikos Kafas, Marine Scotland – Science

Dr Paul Macdonald, NAFC Marine Centre

NAFC Marine Centre
Port Arthur
Scalloway
Shetland
ZE1 0UN
email: info@uhi.ac.uk
web: www.nafc.ac.uk

Marine Scotland - Science
Marine Laboratory,
375 Victoria Road,
Aberdeen,
AB11 9DB
email: marinescotland@gov.scot
web: www.gov.scot/marinescotland

Suggested citation: *Shelmerdine R.L., Shucksmith R.J., and Mouat B. (2017): Fisheries management in the context of shared seas. Report for Fisheries Innovation Scotland, project FIS014. Pp. 55.*

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Acronyms

AIS	Automatic Identification System
ASCOBANS	Agreement on the Conservation of Small Cetaceans in the Baltic, North East Atlantic, Irish and North Seas
BGS	British Geological Survey
CDA	Common Data Access Limited
CMEM	Copernicus Marine Environment Monitoring Service
COAST	Community of Arran Seabed Trust
cSAC	Candidate Special Area of Conservation
DDV	Drop-Down Video
DEFA	Department of Environment, Food and Agriculture
EEZ	Exclusive Economic Zone
EMODnet	European Marine Observation and Data Network
EU	European Union
GEBCO	General Bathymetric Chart of the Oceans
GMR	Galápagos Marine Reserve
GNPS	Galápagos National Park Service
ICES	International Council for the Exploration of the Sea
IFCA	Inshore Fisheries and Conservation Authority
INSPIRE	Infrastructure for Spatial Information in Europe
IPA	Inshore Potting Agreement
iVMS	inshore Vessel Monitoring System
JNCC	Joint Nature Conservation Committee
MFPO	Manx Fish Producers Organisation
MMO	Marine Management Organisation
MPA	Marine Protected Area
NBN	National Biodiversity Network
NGO	Non-Government Organisation
nm	nautical miles
NMPi	National Marine Plan interactive
OAA	Open Access Area
OGA	Oil and Gas Authority
QRA	Quota Regulated Area
QSMB	Queen Scallop Management Board
RO	Regulating Order
SAC	Special Area of Conservation
SBP	Sub-Bottom Profile
SDM	Species Distribution Model
SFA	Shetland Fishermen’s Association
SFCs	Sea Fisheries Committees
SIFIDS	Scottish Inshore Fisheries Integrated Data System
SIMSP	Shetland Islands’ Marine Spatial Plan
SMRU	Sea Mammal Research Unit Ltd.
SNH	Scottish Natural Heritage
SSMO	Shetland Shellfish Management Organisation
UKHO	United Kingdom Hydrographic Office
VMS	Vessel Monitoring System

Executive Summary

There is increasing legislative and policy emphasis on the importance of effective management of the marine environment as a shared resource, with aspirations to maximise environmental, economic, and social benefits, also termed the ecosystem approach to management. As extensive and long-term users of the marine environment, fisheries and the integration of fisheries management into a wider marine management system, play a major role in achieving these objectives as well as helping to ensure the long-term sustainability and existence of the sector. There are many examples of managing fisheries interactions within the UK and globally. Many of these are related to a single interaction. Many Marine Protected Areas (MPAs) have been shown to have a positive effect on fisheries when the MPAs have been integrated within fisheries management measures outside of the MPA area.

While seeking to achieve the UK management objectives of increased economic prosperity by growing economic use, particularly of emerging industries such as marine renewables, coupled with increased protection through a network of MPAs, fisheries are being subject to increased spatial conflicts which need to be understood and effectively managed. Due to the nature of these interactions, the majority of conflicts occur relatively close to shore and have a greater effect on the inshore fisheries.

The report addresses three main areas covering conflicts (Section 2), available data (Section 3), and example case studies (Section 4). There are a number of marine management measures that have been trialled and/or implemented around the world to tackle a range of spatial and temporal use conflicts. Spatial and temporal management measures were considered under three main topics of fisheries management measures (Section 2.1), marine conservation management (e.g. MPAs, Section 2.2), and licencing mitigation and management measures (e.g. safety zones during marine developments, Section 2.3).

Understanding what data is available, its accessibility, limitations, and at what spatial and temporal scale would be appropriate for management decision making is an important but complex task for any manager (Section 3). However, without such knowledge, management decisions may be questioned by stakeholders and governance structures may be weak or difficult to enforce. This section outlines some of these issues, highlights alternate data sources which are freely available, discusses how the data can be used with its limitations, and how it can be enhanced through stakeholder/fisher engagement.

Six case study areas (Section 4) were identified with aspects of their management and management tools being highlighted. Case studies covered multiple geographic scales from local through to international management strategies. The use of spatial planning, voluntary codes of practice, stakeholder engagement, and more detailed fishing information were key factors in several of the areas.

Finally, the information was pooled together to outline some key recommendations for managers (fisheries and marine) and recommendations for the use of data (Section 5.1). Recommendations for managers included a better understanding of how scale can influence decisions, stakeholder engagement, establishing trust through open dialogue, and the consideration of temporal impacts of developments. Data recommendations included fisheries data, socio-economic data, availability of data in online databases, and the use of predictive habitat maps and what information should accompany them.

1 Introduction

There is increasing legislative and policy emphasis on the importance of effective management of the marine environment as a shared resource, with aspirations to maximise environmental, economic, and social benefits (DEFRA, 2009; The Scottish Government, 2015), also termed the ecosystem approach to management (Ottersen*, et al.*, 2011). As extensive and long-term users of the marine environment, fisheries and the integration of fisheries management into a wider marine management system, play a major role in achieving these objectives as well helping to ensure the long-term sustainability and existence of the sector.

At a Scottish level the National Marine Plan (The Scottish Government, 2015) requires consideration to be given to the cultural, economic, and environmental impacts of other uses of the marine environment on fisheries and fisheries dependent communities. The future development of regional marine planning may add additional area specific requirements, but will have to be in line with the overarching aims, objectives, and policies detailed within the National Marine Plan. While fisheries management is primarily focused on stock health and is undertaken at a number of scales, including EU, national (Scottish), and in some areas at a local level, the management of other uses within the marine and coastal environment is dominated by spatially specific licences, issued by local and central government organisations.

There are many examples of managing fisheries interactions within the UK and globally. Many of these are related to a single interaction, for example: fishing activity and marine mammals in Spain (Goetz*, et al.*, 2014), scallop dredging and horse mussel beds in Wales (through the Scallop Fishery (Wales) (no.2) Order 2010 and 2011.) and Shetland (Shelmerdine*, et al.*, 2014), and gear interactions in Devon (Hart*, et al.*, 2003; Blyth*, et al.*, 2004), and between fisheries and other sectors (e.g. the use of exclusion zones and temporal management in aggregate extraction, Walker*, et al.*, 2016). Many Marine Protected Areas (MPAs) have been shown to have a positive effect on fisheries when the MPAs have been integrated within fisheries management measures outside of the MPA area (Follesa*, et al.*, 2008; Follesa*, et al.*, 2011; Moland*, et al.*, 2013; Bennett and Dearden, 2014).

Data is vital to an effective management process. Understanding what data is available, how accessible the data is, what the limitations of the data are, how data sets can be combined, and at what spatial and temporal scale would be appropriate for management decision making is an important but complex task for any manager. However, without such knowledge, management decisions may be challenged by stakeholders and governance structures may be weak or difficult to enforce. For example, the offshore fishing fleet already has an established Vessel Monitoring System (VMS) reporting vessels' positions every two hours. This frequency of reporting, however, would not be appropriate for an inshore fishery or for areas (including offshore areas) where more detail on vessel movements is required (Skaar*, et al.*, 2011). The increase in use of the Automatic Identification System (AIS) provides additional, more detailed, information on vessel movements (Shelmerdine, 2015) and work has been carried out using inshore VMS systems which report more regularly for the inshore scallop fisheries of Shetland (Shelmerdine and Leslie, 2015), Wales (Rossiter, 2016), and Lyme Bay (MMO, 2012). Combining these data sets with fishery specific data, often gathered at the local level, can help developers and decision makers link fisher usage with onshore dependent areas, communities, and families, which these data sets on their own cannot provide.

Environmental data is widely available in most areas of the UK, although at a variety of spatial scales, and there is a significant increase in the availability of high resolution bathymetry data through the UK Hydrographic Office online portal (INSPIRE)[1]. The British Geological Survey has nation-wide information on sediment types and there is an increasing amount of data added to the National Marine Plan interactive online portal (NMPi)[2]. Predictive habitat maps can then be produced by combining these data types with species information (e.g. Gormley, *et al.*, 2013). This type of mapping has been used extensively to highlight areas in need of protection but the interpretation of such maps requires knowledge of the quality of the inputted data as well as an understanding of the spatial scale of the information (Shelmerdine and Shucksmith, 2015). Shelmerdine and Shucksmith (2015) demonstrated that predictive habitat maps at a large scale (regional or even national) would not be adequate at a local level, the scale at which spatial management decisions are likely to be made. In addition, when data sets are scrutinised they can include a range of errors (Shelmerdine, *et al.*, 2014) and require the collection of additional site-specific data, leading to increased data confidence and stakeholder buy-in (Shucksmith and Kelly, 2014; Shucksmith, *et al.*, 2014).

1.1 Objectives

The overall objective of this project was to provide practical information to ensure appropriate consideration of fisheries management requirements within an increasingly multi-use or 'shared seas' environment. In order to do this, the project was divided into three distinct objectives:

Objective 1: To understand and assess the options available for effective management of fisheries in relation to other users and the environment, and how management decisions could be integrated into areas where interactions with fisheries play a key role.

Objective 2: To summarise what data may be available for effective management and how this data can be optimally used to better inform management decisions.

Objective 3: To publish two best practice guidance documents, one for fishers and one for developers and decision makers.

This report examines the first two objectives, with Objective 3 reported separately, and mostly focusses on inshore fisheries where there is a higher likelihood of interactions occurring. Objective 1 is covered in Sections 2 and 4 where a review of the literature on shared seas management is summarised with focus on some specific case study areas. Objective 2 is covered in Section 3 and summarises the different data types available for managers, developers, and fishers.

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[1] www.gov.uk/guidance/inspire-portal-and-medin-bathymetry-data-archive-centre
[2] www.gov.scot/Topics/marine/seamanagement/nmpihome

2 Conflicts, management measures, and tools available

Conflicts and opportunities exist between fisheries and other users of the marine environment (commercial, recreational, or environmental) in the use and management of the marine space. Conflicts can arise where there is a desire to use the same area of sea for new or expanding uses of the marine environment and where there is limited capacity to create enhanced fishing opportunity, creating spatial conflict. This can occur where there is growth of a fishery, creating conflict of existing other uses (including other fishers) or environmental sustainability; or where there is growth of another sector (for example aquaculture, oil and gas, marine renewables, angling); or where there is a desire to implement marine environmental protection measures to help achieve environmental sustainability objectives (for example the creation of a MPA).

These conflicts can be part of a long-term existing conflict or an emerging conflict which can be:

- Permanent spatial conflicts e.g. between a permanent development and a fishery
- Spatial-temporal conflicts e.g. exclusion zones during a construction phase, or during a specific period of a protected marine species life cycle

In the case of commercial uses conflicts can occur during construction, operation, and decommissioning phases, with each of these phases potentially causing different scales of conflict.

Britain's exit from the European Union (EU) has the potential to alter fisheries spatial and temporal use patterns, for example due to changes in the number of days at sea and quota allocation. This has the potential to create new spatial and temporal conflicts, increasing the need for effective management strategies. Conflicts can be managed either through the implementation of statutory or voluntary measures to reduce, mitigate, or remove spatial and temporal conflicts. In some instances these may be implemented by government led organisations or departments, such as during the licensing process or through the implementation of designations (e.g. MPAs). In Scotland the National Marine Plan requires consideration to be given to the cultural, economic, and environmental impacts of other uses of the marine environment on fisheries and dependent communities, and the emergence of regional marine plans may add additional regionally specific requirements.

There are a number of marine management measures that have been trialled and/or implemented around the world to tackle a range of spatial and temporal use conflicts. They promote co-use and co-existence or promote sustainability; measures which could help to ensure the requirements of the National Marine Plan are met and use of marine space is optimised. These include:

- marine protected areas,
- closed and restricted areas,
- measures to reduce gear conflict,
- development restrictions (spatial and temporal), and
- measures to reduce the impact on the marine environment.

Examples of these, and their tools, are detailed below. Information has been obtained via published papers, reports, websites (government and local fisheries management), personal communications, and local knowledge. The majority of scientific literature (published papers and reports) provided insufficient detail on management measures and the policies underpinning them for the purpose of this report. This level of detail was obtained from government websites and local fisheries management websites. This is not intended to be a comprehensive list of management measures and tools but does highlight management measures and tools which are common in multiple areas as well as those that were considered innovative. Where possible, known conflicts are also highlighted.

Spatial and temporal management measures are considered under three main topics of fisheries management measures, marine conservation management, and licencing mitigation and management measures. Marine conservation management relates to areas designated for the protection and conservation of nature through limiting or excluding certain fishing methods. Examples of which would include Marine Protected Areas (MPAs), Special Areas of Conservation (SACs), or No Take Zones. Exclusion of fishing activity around some marine developments (the creation of a Safety Zone) is necessary for the safety of both the fishers and the marine infrastructure. Finally, we discuss some management tools relating to the management measures.

2.1 Fisheries management measures

Fisheries management measures include fisheries closed areas (both spatial and temporal closures) in order to protect the fished stock and management measures taken in order to minimise gear conflicts.

2.1.1 Spatial and temporal management

Two examples of real time temporal closures to protect stocks include real time cod closures and juvenile real time closures. Real time cod closures have been implemented in Scottish waters since 2007 to help in the recovery of the cod stock[3] (see also Holmes*, et al.*, 2011). In order to protect the stocks during spawning, when dense aggregations of cod were encountered by fishers, a temporal closure was initiated by the Scottish Government which lasted for 21 days. Closed areas were based on physical samples from Marine Scotland and independent observers, or analysis of landing data. The aim of the closures was to reduce fishing mortality by preventing the capture and then discard (due to quota restrictions) of cod. Restrictions limited the number of closed areas at any one time to eleven (plus three extra in the event of a positive sample). The juvenile real time closure scheme was independent to the Scottish real time closure scheme and has been operational since 2009. The juvenile real time closures were implemented by the European Commission and Norway for; cod, haddock, whiting, and saithe[4]. Closures were based on at-sea inspections with pre-defined trigger levels and lasted for 21 days.

2.1.2 Seasonal (temporal) measures to protect breeding stocks

Seasonal closures can be effectively used to protect species during certain stages in their life cycle, for example juvenile or spawning areas. An example of this is the recent work, carried out through Sussex Inshore Fisheries and Conservation Authority (IFCA), which has introduced seasonal management measures within the Kingmere Marine Conservation Zone[5]. The measures incorporated a zoning approach to fisheries and were designed to protect the sea bream breeding season and the features of conservation interest. Between 1st April and

[3] See www.gov.scot/Topics/archive/closures
[4] See www.gov.scot/Topics/marine/Sea-Fisheries/management/restrictions/Juvenileclosedareas
[5] Information provided by Tim Dapling of Sussex Inshore Fisheries and Conservation Authority.

30th June, the majority of fishing activity is restricted in all four zones. Although some fishing activity (e.g. angling, dive gathering, lining, and potting) is permitted in three of the four zones, only angling is permitted to retain a maximum of four bream per person. Fishing is permitted in all zones for the remainder of the year with the exception of towed gear which is only permitted in one of the zones. These management measures relied on knowledge of sea bream breading times and locations to allow effective management.

