NAFC Marine Centre
University of the Highlands and Islands

Mapping fisheries and habitats in the North and East Coast RIFG area

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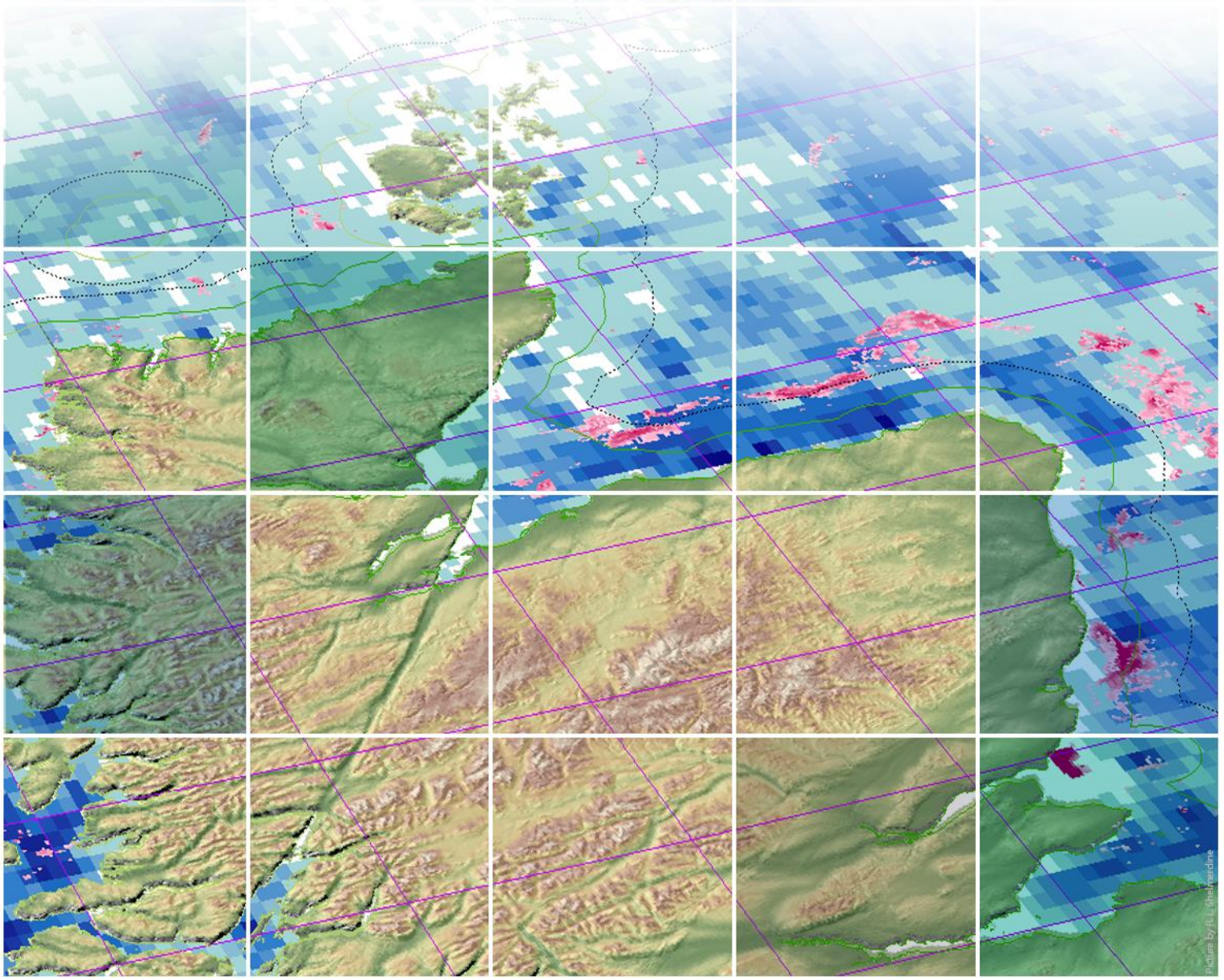

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1 Introduction

Five Regional Inshore Fisheries Groups (RIFGs) have been established around Scotland. The RIFGs are non-statutory bodies with the aim of improving inshore fisheries management around Scotland and providing the commercial fishers with a strong voice in wider marine management developments. The North and East Coast RIFG (N&EC RIFG) extends along the east and northern coastline of the Scottish mainland. To enable the N&EC RIFG to continue to implement their management plan, it is important to better understand the fishing activity and critical habitats of key species within 12 nautical miles (nm) of the coast. A total of 22 key species were identified and included: blue mussel, brown crab, brown shrimp, clams, cockle, cod, dab, haddock, herring, lemon sole, lobster, mackerel, native oyster, Norway lobster (*Nephrops*), pink shrimp, plaice, razor fish, scallop, sprat, squid, velvet crab, and whelk.

In Scotland, landings information is reported through three main sources (FISH1 Form, paper EU logsheets, and the E-log), depending on the vessel size. The logsheet information also includes fishing location through ICES statistical rectangles and a latitude-longitude start position. All fishing vessels 12 m or more in length are fitted with an EU Vessel Monitoring System (VMS) unit that reports the vessel's position every two hours. This information can be used to map demersal fishing activity (see Shelmerdine*, et al.*, 2017) but it does not include the smaller vessels which predominantly make up the inshore fleet. The ScotMap project aimed to address this lack of data and provides a snap-shot of fishing activity from smaller vessels (Kafas*, et al.*, 2014; Kafas*, et al.*, 2017). Smaller fishing vessels are voluntarily installing Automatic Identification System (AIS) that can be used to map fishing activity (for some examples see Shelmerdine, 2015; Le Guyader*, et al.*, 2017; James*, et al.*, 2018). The Outer Hebrides RIFG trialled an Anchor Lab fisheries monitoring system on static and dredged gear. The system reported when gear was deployed and produced accurate information on fished areas. A report by Shelmerdine*, et al.* (2017), and the associated guidance documents (Batts*, et al.*, 2017a, b), highlight the advantages of available and mapped fishing areas for fisheries managers, developers, and fishers.

1.1 Aims

The aim of this work was to gather together all the available information on fishing activity (location, landings, and value) and important habitat information for key species listed in the Invitation to Tender document to create a series of maps for the N&EC RIFG to integrate into their management plan.

2 Materials and Methods

This Section summarises what data and information was used within the work but a more detailed description of the methodology can be found in Appendix D, "Scientific analysis", on page 61.

Fishing activity was available in three formats:

- vessel tracking such as VMS and AIS
- surveyed information from the ScotMap project[1], the Creel Fishing Effort Study[2], and the Scottish Marine Recreation and Tourism Survey 2015[3]
- fishers logsheet returns (for example, information submitted through the FISH1 Form)

Fishing grounds were mapped from multiple sources including:

- European Union (EU) Vessel Monitoring System (VMS) data for 2009 to 2016 from ICES
- Automatic Identification System (AIS) vessel tracks for 2011 to 2015 from the Marine Management Organisation (MMO)
- AIS vessel positions from a European Fisheries Fund (EFF) funded Marine Scotland project (James*, et al.*, 2015)
- Global AIS fishing activity for 2016 from Global Fishing Watch
- ScotMap information for inshore fisheries
- Creel Fishing Effort survey
- Scottish Marine Recreation and Tourism Survey 2015

Fishing grounds were first mapped using AIS data of fishing vessel movements from the MMO AIS vessel tracks and the EFF AIS data that had been transformed from fishing locations to fishing tracks. Each identified ground was assessed for confidence and categorised as low, medium, or high, based on the overall density of vessel activity and the likelihood of that activity being fishing. The AIS grounds were then compared to VMS, Global AIS, and the three survey data sets from ScotMap, Creel Fishing Effort Study, and the Marine Recreation and Tourism Survey. Where there was a good match between these data and the fishing grounds, the overall confidence was increased from either low to medium or from medium to high (an initial confidence of high, remained at high). Although this method can be very accurate in defining fishing grounds, it does not cover 100% of all fishing activity. Fishing grounds can be hidden in areas of high vessel movement (such as steaming, as seen around ports and harbours or along traffic routes around headlands for example) or where fishing activity occurs in relatively straight lines and in the same direction as vessel traffic. In these cases, it is very hard to distinguish between vessel movement and fishing activity without information on the vessel's speed, which was not available with the MMO AIS data sets. To compensate for this, the identified fishing grounds were combined with the other fishing

[1] ScotMap: https://data.marine.gov.scot/dataset/scotmap-inshore-fisheries-mapping-scotland-recording-fishermen%e2%80%99s-use-sea
[2] Creel Fishing Effort: http://www.spatialdata.gov.scot/geonetwork/srv/eng/catalog.search?node=srv#/metadata/Marine_Scotland_FishDAC_1988
[3] Scottish Marine Recreation and Tourism Survey: https://data.marine.gov.scot/dataset/scottish-marine-recreation-and-tourism-survey-2015

information (e.g. VMS, ScotMap, Creel Fishing Effort Study, and the Recreation and Tourism Survey) to produce a series of maps showing the distribution of gear types and species.

Catch information from fishers' logsheet entries was gathered from Scottish Sea Fisheries Statistics which is based on ICES statistical rectangles and provides information on landings and value for all Scottish vessels as well as effort information for all vessels over 10 m in length[4]. A request for location information (latitude/longitude coordinates) entered on FISH1 Forms was submitted to Marine Scotland but, due to quality control issues, the coordinate information was not available for release and so could not be used, leaving the ICES statistical rectangles as the only locational information.

Critical habitat information for the species listed included spawning grounds, nursery grounds, and predicted sensitive areas. These were all available through Marine Scotland's National Marine Plan data portal (NMPi) and covered the following species: cod, haddock, herring, lemon sole, mackerel, Norway lobster, plaice, and sprat.

Species habitat preferences were outlined for all other listed species that had no critical habitat information. Information for habitat preferences were sourced from scientific publications, reports, and other literature sources. A national database (JNCC's Marine Recorder database) holds location information for species around the coast that have been found during recent and historic surveys. Species records were exported from the database and their locations were mapped.

3 Outputs

3.1 Fishing activity and their location

The North & East Coast RIFG covers a large area from Cape Wrath in the northwest, along the northern coast of the Scottish mainland, and down the eastern coast to the Scottish-English border. Fishing activity within the area was found to be extensive (see Figure 1 and Figure 2) using multiple gear types. Fishing grounds were identified from existing AIS information (see Figure 2 and Figure 3) but they are not gear or species specific with many grounds associated with multiple species and/or multiple gear types. Landings information was only available for each ICES statistical rectangle and without correct start coordinates from the FISH1 Forms, it was not possible to link the landings and effort data with identified fishing grounds.

[4] For all data see www2.gov.scot/Topics/Statistics/Browse/Agriculture-Fisheries/RectangleData

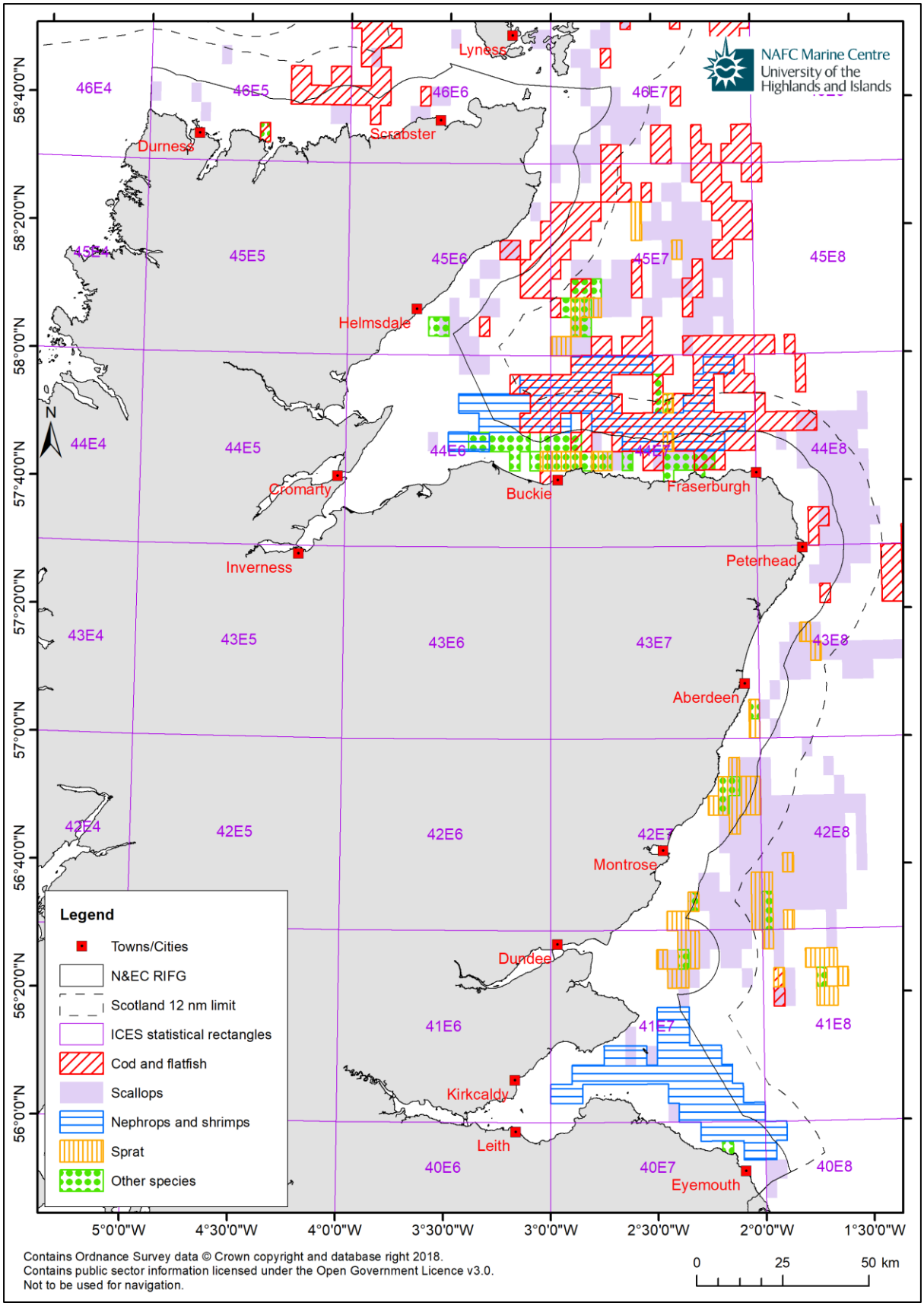

Figure 1 Summary of the main fishing areas by species based on available VMS information (sourced from ICES, 2017).

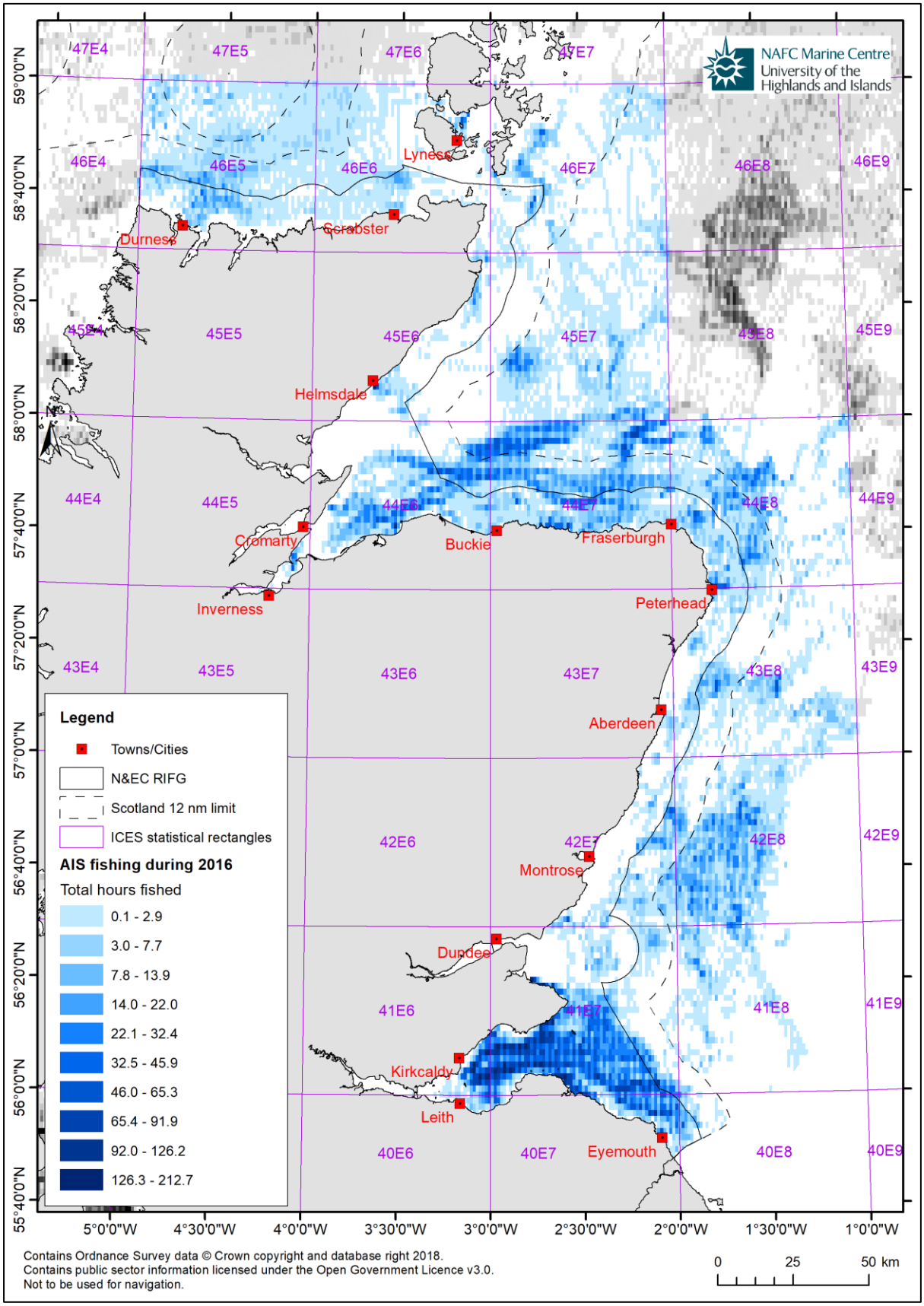

Figure 2 Fishing activity for 2016 based on information available from Global Fishing Watch.

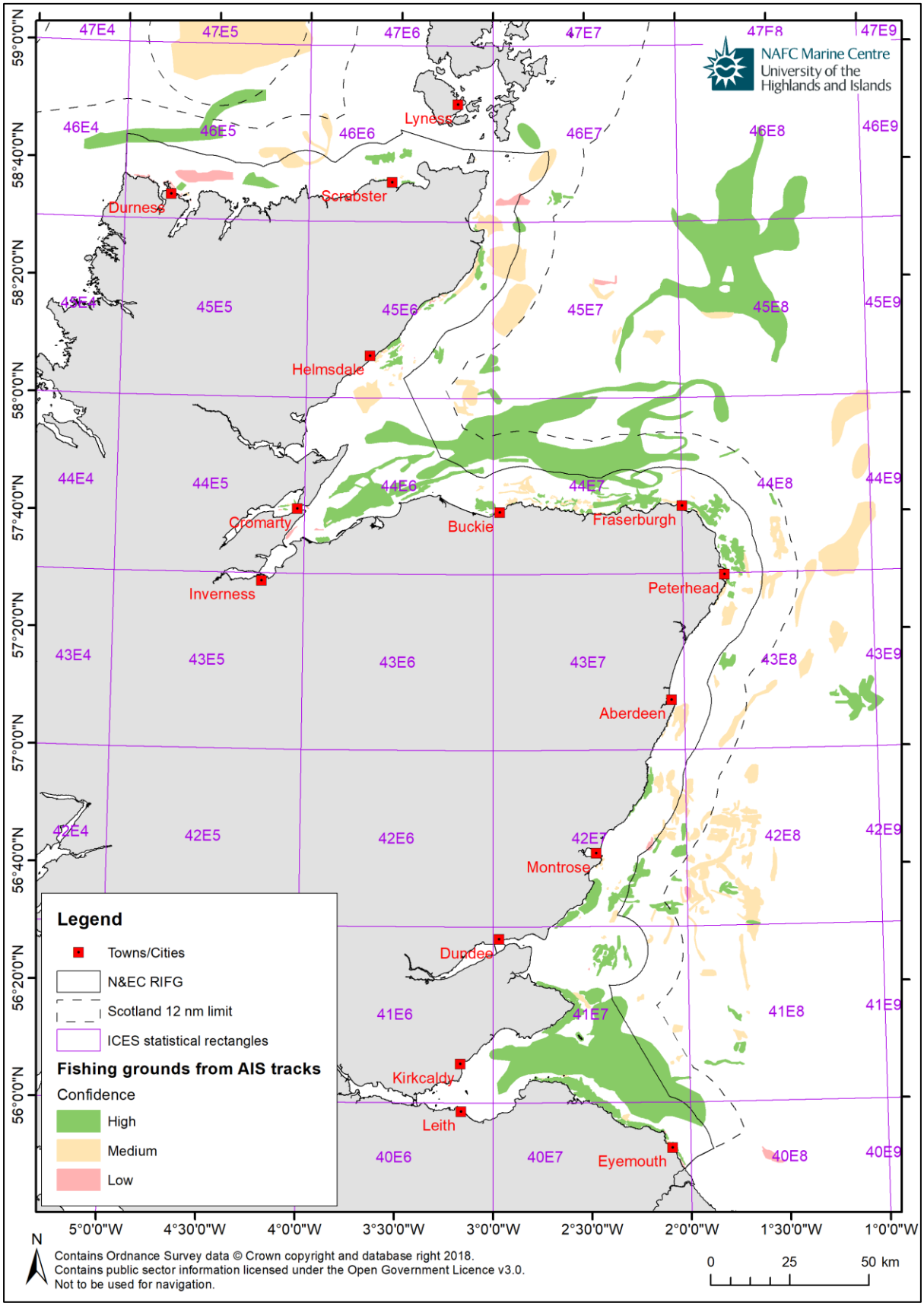

Figure 3 Fishing grounds derived from AIS tracks available from the MMO and an EFF funded project.

Fishing grounds derived from AIS tracks can give an accurate indication of where fishing activity occurs (see Figure 3). However, they are not complete as not all vessels have an AIS unit fitted and the available data is limited to either a selection of vessels (e.g. the EFF AIS data) or a selected time period (e.g. AIS from the MMO only covers the first week of each month). To try and provide a more complete map of fishing grounds and species, all the different available data sets were combined. The following combined fishing activity maps (see Figure 4 to Figure 8 for fishing grounds and Figure 9 to Figure 11 for species groups) give an indication of where fishing activity occurs but it is important to understand that they have been created using existing information, which is not always complete. The ICES VMS data is only related to fishing gear that contacts the seabed so there is no available information to create species activity maps for pelagic species such as mackerel and herring. Combining different sources of fishing activity in this way does not take into account habitat suitability of the species being fished or the intricate nature of fishing activity. This can result in some areas highlighted as having a high likelihood/occurrence of fishing activity when in reality there is no fishing activity for that specific species in that area. In order to have a complete and comprehensive set of maps showing fishing activity, it will be necessary to interview local fishers and carry out a comprehensive mapping exercise of their specific fishing activity, which is outside the scope of this work.

3.1.1 Combined gear and species maps

Data used for the combined creel fishing map (Figure 4) included AIS fishing tracks, Creel Fishing Effort Study data, and ScotMap data for both crab and lobster creels and also Norway lobster creels. Fishing activity using creels is shown to occur throughout the area. The majority of fishing activity (darker areas) occurred close to shore and are likely to be areas fished for velvet crabs and lobsters with possibly some brown crabs. Brown crab fishing also occurs further offshore. The combined map for crabs and lobsters (Figure 9) shows a similar pattern with the creel fishing map. This is because there is only a small area reported to be used for Norway lobster creels (reported in the ScotMap project) which extends from Cromarty north to Helmsdale.

AIS fishing tracks, VMS data (Figure 12, page 34), and ScotMap data were used to create the combined fishing map for scallop dredging (Figure 5). This map shows the likely locations of dredging and the likely locations of scallops. Scallop dredging had a distribution throughout the area, off Montrose, Aberdeen, Peterhead, the Moray Firth up to Orkney, and the northern coast. A high likelihood/occurrence of scallop dredging in the Moray Firth was identified which overlaps with a known area of mud containing *Nephrops* burrows (see Figure 24). It is possible that this may be an artefact of the data with the mapped AIS fishing ground (Figure 3) found to correspond with a large area highlighted as scallop grounds in the ScotMap data. Interviewing fishers would allow a better understanding of whether this area is a genuine artefact or part of a mixed-species fishing ground.

AIS vessel tracks and VMS data for Danish and Scottish seine nets (Figure 15, page 37 and Figure 16, page 38) were used to create the combined fishing map for seine nets (Figure 6). Fishing grounds were mostly distributed north of Peterhead with the higher likelihood of activity (darker shading) occurring outside the 12 nm limit. Possible fishing grounds occur north of Strathy Beach on the north coast and to the southeast of Wick. As with the map of scallop dredging, a higher likelihood/occurrence of seine nets was identified in the Moray Firth. The

identified fishing ground, derived from AIS vessel tracks, was linked with seine nets through VMS information but the fishing ground overlaps with a known area of mud containing *Nephrops* burrows (see Figure 24). Seine netting has a characteristic pattern when examining AIS information but this pattern can be easily masked by high levels of trawling activity, such as those observed within the identified fishing area. If seine netting occurred in, or near, this fishing ground, as is suggested with the VMS data, the extent of the fishing area would be overestimated and potentially include unsuitable habitat. Interviewing fishers would allow a better understanding of whether this area is a genuine artefact or part of a mixed-species fishing ground.

Trawling grounds were created by combining AIS vessel tracks, VMS data for otter trawls (targeting cod or plaice Figure 14, page 36; sprat or sandeel Figure 17, page 39; Norway lobster or shrimps Figure 13, page 35; and 'other' species Figure 18, page 40), and ScotMap data for Norway lobster and non-Norway lobster trawling. Trawling was found to occur throughout the region with two higher concentrations from Eyemouth to Firth of Forth and Fraserburgh to Moray Firth (Figure 7). Trawling grounds could be broken down into two species groups: Norway lobster (Figure 10) and demersal species (cod, haddock, plaice, and flatfish; Figure 11). Norway lobsters had two large and distinct areas from Eyemouth to the Firth of Forth and from Fraserburgh to the Moray Firth. Although fishing for cod, haddock, plaice, and flatfish was found to likely occur throughout the region, there was a higher likelihood of occurrence (darker shade) north of Fraserburgh.

Information for hand line fishing grounds were taken from ScotMap data (line mackerel) and the Marine Recreation and Tourism Survey (sea angling from boats and shore). This was combined with AIS vessel track data to create the combined hand line map (Figure 8). Hand line activity was found to occur throughout the region.

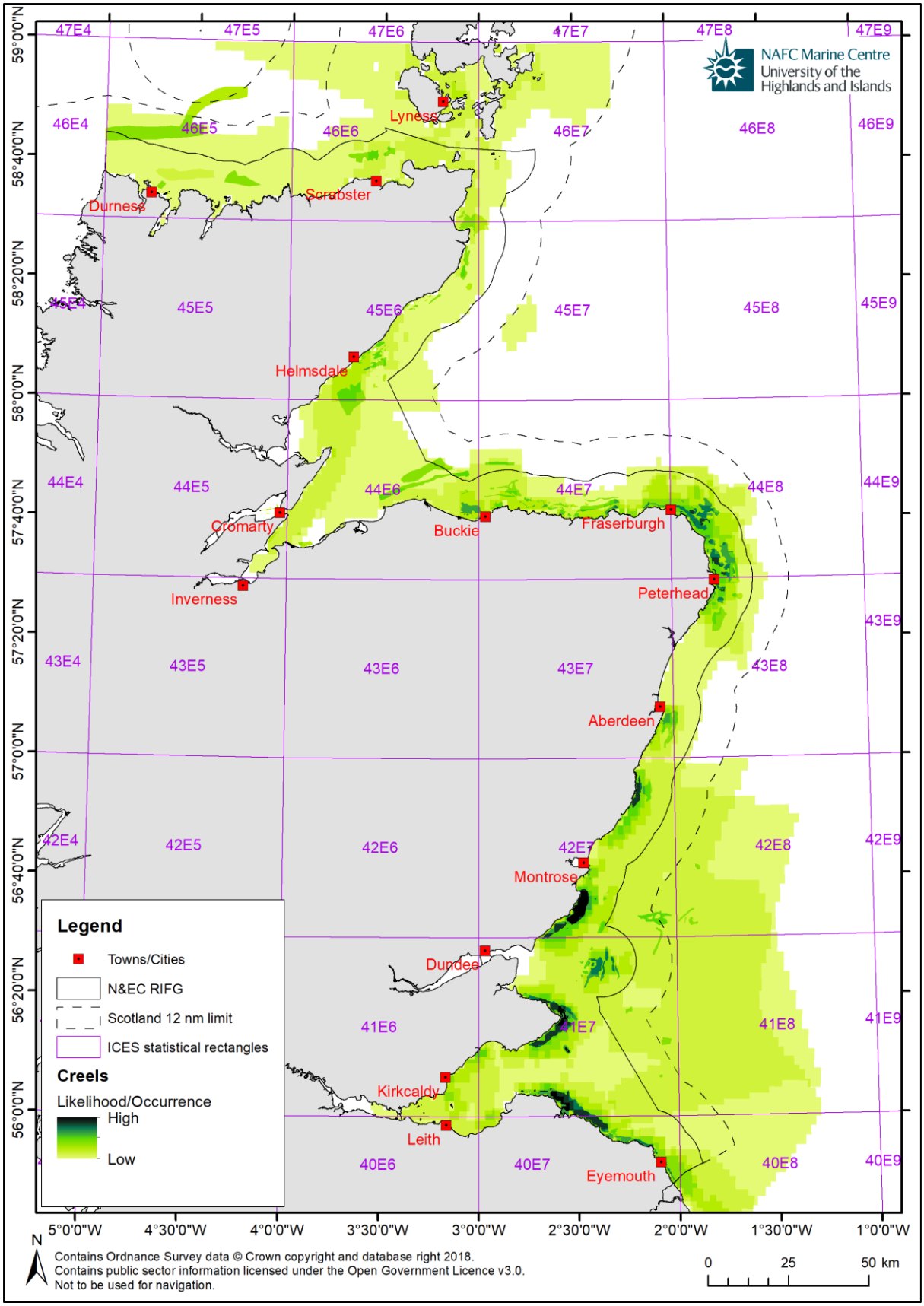

Figure 4 Combined fishing activity for creels with darker shades of green corresponding with fishing areas of higher likelihood and/or higher occurrence.

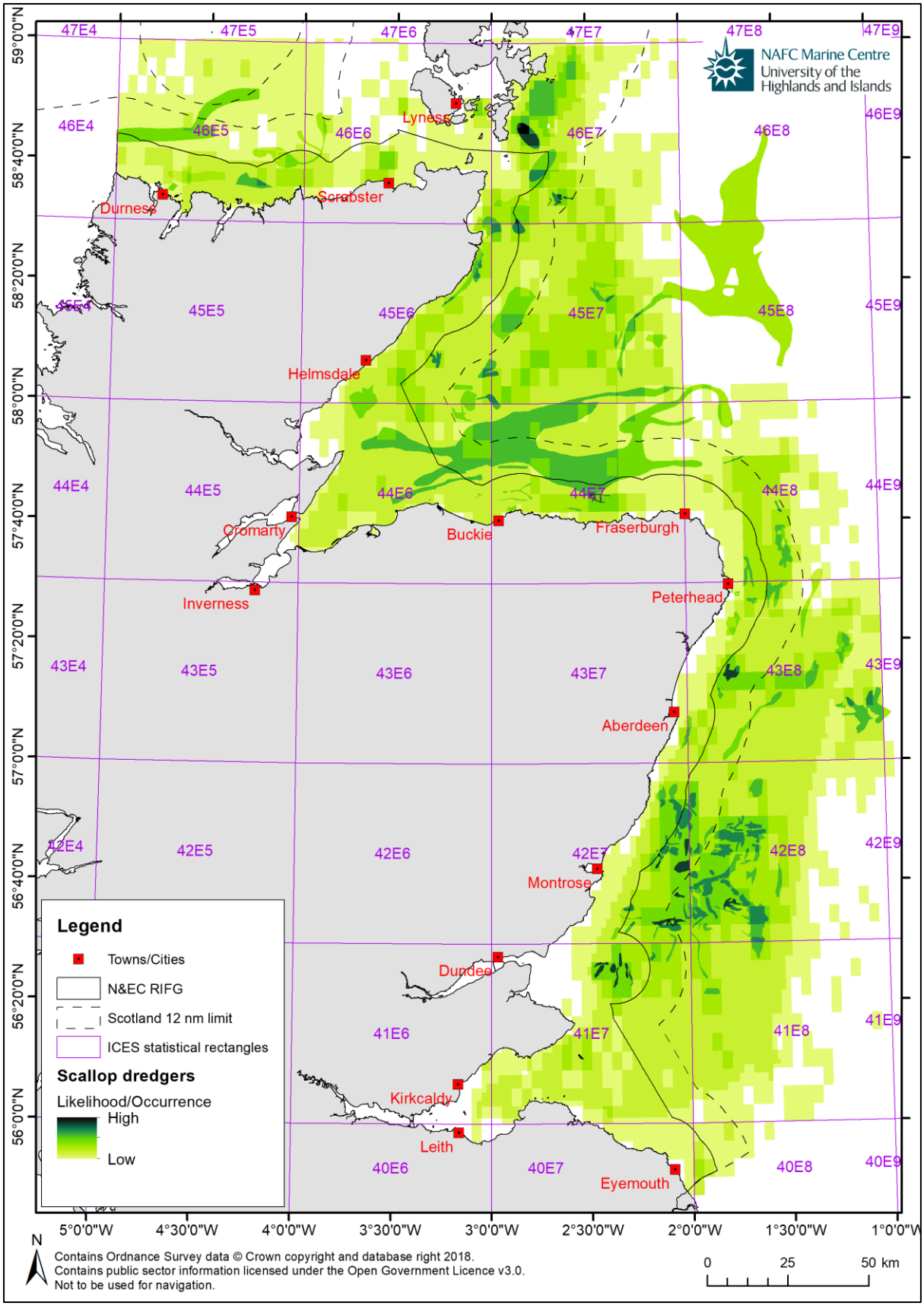

Figure 5 Combined fishing activity (and species) for scallop dredgers with darker shades of green corresponding with fishing areas of higher likelihood and/or higher occurrence.

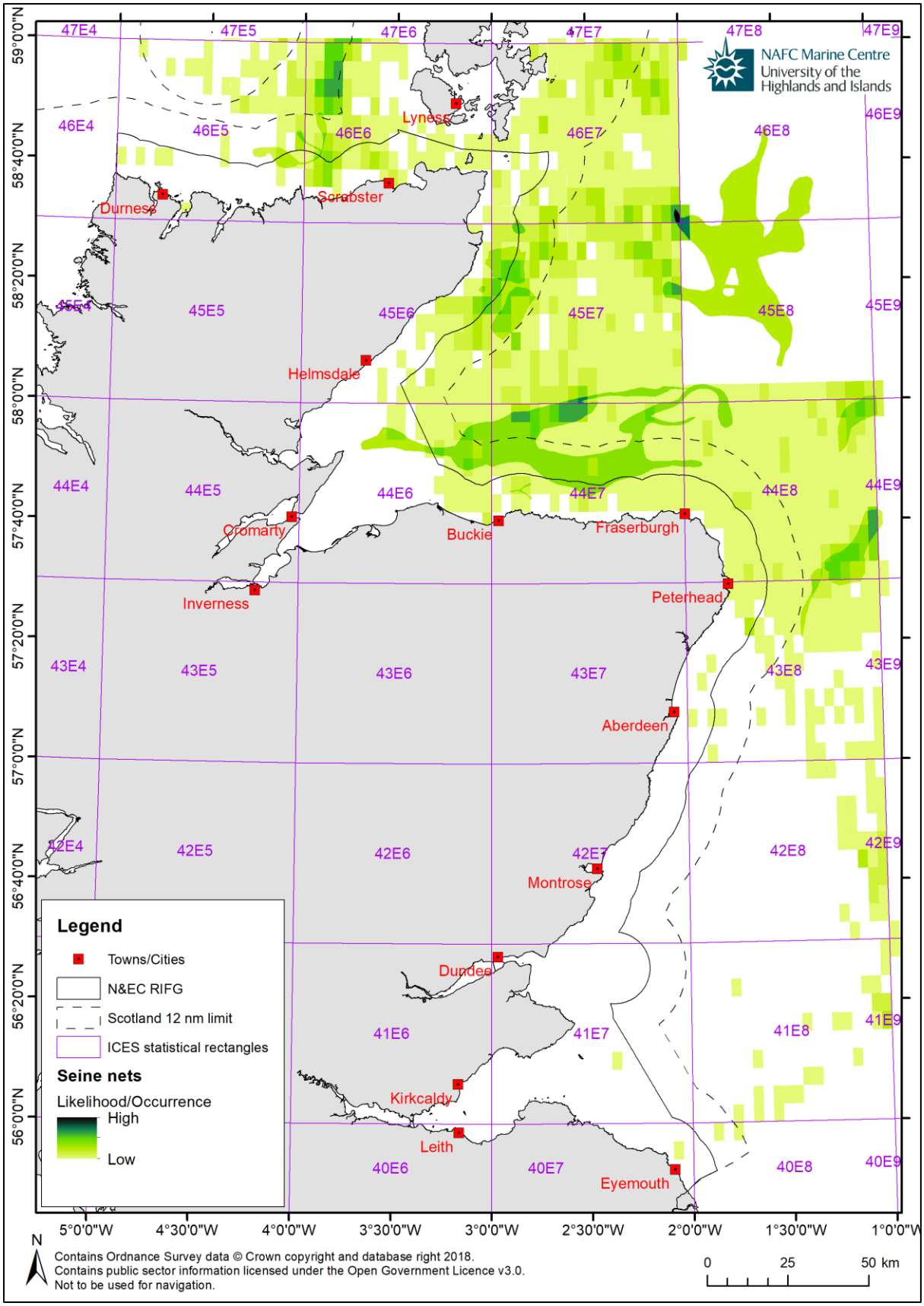

Figure 6 Combined fishing activity for seine nets with darker shades of green corresponding with fishing areas of higher likelihood and/or higher occurrence.