2.1.3 Gear conflicts

Gear conflicts can occur when more than one fishery type wishes to target the same area, for example static and mobile gear. Gear conflicts have been documented in Scottish waters with the Scottish Government forming a task force in 2013 to evaluate the extent of the conflicts[6]. Most conflicts were reported close to shore within 3 nm and occurred between static and mobile gear types as well as between static and static gear types. Monitoring of fishing activity is the responsibility of Marine Scotland Compliance but in the case of gear conflicts, it is difficult to determine exactly where each vessel was during the conflict, making it difficult to assess the scale of these conflicts. Vessels over 12 m in length are fitted with a VMS unit but these only report every two hours and, apart from Marine Scotland Compliance, it is not possible to access the information of individual vessels as the information is subject to data protection legislation and a report every two hours would not provide sufficient information to resolve gear conflict situations. Gear conflicts have been resolved in some areas through dialogue between fisheries, for example, the Inshore Potting Agreement (IPA) in the Devon and Severn IFG (see section 4.1).

2.2 Marine conservation management

In Scotland, Marine Scotland's Nature Conservation Strategy (Marine Scotland, 2011) outlines the vision, aims, and objectives for protecting marine biodiversity. The strategy is based on a three pillar approach to marine conservation; species conservation, site protection, and wider seas polices and measures. Site protection measures include the creation of Marine Protected Areas (MPAs), which are increasingly seen as a management tool to deliver conservation objectives, and in some instances enhance fisheries. In the UK, MPAs have been created to fulfil a range of international (e.g. OSPAR[7], Convention on Biological Diversity[8]), national, and local legislative and management requirements. Management measures may include:

- Spatial and temporal closures to protect specific species or habitat
- Technological restrictions to minimise impacts (e.g. gear restrictions)
- Effort restrictions

Closed areas have been widely incorporated into fisheries and marine management as a tool to protect demersal and benthic species, as well as important benthic habitats. In most cases they are specific to the type of gear, allowing optimal co-use of space and only places restrictions where necessary, rather than a complete ban on all fishing types across large areas. For example, within the fisheries management measures for the South Arran MPA there are four defined zones of fisheries closures including:

- a scallop dredge prohibition covering the entire MPA,

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[6] See www.gov.scot/Publications/2014/11/6562/3
[7] See www.ospar.org
[8] See www.cbd.int

- a slightly smaller area prohibiting scallop dredgers and trawlers,
- four small areas where all fishing that contacts the bottom (trawls, dredges, and creels) is banned,
- a no take zone where all fishing is prohibited.

See Section 4.2 for further information.

There are comprehensive spatial restrictions on scallop dredging, banning or limiting their activity within designated areas, to protect Special Areas of Conservation, particularly in the Isles of Scilly, Cornwall, Devon, Dorset, inshore Welsh waters, Hampshire, Isle of White, and inshore Sussex[9].

The Arrábida Marine Park MPA in Portugal is a coastal multiple-use MPA with eight zones covered by three protection levels of: fully protected, partially protected, and buffer areas (Batista*, et al.*, 2015). The management plan outlines broad objectives including the protection of local, small-scale fisheries of high socio-economic importance (Batista*, et al.*, 2015). Only vessels under 7 m are permitted to operate within the Park. Commercial fishing requires a licence, which is renewed annually if active, and the vessel must be registered in the fishing port within the Park. No trawling, dredging, purse-seining, spearfishing, or discarding are permitted. The partially protected areas only permit traps and jigging beyond 200 m from the coast and the fully protected area prohibits all human presence unless officially authorised (e.g. scientific research).

2.3 Licencing mitigation and management measures

During the licencing process impacts on fisheries and dependent communities must be considered; this includes the construction, operation, and decommission phases. Where possible development location should be modified to avoid or minimise conflict with fishers, or where this is not feasible allow or promote co-location. For example offshore wind turbines can be positioned to allow the continued useable access to creel and towed fisheries provided that consideration is given to their requirements, including turning areas and creel/pot leader lengths. Or in the case of pipelines and cables design measures, such as burying the structure, can allow fishers to access the area of seabed after instillation. Some fisheries can also be highly seasonal (e.g. squid fisheries) and fish stocks can have vulnerable periods (e.g. spawning time) so a temporal restriction on construction to avoid these periods can mitigate conflicts.

There may be occasions where for safety reasons it is necessary to implement either temporary or permeant exclusion zones around a development. In the UK, the Petroleum Act 1987[10] requires a 500 m safety zone around all oil and gas installations projecting above the sea surface. Subsea structures may also be protected by statutory instrument with the safety zone extending out to 500 m from a central point[11]. Similarly in Vietnam they have implemented a 500 m exclusion zone around each oil and gas platform and emerging structure (similar to the situation in Norway, see Section 4.4) but Vietnam has extended the exclusion zone to subsea installations and introduced a 2 km restriction on anchoring (Arbo and Thủy, 2016). In the UK, the "Energy Act 2004" and the explanatory memorandum to "The electricity

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[9] See www.goodfishguide.org/fish.php/429/Scallop,%20King,%20scallops
[10] See www.legislation.gov.uk/ukpga/1987/12/contents
[11] See www.fishsafe.eu/en/safety-zones.aspx

(offshore generating stations)(safety zones)(application procedures and control of access) regulations 2007" allow for the creation of a temporary 500 m safety zone around marine renewable devices in UK waters during construction, repair, or maintenance. When in operation, the operator may apply a 50 m safety zone but there are no UK regulations prohibiting fishing within an offshore windfarm area[12], although anchoring systems and cabling may prohibit safe use of towed gears within the site. These safety zones increase the area lost to fisheries outside of the development footprint. For offshore wind, where the developments can have a large overall footprint, but have large areas of 'free space' in-between turbines, potential loss of fishing grounds can be quite extensive, despite the comparatively small footprint of the turbines themselves.

There are examples of combining exclusion zones with temporal management to maximise co-use. Off the coast of Dieppe, France, fisheries and aggregate extraction operations co-exist through spatial and temporal restrictions (Walker, *et al.*, 2016) of both industries. Aggregate extraction by dredging is prohibited for three months during the herring spawning season and for a further five weeks within the 3 nm limit of the aggregate extraction licenced area for fishers to catch cuttlefish. During loading of the extraction dredger, fishers are permitted to operate within a set distance of the dredger and messages are issued for net and pot fishers 24 to 48 hours prior to commencement of extraction operations[13].

2.4 Management tools

Technology is increasingly being used to implement management measures and ensure compliance. This includes remote vessel monitoring systems and the use of drone technology. In the UK, inshore Vessel Monitoring Systems (iVMS) are used in some inshore scallop dredge fisheries to protect sensitive habitats including those in Wales, Lyme Bay, and Shetland. Data packets, termed pings, are transmitted from the fishing vessel at specified time intervals (10 minutes in Wales and Shetland, and one minute in Lyme Bay). Pings usually provide information including vessel ID, position, a time stamp, speed, and course. This can be used to monitor the location of fishing vessels and ensure that fishing does not take place within sensitive areas.

In the Galápagos both VMS and AIS (for vessels under 20 tonnes) are used, with fisheries enforcement carried out by both the Galápagos National Park Service (GNPS) and the Navy. This joint enforcement approach has, however, caused conflicts over control of the Galápagos Marine Reserve (GMR). In addition, there is a fishing ban within 40 nm for all incoming vessels and local vessels fishing long-lines or "industrial fishing" (to protect pelagic migratory species) although evidence suggests illegal fishing still occurs by both local and outside vessels, possibly due to a failure in enforcement. Artisanal fisheries are allowed but they have depleted coastal waters of key species[14]. Illustrating the need for governance structures to be in place to support and enforce technological measures.

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[12] See www.kis-orca.eu/safety/reducing-risks-whilst-fishing#.WFfq_1zlwt8
[13] Detail provided by Michel Desprez
[14] Toral-Granda V, Hearn A, Henderson S and Jones PJS. (2011) Galapagos Marine Reserve – governance analysis. Pages 97-104 in PJS Jones, W Qiu and EM De Santo (Eds) Governing Marine Protected Areas: getting the balance right – Volume 2. Technical Report to Marine & Coastal Ecosystems Branch, UNEP, Nairobi.

Off California, interactions have been identified between the Dungeness crab fishery and humpback whales. Department of Fish and Wildlife for the State of California use adaptive management measures to reduce conflicts as they occur, allowing them to instruct fishers to move their gear away from whale foraging areas, adjust their gear to minimise entanglements, follow best practice for whale encounters, and work together to limit effort in an area[15].

An ocean-going wet drone is to be used in the large Marine Reserve around the Pitcairn Islands[16]. The drone will gather data on illegal fishing activity which is monitored in the UK.

3 Data availability and validity

There is a large amount of data available to managers, developers, and fishers but challenges exist on where to access the data as well as understanding the limitations of each data set. Marine Scotland's National Marine Plan interactive (NMPi) has compiled much of this data in one central location on the internet via an interactive mapping tool. This provides a valuable service for viewing different data types but many of the data sets are not available for download, mainly due to permission requirements from the data owner and challenges of keeping data sets up-to-date. This is also the case for other online databases such as National Biodiversity Network (NBN) Gateway which collates species record information. In order to use the raw data, permission is required from the data owners (the suppliers of the data), which in many cases are individuals. Such requirements may have a negative effect when trying to incorporate data for management decisions and developers during the planning process. Many fisheries data sets have similar restrictions, requiring anonymity of the information for data protection purposes but also requiring the data to be gridded in such a way as to ensure individual fishing tracks are indistinguishable. These requirements can pose problems for managers and developers who could benefit from incorporating anonymised vessel activity information to help avoid conflicts and delays within the licencing process. Incorporating vessel activity information at an early stage of the development planning process would also benefit fishers by potentially reducing temporal and spatial conflicts with the fleet.

This section outlines some of these issues, highlights alternate data sources which are freely available, discusses how the data can be used with its limitations, and how it can be enhanced through stakeholder/fisher engagement. Although every effort was made to compile a comprehensive list of key data sets, we acknowledge that due to the large number of data sets available the list is not exhaustive.

Each data set was attributed a resolution of high, medium, or low within each data type where applicable (see Table 3.1 to Table 3.5). High resolutions were attributed to comprehensive data sets with the most detail. General comments about each data set and where they were sourced are detailed in Table 8.1 and Table 8.2, respectively, within the Appendix (Section 8).

3.1 Fisheries data

Data on the distribution of fisheries, both spatial and temporal, allows fishing organisations, developers, and licencing bodies to better understand the use of the marine environment by fishers and enables them to apply this information in a socio-economic context. Fisheries data

[15] See www.wildlife.ca.gov/Conservation/Marine/Invertebrates/Crabs#315201121-news-releases-memos-notices-and-findings
[16] See www.bbc.co.uk/news/technology-35783564

can be used to evidence fishing activity, monitor compliance with closed or restricted areas, or influence the positioning of developments.

3.1.1 Spatial fisheries data

All EU fishing vessels 12 m or greater in length are required to have a working VMS unit fitted. In Scottish waters, these units report (ping) every two hours, sending information on the vessel, its location, and a timestamp. The information is confidential and cannot be distributed without written permission from the skipper. However, anonymised and gridded VMS data is available for download through the Marine Management Organisation (MMO) and International Council for the Exploration of the Sea (ICES, see Table 3.1). These are processed data sets at a grid resolution of approximately 3 × 3 km. These data sets do not include the inshore fleet which are generally represented by vessels smaller than 12 m in length, although some of the larger scallop dredgers and vivier crabbers would be included. This is of particular concern for the static gear fleets which tend to be less than 12 m in length. However, it is likely that the time taken for fishing activity of both scallop dredgers and vivier crabbers would not match up to the two hour reporting frequency of the VMS data (see Katara and Silva, 2017). The miss-match between fishing activity and VMS reporting frequency creates areas of fishing activity which should have been attributed to steaming as well as not being able to identify actual fishing grounds. This problem has also been associated with other (whitefish) fishing methods, as summarised by Katara and Silva (2017).

Although more detailed, or raw, VMS data is not nationally available it can be made available with consent of the fishing skipper. This has occurred in Shetland, where all the Shetland registered whitefish vessels gave permission for their VMS data to be made available to the NAFC Marine Centre to inform marine spatial planning. This has allowed the VMS data to be scrutinised by skippers for data errors and to make data available at a higher resolution. The availability of more detailed data has assisted in the siting of developments away from important fishing grounds (see Section 4.5 for further information).

Detailed fishing vessel tracks are not widely available as many fishers are reluctant to provide this level of detail. Reasons can include (but are not limited to): concern over sharing details of grounds (due to commercial sensitivity), concerns they wish to expand their fishing in the future, and concerns about how the data might be used. Although some regions use an inshore VMS system (see Section 4), in Scotland, only Shetland has such a system but currently units are not fitted to every vessel within the scallop dredge fleet (Shelmerdine and Leslie, 2015) and vessels working static gear are not currently included. The iVMS units report every 10 minutes and the information is used to monitor compliance with the regulations and to advise the local management organisation (SSMO) on any potential conflicts with proposed developments. In addition, this data is not yet publicly available although it is intended that this data will become available in the future within the Shetland Island’s Marine Spatial Plan, subject to agreement with the fishers and agreement to a suitable scale.

An alternate source of fishing vessel tracks is the Automatic Identification System (AIS) which reports every two to three minutes. All fishing vessels 15 m or larger are required to have a working AIS system fitted but many smaller vessels have voluntarily installed AIS units. Unlike VMS, AIS is publically accessible either through purchasing data from a database, or setting up a shore based antenna array and decoding the information. The MMO has freely downloadable AIS track data (see Figure 3.2 and Table 8.2). This is anonymised data for all vessels including fishing vessels 15 m or longer but there is no information on vessel speed which is needed to identify fishing activity. Comparing the MMO fishing vessel data for 2014 with raw AIS data, obtained from a single antenna in Shetland for the same year and vessel length, showed large areas of missing data in the MMO data set (Figure 3.3), most probably due to data entry errors when setting up the AIS units and which have not then been corrected during processing of the raw data (Shelmerdine, 2015).

In Scotland, the first comprehensive mapping of the inshore fleet fisheries grounds (covering vessels less than 15 m in length but excluding Shetland based vessels) was undertaken by Marine Scotland during the ScotMap project via participatory mapping on a GIS platform (Kafas*, et al.*, 2014). At the time there was not a requirement for these vessels to have a VMS unit fitted so information on the spatial use of the fleet was sparse, and in most cases, not available. The ScotMap data was anonymised and made available at a gridded resolution of approximately 2 × 2 km. The data set has been processed to four main categories: number of vessels, number of crew, monetary value, and relative value. Compared with ICES rectangles (approximately a 56 × 56 km grid in the north) or Shetland Shellfish Management Organisation (SSMO) squares in Shetland (approximately a 9 × 9 km grid), resolutions of 2 or 3 km are a great improvement at a national level. Data is only available for the period of collection (2007 to 2011) and there is no planned up-date to the data set. A further caveat was the regional variation in interview coverage which ranged from 42% in Ayr to 100% in Orkney with a total of 72% of vessels interviewed.

Although the VMS and Scotmap data sets represent a comprehensive national overview and provide an important resource for strategic national level decision making, at a local or planning and licensing level, especially for small scale developments (aquaculture sites, cable routing, etc) and management measures within protected areas, a 2 × 2 km grid resolution can be lacking the required spatial detail to guide the placement of a development during the licencing process, or to resolve intra-fishing conflicts (Figure 3.1a to d). At this resolution fishing tracks are masked but the resultant gridded map also falsely shows developers and managers that fishing activity occurs everywhere in the area. In this instance, if a developer is shown such a low resolution fishing map, the developer would gain the false impression that fishing takes place throughout the area, and the subsequent impact may be relatively small and/or that they do not have any options of siting the development in areas free of fishing and will instead site their development in an optimal position for them, not the fisher. Inaccurate information, such as this, can lead to less than optimal decision making and increase the likelihood of conflict and distrust between the fishing industry and the developer. With more detailed fishing information (using vessel tracks or a greater resolution of grid, e.g. 50 × 50 m), areas of reduced fishing or those not fished are more easily highlighted (see Figure 3.1a and b) and potential developers may be able to re-site their development in order to minimise conflict. Comparing the 50 × 50 m (Figure 3.1b) and 2 × 2 km (Figure 3.1d) grid resolutions, some areas highlighted red in the higher resolution map of 50 × 50 m show up as green or yellow in the 2 × 2 km resolution (see the areas between the chain of three islands). Equally, there is a red area highlighted in the centre of the 2 × 2 km map which corresponds to a low density of vessel activity at the higher resolution.