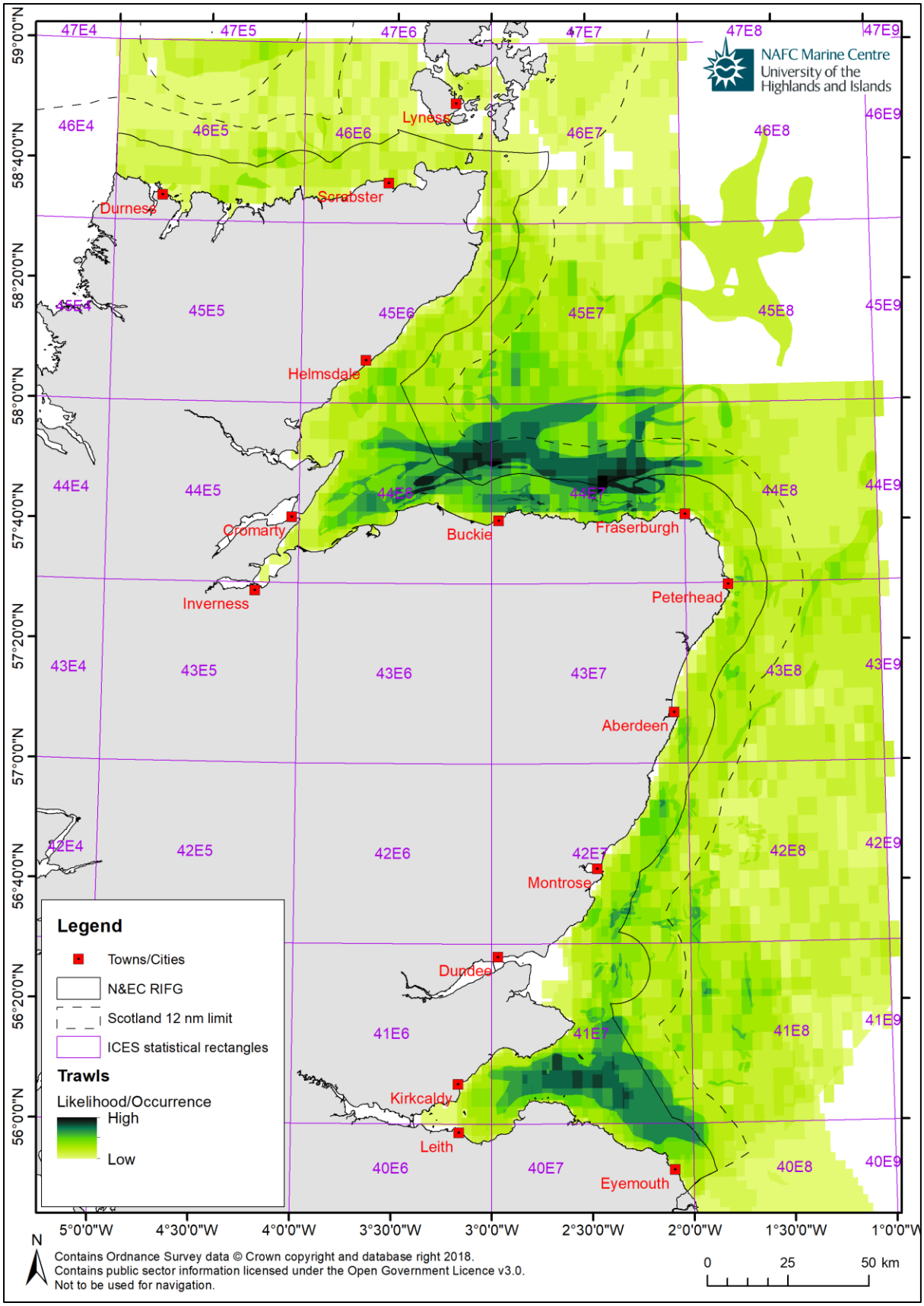

Figure 7 Combined fishing activity for trawls with darker shades of green corresponding with fishing areas of higher likelihood and/or higher occurrence.

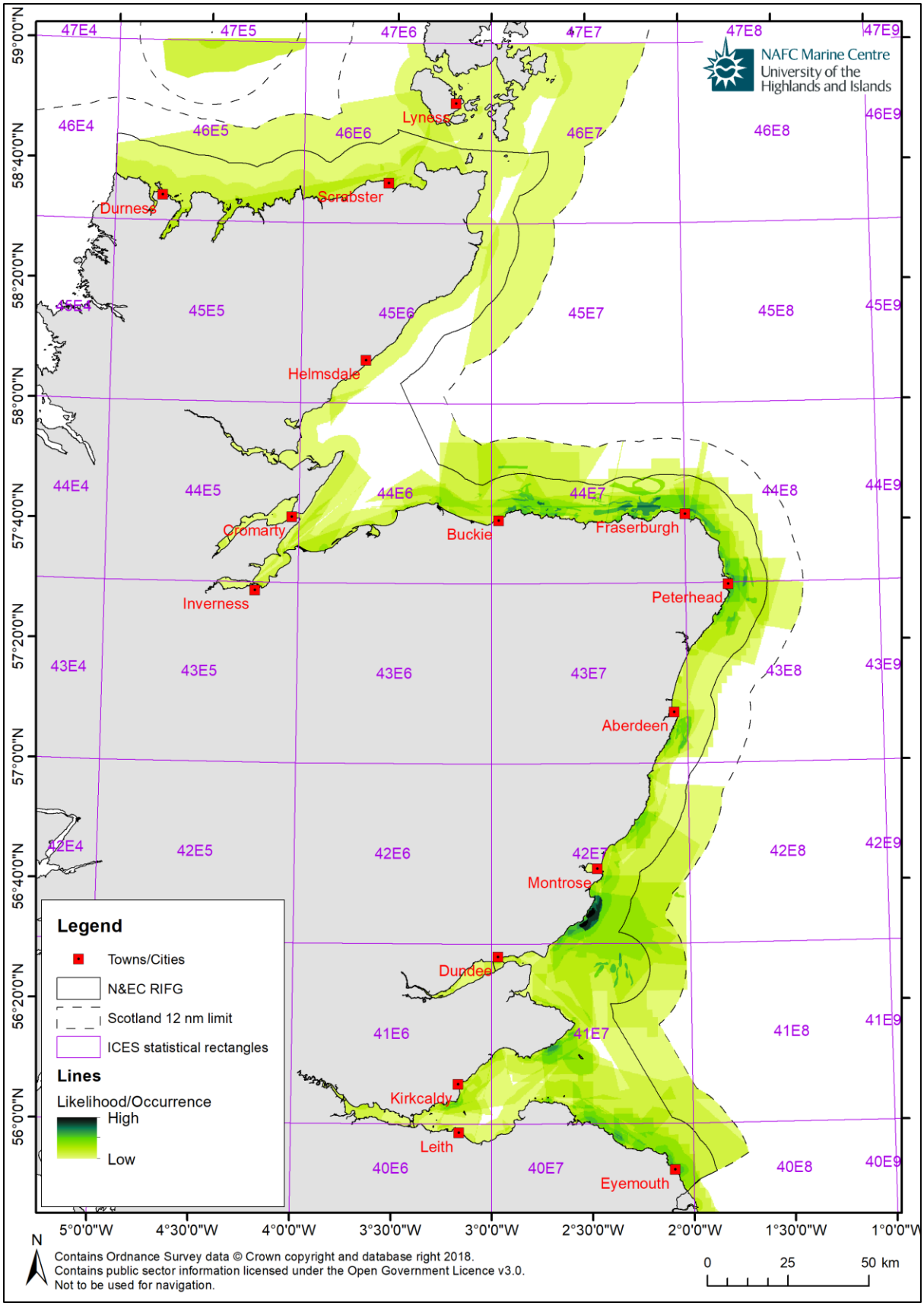

Figure 8 Combined fishing activity for hand lines with darker shades of green corresponding with fishing areas of higher likelihood and/or higher occurrence.

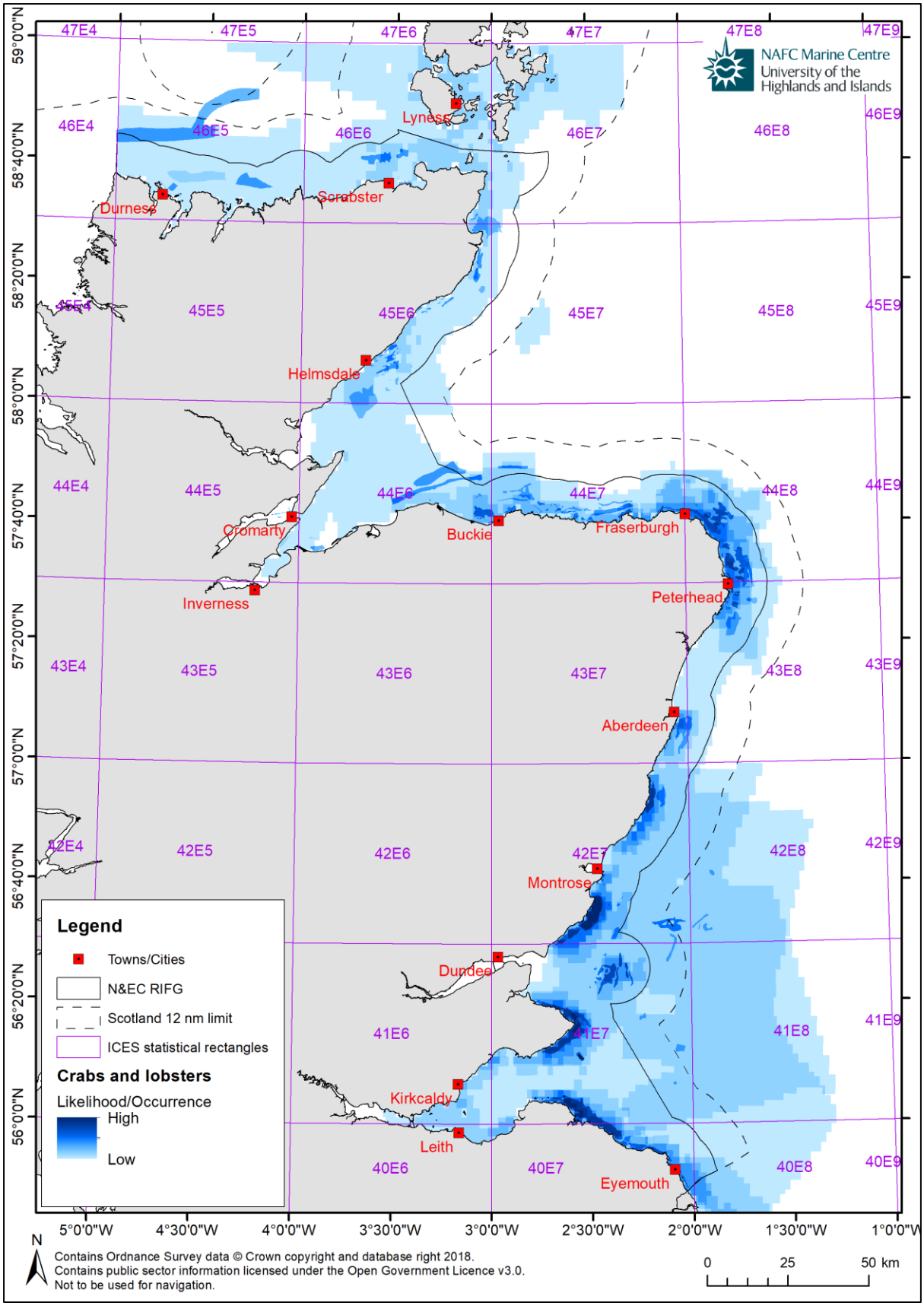

Figure 9 Combined species groups, based on reported fishing activity, for crabs and lobsters with darker shades of blue corresponding with fishing areas of higher likelihood and/or higher occurrence.

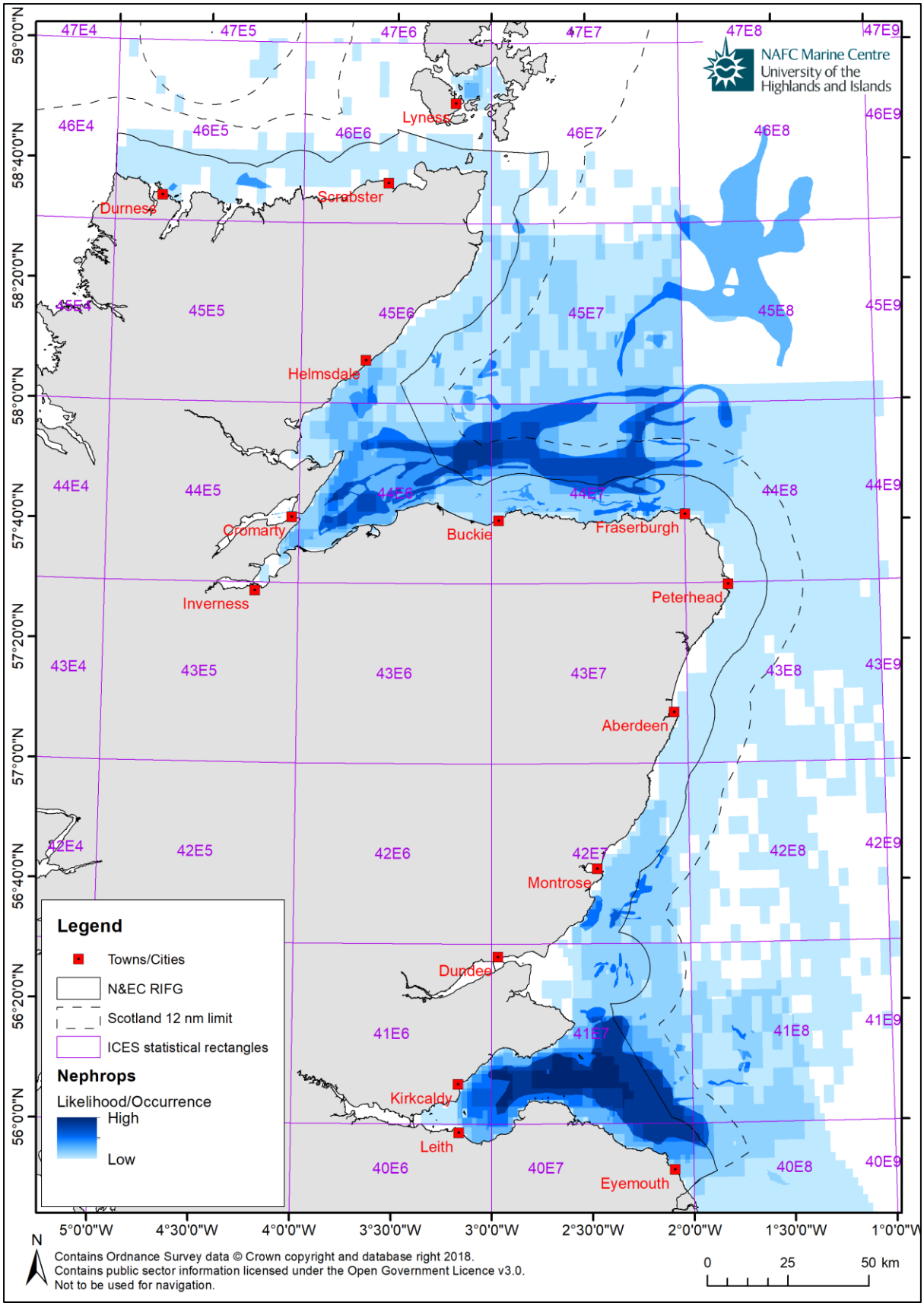

Figure 10 Combined species groups, based on reported fishing activity, for Norway lobster with darker shades of blue corresponding with fishing areas of higher likelihood and/or higher occurrence.

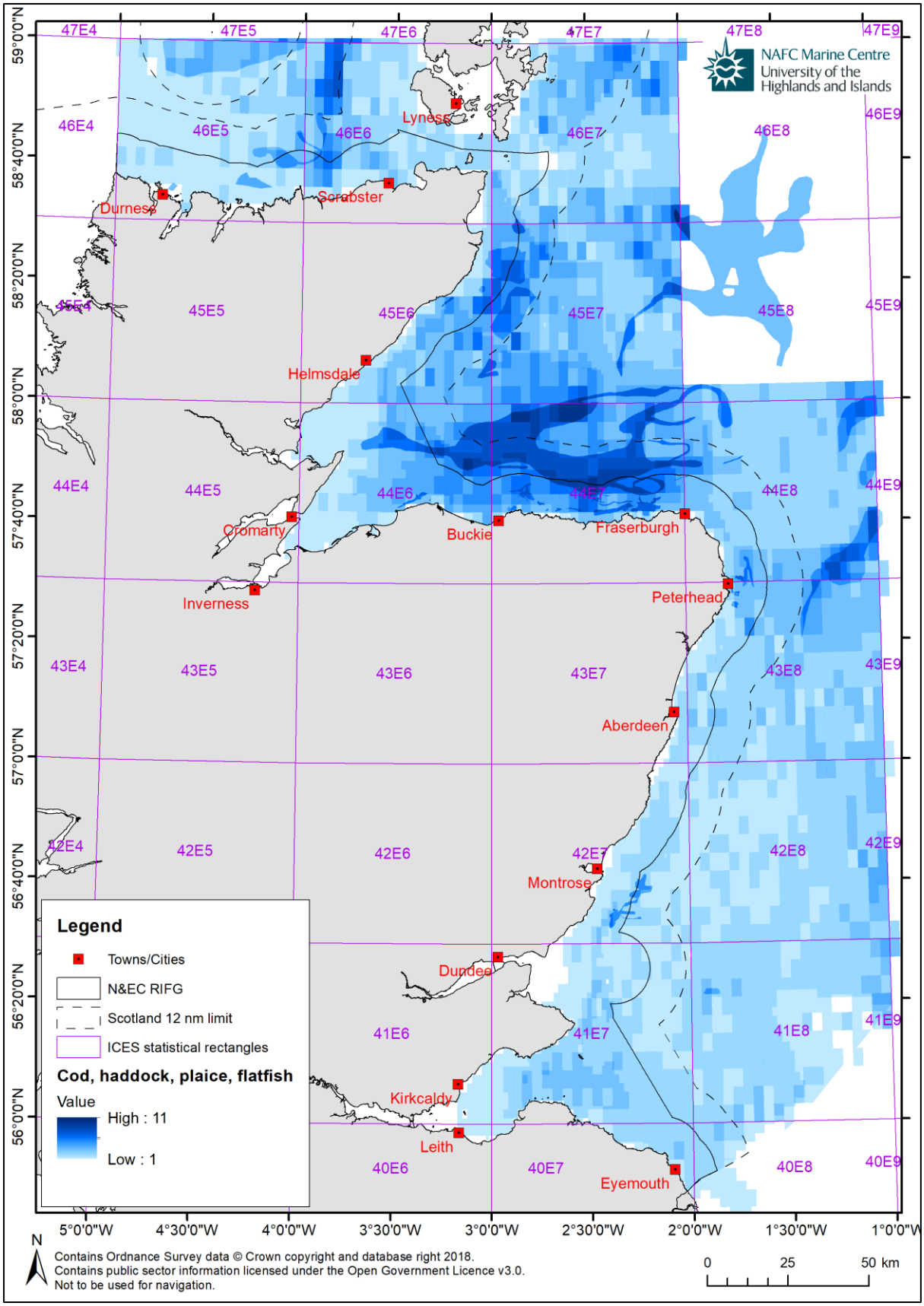

Figure 11 Combined species groups, based on reported fishing activity, for cod, haddock, plaice, and flatfish with darker shades of blue corresponding with fishing areas of higher likelihood and/or higher occurrence.

3.2 Landings and value

It was not possible to link landings and value information to fishing activity with existing data sets and available information. This Section summarises landings and value information for the N&EC RIFG (Table 1) and through a series of tables that have separated the species data based on sub-areas of the N&EC RIFG region (Table 2 to Table 6). Of the 21 listed species, only those with recorded landings/value information for each ICES rectangle were listed in the sub-area tables.