Table 3.1 Sources of fisheries data and their access requirements.

Data type	Source	Resolution	Restrictions	Access
AIS		High	Local networks	Free
AIS density grid	MMO	Medium	Incomplete	Free
AIS tracks	MMO	Medium	Incomplete	Free
ScotMap	ScotMap	Medium	Not Shetland	Free
iVMS	SSMO	High	Scallop dredgers	Permission
VMS	ICES	Medium-Low	Vessels ≥15 m	Free
VMS	MMO	Medium-Low	Vessels ≥15 m	Free
VMS	NMPi	Low	Vessels ≥15 m	Permission

Automated data gathering (via iVMS, VMS, or AIS) can offer several benefits over participatory mapping techniques. Large fisheries data sets can be gathered and consultation with fishers can focus on quality checking, rather than significant time spent mapping grounds. When gathering data by participatory mapping fishers can have difficulty identifying grounds to a high level of spatial accuracy, particularly for grounds which are some distance from the coast or defined seabed feature. Gathering data while on board fishing vessels can assist in this process as data from plotters can be used to guide ground identification. There are limited examples of automated data gathering for static gear fisheries and challenges exist in gathering this data including the large and dispersed fleet structure, the part time occupation of many fishers, and because smaller vessel operators are less likely to be members of any trade or representative organisation.

Mapped grounds provide an important evidence base for fishers to prove their use of an area of seabed. However, these data sets do not allow a developer or decision maker to understand the current distribution of fishing activity in the context of existing pressures, whether these are regulatory, technical, market driven, or due to other developments. For these reasons fishing may have already been pushed into sub-optimal areas or the viability of the industry reduced. Understanding additional pressures needs to be undertaken in this context. However, many of these data limitations can be overcome through engagement with fishing fleets to allow the data to be used at a development level. An understanding of individual mapped grounds is also necessary for development planning. For example, the occurrence of a small overlap in a part of a fishing ground with a planned development may render the whole fishing ground unusable if the overlap coincides with existing turning space for a towed fishery.

3.1.2 Temporal fisheries data

Seasonal/temporal variation has not been accounted for in any of the data sets listed (ICES, MMO, or ScotMap). This can be an important factor to consider for any manager or developer, especially for an inshore fleet which may target different species using different gear at certain times of the year. For example a fleet that normally dredges for scallops may change their gear-type and target-species to the more lucrative squid for one month each year. A developer may be able to minimise the impact on the lucrative, but short-term, squid fishery by proposing installation works occur outside of this time period. These data could be obtained through interviews with fishers within an area and this information could be used to enhance these data sets.

3.1.3 Biological fisheries data

Biological fisheries data is available to view through the NMPi site and includes broad area information on nursery and spawning grounds of 13 finfish and one shellfish species. The information was published in 1998 and is not downloadable as a mapped layer. The information is in the process of being updated using a modelling approach and this information will be made available through the NMPi site[17]. More detailed information on spawning and nursery grounds would aid developers, reduce conflict situations, and enable more precise management of these areas as demonstrated for sea bream within the Kingmere Marine Conservation Zone (see Section 2.1.2).

3.1.4 Social and economic fisheries data

Since 1922 Scottish Sea Fisheries Statistics have been gathered on a yearly basis. Currently Marine Scotland gather information by port relating to vessel number and specifications (e.g. engine size), employment levels, and fish landings[18]. This information can be considered within the context of other regional data to inform developers and decision makers on the relative dependency of the region on fisheries. While the data provides valuable port statistics it does not provide in-depth detail which would enable a clear link to be established between port information, linked communities, and fishing grounds. For example the whitefish and pelagic fleets may travel relatively large distances (over 100 nm) to land catch at a port due to the presence of a fish market or more favourable prices.

While there are examples of detailed economic assessments for some fleets (e.g. Seafish reports)[19], these do not include clear links to specific fished areas, with landings presented at the ICES square level. In addition, these detailed analyses tend to be undertaken infrequently providing a snap shot of economic information for an industry operating in an ever changing market and regulative framework.

While there is an absence of readily available economic and community data for fisheries which would allow developers and decision makers to fulfil the assessment criteria required under the National Marine Plan without additional data gathering.

[17] Personal communication through Marine Scotland Science
[18] See www.gov.scot/Topics/Statistics/Browse/Agriculture-Fisheries/PubFisheries
[19] See www.seafish.org/publications-search?search=&category=Economics%20and%20Business&date_month=&date_year=&published_beforeafter

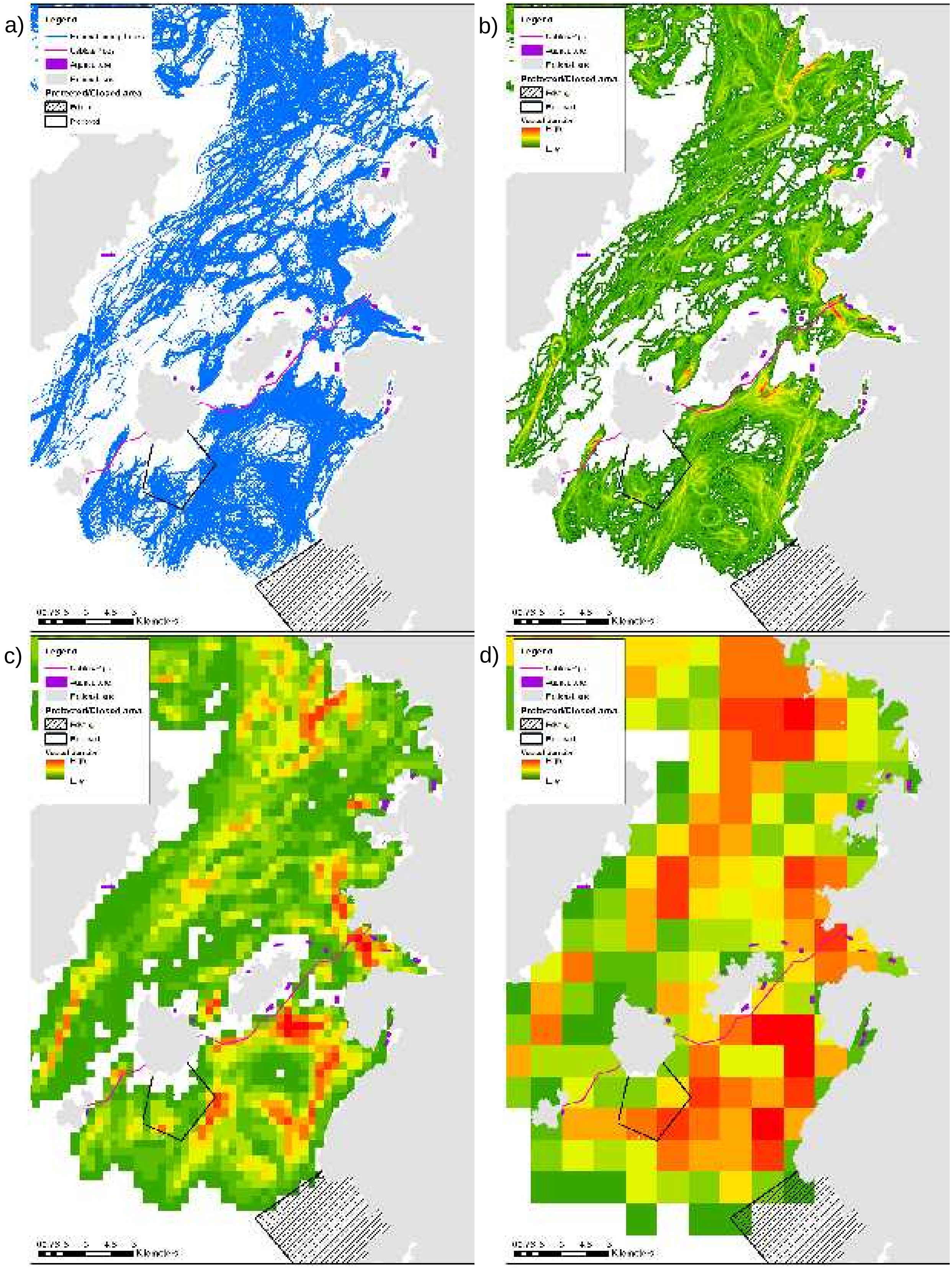

Figure 3.1 A fictional example of fishing vessel tracks (a), demonstrating the effect of three different scales of gridding the same data (b) 50×50 m, (c) 500×500 m, and (d) 2×2 km (similar to ScotMap). Aquaculture sites (purple boxes), cables and pipes (pink lines), existing closed area (black hash), and proposed protected area (black outline) are shown. All four figures are derived from the same data set.

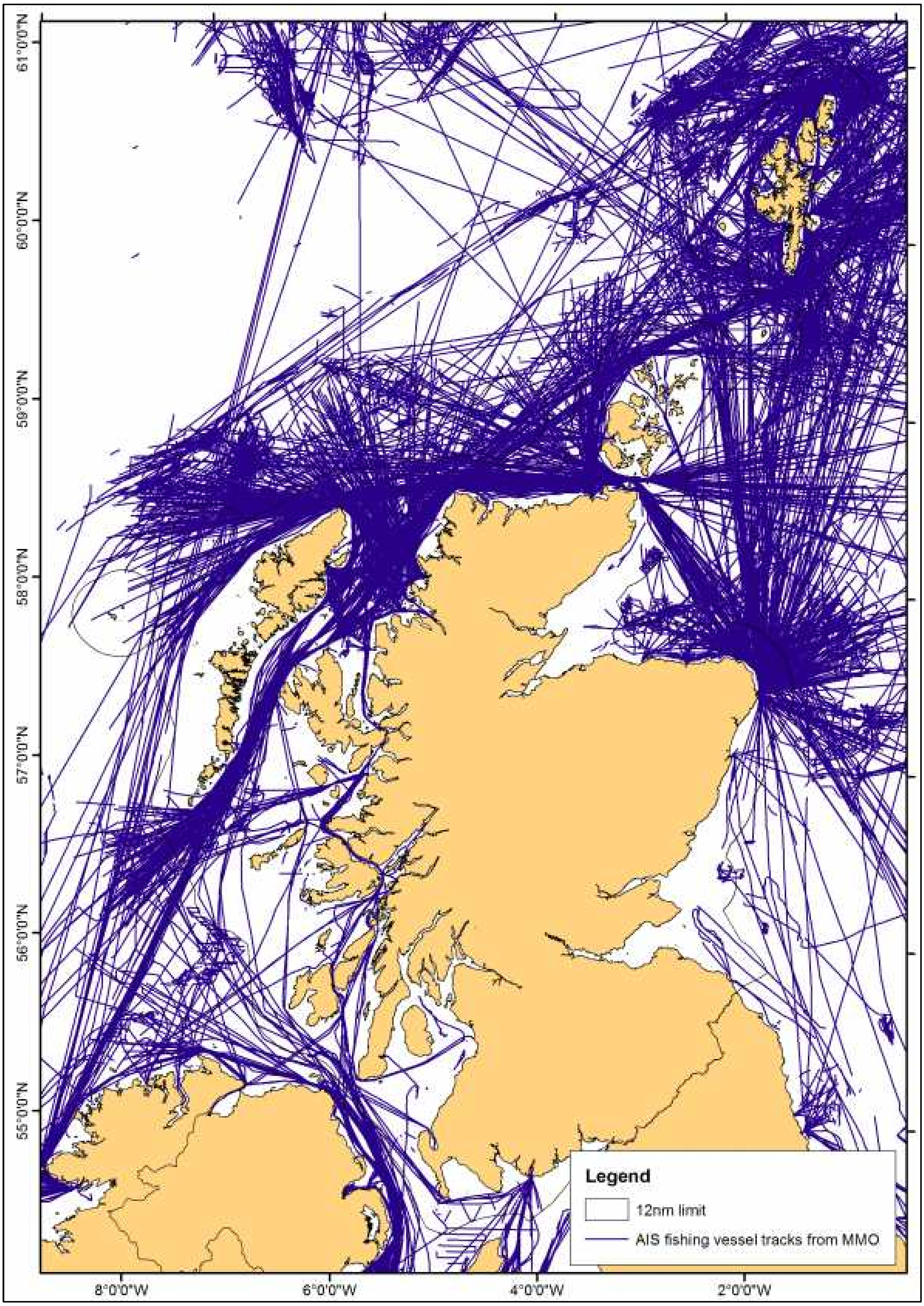

Figure 3.2 Automatic Identification System (AIS) data for fishing vessels 15 m and greater in length. Data shows all vessel movements including steaming. Marine Management Organisation (MMO) data, accessed November 2016, licensed under Open Government Licence.

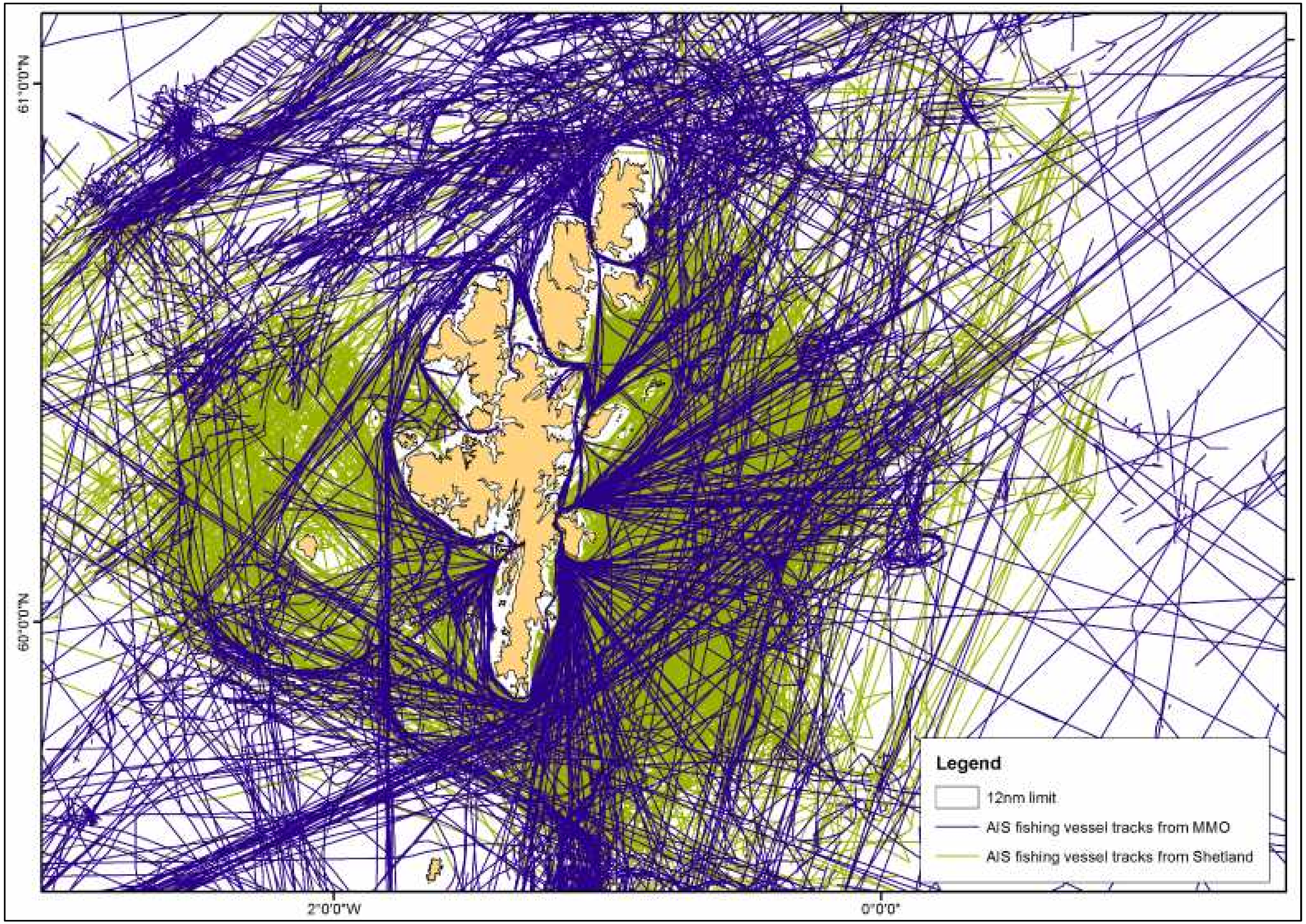

Figure 3.3 Comparing AIS data between the MMO derived track lines (blue lines) and AIS data processed by NAFC Marine Centre (green lines). All data are for fishing vessels 15 m and greater in length during 2014. Data shows all vessel movements including steaming.