For all ICES statistical rectangles within the N&EC RIFG, herring had the highest average yearly landings of 452 tonnes (Table 1) followed by scallops (258 tonnes) and brown crab (215 tonnes). Norway lobster had the highest average yearly value of £611 000 (Table 1) followed by scallops (£559 000) and lobsters (£519 000). The highest landings (and value) of each listed species within each sub-area were recorded from nine ICES rectangles (Table 2 to Table 6). The North coast sub-area had the highest landings for herring, mackerel, and squid (from 46E5); and brown crabs, cockle, cod, and velvet crabs (from 46E6, Table 2). This was the only area where cockle were landed. The Moray Firth sub-area had the highest landings for blue mussel and whelk (from 44E5); oyster and sprat (from 44E6); dab and plaice (from 44E7); and haddock and lemon sole (from 44E8, Table 4). Oyster and sprat were not landed in any other areas. Peterhead to Dundee sub-area had the highest landings of crabs (mix) and pink shrimp (from 42E7); and scallops from 42E8 (Table 5). The remaining species all had highest landings from 41E7 in the South of Dundee sub-area and included brown shrimp (not landed in any other areas), clam, lobster, *Nephrops*, and razor fish (Table 6).

Table 1 Yearly mean landings (tonnes) and their value for each listed species from all ICES rectangles within the N&EC RIFG area and out to 12 nm from 2013 to 2017. Maximum weights and values are shown in brackets. All values are rounded up.

Species	Mean landings (tonnes)	Mean value (£)
Blue mussels	27 (max = 98)	£11 608 (max = £41 026)
Brown crab	215 (max = 773)	£302 923 (max = £1 309 728)
Brown Shrimps	0.4	£0
Clams	14 (max = 50)	£26 422 (max = £83 697)
Cockles	0.04	£47
Cod	18 (max = 297)	£3 4431 (max = £630 648)
Crabs (mix)	0.1 (max = 0.2)	£112 (max = £256)
Dabs	0.9 (max = 5)	£363 (max = £2 174)
Haddock	189 (max = 1551)	£209 471 (max = £1 405 056)
Herring	452 (max = 4618)	£163 502 (max = £1 846 833)
Lemon Sole	2 (max = 9)	£3 8183 (max = £24 256)
Lobsters	46 (max = 275)	£519 488 (max = £3 423 486)
Mackerel	143 (max = 3160)	£131 185 (max = £3 065 365)
Norway lobster	197 (max = 1955)	£611 166 (max = £5 570 232)
Oysters	0.06 (max = 0.1)	£173 (max = £254)
Pink shrimps	0.1 (max = 0.2)	£1 575 (max = £6 269)
Plaice	8 (max = 80)	£5 351 (max = £93 822)
Razor clam	14 (max = 64)	£56 153 (max = £388 678)
Scallops	258 (max = 1227)	£558 602 (max = £2 942 709)
Sprats	0.8 (max = 2)	£226 (max = £475)
Squid	47 (max = 590)	£162 118 (max = £2 282 455)
Velvet crab	27 (max = 142)	£62 283 (max = £440 068)
Whelks	37 (max = 206)	£34 343 (max = £189 505)

Table 2 North coast sub-area mean landings (in tonnes) and their mean value (shown in brackets) for each ICES statistical rectangle from 2013 to 2017. Data are only shown for the listed 21 species with landings data. All values are rounded up.

	Mean landings (tonnes) and mean value (£) for each ICES statistical rectangle	
Species	**46E5**	**46E6**
Blue mussel		0.02 (£96)
Brown crab	512 (£812 738)	702 (£1 007 381)
Clam		0.04 (£107)
Cockle		0.04 (£47)
Cod	4 (£8 196)	159 (£323 770)
Haddock	247 (£325 643)	516 (£651 492)
Herring	2869 (£1 147 851)	355 (£115 204)
Lemon sole	2 (£4 676)	3 (£8 157)
Lobster	11 (£118 748)	44 (£530 073)
Mackerel	1037 (£915 139)	14 (£10 933)
Nephrops	13 (£87 506)	3 (£12 235)
Plaice	3 (£2 316)	8 (£5 524)
Razor fish	5 (£20 715)	2 (£6 061)
Scallop	150 (£288 682)	123 (£294 693)
Squid	370 (£173 515)	10 (£35 604)
Velvet crab	7 (£18 013)	81 (£230 124)
Whelk	0.3 (£243)	53 (£47 335)

Table 3 Northeast coast sub-area mean landings (in tonnes) and their mean value (shown in brackets) for each ICES statistical rectangle from 2013 to 2017. Data are only shown for the listed 21 species with landings data. All values are rounded up.

	Mean landings (tonnes) and mean value (£) for each ICES statistical rectangle		
Species	**45E6**	**45E7**	**46E7**
Brown crab	277 (£390 792)	1 (£1 327)	199 (£280 533)
Cod	0.2 (£419)	8 (£14 638)	38 (£76 621)
Dab	0.03 (£7)	0.06 (£24)	0.09 (£44)
Haddock	34 (£34 353)	459 (£509 995)	302 (£354 906)
Herring	28 (£7 084)	114 (£4 2819)	601 (£177 272)
Lemon sole	0.03 (£64)	0.8 (£2 133)	2 (£6 339)
Lobster	27 (£300 556)	0.1 (£886)	11 (£128 131)
Mackerel	2 (£1 147)	6 (£5 219)	23 (£17 006)
Nephrops	0.8 (£5 377)	21 (£73 901)	2 (£8 484)
Pink shrimp		0.02 (£0)	0.06 (£0)
Plaice	2 (£699)	9 (£6 549)	28 (£29 017)
Razor fish	0.7 (£5 249)		
Scallop	169 (£366 531)	634 (£1 470 569)	312 (£616 693)
Squid	8 (£29 738)	57 (£218 308)	3 (£10 200)
Velvet crab	25 (£57 379)	0.2 (£519)	27 (£71 644)
Whelk	49 (£43 792)	3 (£2 856)	39 (£31 937)

Table 4 Moray Firth sub-area mean landings (in tonnes) and their mean value (shown in brackets) for each ICES statistical rectangle from 2013 to 2017. Data are only shown for the listed 21 species with landings data. All values are rounded up.

	Mean landings (tonnes) and mean value (£) for each ICES statistical rectangle			
Species	**44E5**	**44E6**	**44E7**	**44E8**
Blue mussel	98 (£41 026)	10 (£4 149)		
Brown crab	7 (£8 590)	36 (£48 237)	203 (£291 381)	452 (£652 433)
Clam			0.003 (£5.00)	
Cod	0.001(£4)	0.7 (£1 004)	16 (£27 910)	21 (£40 147)
Crabs (mix)				0.006 (£8)
Dab		2 (£507)	3 (£1 075)	0.4 (£123)
Haddock		27 (£22 103)	467 (£457 112)	729 (£747 963)
Herring		0.4 (£156)	5 (£2 946)	121 (£41 400)
Lemon sole		0.6 (£1 250)	7 (£13 272)	8 (£16 702)
Lobster	0.2 (£1 995)	21 (£240 117)	18 (£21 7392)	32 (£350 966)
Mackerel	0.2 (£122)	16 (£2 1516)	140 (£180 836)	879 (£782 683)
Nephrops	0.3 (£700)	396 (£1 321 047)	473 (£1 628 079)	121 (£428 023)
Oyster		0.09 (£254)		0.04 (£92)
Plaice		6 (£3 013)	39 (£19 627)	17 (£11 466)
Scallop		94 (£257 558)	116 (£253 452)	547 (£1 123 903)
Sprat		2 (£343)	0.7 (£187)	
Squid		186 (£48 8441)	303 (£1 133 372)	24 (£90 306)
Velvet crab	0.3 (£615)	24 (£58 420)	25 (£55 304)	44 (£86 925)
Whelk	124 (£118 353)	58 (£54 400)	2 (£943)	0.02 (£17)

Table 5 Peterhead to Dundee sub-area mean landings (in tonnes) and their mean value (shown in brackets) for each ICES statistical rectangle from 2013 to 2017. Data are only shown for the listed 21 species with landings data. All values are rounded up.

	Mean landings (tonnes) and mean value (£) for each ICES statistical rectangle			
Species	**42E7**	**42E8**	**43E7**	**43E8**
Brown crab	270 (£372 435)	4 (£3 987)	54 (£65 607)	141 (£179 324)
Clam	0.6 (£1146)			
Cod	3 (£3 694)	8 (£1 3036)		2 (£2 537)
Crabs (mix)	0.2 (£181)			0.3 (£256)
Dab	0.2 (£74)			
Haddock	0.08 (£66)	7 (£6 202)	0.3 (£173)	72 (£66 851)
Herring	6 (£2 488)	31 (£10 082)	3 (£1 179)	1249 (£385 223)
Lemon sole	0.05 (£147)	0.4 (£859)		0.4 (£658)
Lobster	141 (£1 673 667)	2 (£20 428)	7 (£69 645)	10 (£112 015)
Mackerel	34 (£34 616)	19 (£18 234)	6 (£4 761)	108 (£96 226)
Nephrops	59 (£195 833)	5 (£14 818)	2 (£6 128)	6 (£18 049)
Pink shrimp	0.3 (£6269)			0.07 (£31)
Plaice	0.09 (£85)	0.5 (£337)	0.6 (£229)	2 (£1 010)
Razor fish	4 (£20 453)			
Scallop	294 (£636 264)	831 (£1 835 004)	9 (£17 025)	494 (£1 017 936)
Squid	31 (£115 181)	15 (£63 233)	6 (£24 884)	3 (£13 212)
Velvet crab	73 (£189 620)	1 (£1 683)	2 (£3 575)	10 (£22 272)
Whelk	7 (£6 372)		3 (£2 382)	0.02 (£25)

Table 6 South of Dundee sub-area mean landings (in tonnes) and their mean value (shown in brackets) for each ICES statistical rectangle from 2013 to 2017. Data are only shown for the listed 21 species with landings information. All values are rounded up.

	Mean landings (tonnes) and mean value (£) for each ICES statistical rectangle					
Species	**40E6**	**40E7**	**40E8**	**41E6**	**41E7**	**41E8**
Blue mussel		0.2 (£1159)				
Brown crab	0.4 (£663)	144 (£192 243)	481 (£612 053)	2 (£2 084)	177 (£221 081)	111 (£175 142)
Brown shrimp					0.4 (£0)	
Clam					24 (£47 078)	
Cod		2(£2 193)	2 (£2 671)	0.03 (£14)	2 (£2 108)	0.1 (£149)
Crabs (mix)			0.002 (£4)			
Dab		0.3 (£151)	0.4 (£258)		2 (£750)	0.04 (£10)
Haddock		0.5 (£556)	2 (£2 107)		3 (£2 355)	3 (£2 225)
Herring			0.02 (£6)		0.3 (£134)	0.9 (£555)
Lemon sole		0.3 (£397)	0.5 (£832)	0.001 (£2)	0.6 (£915)	0.06 (£133)
Lobster	4 (£42 318)	84 (£947 374)	175 (£1 885 147)	5 (£51 486)	221 (£2 464 795)	12 (£156 745)
Mackerel		67 (£68 304)	0.6 (£612)	2 (£1 022)	40 (£44 455)	7 (£6 402)
Nephrops	0.2 (£855)	356 (£1 119 306)	138 (£474 451)	115 (£396 925)	1 584 (£4 451 765)	10 (£28 874)
Plaice		0.3 (£187)	2 (£755)		2 (£592)	0.2 (£1156)
Razor fish		2 (£4 728)		6 (£25 183)	35 (£146 064)	
Scallop		20 (£39 970)	123 (£267 879)	0.7 (£1 953)	131 (£264 095)	189 (£410 030)
Squid		9 (£18 985)	0.9 (£2575)	2 (£4 947)	17 (£39 138)	4 (£15 168)
Velvet crab	0.3 (£765)	23 (£47 148)	36 (£5 4561)	3 (£5 972)	58 (£128 312)	4 (£9 403)
Whelk	1 (£1 098)	3 (£1 885)	2 (£1 089)	96 (£88 312)	67 (£66 253)	

3.3 Critical habitat areas

Three main data sources are available which detail areas considered to be important to certain commercial fish species. These data include information on spawning and nursery grounds and a predicted sensitivity map of important areas for fish in their first year of life. Spawning and nursery ground maps were created during the late 1990s by Coull*, et al.* (1998) based on survey data and fishers' knowledge. The information focused on 14 commercially important species, eight of these were appropriate for this work. The outputs were quite broad-scale, covering very large areas. During 2015 a series of predicted maps were created which built on the spawning and nursery ground maps (Aires*, et al.*, 2014). These maps showed species sensitivity areas that predicted important areas for fish species in the first year of life. Sensitivity areas provide more local detail to areas considered important for each species but they should be viewed alongside the spawning and nursery ground maps. Summaries of this species information is listed below and the mapped data are shown in Appendix B "Critical habitat".

3.3.1 Cod

The edge of two cod (*Gadus morhua*) spawning areas were identified, one to the northwest of Buckie and the other to the east of Aberdeen (Figure 19, page 42). A large nursery area was identified which extended from south of Stonehaven to north of Eyemouth. A large predicted cod sensitivity area was recorded off St. Andrews with some smaller sensitivity areas located closer to shore off Stonehaven and Newburgh. Other, smaller sensitive areas were located along the coast north of Helmsdale and at Durness.

3.3.2 Haddock

No haddock (*Melanogrammus aeglefinus*) spawning grounds were recorded within the N&EC RIFG (Figure 20, page 43). The northern portion of the region was covered by a haddock nursery ground and several sensitivity areas were located throughout the region. The largest of these sensitivity areas was located off Montrose, which had a high likelihood of finding small haddock. Similarly high likelihoods were found to the north of Buckie, north of Banff, and east of Aberdeen.

3.3.3 Herring

Two large herring (*Clupea harengus*) nursery grounds were identified extending out from the Moray Firth and from the Firth of Forth (Figure 21, page 44). Four large spawning grounds were also identified which covered most of the northern coast, the central east coast, and the south of the Firth of Forth. No sensitivity areas were located within the region.

3.3.4 Lemon sole

No sensitivity areas were available for Lemon sole (*Microstomus kitt*). The nursery and spawning areas completely covered the region out to 12 nm (Figure 22, page 45).

3.3.5 Mackerel

There were no known mackerel (*Scomber scombrus*) nursery or spawning grounds and no known sensitivity areas located within the region (Figure 23, page 46).

3.3.6 Norway lobster

The Norway lobster (*Nephrops norvegicus*) spawning and nursery grounds covered the same area, which extended across most of the east coast (Figure 24, page 47). However, these areas include sediment that would not be suitable habitat for Norway lobsters and it is likely that they include the planktonic phase of their life cycle. No sensitivity areas were present for this species. Information was available on the density of Norway lobster burrows with the highest densities found in the Firth of Forth followed by the Moray Firth and along the Buckie-Fraserburgh coast.

3.3.7 Plaice

Plaice (*Pleuronectes platessa*) nursery grounds were found close to shore around most of the region's coast line (Figure 25, page 48). They extended further offshore at Dornoch and St. Andrews but remained within the 6 nm limit. Four spawning grounds were identified around the 6 nm limit and extending past the 12 nm limit in some cases. These areas were located off Helmsdale, Banff, Aberdeen and Montrose, and Eyemouth. Although some very small sensitivity areas were located in the Firth of Forth and off Montrose, the likelihood of small plaice occurring in these locations was not high.

3.3.8 Sprat

Both the nursery and spawning grounds for sprat (*Sprattus sprattus*) were found to be large (Figure 26, page 49). Nursery grounds covered the entire east coast from shore out past the 12 nm limit. Spawning grounds covered the entire northern coast and extended from the shore out past the 12 nm limit. The spawning ground area came within the 12 nm limit north of Fraserburgh and east of Peterhead. No sensitivity areas were noted for sprat within the region.

3.4 Species habitat preferences and available fisheries information

Fourteen species did not have any defined critical habitat areas (spawning and nursery grounds or sensitive areas). For these species, a search of the literature and online information sources was carried out to summarise key information on species life history and any known fishing activity within the N&EC RIFG region. Where there was information available on species distributions, maps were created and shown in Appendix C "Maps of species records". Predictive species habitat maps (also known as species distribution models) may be available for some of the listed species. However, they were not incorporated into this work, as the quality of each map is defined by the underlying data sets, which are not always very reliable.

3.4.1 Blue mussel

Blue mussels (*Mytilus edulis*) are common around the Scottish coast and are found from the intertidal down to about 12 m deep (Chapman, 2004). Within the N&EC RIFG, there is a wide distribution of records from the Marine Recorder database (Figure 27, page 51). Mussels settle on hard surfaces using threads called byssus. Movement once settled is possible but considered to be limited. Blue mussels reproduce through spawning with a larval phase lasting about 30 days (Chapman, 2004). During this phase, the larvae can travel large distances in oceanic and wind-driven water currents before a suitable settlement surface is encountered.

Marketable sized mussels were recorded at 11 locations within the N&EC RIFG, as reported by McKay and Fowler (1997). The authors did not report any marketable sized mussels along the north coast and the furthest north site was at Loch Fleet. Moving south, marketable sized mussels were recorded at Dornoch Firth, Cromarty Firth, Inverness Firth, Culbin Bars, Ythan Estuary, Dee Estuary, Montrose Basin, Tayport, Eden Estuary, and Musselburgh. McKay and Fowler (1997) reported that "the majority of the natural mussel beds in Scotland consist of large thick-shelled blue mussels which would only be suitable for the processing market" with the authors further stating that many contained large quantities of pearls which would further exclude them from this market. The authors reported a fishery in the Dornoch Firth (two vessels), six collectors from the Montrose Basin, and five local fishers at Culbin Shore. Chapman (2004) only reported fisheries in the Dornoch Firth and Montrose Basin. Within Marine Scotland's National Marine Plan interactive web portal, blue mussel beds are listed as being present in the Dornoch Firth, Inverness Firth, Tay Estuary, and the Firth of Forth near Kincardine. Intertidal blue mussel beds were found at Loch Eriboll, Loch Fleet, Dornoch Firth, Cromarty Firth, Inverness Firth, Moray Firth, Montrose Basin, Tay Estuary, and Firth of Forth.

These reports match up with the reported fishing information. Landings of blue mussels were recorded in the North sub-area from 46E6 (Table 2, page 18), although this ICES statistical rectangle also includes Orkney. The Moray Firth sub-area had two ICES statistical rectangles with landings data (Table 4, page 19): 44E5 included Loch Fleet, Dornoch Firth, Cromarty Firth, and Inverness Firth while 44E6 included the Culbin shore. Landings from 40E7 would include part of the shore to the east of Musselburgh (Table 6, page 20).

3.4.2 Brown crab

Brown crabs (*Cancer pagurus*), also known as edible crabs or partans, have a wide distribution throughout the region and Scotland (Figure 28, page 52). They are found on many seabed types including hard substrates (rocks, cobbles, and boulders), gravel, sand, and mud, down to about 100 m deep (Chapman, 2004). It is thought that females move to deeper water to reproduce and incubate their eggs, which they carry on the underside of their bodies. During this time the females stop feeding so very few are caught in baited traps (Tallack, 2007) but they have been known to gather in large groups (as summarised by Chapman, 2004). These gatherings of non-feeding, egg-bearing females are thought to be vulnerable to other types of fishing activity such as dredging and trawling. However, their inactivity also makes it very difficult to accurately sample this stage of their life cycle. They hatch as larvae into the water column where they live for one to six months and can potentially travel more than 10 km during this period (Neal and Wilson, 2008).

There is an inshore and offshore element of brown crab fisheries around Scotland. Inshore grounds overlap with other shellfish species, notably the European lobster (see Section 3.4.7) and velvet crab (see Section 3.4.13), and usually involve the smaller inshore fleet. Larger vessels and vivier vessels mostly fish for brown crabs further offshore. Landings information were recorded from all ICES statistical rectangles within the region (see Table 2 to Table 6).