3.2 Biological data

When considering biological data, reliable species records are of greatest importance (Table 3.2). It is these records that are used when creating habitat maps which in turn are used by managers and developers. The data is normally expressed as point records which do not show habitat extent but rather the presence or absence of the feature in that particular space and time. There are two main databases that hold species information at a national level, Marine Recorder and NBN Gateway[20], but several regional or local repositories also exist.

Table 3.2 Sources of biological data and their access requirements.

Data type	Source	Resolution	Restrictions	Access
Habitat maps	EMODnet	N/A	Uses some withdrawn data[21]	Free
Protected areas	SNH	N/A		Free
Protected areas	JNCC	N/A		Free
Protected features	NMPi	N/A	No download, only image	Free
Species data	Marine Recorder	N/A		Free
Species data	NBN Gateway	N/A	Permission required	Permission

Much of the available data comes as a point record (i.e. a dot on a map which has coordinates and usually contains information on what species was found there). These point data sets are a good way of displaying where people have looked for and found a certain species or sediment type. However, their usefulness to marine managers is somewhat limited in their raw form, as it would not be possible to manage fisheries around a single point, but they can be incorporated into predictive habitat maps (see Section 3.2.4) and would probably require additional data collection.

Data from both national level databases require a level of quality control prior to inclusion in any habitat map or management decision. For the purposes of the example in this report, both databases were queried to assess the reliability of records. All records for '*Modiolus*' and '*Modiolus modiolus*' (horse mussel) were downloaded and the resulting species point data was analysed.

3.2.1 Marine Recorder

The information was downloaded as a Microsoft Access database from the Joint Nature Conservation Committee (JNCC) website. Once downloaded, the user needs to create a query to access the data. The Scottish Natural Heritage (SNH) data held within Marine Recorder comes under the Open Government Licence and can be freely used with the appropriate copyright statement. From the data downloaded within the 12 nm around Scotland, 6.4% (n=133) of the data points (point records of the presence of the feature in question, e.g. a species or habitat type) were located on land and discarded. The remaining 1 942 data points recorded from the 1970s to the present were used in the analysis (Table 3.3 and Figure 3.4).

[20] Since writing this report, NBN Atlas Scotland was launched (https://scotland.nbnatlas.org)
[21] Some of the data used was historical information which has been removed from the appropriate repository but has not been updated and removed within the EMODNet habitat maps data set.

3.2.2 NBN Gateway (currently NBN Atlas Scotland)

Only records for personal interest, education (not PhD or scientific papers), conservation Non-Government Organisation (NGO) work, and statutory work could be downloaded from NBN Gateway. All other reasons for downloading the data required "written permission from the data provider", although it can be viewed online. In the latest version of NBN, NBN Atlas Scotland, all restrictions on data usage are passed to the original data provider. In many cases the data provider is an individual, which can be prohibitive when trying to access large quantities of data. Locational information for the downloaded data is in British National Grid (OSGB36) and will most probably need converting to a more common marine format (WGS84 or UTM). Nearly 10% (n=293) of the downloaded data for around Scotland had unusable grid codes. A further 4% (n=127) were suspiciously ordered in a line, and an additional 4% (n=53) were mapped on land. Several of these were recorded well in-land with one, recorded in 1984, more than 57 km away from the location of the site name and had a recorded precision of 100 m (this data point was also present in the Marine Recorder data). This left 2 425 data points spread from the 1910s to present (Table 3.3).

For this particular example comparing *Modiolus* outputs from the two databases, more records were found in NBN Gateway but it would not be possible for a developer or manager to use the information without gaining written permission. Although Marine Recorder does not have such limitations, knowledge of querying an Access database would be required. Previous research (see Shelmerdine*, et al.*, 2013; Shelmerdine*, et al.*, 2014) would indicate that further data points from both data sets would likely be inaccurate or out dated but it would be hard to determine which ones without local knowledge or carrying out further surveys. Looking at more recent data would minimise these outliers.

Table 3.3 Breakdown of the percentage of records available from NBN Gateway and Marine Recorder for the search terms "*Modiolus*" and "*Modiolus modiolus*".

Decade	NBN Gateway (% of records)	Marine Recorder (% of records)
2010s	22.7	24.7
2000s	17.9	13.2
1990s	19.8	18.5
1980s	25.7	35.3
1970s	8.7	7.8
1960s	4.7	
1950s	2*	
1920s	1*	
1910s	1*	
No dates	0.4	0.5

* Total number of points recorded.

3.2.3 Other benthic data sources

Benthic data is also collected for a range of regulatory and licensing purposes, but due to copyright limitations is not publicly available, so is subsequently 'lost'. When data is submitted to support licence applications the data owner is not currently asked whether they are happy for the data to be used within marine planning or for it to be incorporated into a biological data repository, such as NBN Gateway, although some data owners may withhold full or partial use for commercial reasons.

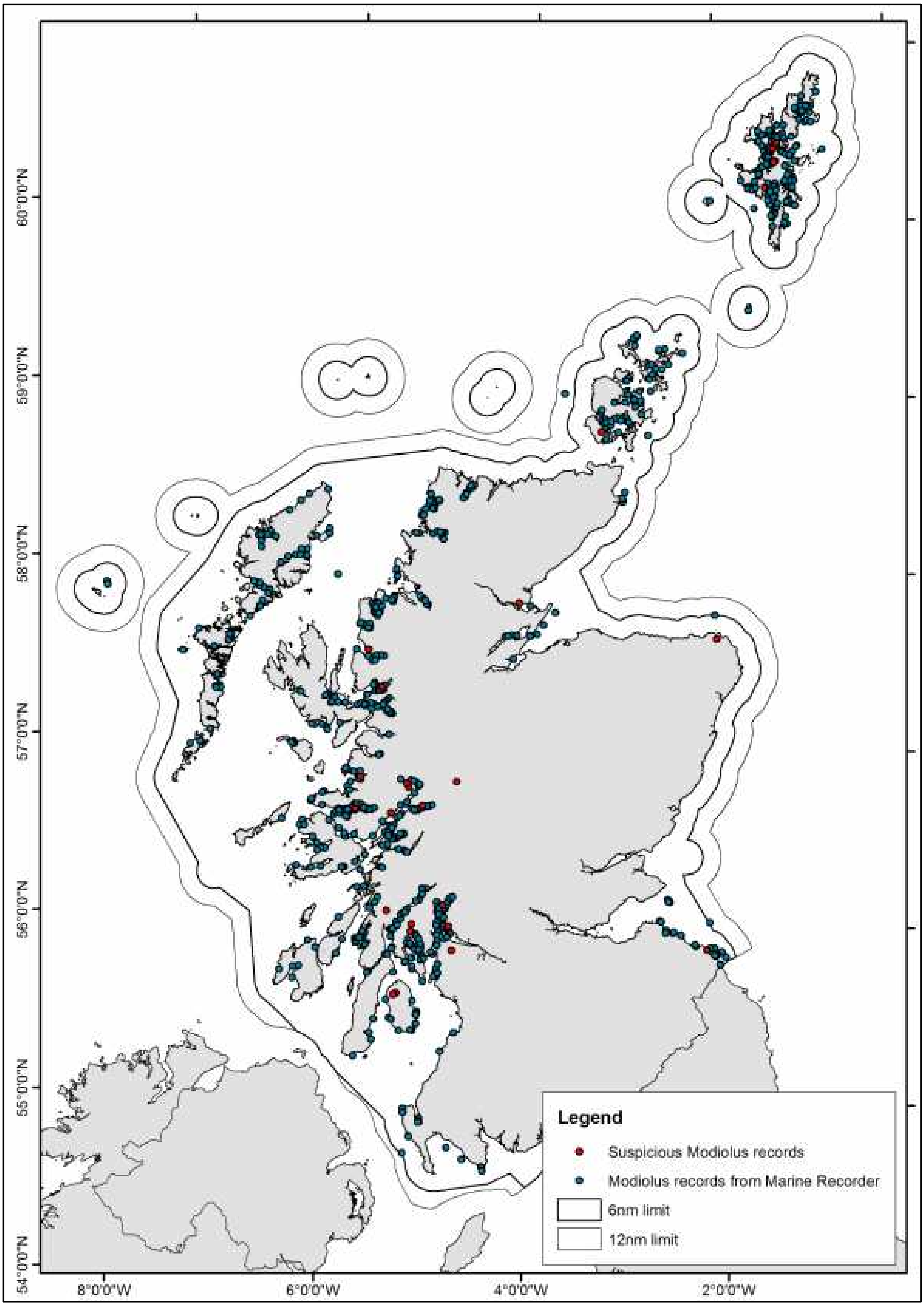

Figure 3.4 All Scottish records for *Modiolus* (green dots) with suspicious records marked in red. Data extracted from the JNCC Marine Recorder snapshot (downloaded on 17th November 2016), © Scottish Natural Heritage 2016.

3.2.4 Habitat maps

Maps which show the extent of a habitat or the spread of a species provide a defined area which can be used by marine management to target specific areas for protection. Such maps are termed habitat maps or species distribution maps. Habitat maps are important tools for decision makers but can have inherent errors associated with them. There are many ways of creating these maps with many using species point data in combination with abiotic factors (e.g. bathymetry, tide, sediment type, etc). The European Marine Observation and Data Network (EMODnet) has collated surveyed habitat maps for download (Table 3.2). These maps can provide some excellent base information but EMODnet also includes some survey data which has subsequently been withdrawn by the original data provider from their records. However, it would be possible to tease out such surveys by using the confidence table, which was included in the download.

Historically, habitat maps were created using a combination of point data, Admiralty charts, and biological knowledge. This produced mapped areas of species distributions with edges closely following the Admiralty chart isobar curves which were related to the biology of the species in question (Figure 3.5). For example, maerl was considered to be found between 20 and 30 meters depth and the orange area of Figure 3.5 demonstrates that association of species presence and bathymetry. The overlaying pink hatched area shows the current distribution, using more modern techniques of video tows and multibeam backscatter, which has maerl in shallower and deeper water than previously accepted and not covering such a large area (Shelmerdine*, et al.*, 2013). The SSMO in Shetland successfully used this technique to accurately map protected features and subsequently close targeted areas to scallop dredging. The habitat maps included defined boundaries to the protected features which were then buffered and closed. This minimised the impact to the fisher by only closing areas that require protection while maximising protection for the feature. Additionally, the defined areas of the maps provide a means of assessing the continued condition, or state, of the feature. For example, multibeam surveys could be carried out five or ten years (depending on the feature) after the closures were implemented to assess actual changes in the boundaries or surface area of the protected features.

Modern techniques using hydro acoustics can produce highly accurate habitat maps but surveys of this kind are expensive to run. A cheaper alternative is to model the species distribution using statistical analysis and/or a species distribution model (SDM) package. These predicted habitat maps can be very useful but they are only as good as the information which is entered into them. Shelmerdine and Shucksmith (2015) demonstrated the effect that scale (the input resolution) had on predictive habitat maps and the difference between the resultant maps. Habitat maps are extremely useful tools for developers and managers but they should be treated with a degree of caution. The production of confidence maps, associated with a habitat map, is an extremely useful approach in assessing the reliability of the map but unfortunately these are not always available.

Most fishers have a good idea of what the seabed would be like within areas which they fish. Engaging with fishers and using their knowledge to quality control predicted habitats is an excellent way of instilling confidence in the mapped outputs and can improve buy-in from the fishing industry.

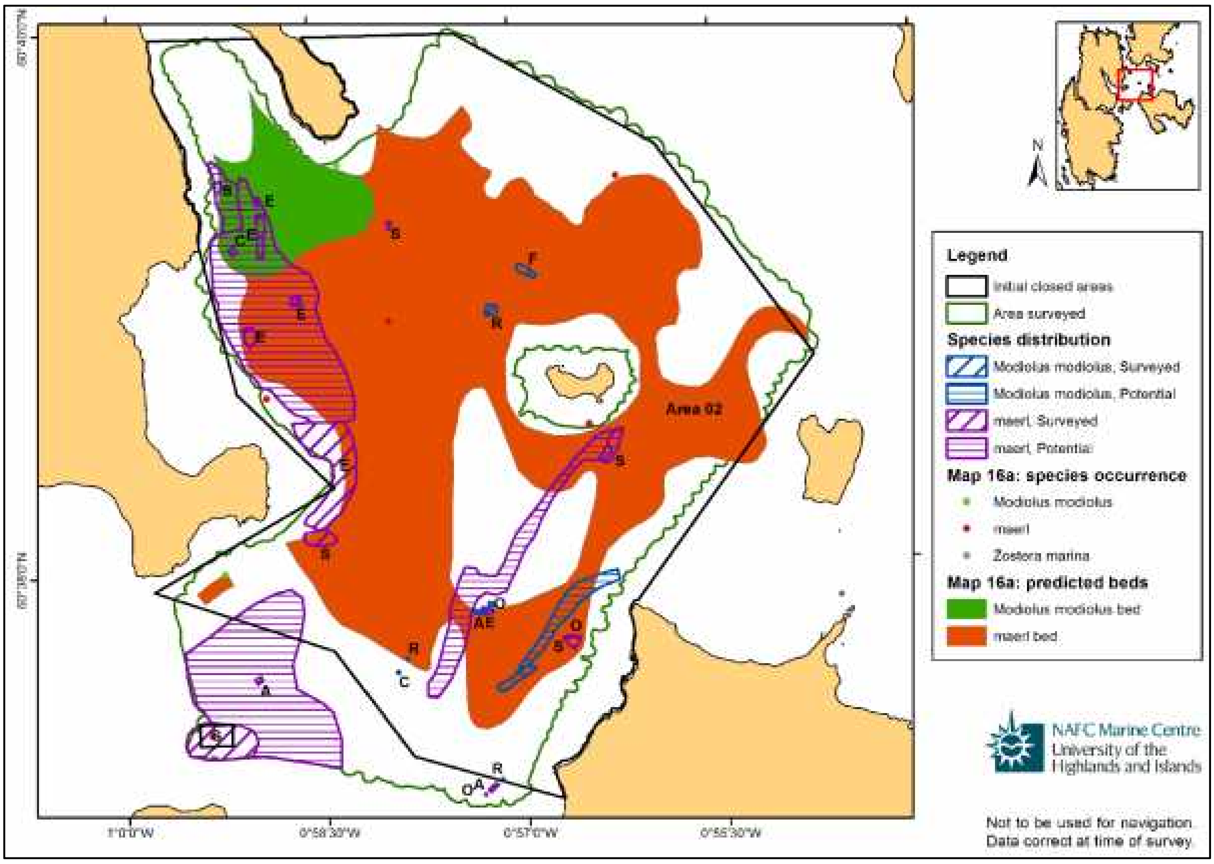

Figure 3.5 Comparison of predicted habitat and surveyed habitat with the predicted maerl and *Modiolus modiolus* beds neatly following the bathymetry contours. Figure taken from Shelmerdine *et al.* (2013).