3.4.3 Brown shrimp

The brown shrimp (*Crangon crangon*) is common on sandy and muddy bottoms from mid-tide level down to about 150 m deep (Chapman, 2004; Neal, 2008). Within the N&EC RIFG region, location records submitted to Marine Recorder extend from Durness down to Eyemouth with clusters located around the Dornoch Firth, Moray Firth, and the Tay Estuary (Figure 29, page 53). Reproduction is thought to occur all year round with the females carrying the eggs for four to 13 weeks (Neal, 2008). They hatch as larvae into the water column where they live for one to six months and can potentially travel more than 10 km during this period.

Within the N&EC RIFG region, there have been reports of occasional landings of brown shrimp from the Moray Firth, usually by beam trawlers (Chapman, 2004). However, no landings of brown shrimp have been reported from that area since 2013 with the only landings recorded from 41E7 (Table 6, page 20).

3.4.4 Clams

The native clam (*Ruditapes decussatus*), also known as the chequered carpet shell, mainly occurs along the west coast of Scotland, Shetland, and southern England (Carter, 2003). One record of the native clam was reported in Marine Recorder 12.5 nm east of Newtonhill. The native clam is found in sheltered bays and estuaries on the lower shore and in shallow waters, buried in sand, muddy gravel, or clay (Carter, 2003). Larvae are free-swimming in the water column for 10 to 15 days before settling on the substrate[5].

A non-native clam species, known as the sand gaper, (*Mya arenaria*) also occurs and has a widespread distribution around the Scottish coast. Records from the Marine Recorder database show a distribution in sheltered areas including Loch Eriboll, Dornoch Firth, Cromarty Firth, Moray Firth, Montrose Basin, Firth of Tay, and Firth of Forth (Figure 30, page 54). It is found from the intertidal down to depths of 192 m and lives in 50 cm deep burrows in sand, mud, sandy mud, and sandy gravels (Tyler-Walters, 2003). The larval phase of the non-native clam lasts for 11 to 30 days with an estimated distribution of more than 10 km during this period (Tyler-Walters, 2003).

Despite the more westerly distribution of the native clam, natural beds occur around the UK coast but are not thought to be sufficient enough to support a major fishery (Seafish, 2002). During 2017, a total of 32 tonne of clams (unknown species), accounted for 100% of the Scottish total landings, were landed into the N&EC RIFG districts (Scottish Government, 2018).

Clam landings were distributed from 46E6 in the North coast sub-area (Table 2, page 18), between Buckie and Fraserburgh in 44E7 (Table 4, page 19), Montrose (42E7; Table 5, page 19), Dundee, and Firth of Forth (41E7; Table 6, page 20).

[5] See www.fao.org/tempref/FI/CDrom/aquaculture/I1129m/file/en/en_groovedcarpetshell.htm

3.4.5 Cockle

The common cockle (*Cerastoderma edule*) is widely distributed around the Scottish coast in suitable habitat (Tyler-Walters, 2007). Records from the Marine Recorder database show a wide distribution within the N&EC RIFG from Kyle of Durness and Loch Eriboll in the north to Dunbar in the south (Figure 31, page 55). Loch Fleet, Durnoch Firth, Moray Firth, Montrose Basin, and Tay Estuary were found to have higher concentrations of records. All records were located close to shore.

Cockles are mostly found in sheltered bays and estuaries from mid-shore down to shallow waters. Their preference is for clean sand, mud, or muddy gravel where they can burrow to a depth of no more than 5 cm. According to Tyler-Walters (2007), the larval stage (how far they move and for how long) of the common cockle is not well known but are considered to be free-swimming.

Fishing for cockles using a vehicle within the N&EC RIFG is prohibited under "The Inshore Fishing (Prohibition of Fishing for Cockles) (Scotland) Order 2006"[6]. However, hand gathering would be permitted and a small quantity of cockles (35 kg) were fished in the north within ICES statistical rectangle 46E6 (Table 2, page 18).

3.4.6 Dab

Dab (*Limanda limanda*) are a common flatfish found all around the British coast. They live in sandy areas from the shore down to 150 m but are most commonly found between 20 and 40 m (Ruiz, 2008). Marine Recorder records showed dab distributed throughout the region with a cluster off Eyemouth (Figure 32, page 56). Spawning occurs between January and August with the eggs hatching after about ten days when the larvae then settle at depths of 10 to 20 m[7].

Dab are caught as bycatch in fisheries mostly targeting plaice and sole (Seafish, 2010). Their landings were recorded throughout the "Northeast coast sub-area" (Table 3, page 18), "Moray Firth sub-area" (Table 4, page 19), from 42E7 in the "Peterhead to Dundee sub-area" (Table 5, page 19), and in the "South of Dundee sub-area" (Table 6, page 20).

3.4.7 Lobster

The European lobster (*Homarus gammarus*) has a wide distribution around the Scottish coast with a preference for sheltered areas of rocky shores, reefs, cobbles, boulders, and wrecks (Bannister and Addison, 1998). Their depth range is from low water spring tides down to about 60 m (Chapman, 2004). This distribution is reflected in the Marine Recorder records for the region (Figure 33, page 57). Female lobsters carry their eggs for about nine months before hatching in the spring. Once hatched, the larvae enter the upper water column at about 0 to 15 m deep but remaining in the same location as the adults (Chapman, 2004). Juveniles settle on the seabed in similar habitats to the adults but remain concealed for at least two years before emerging.

[6] www.legislation.gov.uk/ssi/2006/58/body/made
[7] www.fao.org/fishery/species/3361/en

Lobster fisheries occur close to shore and are generally fished by smaller vessels less than 10 m in overall length (Chapman, 2004). They were landed throughout the region (Table 2 to Table 6). Seven of the ICES statistical rectangles recorded lobsters in the top three for quantity landed. These were located from Newburgh to the Scottish-English border.

3.4.8 Native oyster

Native oysters (*Ostrea edulis*) have a wide geographic distribution but the stronghold of the UK population is thought to occur in sea lochs on the Scottish west coast where scattered populations exist (Laing*, et al.*, 2005; UMBS, 2007). They have been found on varying substrates such as hard silt, muddy gravel with shells, sand, and rock (Laing*, et al.*, 2005; Airoldi and Beck, 2007) but have been shown to prefer attaching to shells (UMBS, 2007). Their depth ranges from low tide down to about 80 m. The larval stage lasts for two to three weeks (Laing*, et al.*, 2005) and it has been shown that they may drift up to 10 km during this time (Berghahn and Ruth, 2005). All naturally occurring stocks belong to The Crown Estate, except where these rights have been specifically granted to other persons (Anonymous, 1999). The native oyster is protected in the UK and are considered a sensitive species, which means location records are not made publically available.

Only two landings records were recorded for oysters from 44E6 (86 kg during 2015) and 44E8 (31 kg during 2013; Table 4, page 19).

3.4.9 Pink shrimp

Pink shrimp (*Pandalus borealis*) are a northern species with their southern distribution on the Fladen Grounds and Farne Deeps (Allen, 1959; Chapman, 2004). They live on fine mud at depths of 80 to 650 m. On the Fladen Ground, females carry their eggs for the winter months before the larvae hatch into the water column where they remain for three months. Juveniles then settle on the seabed in the area of the adults.

Only two fishing grounds for pink shrimp have been identified near the N&EC RIFG region: the Fladen Ground east of the Moray Firth and Farne Deeps (northeast of Newcastle-Upon-Tyne). The highest recorded landings of pink shrimp from 2013 to 2017 was 240 kg from 42E7 during 2017 (Table 5, page 19). Other landings included 43E8 during 2013, 45E7, and 46E7 (both from 2017; Table 3, page 18).

3.4.10 Razor fish

Razor fish (*Ensis* spp.) burrow into sandy substrates from low water of the intertidal down to a water depth of about 40 m. Razor fish are found all around the Scottish coast in suitable habitat and have a wide distribution within the N&EC RIFG region with records from Loch Eriboll, Dornoch Firth, Cromatry, north Aberdeen, St. Andrews, and Eyemouth (Figure 34, page 58). The mobile larvae spend about one month in the water column before settling into the sandy sediment (see Fraser*, et al.*, 2018 for a review).

Historically, razor fish fisheries ranged from intertidal hand gathering, diver gathering, dredging, and electrofishing. In Scotland, new regulations which came into force on 1st February 2018 prohibits all fishing and landing of razor fish except for scientific investigation and "*for the traditional hand gathering of razor clams from the shore, a person carrying out*

such harvesting is allowed to take up to 30 razor clams per day"[8]. The legislation was introduced to support a scientific trial of electrofishing.

Prior to the new regulations, 41E7 from Dundee south to the Firth of Forth had the highest recorded landings in 2013 (49 tonnes), 2014 (36 tonnes), 2016 (19 tonnes), and 2017 (63 tonnes).

3.4.11 Scallop

The scallop (*Pecten maximus*) is most commonly found between 20 and 45 m, although they are found as deep as 180 m (Gosling, 2003). They are mostly found on coarse clean sand, fine clean sand, sandy mud, muddy sand, and gravel/shingle (Gosling, 2003; Marshall and Wilson, 2008). Larvae remain in the water column for up to 30 days with a high dispersal potential (Marshall and Wilson, 2008).

Larger scallop dredge vessels are fitted with an EU VMS system for tracking their activity (Figure 12, page 34). The VMS information shows extensive fishing activity within the N&EC RIFG region. Areas of higher fishing activity were recorded off Eyemouth, Dundee to Aberdeen, Peterhead to Buckie, Helmsdale to Orkney, and Scrabster to Durness. Both inshore and offshore fishing activity was evident from the VMS and this was reflected in the landings information.

3.4.12 Squid

Several different squid species are caught around the Scottish coast (Hastie*, et al.*, 2009). They are highly mobile but come inshore to reproduce and lay their eggs.

Directed squid fishing has been reported in the Moray Firth (Campbell and McLay, 2007; Hastie*, et al.*, 2009), Firth of Forth, and off Aberdeen (Hastie*, et al.*, 2009). The main Scottish fishery for one of the squid species (*Loligo forbesi*) was found to occur in coastal waters, although the species is found to be widely distributed over the continental shelf (Hastie*, et al.*, 2009). In the Moray Firth, the majority of the squid catch was from the inshore along the coast from Lossiemouth to Fraserburgh (Campbell and McLay, 2007). Historically, a large portion of the recorded landings were bycatch from the whitefish fishery (Pierce*, et al.*, 1994) but current landings data show an extensive squid fishery in the region with the highest landings recorded from 46E5 on the northern coast of Scotland (see Section 3.2).

3.4.13 Velvet crab

The velvet crab (*Necora puber*) is widely distributed around the Scottish coast with similar habitat to the European lobster. This is shown in the records from Marine Recorder (Figure 35, page 59). Velvet crabs are found close to shore in rocky areas down to about 15 m deep (Chapman, 2004). Female crabs carry the eggs until they are ready to hatch. Once hatched, the larvae enter the water column for up to 40 days where they are widely dispersed (Chapman, 2004).

This is a near-shore creel fishery over rocky habitat, usually coinciding with catches of lobster but also some brown crab.

[8] www.legislation.gov.uk/ssi/2017/419/contents/made

3.4.14 Whelk

The common whelk (*Buccinum undatum*) has a wide distribution around the Scottish coast and is common from shallow water down to 200 m deep (Thomas and Himmelman, 1988). This is evident in the distribution of records within the N&EC RIFG from the Marine Recorder database (Figure 36, page 60). Whelks are mobile animals which live on the seabed and have been recorded on most seabed types (Morel and Bossy, 2004). They reproduce by laying clumps of eggs on hard substrates with juveniles hatching after three to five weeks during February to March (Chapman, 2004).

The common whelk is fished throughout the whole of Scotland but most of the catch comes from the North Sea, Orkney, and Shetland (Chapman, 2004).

4 Summary of outputs, their data gaps and constraints

A detailed knowledge of the location and size of fishing grounds is necessary for any inshore fishery management area, for example to inform management decision making and provide evidence for marine spatial planning. In addition, it is important to have a good understanding of the distribution and sensitivities of commercially important species. Although some of this information is available (a lot of the information is accessible through Marine Scotland's National Marine Plan interactive, NMPi), some may require processing (e.g. Global AIS) or interpretation (e.g. AIS vessel tracks).

Vessel location data linked with logsheet returns is the crucial element for any fishery management in knowing exactly where vessels fish, for what, and when. This has been addressed with recent updates to the FISH1 Form requiring fishers to enter coordinates of their fishing activity. Unfortunately, at the time of producing this report, the available data required further quality control and was therefore not available for use.

Since location information was not available for this work, it was necessary to take a different approach to try and map the fishing areas within the N&EC RIFG region. This relied on vessel track information from AIS data. The AIS data gave very detailed information on fishing grounds in the region but it should be noted that it was not a complete picture of all fishing activity. Both of the AIS data sets included all fishing vessel movements (steaming and fishing). In the case of the EFF data set, it was possible to calculate each vessel's speed, which allowed for a better differentiation between steaming and fishing activity. This was not possible with the AIS data from the MMO. In this instance, all activity had been grouped together which meant that in areas of high vessel movement (e.g. approaches to ports or common steaming lanes such as areas around headlands) it was either not always possible to differentiate between steaming and fishing or the large amount of steaming tracks hid the fishing in that area. Another drawback to the MMO data was that it was only available for the first seven days of each month. However, in order to improve the overall output, multiple years were combined for the analysis. In contrast, the EFF AIS data was a more complete data set but it only represented a limited number of vessels over a couple of months. Where possible the data gaps were filled by including information from ICES VMS data, ScotMap, Creel Effort Survey, and the Scottish Marine Recreation and Tourism Survey. Combined maps for different gear types and species groups were created (see Section 3.1.1). The combined maps show a varying likelihood of occurrence (darker areas are more likely to occur than

lighter areas) but it is important to understand that these maps are only as good as the available input data and the willingness/availability of fishers to participate in these surveys.

Species sensitivity maps provide more detailed information on the expected (predicted) occurrence of young fish. These areas are much smaller than the spawning and nursery grounds that, in some cases, cover the entire N&EC RIFG region. Recent work has highlighted that more detailed information on spawning and nursery grounds would be advantageous to potential developers (Shelmerdine*, et al.*, 2017).

Information on the distribution of species within the N&EC RIFG region is useful but interpretation of the maps in Appendix C should be treated with caution. Although the maps show location information of where the species were found, they can be an indication of where surveys took place and not a complete record of the full extent of the overall distribution. It is important, therefore, that any location 'gaps' in the maps might mean that no survey work was carried out there, rather than species do not occur there. These are the only kind of 'gaps' (also known as data gaps) that can be highlighted from a desk-based report. Identifying any information gaps (e.g. fishing grounds not shown through analysis of the existing data) would require consultation with fishers.

In order to better understand fishing activity and provide a complete map of all fishing grounds, it would be necessary for future work to carry out a series of interviews with the fishers. This would be especially useful in areas with little or no AIS vessel track data (compare Figure 3 with the combined maps in Section 3.1.1). Even in areas with AIS information, it is beneficial to consult and interview fishers as they will be able to provide additional information on each ground such as gear types used, species caught, frequency of use, and the importance of the area to the fisher. Interviews can also help to better understand fishing grounds with multiple gear types.

Future work could also include an estimation of the distribution of the species of interest, which could be carried out using predictive habitat modelling techniques. This can be a cost effective way of producing habitat maps for the key species listed, especially over large areas such as the N&EC RIFG region and has been used recently in Wales to map potential razor fish grounds (see Fraser*, et al.*, 2018). However, any maps that are created should be included in an interview process with the fishers to ensure their accuracy. This technique is limited by the data that is entered into each species model and any area with little or poor data will not have an accurate output. Key data that would be required for most of the species would include a good spread of species occurrences, sediment types, and bathymetry. Species information listed in Section 3.4 would also provide additional data sets that would help to improve any species outputs.

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6 Acknowledgements

The work was carried out using available data sets, which can be viewed and accessed online. The authors would like to thank Marine Scotland's Fisheries Statistics team who were very helpful with our request for information and for explaining the current problems with the locational information.

Appendix A VMS fishing intensity maps

This Section displays fishing effort maps from VMS data (2009 to 2016), sourced from ICES (2017), for different bottom gear types. Darker areas correspond with higher fishing effort.

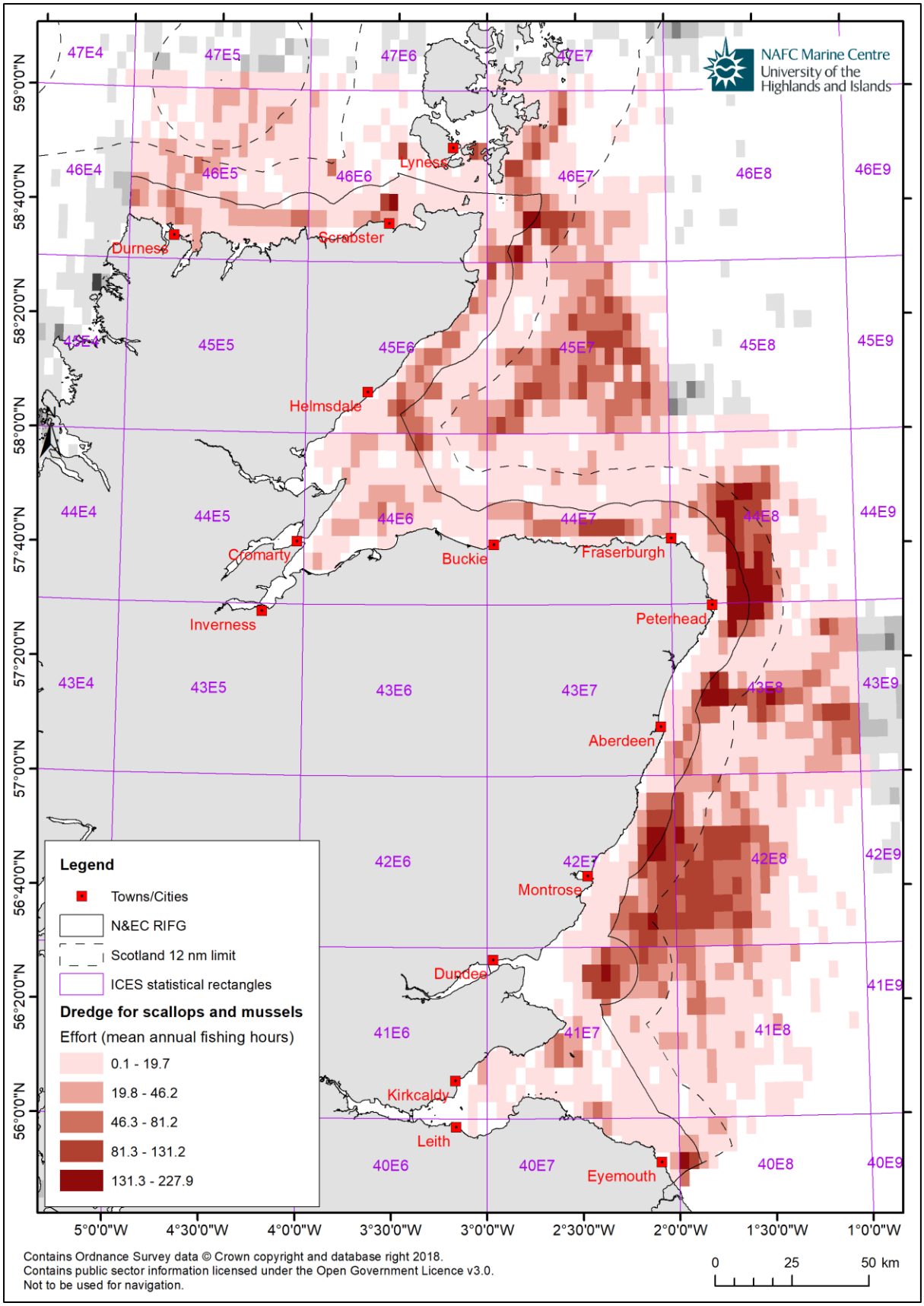

Figure 12 VMS fishing activity for scallop dredgers.