3.3 Physical and Climatic data

Physical data provides information about the non-biological element of the marine environment and can be quite detailed (Table 3.4). However, in order to gain a better understanding of the environment as a whole, it is important to look at these data in relation to biological information. One of the more common, free to download, bathymetry data sets is the General Bathymetric Chart of the Oceans (GEBCO) which has a global coverage but at a low resolution of around 670 × 670 m. A more recent data set, EMODnet, combines all the best available high resolution bathymetry data into a single bathymetry layer. The data has a European extent with a resolution of around 380 × 380 m (reported as ⅛ × ⅛ minutes) and includes high resolution survey data. Recent updates of the data have occurred in 2015 and 2016 which have included additional new survey data and corrections of anomalies. The UK Hydrographic Office provides an online portal for bathymetry survey data with most of the data at a very high resolution ranging from 2 to 8 m, depending on water depth. High resolution bathymetry also provides locational information on rocky outcrops and smoother sea bed (Figure 3.6). This information can be used by developers to source potential suitable site locations (e.g. proposed cable routing or anchoring sites requiring sediment depth) prior to consultation and by fisheries managers to highlight areas that may have potential conservation importance (e.g. reef systems). Detailed information of reef locations requiring protection from fisheries can help with more targeted closures for the feature. Without this data, large areas of seabed extending beyond the reef would normally be closed to fisheries leading to an increased loss of fishing grounds with no feature present.

Table 3.4 Sources of physical and climatic data and their access requirements.

Data type	Source	Resolution	Restrictions	Access
Bathymetry	UKHO INSPIRE[b]	High		Free
Bathymetry	EMODnet	Medium-High	Processing for smaller areas	Free
Bathymetry	GEBCO	Low	Processing for smaller areas	Free
Ocean currents	Copernicus	Medium-Low		Free
Sediment map	EUSeaMap	Medium	Predictive	Free
Sediment types	BGS[a]	Medium	Offshore	Cost
Tide	ABPmer	High		Free
Wave	ABPmer	Medium		Free
Wind	ABPmer	Medium		Free
Wind	Copernicus	Low		Free

[a] British Geological Survey (BGS)

[b] United Kingdom Hydrographic Office (UKHO) Infrastructure for Spatial Information in Europe (INSPIRE)

It is also possible to use the information to ‘ground-truth’ predictive maps of sediment types such as those in the EUSeaMap data (Figure 3.7). It can be seen, that for the area shown, EUSeaMap substrate types corresponded quite well with the underlying high resolution bathymetry. In this instance, the boundary between substrate types can be refined using the bathymetry (as shown by the red box in Figure 3.7). The data covers offshore as well as inshore areas but is a predictive map based on survey data. The British Geological Survey provides a sediment map at a scale of 1:250 000 but for the offshore only and the information is charged per km^2.

The Atlas of UK Marine Renewable Energy (published by ABPmer, see link in Table 8.2 of Section 8) provides higher resolution tidal (around 1.5 × 2 km), wave, and wind information (the latter two with a resolution of around 9 × 12.5 km). Temporal information is included in the wave and wind data which is broken down by year, season, and month. Additional wind and ocean current information is also available through Copernicus Marine Environment Monitoring Service (CMEM or Copernicus) using satellites but this data has a much lower resolution. These data sets highlight areas of potential developments for marine renewables and when combined with fishing activity information can highlight areas of potential future conflict. Fisheries managers may then be able to collate appropriate fisheries data for these areas at an early stage enabling the managers to engage more effectively with developers and other stakeholders prior to and during any planning application.

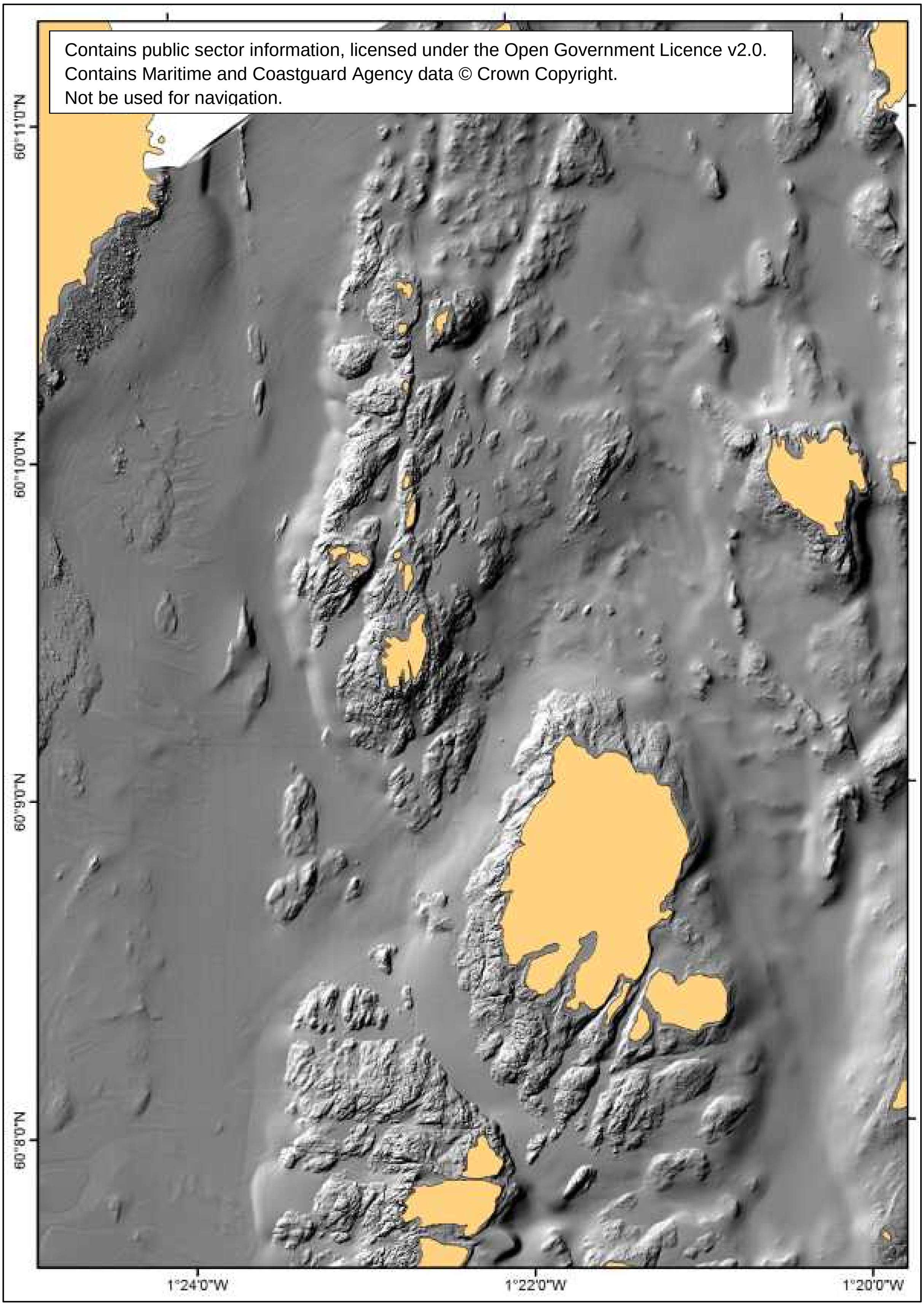

Figure 3.6 High resolution bathymetry, processed using data available through the UKHO INSPIRE portal. Areas of smooth seabed and rock outcrops are easily distinguishable.

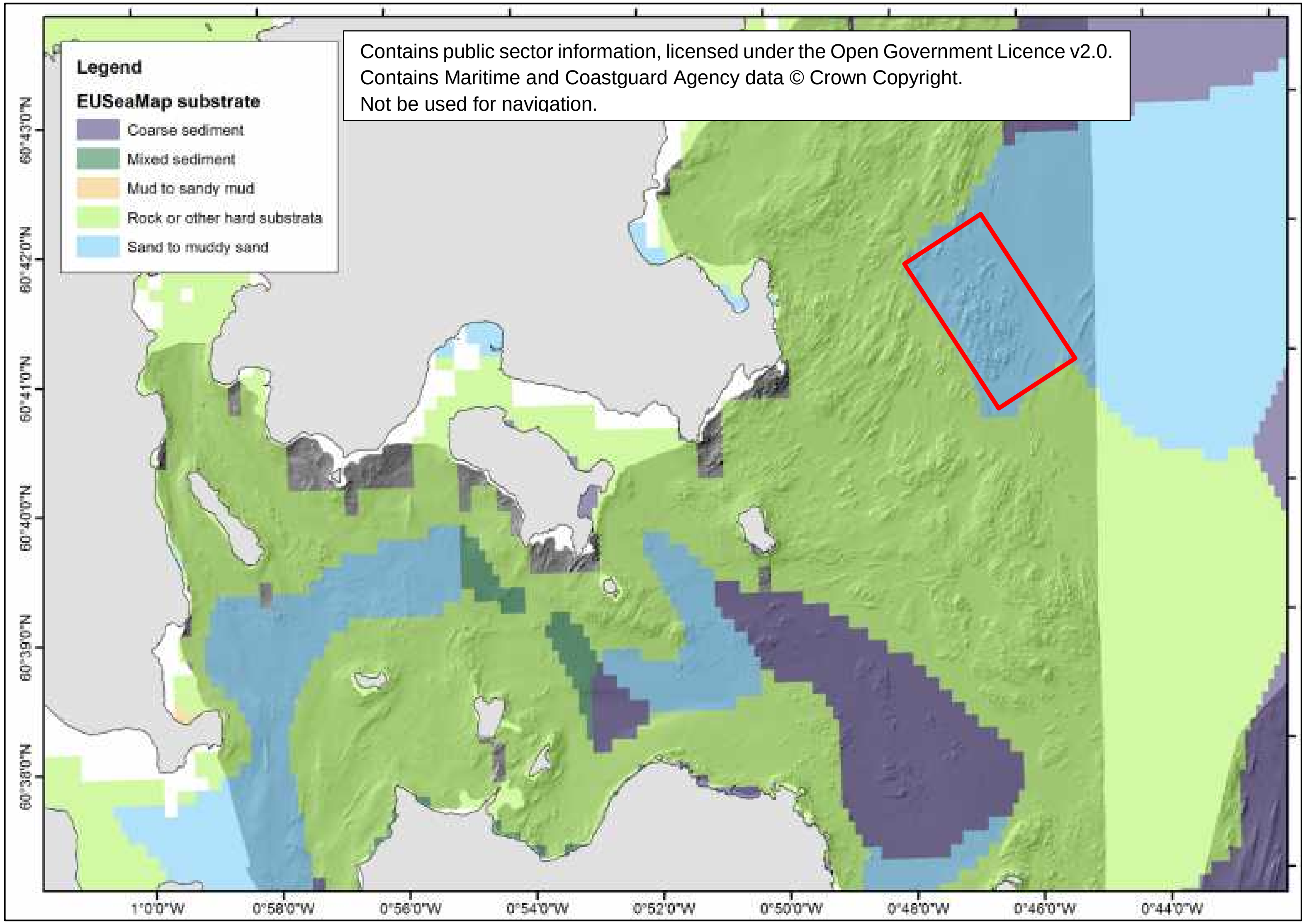

Figure 3.7 EUSeaMap substrate data (from EMODnet Seabed Habitats, accessed November 2016) overlaid on high resolution bathymetry (from UKHO INSPIRE portal). The red box indicates an area where substrate type does not match the bathymetry output.

3.4 Marine development data

Information on the infrastructure from industries, such as oil and gas, renewables, telecommunications, and aquaculture, concerns mostly defined areas as these are spatially licenced industries (Table 3.5 and Figure 3.8). The National Marine Plan Interactive also lists additional information within their Productive category covering Recreation and Leisure, Military Defence, and Waste Disposal, amongst others.

These data sets can provide fisheries managers with a useful oversight in existing restrictions on fishers. This would enable cumulative impacts on fisheries to be considered, both in the context of the impacts of other commercial uses but also with management measures, including conservation measures, between fisheries, and due to ground availability (e.g. see Section 3.1 and 3.3). It is a common misconception that fisheries occurs everywhere and including these constraints into a cumulative impact provides a better idea as to whether fishing tows or creeling would be viable.

However it should be noted that the location of cables and pipelines, particularly those laid some time ago, may contain spatial inaccuracies. In addition, even with newer activities, such as recent cable lays, if the development is not adequately secured to the seabed it may move, for example during entanglement with fishing gear, making locating the development difficult.

Table 3.5 Sources of pipes, cables, wells, and fields and their access requirements.

Data type	Source	Resolution	Restrictions	Access
Aquaculture	NMPi	N/A		Free
Cables	Kingfisher	N/A	No oil and gas	Free
Draft Plan Options	NMPi	N/A		Free
Pipes and cables	CDA[a]	N/A	Register to view	Cost
Wells and fields	OGA[b] open data	N/A		Free
Windfarms	Kingfisher	N/A		Free

[a] Common Data Access Limited (CDA)
[b] Oil and Gas Authority (OGA)

3.5 Additional data sources

Other data sources which may be useful, but were not analysed in this document include:

- Cetacean information from, Agreement on the Conservation of Small Cetaceans in the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS) JNCC[22],
- Seal usage maps from Marine Scotland Information[23] and Sea Mammal Research Unit Ltd. (SMRU)[24],
- Backscatter for habitat maps from Marine Scotland Information
- Drop-down video (DDV) of habitats from Marine Scotland Information
- Sub-bottom profiles (SBP) for sediment depths from Marine Scotland Information

Many of the data sets from Marine Scotland Information are very site specific but it would be worth checking for any overlap with particular sites of interest. Additional data sets are also held within NMPi (e.g. military practice areas, anchorages, and navigation) and it would be worth looking at this resource in relation to sites of interest.

[22] ASCOBANS, JNCC: http://jncc.defra.gov.uk/page-1384
[23] Marine Scotland Information: http://marine.gov.scot/
[24] SMRU Ltd: www.smru.st-andrews.ac.uk/smrudownloader/

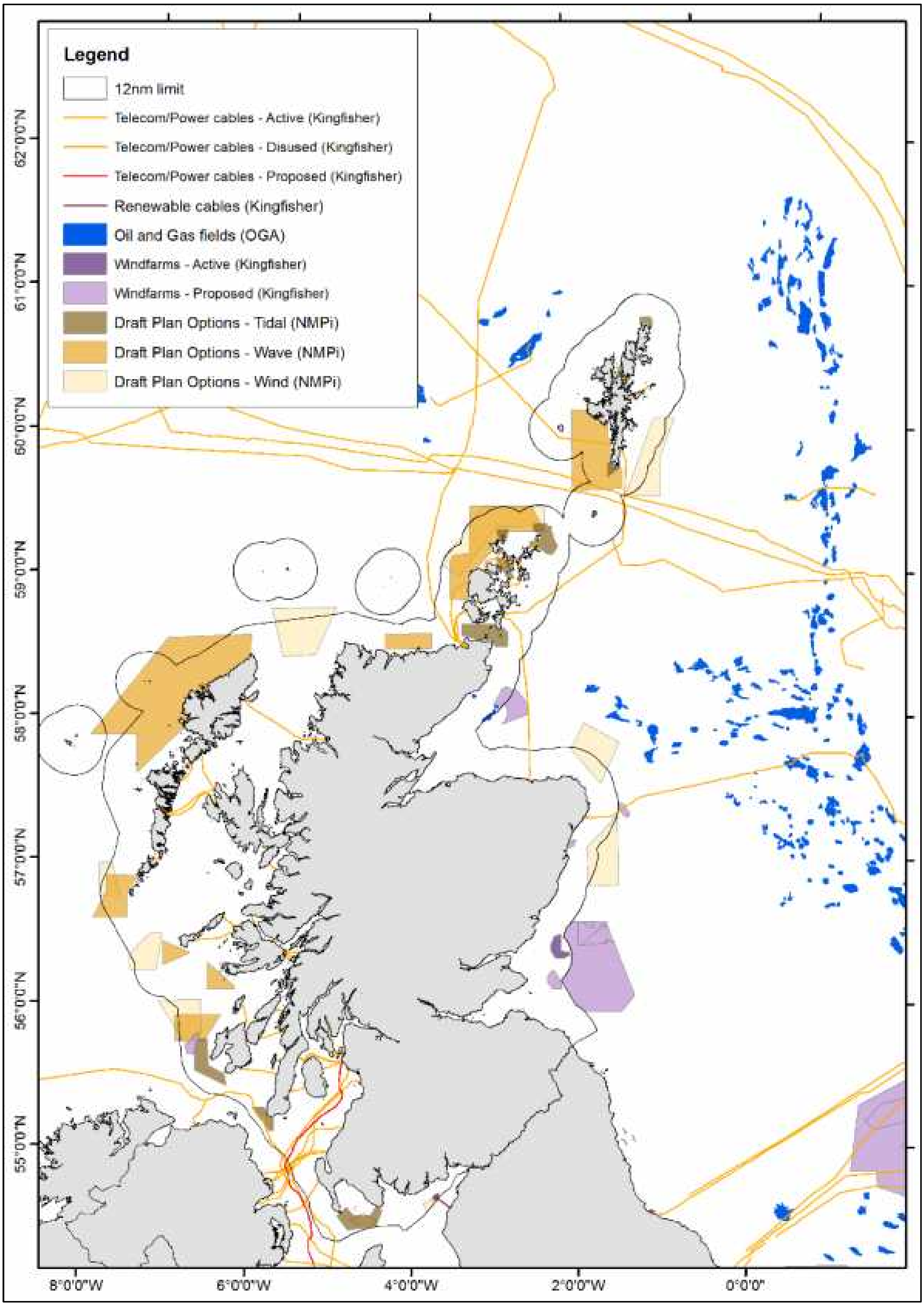

Figure 3.8 Some of the available marine development data including cables (orange, red, and purple), oil and gas fields (blue), windfarms (purples), and Draft Plan Options (browns). Each data source is listed, in brackets, within the legend. Aquaculture sites are not shown.