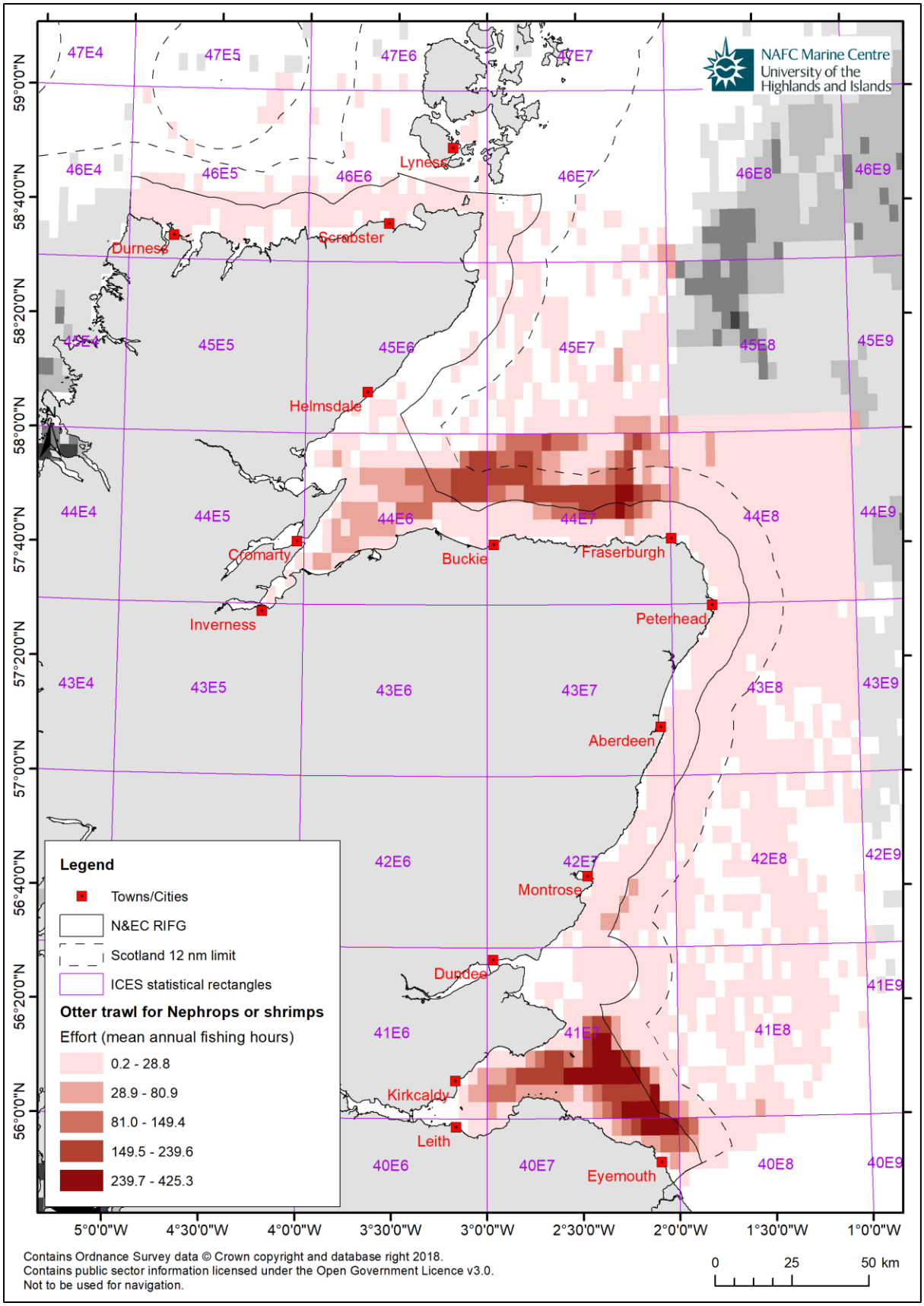

Figure 13 VMS fishing activity for Norway lobster and shrimps using otter trawls.

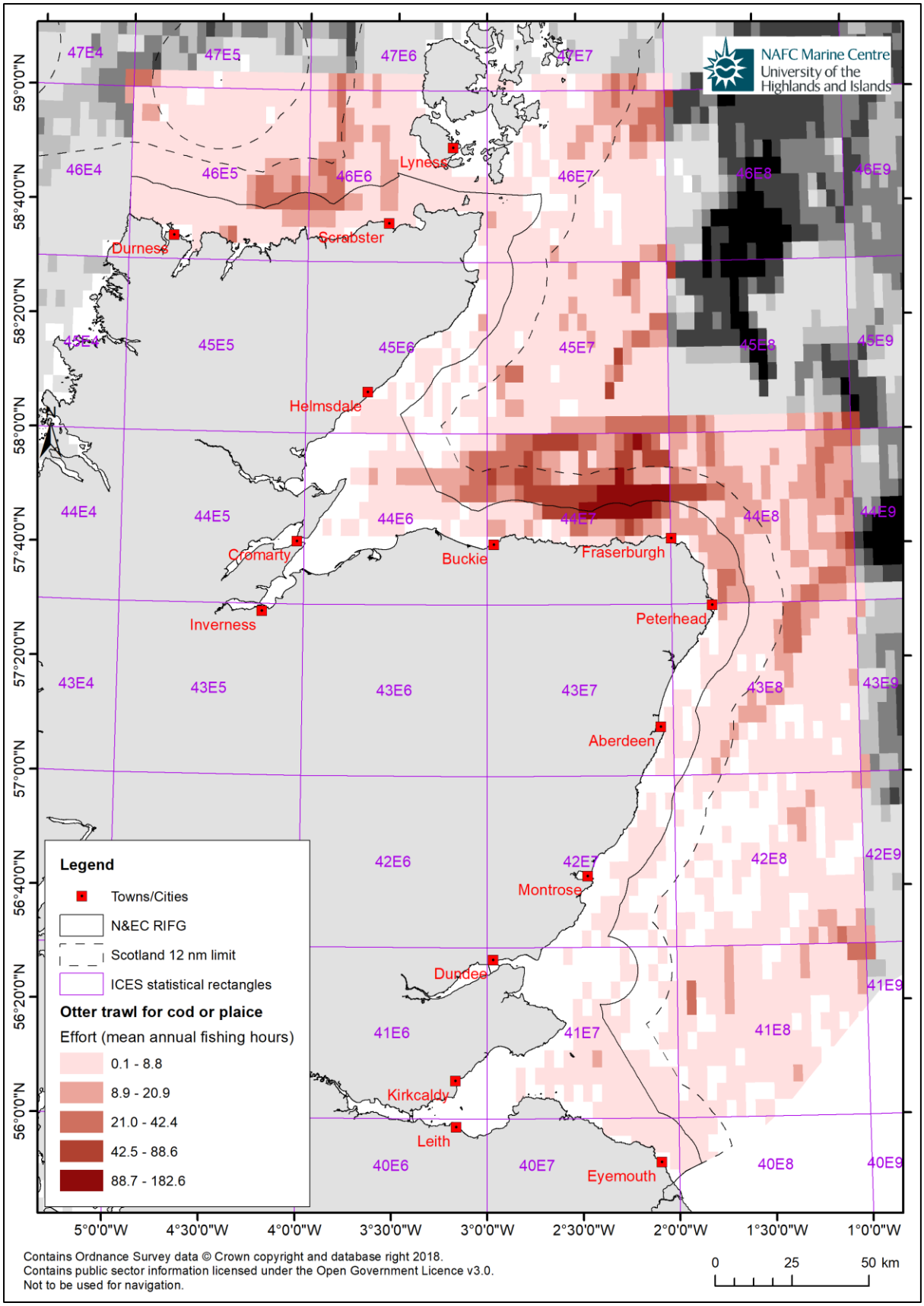

Figure 14 VMS fishing activity for cod and plaice using otter trawls.

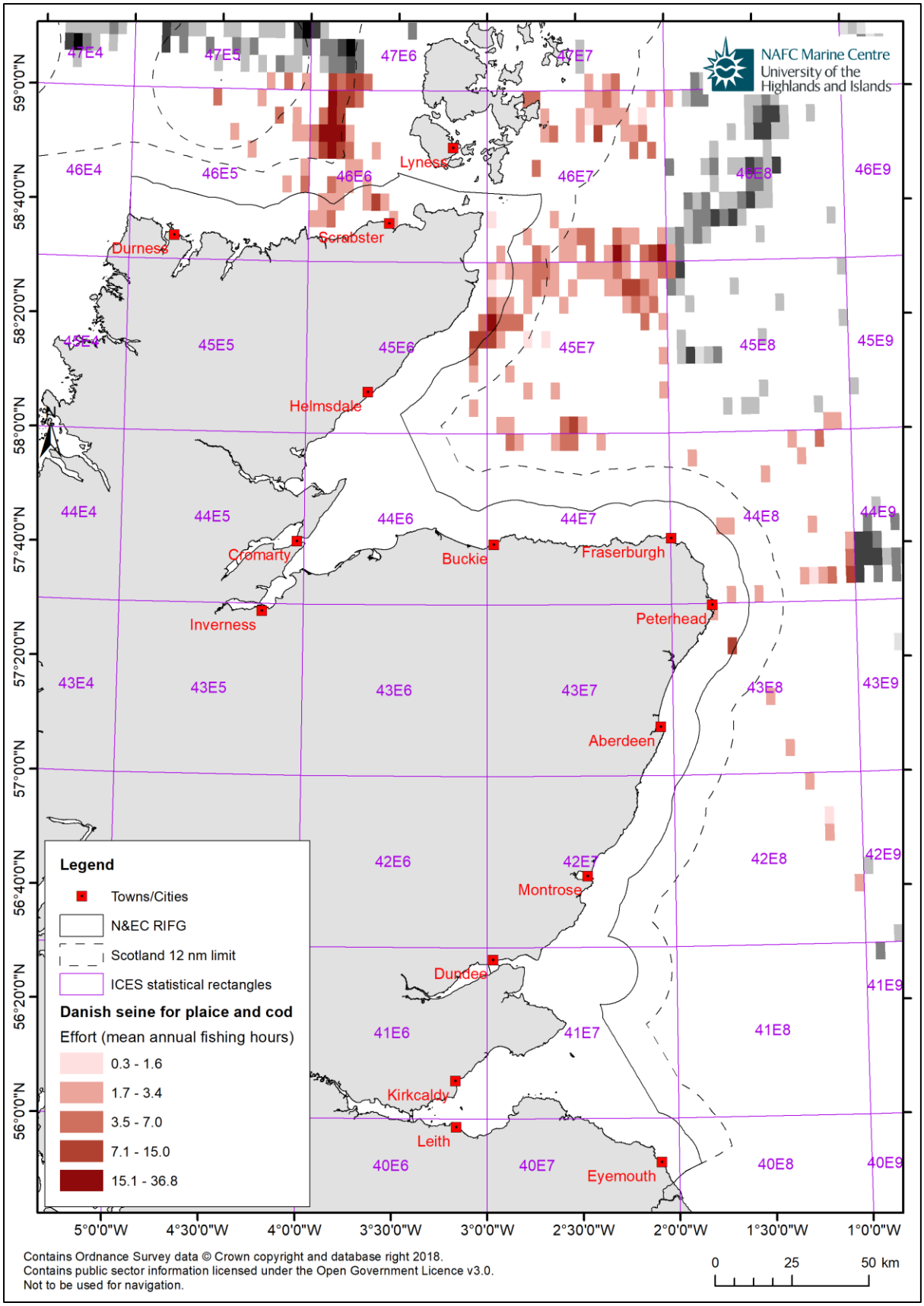

Figure 15 VMS fishing activity for cod and plaice using Danish seine nets.

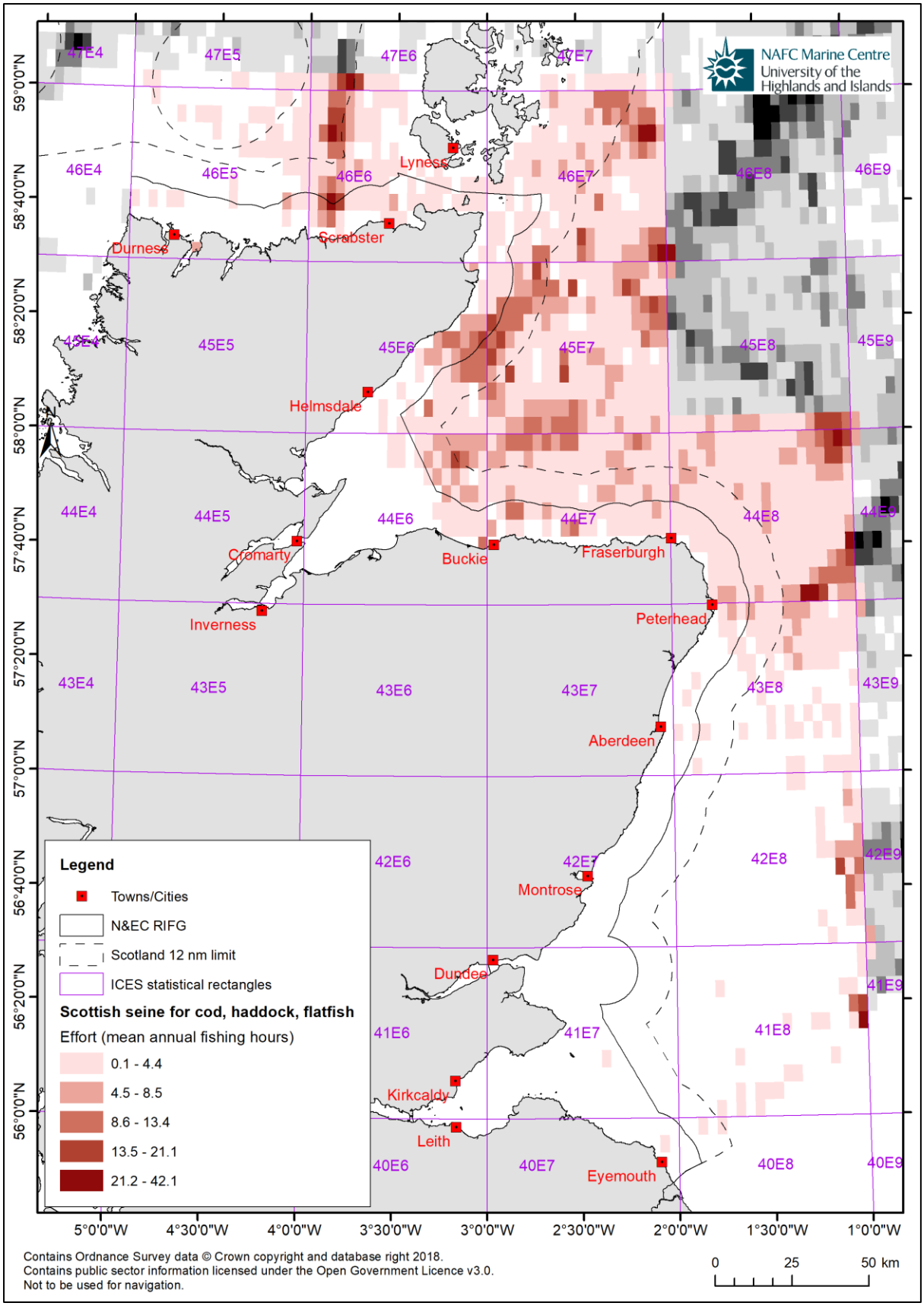

Figure 16 VMS fishing activity for cod, haddock, and flatfish using Scottish seine nets.

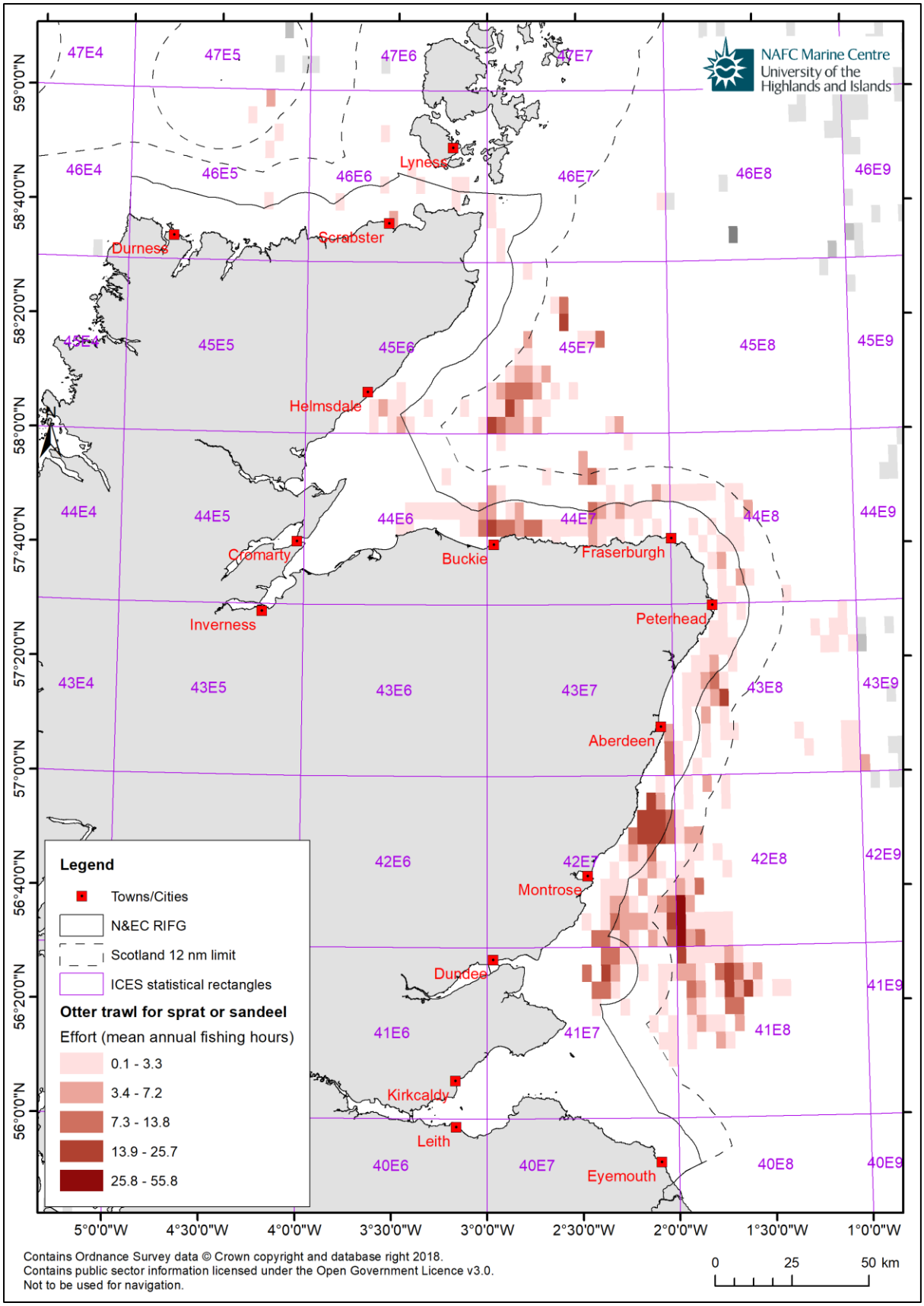

Figure 17 VMS fishing activity for sprat using otter trawls.

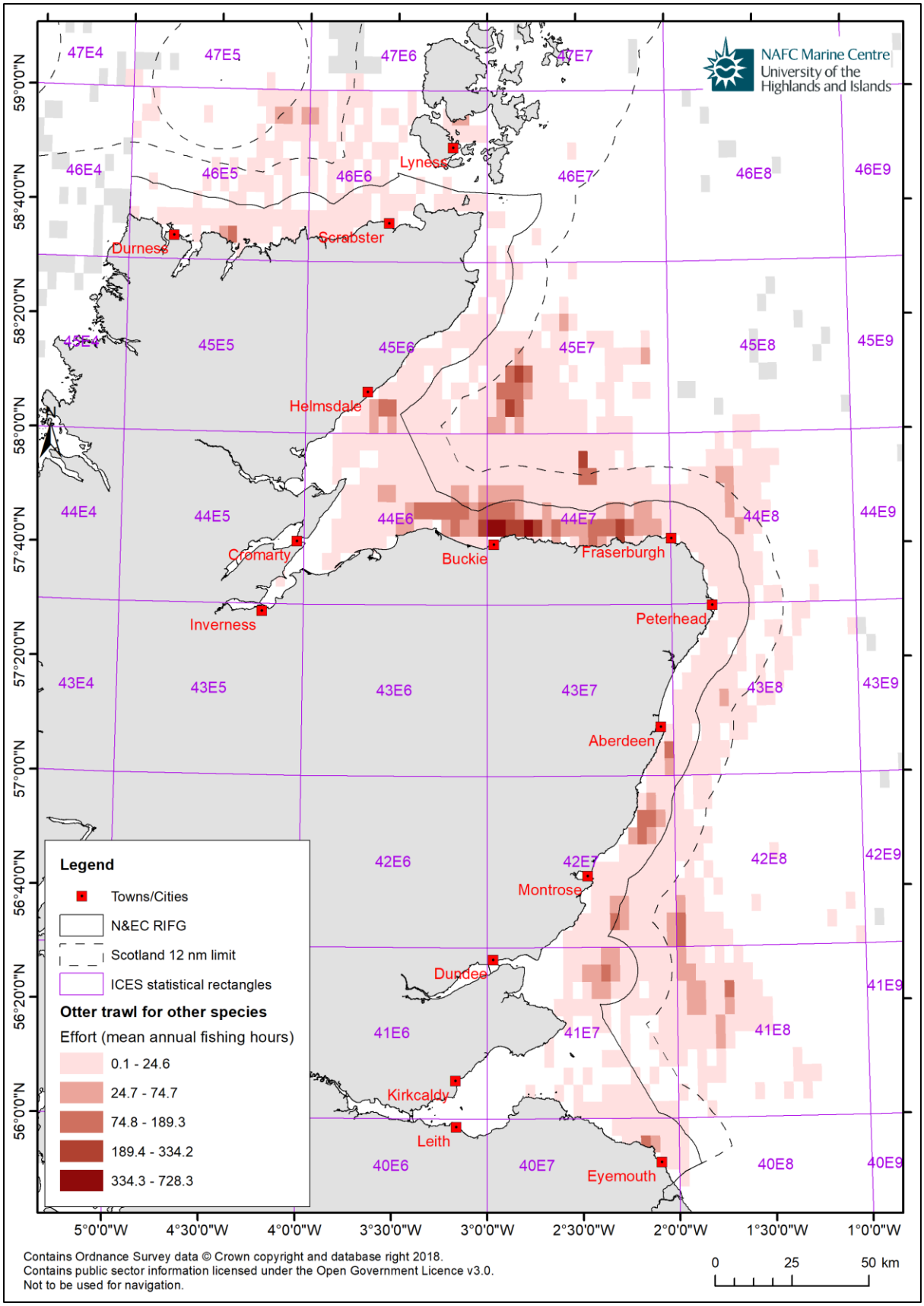

Figure 18 VMS fishing activity for 'other species' using otter trawls.

Appendix B Critical habitat maps

This Section displays mapped information on spawning (blue hatching) and nursery (green shading) grounds and predicted species sensitivity areas (yellow to brown shading; Aires*, et al.*, 2014). The species sensitivity areas show important locations for fish in their first year of life. Information is available for eight species including cod (Figure 19), haddock (Figure 20), herring (Figure 21), lemon sole (Figure 22), mackerel (Figure 23), Norway lobster (Figure 24), plaice (Figure 25), and sprat (Figure 26). For more detailed information of each species, see Section 3.3 on page 21.

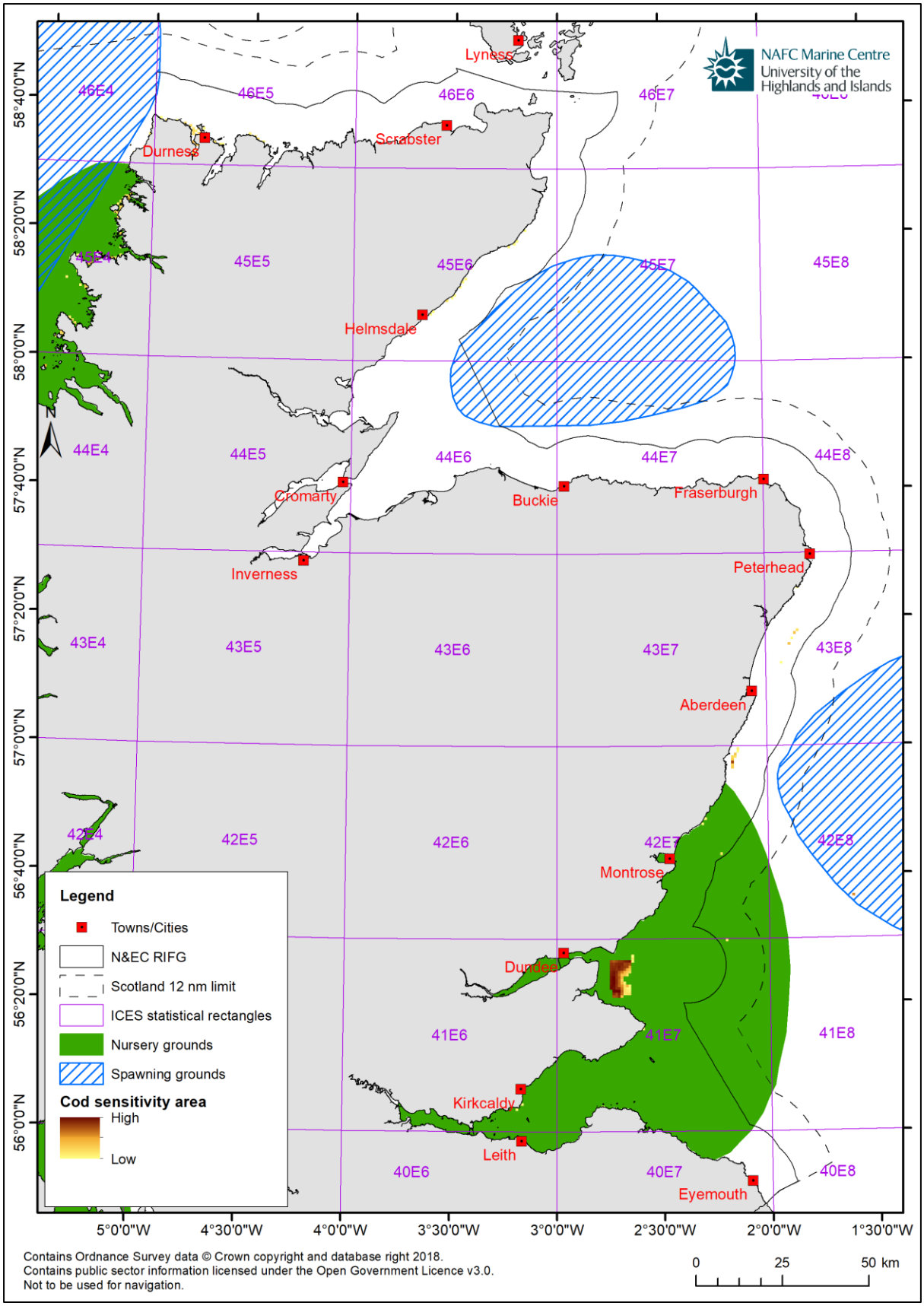

Figure 19 Cod sensitivity areas with nursery and spawning grounds.

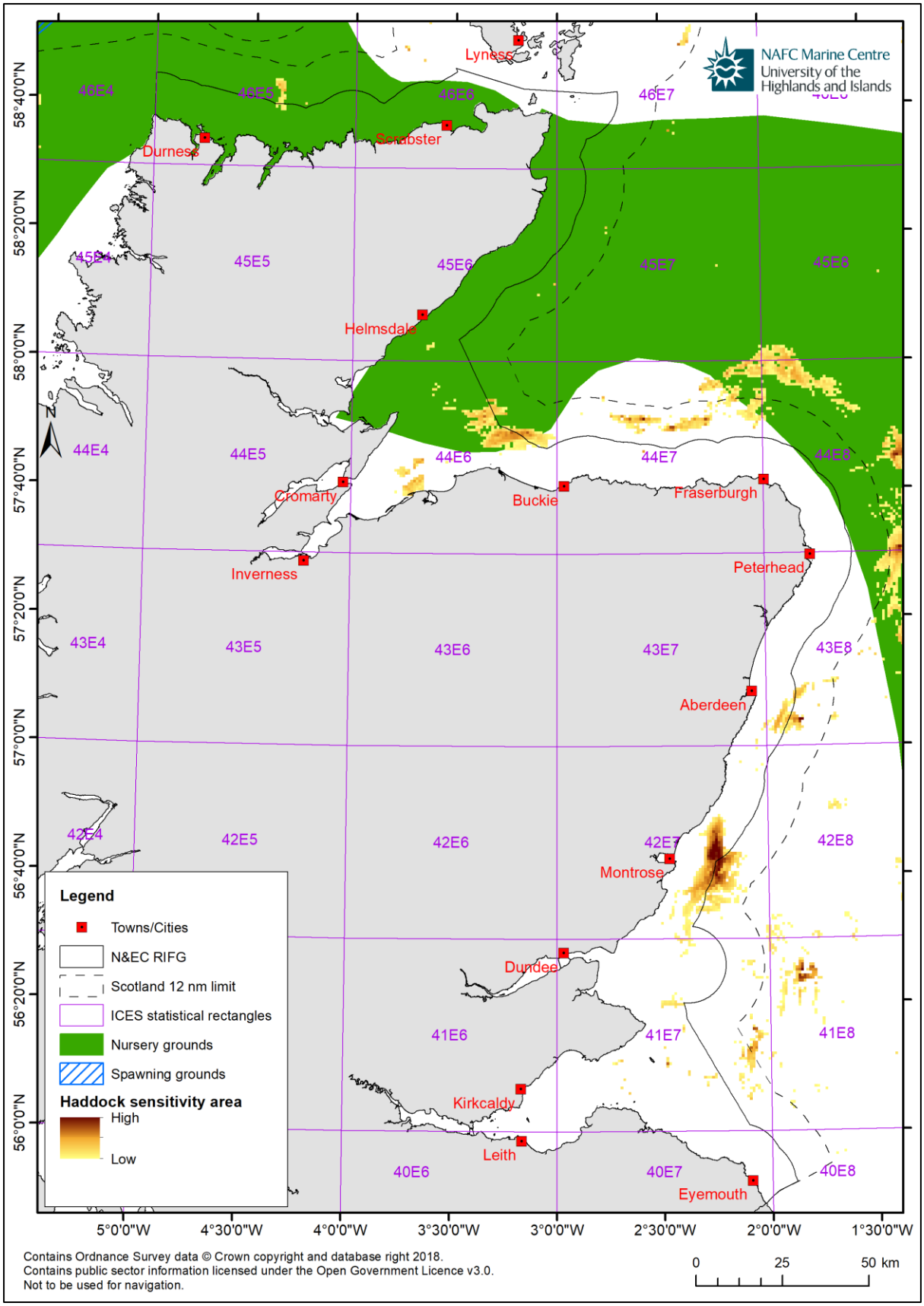

Figure 20 Haddock sensitivity areas with nursery and spawning grounds.

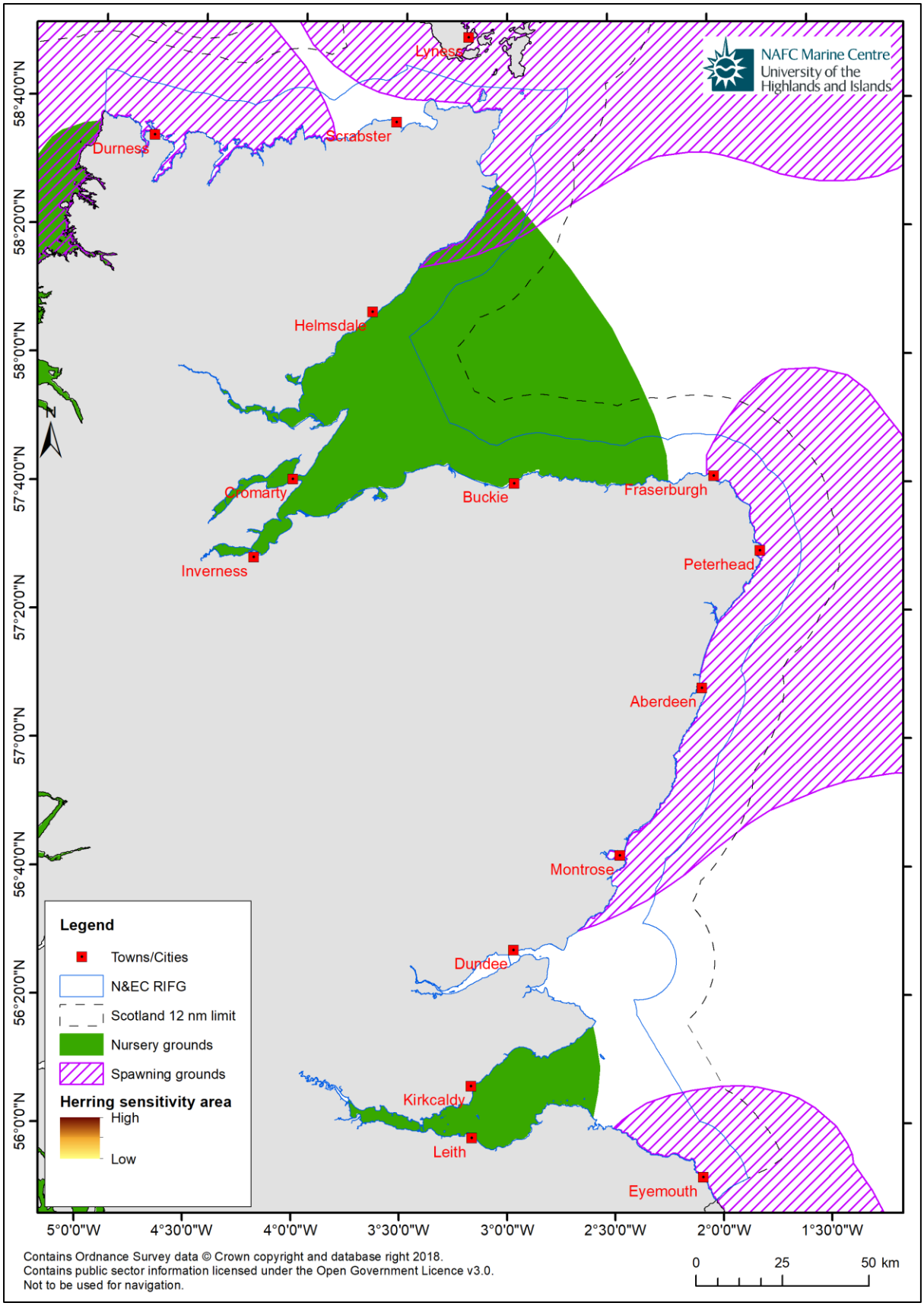

Figure 21 Herring sensitivity areas with nursery and spawning grounds.

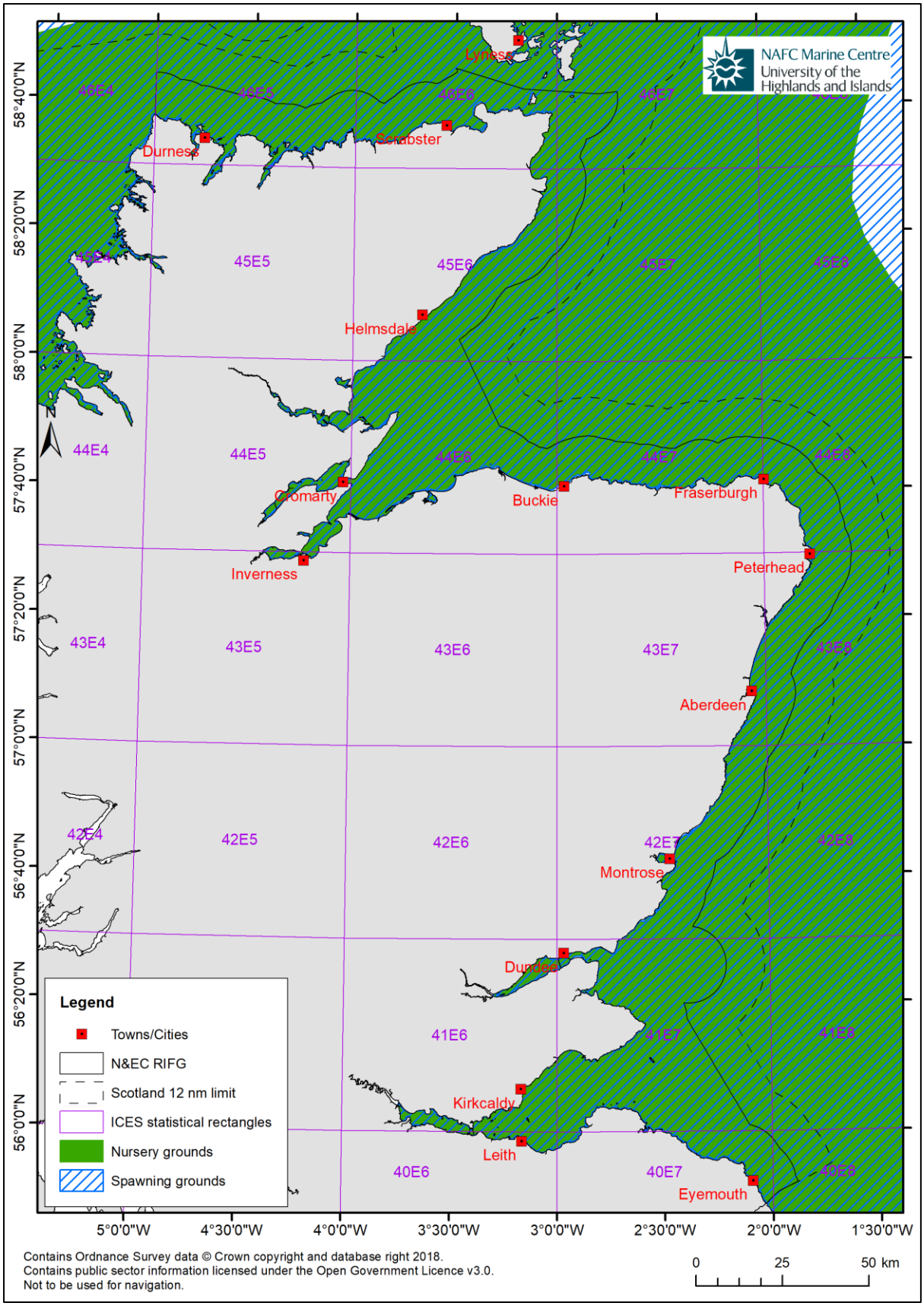

Figure 22 Lemon sole nursery and spawning grounds.