4 Specific case study areas

Six areas were identified as "Case Studies", highlighting aspects of their management and management tools. These are described in Section 2.1 and Sections 4.1 to 4.6. Case studies cover multiple geographic scales including local, regional, national, and international management strategies. Prior to examining each case study in detail, a summary of the main factors highlighting why each case study was chosen has been detailed, below:

- Devon and Severn IFCA (Section 4.1)
  - Managing gear conflicts
  - Establishing a working group to promote engagement and encourage fishers in taking a role in conservation
  - The use of voluntary codes of practice
  - Effective use of management tools; iVMS units reporting at a very high rate
  - The use of spatial planning with closed areas for both mobile and static gears
- Isle of Arran, COAST (Section 4.2)
  - Land-based community engagement and participation
  - The use of spatial planning as a tool for environmental protection
- Isle of Man (Section 4.3)
  - Zoning to encourage fisheries co-management
  - The use of MPAs as a conservation tool
  - Spatial management to protect habitats and enhance fisheries
- Norway (Section 4.4)
  - Comprehensive and integrated spatial planning
  - Conflict resolution between fisheries and other users
  - Management of a non-native species introduction
- Shetland, SSMO (Section 4.5)
  - Statutorily devolved decision making to a local organisation
  - The use of closed areas to protect marine features
  - Inshore VMS units for monitoring compliance with closed areas and curfews
  - Stakeholder engagement
- Wales (Section 4.6)
  - Effective use of management tools; iVMS units fitted to all working scallop dredgers
  - Using iVMS to monitor fishing around closed areas

4.1 <u>Devon and Severn Inshore Fisheries and Conservation Authority</u>

The Devon and Severn Inshore and Conservation Authority provides examples of: the use of technology (iVMS) to protect the environment; establishing a working group to promote engagement and encourage fishers in taking a role in conservation; and good stakeholder engagement to better manage gear conflicts combined with voluntary codes of practice. Inshore fisheries management in England is managed by regional Inshore Fisheries and Conservation Authorities (IFCAs) which are responsible for the sustainability of inshore fisheries as well as achieving conservation objectives. Each IFCA District extends from the coast out to 6 nm and takes a co-management approach to fisheries management. This is to try and achieve high levels of compliance by allowing fishers to engage with the Authority over local management approaches to be taken.

4.1.1 Identified conflicts

Several conflicts existed within the Devon and Severn IFCA area, between fisheries, within fisheries, and between fishers and conservation interests. The evolution of mobile gear design (e.g. spring-loaded dredges and rock-hoppers) permitted dredge and tow fisheries access to rougher ground which were traditionally static gear grounds inaccessible to the mobile fleet. In addition, new materials were being used in the construction of traps, enabling them to be more robust and durable, which meant the trap fishery could leave their gear in the water for longer. This led to conflicts between the two gear types in the mid-1970s (see Blyth, *et al.*, 2003 for a review). A meeting between representatives of the static and towed gears was held in 1978 to address the conflict, mediated by the Ministry of Agriculture, Forestry and Fisheries, with the outcome being the Inshore Potting Agreement (IPA). The IPA was a voluntary management measure to reduce conflict between static (traps and nets) and mobile (dredge and trawl) fishing gear (Blyth, *et al.*, 2003; SIFT, 2012). The IPA zoned the area into exclusive use for static and towed gear and areas of seasonal use by static and towed gears. Byelaws in 2002 made the scheme statutory (Jones, 2008) and has now been integrated into the Devon and Severn IFCA.

Space was a limiting factor within the trap fishery and fishers left their gear in the water over winter to discourage other fishers from setting their gear at that location. This domination of space meant that new fishers to the fishery were unable to fish without first purchasing second-hand gear already in place (see Blyth, *et al.*, 2003 for a review). The IPA, however, does not address this conflict and the authors noted in their interviews with fishers that the intra-sector conflict still existed and was a result of competition for space. Newcomers, increased gear quantity, and opening of seasonal closures were highlighted as drivers of the conflict.

One static gear fisher, interviewed by Blyth, *et al.* (2003), had the most conflict with anglers' boat anchors either tangling with traps or pulling the traps off their original location. Loss of catch, cutting away gear, and extra time spent in recovery were listed as the consequences.

Lyme Bay is a large inshore Special Area of Conservation (SAC) which partly falls within the Devon and Severn IFCA's authority. In 2008, a 60 square mile area was closed off to scallop dredging in order to protect the features, however, static gear (pots and nets) continued to fish the area[25]. In order to address the mistrust which had built up between fishers and conservationists, Blue Marine Foundation set up a working group called the Lyme Bay Fisheries and Conservation Reserve[26] which included representatives from regulators, fishers, conservationists, scientists, and other stakeholders. In 2014 the Group commissioned a report looking at the integrated fisheries management within the area (Chambers, *et al.*, 2014). Overall, the report found that the working group had a positive impact on the reserve and, although management issues were identified which would still require addressing, the working group's collaborative approach was viewed as a positive and inclusive way forward for a sustainable and healthy fishery.

Renewable energy in the form of tidal lagoons is an emerging industry, with tidal lagoons proposed for the Severn Estuary. Devon and Severn IFCA produced a briefing note in August 2015 which summarised what a tidal lagoon is, the planned development sites, how they may

[25] See www.bluemarinefoundation.com/project/lyme-bay/ for more detail.
[26] See www.lymebayreserve.co.uk/ for details.

affect fish and their habitats. The document highlights which fisheries may be affected and outlines data gaps which it believes should be addressed. In addition, Devon and Severn IFCA sit on the Fish Expert Topic Group for Tidal Lagoon Cardiff Bay.

4.1.2 Technology

After a trial on the effectiveness of an inshore VMS system to monitor scallop dredge activity within the Lyme Bay and Torbay candidate Special Area of Conservation (cSAC, MMO, 2012), a Voluntary Code of Conduct was created. The Code states that, "Any registered fishing vessel wishing to fish within the Lyme Bay cSAC will voluntarily fit Inshore Vessel Monitoring Systems". The iVMS systems are required to report every minute to ensure vessels fishing alongside closed area boundaries remain outside of the protected features. Not all vessels have signed up to The Code (Chambers, *et al.*, 2014) and it is unclear what affect that would have on levels of compliance.

4.1.3 Regulations, compliance, and spatial planning

A risk based approach to enforcement is employed with planned enforcement operations. This relies on information from the public reporting to the Authority any suspicious fishing activity.

Through the IPA there are a series of closed areas (spatial and seasonal) for towed and static gear. Within Lyme Bay SAC, there is a ban on scallop dredging with a voluntary scheme permitting scallop dredging within defined areas when using an inshore VMS system.

4.1.4 Further reading

- Devon and Severn IFCA: www.devonandsevernifca.gov.uk/
- Lyme Bay and Torbay Site of Community Importance document archive: http://webarchive.nationalarchives.gov.uk/20140108121958/http://www.marinemanagement.org.uk/protecting/conservation/lyme_bay.htm

4.2 Isle of Arran, Community of Arran Seabed Trust (COAST)

The Isle of Arran case study provides an example of an environmental initiative led by a land-based community, which was supported by Arran based creel fishers. The South Arran MPA is a Nature Conservation MPA which encompasses an already established No Take Zone of Lamlash Bay. The Community of Arran Seabed Trust (COAST) is a community led organisation which successfully campaigned for the No Take Zone at Lamlash Bay and is now campaigning for the effective management of the South Arran MPA.

4.2.1 Identified conflicts

The main identified conflict is between bottom trawlers/dredgers and the environment. The community led campaign took 13 years before they were successful in implementing management measures for a No Take Zone and a further six before the designation of the MPA. In the future the new Scottish Government 'Demonstration and Research' MPAs and associated guidance, may provide a clearer structure for community led initiatives[27], facilitating engagement between communities and fishers, and facilitating the development of governance structure. In addition there is some anecdotal evidence that there is potential for conflict between static and mobile gear fishers since the establishment of the MPA, with mobile

[27] Guidelines on the selection of MPAs- Supplementary guidelines for demonstration and research MPAs www.gov.scot/Resource/0051/00515465.pdf

gear fishers unhappy with the uncontrolled increase in static gear in areas prohibiting mobile gear[28]. The static gear fishers are members of the Arran community.

4.2.2 Regulations, compliance, and spatial planning

The South Arran nature conservation MPA has five different fisheries management zones including:

- A No Take Zone where all fishing is prohibited and the removal of any marine life is prohibited
- Demersal trawl, dredge, and creels prohibited in four areas
- Demersal trawl and dredge prohibited
- Dredge prohibited with some demersal trawling permitted subject to conditions

The last zone encompasses the entire MPA.

COAST produced a leaflet called the Kipper explaining to members of the public how they can 'police' the MPA area through reporting fishing activity to Marine Scotland Compliance and what is required for evidence.

4.2.3 Further reading

- Community of Arran Seabed Trust: www.arrancoast.com
- Nature Conservation MPAs: www.gov.scot/Topics/marine/marine-environment/mpanetwork/ncmpas
- South Arran Marine Protected Area: www.gov.scot/Topics/marine/marine-environment/mpanetwork/developing/DesignationOrders/ARRDOrder
- South Arran Marine Protected Area (SNH): www.snh.gov.uk/protecting-scotlands-nature/protected-areas/national-designations/mpas/mpa-arr

4.3 Isle of Man

The Isle of Man case study is an example of an integrated zoning and MPA network to protect the environment while preserving the dredge fishery. An ecosystem approach to fisheries management has been adopted by the Isle of Man Department of Environment, Food and Agriculture (DEFA) with policies underpinned by scientific data (Isle of Man Government, 2015). The authors note that good historical marine and fisheries scientific data combined with a "strong community recognition and association with the marine environment" has led to a largely successful, typically holistic, ecosystem-based approach to marine management and provides a good example of the effective implementation of closed areas.

The main fisheries in Isle of Man territorial waters (out to 12 nm or median line with UK) are for king scallops, queen scallops, brown crab, lobster, and whelk. Regulations are produced by DEFA and are effective once signed by the DEFA Minister. As well as being the responsible authority for fisheries management, DEFA has responsibility for the protection of marine habitats and species including restricting species introductions. There is no exclusive fisheries zone for Isle of Man vessels (Isle of Man Government, 2015). Historic access rights for Belgium, France, Ireland, and UK apply between 6 and 12 nm with UK and Isle of Man vessels having access out to 6 nm through appropriate licence requirements. The Isle of Man's sea

[28] Information obtained from the BBC 'Out of Doors' radio show which interviewed Kenneth MacNab of the Clyde Fishermen's Association and Alistair Sinclair of the Scottish Creel Fishermen's Federation (www.bbc.co.uk/programmes/b07kp1gl). The show was aired on 16th July 2016.

fisheries and environment strategy for 2016 to 2021 was published by DEFA in 2015 (see Isle of Man Government, 2015).

4.3.1 Regulations, compliance, and spatial planning

Locally developed management regulate both queen and king scallops through closed areas to protect marine features (Isle of Man Government, 2015). The Queen Scallop Management Board (QSMB) was established in 2010 to advise government on the management of the queen scallop fishery. Members of the board include processors, fishers, and DEFA representatives including the Minister for the Department.

DEFA is responsible for enforcement through Isle of Man Fisheries Officers and one fisheries protection vessel.

Several MPAs have been designated, with the first in 1989, and considered an effective fisheries conservation tool for king scallops (Isle of Man Government, 2015). Additional areas have been designated to protect habitats, increase juvenile queen scallop recruitment through four closed areas, and encourage co-management of fisheries through the Ramsay Marine Nature Reserve. This marine nature reserve is broken down into five zones, each with different levels of protection[29] (Table 4.1). Zone 4 enabled stock recovery from depleted stocks in 2009 to a conservatively managed fishery in 2013, through an efficient industry led fishery (Dignan, *et al.*, 2014). Of the protected habitat areas:

- Three (Douglas, Laxey, and Niarbyl Bays) have been designated no-take zones for sea-fish, king scallop, and queen scallop.
- An Experimental Area (Port Erin) permits fishing using either pots or rod and line only.
- The closed area at Baie ny Carrickey prohibits fishing for or taking king and queen scallops. The fishing for, taking or killing of lobsters or crabs is also prohibited except by members of the Baie ny Carrickey Crustacean Fishery Management Association or by hobby fishers.

Table 4.1 Ramsay Marine Nature Reserve zones, their details and protection level.

Zone	Type	Detail	Protection level
1	Conservation Zone	Permanent closure to dredging and trawling (potting allowed)	Moderate
2	Horse Mussel Zone	Closed to all dredging, trawling, and potting	High
3	Eelgrass Zone	Closed to all fishing and marine life extraction	High
4	Fisheries Management Zone	Managed under MFPO[a] Seabed Lease	Low
5	Rocky Shore Zone	Closed to dredging and trawling within 500 m of shore	Voluntary

[a] Manx Fish Producers Organisation (MFPO)

[29] Information taken from https://www.gov.im/categories/business-and-industries/commercial-fishing/closed-or-restricted-area-maps/ramsey-bay-closed-area

4.3.2 Further reading

- Isle of Man Government commercial fisheries: www.gov.im/categories/business-and-industries/commercial-fishing/
- Fisheries Directorate: www.gov.im/about-the-government/departments/environment-food-and-agriculture/fisheries-directorate/
- Statutory documents: www.tynwald.org.im/links/tls/SD/Pages/default.aspx?&s=SD&k=sea%20fisheries&r=

4.4 Norway

The Norwegian fishery provides examples of: conflict resolution through a joint forum with the fisheries and hydrocarbon industries; a comprehensive and integrated spatial plan including a series of MPAs; and a novel method to managing an invasive species by creating a new fishery while protecting and compensating an existing one impacted by the invasion.

4.4.1 Identified conflicts

Conflicts between the fishing industry and the oil and gas (hydrocarbon industry) are well documented in Norway (see Arbo and Thủy, 2016), with the conflicts between the two industries beginning in 1971 due to access restrictions of fishing grounds and gear damage from debris left on the seabed. The 1985 Act on Petroleum Activities left responsibility with the oil companies for pollution and waste from petroleum activity, which may cause damage or financial loss to the fishing industry. However, conflicts remain and include: limiting access to fishing grounds, infrastructure (e.g. pipelines) and fishing gear damage, increased vessel activity, and navigational hazards (Arbo and Thủy, 2016). In addition, Norway have implemented a 500 m exclusion zone around each platform and emerging structure (Arbo and Thủy, 2016), increasing the potential loss of fishing grounds. The relationship between the two industries has reportedly improved and now, eight measures are carried out in order to facilitate coexistence, several cross-sector committees have been formed to look at co-existence and a joint forum, 'One Ocean', has been created between the Norwegian Oil and Gas Association and the Norwegian Fishermen's Association (see Arbo and Thủy, 2016 for details on the measures).

4.4.2 Regulations, compliance, and spatial planning

Norway has implemented integrated ecosystem based management plans for the Barents Sea (Olsen, *et al.*, 2007; Knol, 2010; Olsen, *et al.*, 2016), the Norwegian Sea (Ottersen, *et al.*, 2011), and the Norwegian part of the North Sea. The plans cover all Norwegian sea areas extending from 1 nm out to the Norwegian Exclusive Economic Zone (EEZ) and bring together management regulations for fisheries management, and the hydrocarbon and shipping industries (Olsen, *et al.*, 2007). Olsen, *et al.* (2007) and Knol (2010) note that the plans do not manage specific activities as "that is the responsibility of the relevant ministries and management bodies". In order to reduce conflicts with fisheries, the Barents Sea Plan has enabled shipping lanes to be moved outside of 12 nm (through the International Maritime Organization), and closed areas to hydrocarbon activity (Olsen, *et al.*, 2007; Knol, 2010). A series of MPAs have also been established in Norwegian waters. Moland, *et al.* (2013) examined three MPAs with gear restrictions, permitting only hook and line fishing. Policing within the three MPAs under study was carried out by the Coast Guard, Directorate of Fisheries, and local police.

The red king crab was deliberately introduced to the Barents Sea by Russia in the 1960s to increase the economic output of the Russian fisheries in the region (see Sundet and Hoel, 2016 for details). The introduction was not reported to neighbouring Norway. Conflicts occurred between traditional gillnet fisheries and the spread of the invasive species which prompted further scientific research by a joint Norway-Russia survey programme. By 1993 the Norwegian-Russian fishery commission agreed to start a commercial fishery under joint management. In 2007 it was agreed each nation manage the crab within their own waters and Norway established a new management regime which divided the fishery between a Quota Regulated Area (QRA) and an Open Access Area (OAA). The main aim of the management regime was to limit further expansion of the red king crab (through the use of the OAA) while maintaining a viable commercial crab fishery (through the QRA). Income from the fishery is used to reimburse the gillnet fishery for any economic loss due to the invasive crabs (Sundet and Hoel, 2016). The authors also noted that the management plan appears to be working as intended.

4.4.3 Further reading

- Fisheries Norway: www.fisheries.no
- Directorate of Fisheries: www.fiskeridir.no/English
- Marine Spatial Plan Norway (Barents Sea):
  www.unesco-ioc-marinesp.be/msp_around_the_world/norway_barents_sea

4.5 Shetland Islands marine management

The Shetland case study is an example of locally led marine management initiatives to achieve environmental sustainability and reduce conflicts between marine uses. The Shetland Shellfish Management Organisation (SSMO) was established in 1998 in order to manage the inshore (within 6 nm of the coastline) shellfish fisheries around Shetland. Management is carried out under the Shetland Islands Regulated Fishery (Scotland) Order 2012, with the first Order issued in 1999. The Regulating Order (RO) covers all non-quota shellfish species and includes devolved powers for the SSMO to restrict access to potential fishing grounds on a temporary or permanent basis (as well as additional powers which have been devolved to the SSMO through the RO).

The SSMO board is comprised of eight directors; one community council representative, one shellfish processor, two local authority (Shetland Islands Council) members, and four active fishers; two of whom represent Shetland Fishermen's Association (SFA).

The main purpose of the SSMO is to ensure the sustainable management of Shetland's shellfish fisheries. The main focus is on management of fishing activity relative to stock status, but in recent years the SSMO have also introduced measures to reduce environmental impacts through a series of closed areas. The data collected by the SSMO, in partnership with the NAFC Marine Centre who provide scientific support, in order to sustainably manage the stocks provides a significant data resource which is also used to guide marine development in areas where there is an overlap with inshore fisheries activity. It is also possible to use the extensive data sets to provide information on economic impacts of development on the local fisheries.

The comprehensive collection of fisheries data alone is not enough to guide marine development, and in Shetland this has been effected through policy development and implementation within the Shetland Islands' Marine Spatial Plan (SIMSP)[30]. Since 2006 Shetland has been managing the sea area out to 12 nm through the SIMSP. The SIMSP contains a range of policies linked to spatial data which developers are required to adhere to when submitting a licence application. The policies within the Plan require protection and consideration to be given to the environment (natural and built), community use, and other existing marine users, while the aim of the plan is to ensure the long term use of the marine and coastal environment of Shetland is sustainable. The Plan also contains guidance for the renewables sector, through 'Regional Locational Guidance for the Shetland Islands' (Tweddle*, et al.*, 2014), which uses the spatial data within the plan to guide developers to areas of least constraint.

Fisheries interests are represented within the SIMSP advisory group by the SSMO and also the SFA, helping to integrate fisheries management and marine spatial planning. The inclusive nature of the SIMSP advisory group has resulted in the establishment of trust with the local fleet and a number of data sets have been made available to inform local management. A good example of this is in the provision by individual fishers of private whitefish raw VMS data. This was made available and subject to a data checking exercise, allowing non-fishing areas (for example steaming routes) to be removed from the data set and making the data available at a higher resolution than is currently available nationally. The copyright for this data has been retained by the fishers, a key requirement to build trust. The fishers were also able to consider their data displayed at a number of spatial scales before giving consent to their preferred spatial resolution. The data is not available in GIS format but only in picture form. This has allowed whitefish interests to be considered early in the development design stage while protecting the fishers' desire for anonymity and protection of their commercial interests. The SFA liaises with its members and developers to provide more detailed data when required, and with consent of the fishers.

With respect to inshore fisheries the inclusion of spatial fisheries data within the planning process has resulted in a mechanism which can reduce conflict as the SSMO may now be consulted at several points during the development process. This can be at a pre-application stage where developers seek information to develop their application, or on a consultative basis once an application has been lodged. The communication with industry under the plan allows the correct and most relevant data to be accessed, the specific fishers affected to be contacted, and potential mitigation to occur prior to a planning application being submitted. This is beneficial to industry in reducing impacts of development, but also results in reduced delays and costs for the developers once they begin the statutory planning process. This is a good example of how appropriate data and an effective policy framework can enhance development opportunity, while protecting existing uses. A review of the SIMSP indicated that developers felt the SIMSP made Shetland 'a more attractive place to come', and provided them with information they were not otherwise aware of. The review also indicated that the fisheries data within the Plan was being used as an evidence base within the licencing process, both by developers and by the local authority (Kelly*, et al.*, 2014).

[30] See www.nafc.uhi.ac.uk/research/msp/simsp/simsp

4.5.1 Identified conflicts

Within Shetland there are a number of users of the marine space which have the potential to create spatial conflicts, including aquaculture, oil and gas, and the emerging marine renewables sector. Potential conflicts between dredge fisheries and the environment exist due to areas of known protected habitats, namely horse mussel (*Modiolus modiolus*) and maerl beds. Fishers were presented with a series of predictive habitat maps and historic point data, information originating from a national level database, for these features which did not match up to the fishers' local knowledge. The NAFC Marine Centre was tasked to carry out extensive surveys of these areas which, once analysed, were closed to scallop dredging but only if the features were present. Prior to surveying, fishers were consulted on each area and it was understood that any closed area would reflect the actual area of the feature, thus minimising impact to the fisher (see Shelmerdine*, et al.*, 2013; Shelmerdine*, et al.*, 2014).

4.5.2 Technology

The Shetland whitefish fleet provided their raw VMS data to the SIMSP, which has been presented at a grid resolution of 1 × 1 km (a higher level of detail than is available nationally, see Section 3.1).

Most scallop dredgers have voluntarily installed inshore VMS systems which report every 10 minutes (Shelmerdine and Leslie, 2015). The data is used by the SSMO to monitor compliance with scallop dredge closed areas and curfews. Additionally the SSMO has used the data to evidence marine planning applications which may impact on the fishery. However, as yet this data is not publically available and can only be obtained upon request and with the consent of the fishers, although it is hoped this data will be incorporated within the SIMSP in 2017.

Closed areas have been used in Shetland to protect habitat features (horse mussel, *Modiolus modiolus*, and maerl beds) from the impacts of scallop dredging (Shelmerdine*, et al.*, 2013; Shelmerdine*, et al.*, 2014). Prior to any closure, the SSMO requires an in-depth survey to be carried out of the area using a multibeam system combined with drop down video footage. The area is initially surveyed using the multibeam system which provides information on water depth as well as backscatter, an indication of habitat type. The backscatter is analysed on site and a series of drop down video drifts are conducted over differing backscatter habitat areas. The video drift footage is then analysed and compared with the backscatter data. Habitat maps can then be created and any areas containing the feature as a 'bed' are suggested for closure by the SSMO. In the case of these examples it is important to determine if a bed is present or not, as individuals would not necessarily warrant protection.

4.5.3 Regulations, compliance, and spatial planning

The Shetland Islands Regulated Fishery (Scotland) Order 2012 require vessels to obtain a SSMO licence to commercially fish for shellfish within Shetland's 6 nm limit. All licenced vessels are required to fill out a SSMO logsheet.

A series of scallop dredge closed areas have been established around Shetland (Shelmerdine*, et al.*, 2013; Shelmerdine*, et al.*, 2014). Areas were based on the presence of protected habitats which were accurately mapped providing a reliable and measurable habitat extent. Closed areas started as voluntary and, once surveyed and analysed, the current list of closed areas became statutory through the Regulating Order. The SSMO has committed to investigate, and potentially close areas where interactions with priority marine features have been recorded. Logsheets recording fishing information have been adapted to capture this information.

The SIMSP has been adopted by the Shetland Islands Council as supplementary guidance to its local development plan and includes policies which require developers to consider impacts on fisheries and highlights the need for consultation with the fishing fleet and their representatives. The SSMO and SFA are consultees to licence applications, which give them the opportunity to submit comments on potential impacts on the fishery by other users and uses.

4.5.4 Further reading

- SSMO: www.ssmo.co.uk
- Shetland Islands' Marine Spatial Plan: www.nafc.ac.uk/smsp.aspx

4.6 Wales

The Wales case study is an example of the use of technology to monitor compliance of fishing activity within an SAC. UK and European Union regulations govern all commercial fisheries around Wales[31]. Regulation of Sea Fisheries is achieved through secondary legislation, made by Welsh Ministers under powers from primary legislation. The national Wales Marine Fisheries Advisory Group and the three regional Inshore Fishery Groups of North, Mid, and South Wales were formed as a stakeholder-led approach to fisheries management (see Pantin, *et al.*, 2015 for further details).

4.6.1 Identified conflicts

Conflict type was found to vary between fisher method in Wales (Pantin, *et al.*, 2015). Environmental conservation was found to be the greatest conflict for scallop dredge fishers, followed by conflicts with other scallop dredgers. The study found that static gear fishers reported a much greater range of conflicts with the greatest found to be hobby fishers (including hobby potters), followed by those targeting the same species. In total, 12 conflict types were highlighted by static gear fishers covering: defence, development, divers, the energy sector, other fishers, pleasure boating, and tourism (Pantin, *et al.*, 2015).

4.6.2 Technology

The Scallop Dredging Operations (Tracking Devices) (Wales) Order 2012 stipulates all British vessels with a scallop dredge onboard (and which are not stowed) must be fitted with a working inshore VMS unit which transmits the required information every ten minutes. An analysis of the effectiveness of the iVMS units in the scallop fishery was carried out by Rossiter (2016). This work concluded that iVMS units were effective tools in mapping fishers' activity. However, the report also highlighted the difficulty in distinguishing between fishing types (e.g. scallop trawling and net towing); an issue compounded by the lack of a statutory obligation for all vessels to complete logbooks. In addition, determining when a vessel is fishing has been historically related to vessel speed but Rossiter (2016) reported that the Welsh Government plan to trial technology that will record temperature and depth of fishing gear (a gear-in gear-out sensor attached to the dredge) to enable more accurate mapping of fishing activity. Such

[31] For more information see the Policy section of http://gov.wales/topics/environmentcountryside/marineandfisheries/?lang=en

a sensor would enable better management, as well as enhance compliance and enforcement, of closed areas. It could also be used to look at fishing intensity through effort management.

4.6.3 Regulations, compliance, and spatial planning

The Scallop Fishing (Wales) (No.2) Order 2010 sets out the regulations for British vessels scallop dredging in Welsh waters. Two of these regulations include:

- Nine scallop dredging closed areas have been defined (including Cardigan Bay SAC).
- An area, termed the Kaiser Box and located within Cardigan Bay SAC, is open for dredging from 1st November to 30th April each year.

In addition, byelaws from the former Sea Fisheries Committees (SFCs) require a scallop dredging permit to be held, although this only applies out to 6 nm. Enforcement is carried out through British sea-fishery officers.

The Welsh Government is implementing an integrated ecosystem approach to policy making which will include marine management and fisheries, marine energy, tourism, and transport. A strategic action plan for marine and fisheries was published in November 2013[32] and will be integrated into the Welsh National Marine Plan and marine governance arrangements.

Marine Protected Areas (MPAs) cover 36% of Welsh seas. A steering group, chaired by the Head of Marine and Fisheries Division, was established to look at ways of improving MPA management.

The Cardigan Bay SAC is a closed area to scallop dredging with the exception of a small area called the Kaiser Box. The Box is open to fishing annually from 1st November to 30th April and data from VMS units have been used to monitor compliance with the regulations. Studies have also been carried out looking at increasing the VMS ping rate from the current 10 minute interval to a one minute interval. There are concerns that such intense fishing within a small area is not environmentally beneficial and, combined with evidence suggesting that scallops are not thriving in the surrounding closed area (e.g. overcrowding leading to reduced growth), the Welsh Government carried out a consultation on opening up parts of the SAC to scallop dredging[33]. The consultation closed on 17th February 2016 but the results have not been published at time of writing this document.

4.6.4 Further reading

- Welsh government marine fisheries: http://gov.wales/topics/environmentcountryside/marineandfisheries/?lang=en
- Welsh marine planning portal: http://lle.gov.wales/apps/marineportal

[32] Wales Marine and Fisheries Strategic Action Plan (2013), downloadable from http://gov.wales/topics/environmentcountryside/marineandfisheries/strategy/documents/strategic-action-plan/?lang=en

[33] The consultation closed on 17th February 2016 but the results have not been published at time of writing this document. The consultation can be found at: http://gov.wales/consultations/environmentandcountryside/proposed-new-management-measures-for-the-scallop-fishery-in-cardigan-bay/?lang=en

5 Discussion

Our shared seas environment faces a variety of management challenges which require equally varied solutions to ensure that they provide sufficient spatial and temporal accuracy and flexibility to be effective. Key factors highlighted within the examined case studies illustrate the importance of effective use of available data, the frequent need for additional data collection, and successful communication between relevant stakeholders. In addition, several case studies highlight the need for adequate statutory underpinning of management measures and effective enforcement.

National data sets cover the largest geographic scale and will not always be suitable to address issues occurring at a more localised level, although many can be enhanced with further stakeholder engagement. For some fisheries data sets it may not be cost effective or feasible to try and address this at a national level. However, there may be opportunities at a local level, for example through IFGs or with the development of regional marine planning, for data gaps, errors, and data linkages to be addressed. This can only effectively occur through consultation with fishers to help to validate data sets and provide an understanding of linkages to dependent onshore communities. While there are opportunities to improve and enhance national and local data sets it is likely to remain the case that it will be necessary to carry out new data collection and fisher consultation when developing management measures (such as MPAs) or during the licencing process.

Local management measures, operating at a small geographic scale, were mostly found to be driven at the regional level. Vessel tracking technology (VMS, and iVMS), zoning, gear restrictions, permits, and compliance are common elements shared amongst many of the regional management strategies presented here. These are not new management tools but the use of inshore VMS units, which report at a much higher rate (some reporting every minute) compared with the EU versions, is a fast growing tool for fisheries managers at a local level. They have already been used to accurately map fishing grounds, manage closed areas and curfews, and provide evidence of activity for marine developments. At such a high reporting rate, there would be potential for using them, or the AIS system, as a tool in gear conflicts, although work would have to be done at an early stage to ensure all data protection was adhered to. Outcome 2 of The Scottish Inshore Fisheries Strategy 2015 (Marine Scotland, 2015) outlines Marine Scotland's intention to implement an appropriate form of vessel monitoring by 2020 that will be proportionate and good value. The document acknowledges that this goal would be challenging. To add to the challenge, any system which is rolled out at a national level would need to ensure that the reporting rate and data access rights appropriate for the variable inshore fleet types, local management, and regional marine spatial planning. For example, a reporting frequency of 10 minutes was found to be acceptable for iVMS units fitted to scallop dredgers (although one minute reporting is used in specific cases) but a more frequent reporting frequency would most probably have to be adopted by fishers using static gear in order to accurately identify the footprint of inshore fishing grounds. Consideration would also need to be given as to how the raw data is made available to local/regional managers who may require different scales of information at very short notice (e.g. in order to reply to marine planning applications, or assess whether a fisher was fishing outside of a curfew period, or fishing within a designated closed area).

Sourcing reliable data can be a daunting task for managers and developers and their data requirements will vary depending on the desired outcome, location, and required scale or resolution. This document has tried to summarise some of the key data sets most commonly used with fisheries management and marine developments. The National Marine Plan interactive website provides an excellent starting point, which has collated a vast amount of data into a mapped format. Some data sets are downloadable and others have their sources listed but all can be viewed through their web portal. Marine Recorder holds accessible species information and the EMODnet project assembles data on bathymetry, habitats, and biology, amongst others at a European scale.

The most important data set for marine managers, and most marine developers, is likely to be fishing vessel track information, or the associated gridded information, linked with landings and effort data. Where the technology is available (e.g. iVMS), it is possible, with the fishers' consent, to obtain very high quality and accurate information on fishing vessel's movements and activity. To effectively achieve this, accurate data would require effective stakeholder engagement resulting in fishers by-in and trust between the fishers and managers. When implementing a vessel tracking system to a fishery, fisheries managers should make every effort to explain to each fisher; <u>what</u> the data will be used for, <u>how</u> it will be used, and <u>who</u> will see the data. Different scales of fisheries data have been suggested in order to best reflect the different scales of development or interaction (Table 5.1), for example fisheries data gridded to 500 m would be of little use to an aquaculture development 200 m long. If fishers are in agreement, it is best practice for them to sign a data sharing agreement for their data to be used as outlined by the management in order to provide a quick and accurate response to any enquiry and to give fishers confidence in how their data will be used. A possible order of events may be:

- Managers explain exactly what the vessel data (tracks or gridded) will be used for and how it will be presented (anonymous, amalgamated, at least 3 years of combined annual data, at least 5 years of combined monthly data).
- Fishers who are happy with this should sign an agreement for their data to be used in each scale scenario (see examples in Table 5.1).
- If a scenario appears that is not covered, managers agree to contact fishers for their consent.
- If the developer requires more detail or if it is to be used for a purpose outside the scope of the agreement, managers agree to contact fishers for their consent.

Following these steps would allow quick responses to any requests for fisheries data and ensure that fishers are considered from an early stage of any development. All the information would be anonymous, amalgamated, and combined with at least three years of information, where it is available. The requirement for managers to contact fishers for additional data uses provides a feedback loop by which continued engagement on data sharing can be achieved and further builds trust with fishers. An additional benefit of this mechanism is that fishers have increased awareness of the scenarios in which the provision of their data can be useful, enabling a greater understanding of the value of their data. Fishers are generally reluctant to release their raw data on fishing movements for a number of reasons including: commercial sensitivity, lack of trust, and problems interpreting and understanding the context of the information by third parties. Fisher engagement will, therefore, always be required when trying to interpret raw fishing data.

When considering species and habitat data in the context of fisheries management, many challenges also exist. Species and habitat information is currently dominated by point records spanning many decades. There are inherent problems with using point data to introduce management measures leaving few options for any manager wishing to protect a feature such as a habitat. The manager could create a buffer around each 'dot on the map' but without any accurate information on the extent of the feature, such measures would be ineffective as they would overestimate the actual area covered or, if the buffer is too small, will not provide protection for the feature. Large buffers around points would disadvantage fishers who may have their activity restricted, or even excluded, from areas which the fishers know do not contain the feature. The knock on effects of this could also disadvantage managers with a potential for a lack of fisher buy-in, reduced stakeholder engagement, and loss of trust between fisher and manager; the effects of which could be long lasting while also failing to protect the feature. However, historical point data can be used as an indication of where a feature may be in order to guide further data collection and surveyed habitat maps. This approach has been successfully used at a local level by the SSMO in Shetland and nationally by SNH and Marine Scotland during the creation of nature conservation MPAs in Scotland. New data collection increased the robustness of the data sets and was in part why the MPA process in Scotland led to the successful designation of 30 nature conservation MPAs. Where possible, new data collection should not be limited to point data but include surveyed habitat mapping. Surveyed habitat maps provide definitive areas which outline the extent of the features of interest. Knowing the extent of the feature allows for appropriate protection measures to be put in place, while avoiding unnecessary restrictions and impacts on fishers and other users as well as providing a baseline for environmental monitoring over time.

Predictive habitat maps play an increasingly important role in species and habitat conservation and are more economical than carrying out a full survey. When analysed with up-to-date information, at high resolution, and at a scale appropriate to the area in question, these predictive maps can produce good quality representation of the features of interest. However, an element of risk assessment should be recognised in the use of predictive maps and it should also be noted that fishers can have a good idea themselves of where certain features are. For this reason, once a predictive habitat map has been created, it is useful to discuss the maps with local fishers who can provide an informed opinion on any potential errors based on their local knowledge. This approach was used successfully by SNH and Marine Scotland within the process of developing management measures for SACs. Identified errors could then be targeted for a full survey.

5.1 Recommendations

Four main recommendations for fisheries or marine managers are highlighted and include a better understanding of how scale can influence decisions, stakeholder engagement, establishing trust through open dialogue, and the consideration of temporal impacts of developments.

- Promote the development of successful working relationships between fishers and other marine interests early on in the process through effective stakeholder engagement.
- Establish trust between the fishers and fisheries or marine managers through open dialogue, transfer of copyright, and acknowledgement by the fisheries or marine manager on the commercial sensitivity of fishers' information.

- Ensure appropriate consideration of temporal impacts, including different phases of development, in order to minimise any impact on the fisher.
- Ensure effective consideration of the scale of development and how that links in with the scale and resolution of fisheries data, as highlighted in Table 5.1

Six different, but common, development (and conflict) scenarios have been listed with their corresponding scale in order to provide guidance on the appropriate scale of fisheries data (Table 5.1). Understanding the impact to fishers, managers, and developers of vessel fishing data displayed at different spatial and temporal resolutions would benefit from further study (see also Section 5.2) and would enhance and build on both the information shown in Table 5.1 and that included in the guidance documents (see Objective 3 of Section 1.1).

Table 5.1 Examples of marine development and interaction scenarios, their scale, and the suggested scale of the fisheries data.

Scenario example	Scenario scale (m)	Suggested scale of fisheries data
Gear conflict	10s	Vessel tracks
Pipeline	10s	50 m grid and tracks
Marine licensing	10s	50 m grid and tracks
Aquaculture site	100s	50 m grid
Protected area (e.g. MPAs)	1 000s	100 m grid and tracks by features
Offshore windfarm	10 000s	500 m grid

Four main recommendations for data use are highlighted including fisheries data, socio-economic data, availability of data in online databases, and the use of predictive habitat maps and what information should accompany them.

- Fisheries data (VMS, ScotMap, iVMS, and AIS where available) should include temporal (monthly) variation and at a more defined scale than what is currently available.
- Develop guidance on the process of collecting socio-economic data and ensuring its compatibility with the fisheries spatial data.
- Data collated in online databases (e.g. species data to NBN Gateway) should ensure that the original data owner is asked if they wish to sign over their copyright on submission of their records. This would provide a more open-access and publicly available data source which would enable the information to be more freely available to managers and developers.
- The term “habitat map” should be reserved for surveyed habitats only which do not include predictive data. “Predictive habitat maps” should always have an associated confidence map, a list of data sources used, and the technique used to create the map.

5.2 Recommendations for further work

The guidance documents produced alongside this report (see Objective 3 of Section 1.1) provide a succinct and practical guide to fishers and other marine users which can increase understanding and aid in the exchange of information. However there are further areas of work which would also help to provide wider context. An examination of the ownership of data and how this can affect its availability and usability in marine management would be extremely beneficial, this should include consideration of management processes and integration with policy at the National and local level. This would be particularly relevant for inshore fisheries with the EMFF funded Scottish Inshore Fisheries Integrated Data System (SIFIDS) project currently examining new methods of fisheries data collection, and the potential for new inshore fisheries legislation within the next few years. Added to this is the development of Marine Planning Partnerships. Investment in new data collection methods and technology should consider all of the potential uses for the data. Ensuring that the data collected can be used for as many purposes as possible, adds value to the information and reduces the data collection burden on industry.

Another area which would benefit greatly from further work is socio-economic linkages. Assessing the socio-economic impacts of developments on fishing activity can be difficult to achieve and an examination of the linkages between spatial fisheries data and economic and social data sets is a logical area for future work. For example, the currently anonymised nature of VMS data can make linking fishing grounds to dependent onshore communities difficult. These linkages are important for fishing dependent regions, communities, and at the household level. Further work into the mechanisms to enhance data capture and assessment in this area, including developing recommendations for a standardised approach, would help ensure future quality assurance of such studies.

The implications of changing policy, from the UK leaving the EU, could be looked at in more detail with regards to changing spatial scales of fishers' activity.

6 Acknowledgements

Thanks go to the project team for looking over this work and providing valuable feedback. This work was funded by Fisheries Innovation Scotland, project FIS014.

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8 Appendix

Table 8.1 Available data, their resolution, and comments on the data set used in this report and available for download.

Data-set	Available data	Resolution	Resolution/scale details	Comments
B1	EUNIS habitat map from survey (EMODnet)	N/A	Defined	Has some survey data that is out of date and which has been withdrawn. Includes a confidence table to cross check.
B2	Protected features (NMPi)	N/A	N/A	Lots of species info but can't download the data
B3	Species data (JNCC Marine Recorder)	N/A	Point data	Requires quality controlling
B4	Species data (NBN Gateway)	N/A	Point data	Permission required from data providers Requires quality controlling
E1	Protected Areas (JNCC)	N/A	Defined areas	Access via the "interactive MPA map"
E2	Protected Areas (SNH Natural Spaces)	N/A	Defined areas	
F1	AIS	High	3 minute ping rate (can be lower)	Vessels can switch off their AIS (although units can be set with this functionality disabled), Vessels ≥15m are required, Some smaller vessels have AIS, Need an AIS decoder/database
F2	AIS tracks (MMO)	Medium	Defined lines	Vessels can switch off their AIS, No speed values, Data incomplete, Not all fishing vessels
F3	AIS Vessel Density Grid (MMO)	Medium	2 km	Can't define vessel type
F4	Areas restricting fisheries (NMPi)	N/A	Defined areas of restriction by gear type and species	
F5	Fishing statistics (NMPi)	Low	ICES statistical square	
F6	inshore VMS	High	10 minute ping rate (can be lower)	Permission required by vessel owner, Regional variation

Data-set	Available data	Resolution	Resolution/scale details	Comments
F7	ScotMap (Marine Scotland)	Medium	2 km	No data for Shetland Processed to four categories
F8	VMS (ICES)	Medium-Low	3x5.5 km	
F9	VMS (NMPi)	Low	2 hour pings	Permission required by vessel owner, Vessels ≥15m
F10	VMS Fishing activity (MMO)	Medium-Low	3 km	UK vessels ≥15m
Ph1	Bathymetry (EMODnet)	Medium-High	~380 m	Would need processing for smaller areas
Ph2	Bathymetry (GEBCO)	Low	~670 m	Would need processing for smaller areas
Ph3	Bathymetry (UKHO INSPIRE)	High		Open Government Licence
Ph4	Broad-scale sediment map (EUSeaMap, EMODnet)	Medium	300 m	Can also download a confidence map.
Ph5	Ocean currents (CMEM)	Medium	0.11 degrees (~ 7x7.5 km)	
Ph6	Sediment types (BGS)	Medium	1:250 000 scale	Offshore data set, Image from NMPi, Processed from BGS at a cost
Ph7	Tide (ABPmer)	High	1.5×2 km	
Ph8	Wave (ABPmer)	Medium	9×12.5 km	
Ph9	Wind (ABPmer)	Medium	9×12.5 km	
Ph10	Wind (CMEM)	Low	25 km	
Md1	Aquaculture (NMPi)	N/A	Defined	
Md2	Electric and telecom cables (Kingfisher)	N/A	Defined	
Md3	Oil and Gas pipes and cables (CDA)	N/A	Defined	
Md4	Oil and Gas wells, licences, fields (OGA)	N/A	Defined	
Md5	Windfarms (Kingfisher)	N/A	Defined	

Table 8.2 Data set sources as accessed during November 2016. Data sets with no links do not have direct access to data or data access may vary between regions/areas.

Data set	Link
B1	www.emodnet-seabedhabitats.eu/default.aspx?page=1953
B2	https://marinescotland.atkinsgeospatial.com/nmpi/
B3	http://jncc.defra.gov.uk/page-1599
B4	https://data.nbn.org.uk/
E1	http://jncc.defra.gov.uk/default.aspx?page=4549
E2	https://gateway.snh.gov.uk/natural-spaces/index.jsp
F1	
F2	https://data.gov.uk/data/search?q=AIS
F3	https://data.gov.uk/data/search?q=AIS
F4	https://marinescotland.atkinsgeospatial.com/nmpi/
F5	https://marinescotland.atkinsgeospatial.com/nmpi/
F6	
F7	http://www.gov.scot/Topics/marine/science/MSInteractive/Themes/ScotMap
F8	http://ices.dk/Searchcenter/Pages/default.aspx?k=VMS#Default=%7B%22k%22%3A%22VMS%22%2C%22r%22%3A%5B%7B%22n%22%3A%22FileType%22%2C%22t%22%3A%5B%22equals(%5C%22zip%5C%22)%22%5D%2C%22o%22%3A%22or%22%2C%22k%22%3Afalse%2C%22m%22%3Anull%7D%5D%7D
F9	https://marinescotland.atkinsgeospatial.com/nmpi/
F10	https://data.gov.uk/dataset/fishing-activity-for-uk-vessels-15m-and-over-2014
Ph1	www.emodnet-bathymetry.eu/
Ph2	www.gebco.net/data_and_products/gridded_bathymetry_data/
Ph3	http://aws2.caris.com/ukho/mapViewer/map.action
Ph4	www.emodnet-seabedhabitats.eu/default.aspx?page=1953
Ph5	http://marine.copernicus.eu/
Ph6	www.bgs.ac.uk/products/offshore/DigSBS250.html
Ph7	www.renewables-atlas.info/
Ph8	www.renewables-atlas.info/
Ph9	www.renewables-atlas.info/
Ph10	http://marine.copernicus.eu/
Md1	https://marinescotland.atkinsgeospatial.com/nmpi/
Md2	www.fishsafe.eu/en/downloads/fishing-plotter-files.aspx
Md3	www.ukoilandgasdata.com/dp/controller/PLEASE_LOGIN_PAGE
Md4	http://data.ogauthority.opendata.arcgis.com/
Md5	www.fishsafe.eu/en/downloads/fishing-plotter-files.aspx

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