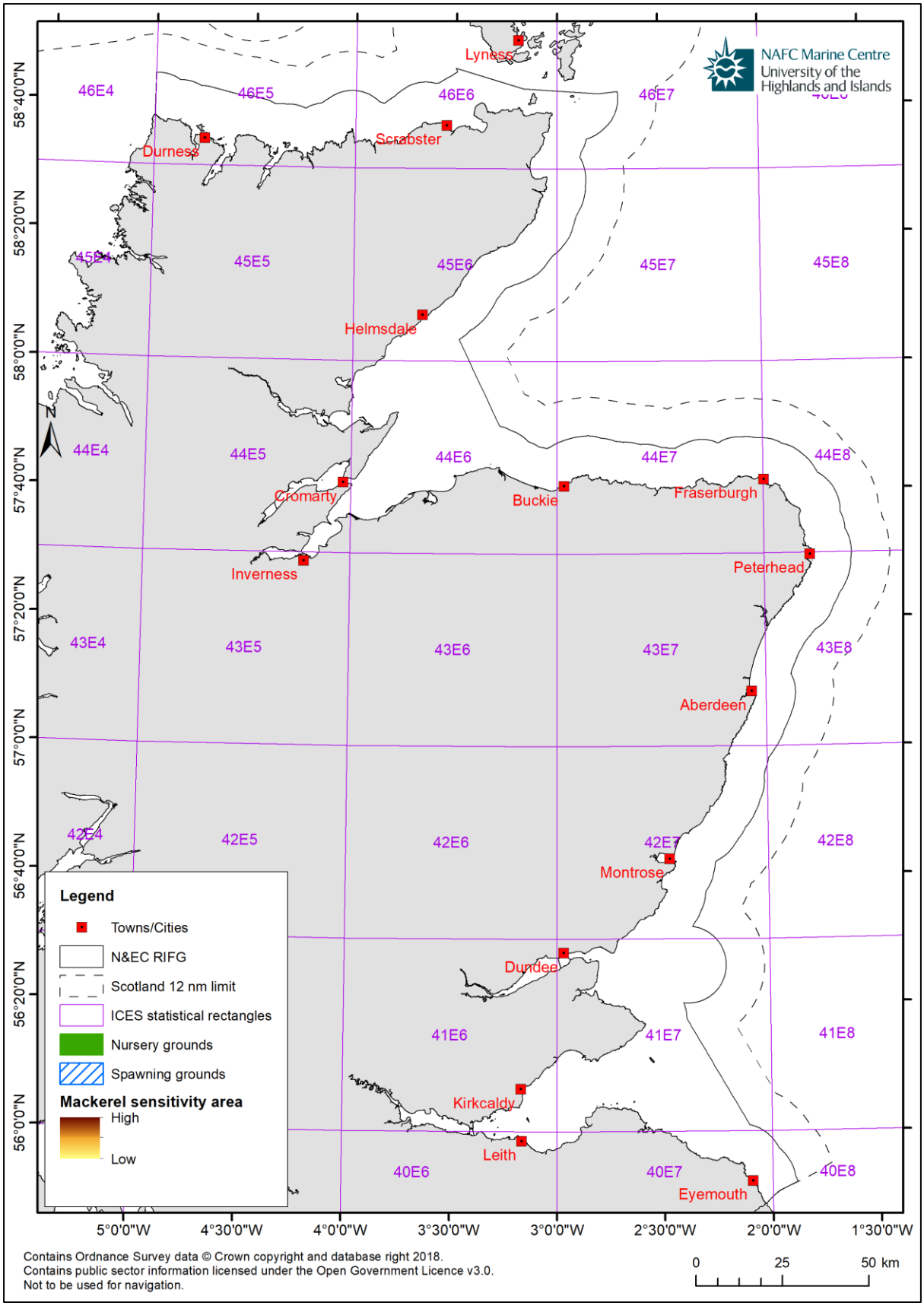

Figure 23 Mackerel sensitivity areas with nursery and spawning grounds.

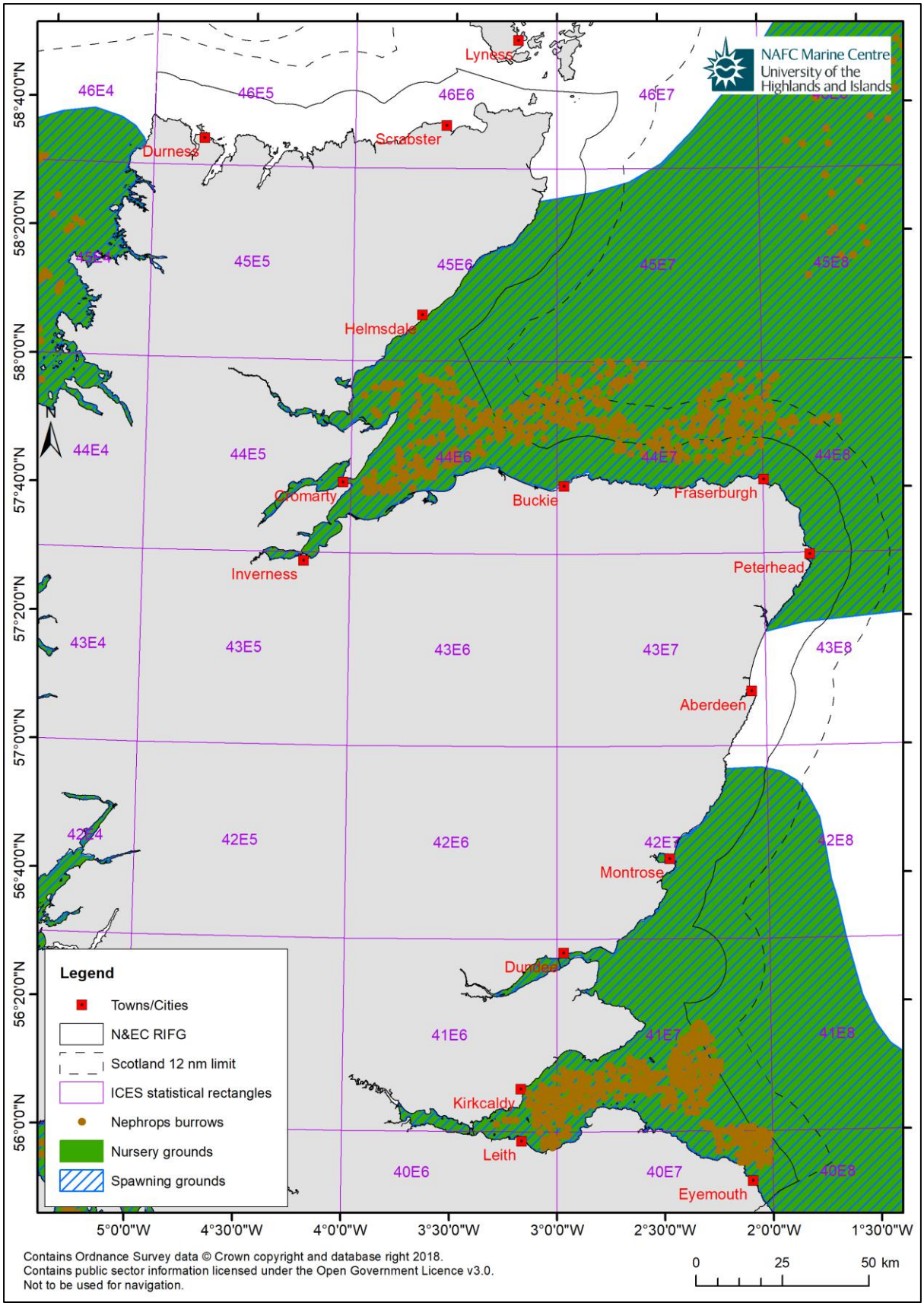

Figure 24 Norway lobster burrow locations from survey data with nursery and spawning grounds.

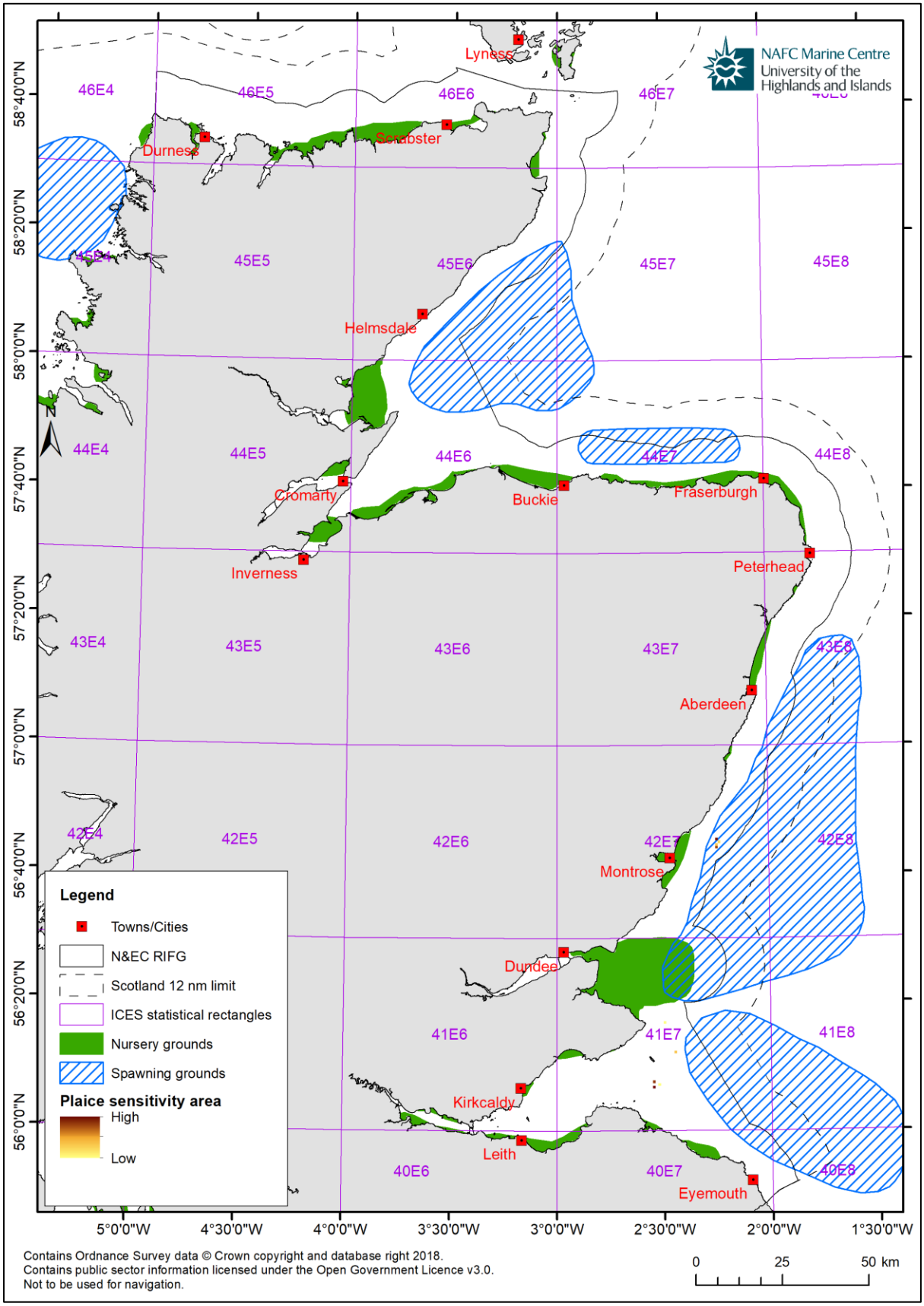

Figure 25 Plaice sensitivity areas with nursery and spawning grounds.

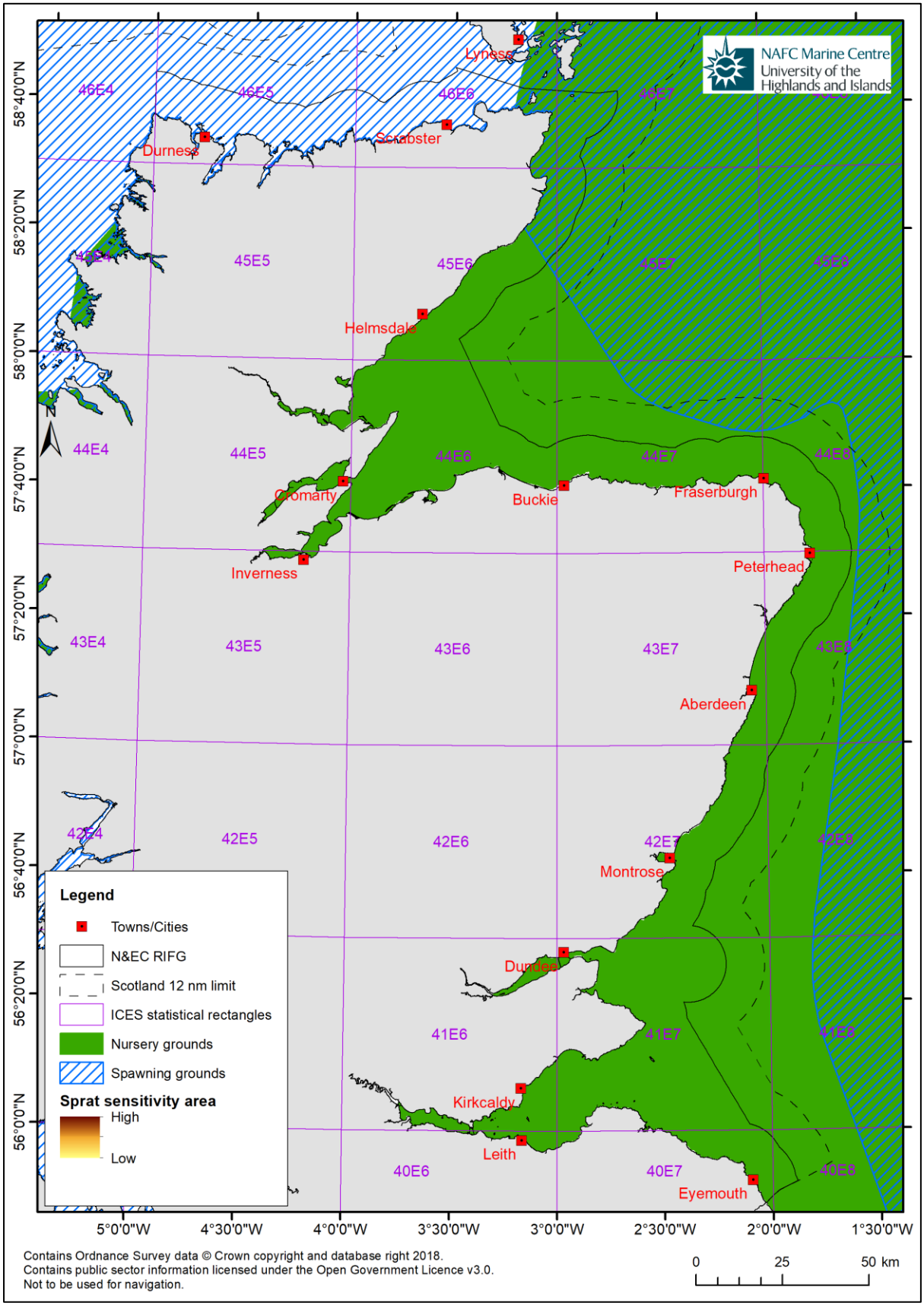

Figure 26 Sprat sensitivity areas with nursery and spawning grounds.

Appendix C Maps of species records

Maps within this Section display the available location records for species listed in Section 3.4. Records were downloaded from a national database, Marine Recorder, but should be treated with caution as any 'gaps' in locations may be due to a lack of surveying in that area, rather than an absence of that species.

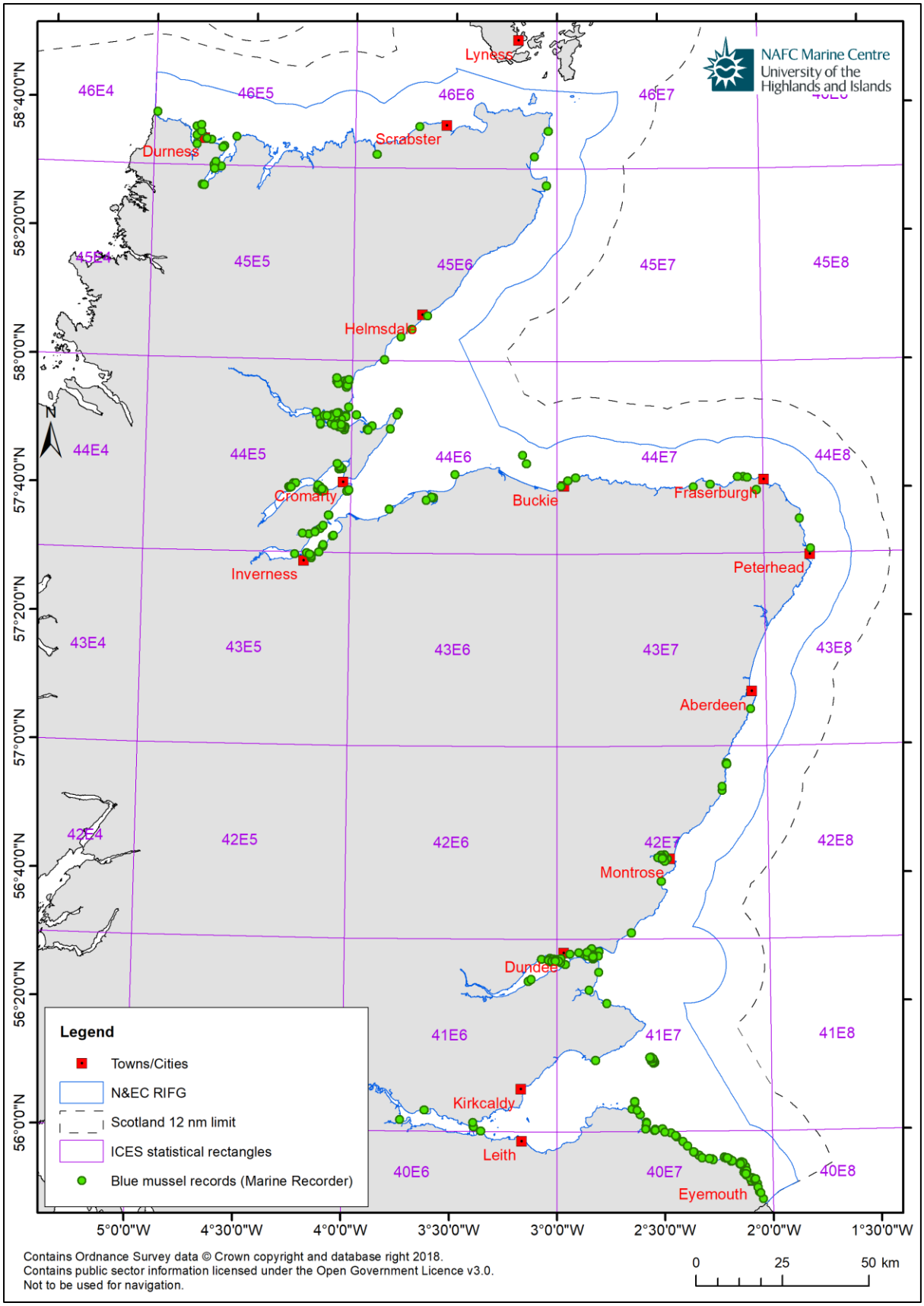

Figure 27 Blue mussel records sourced from the Marine Recorder database.

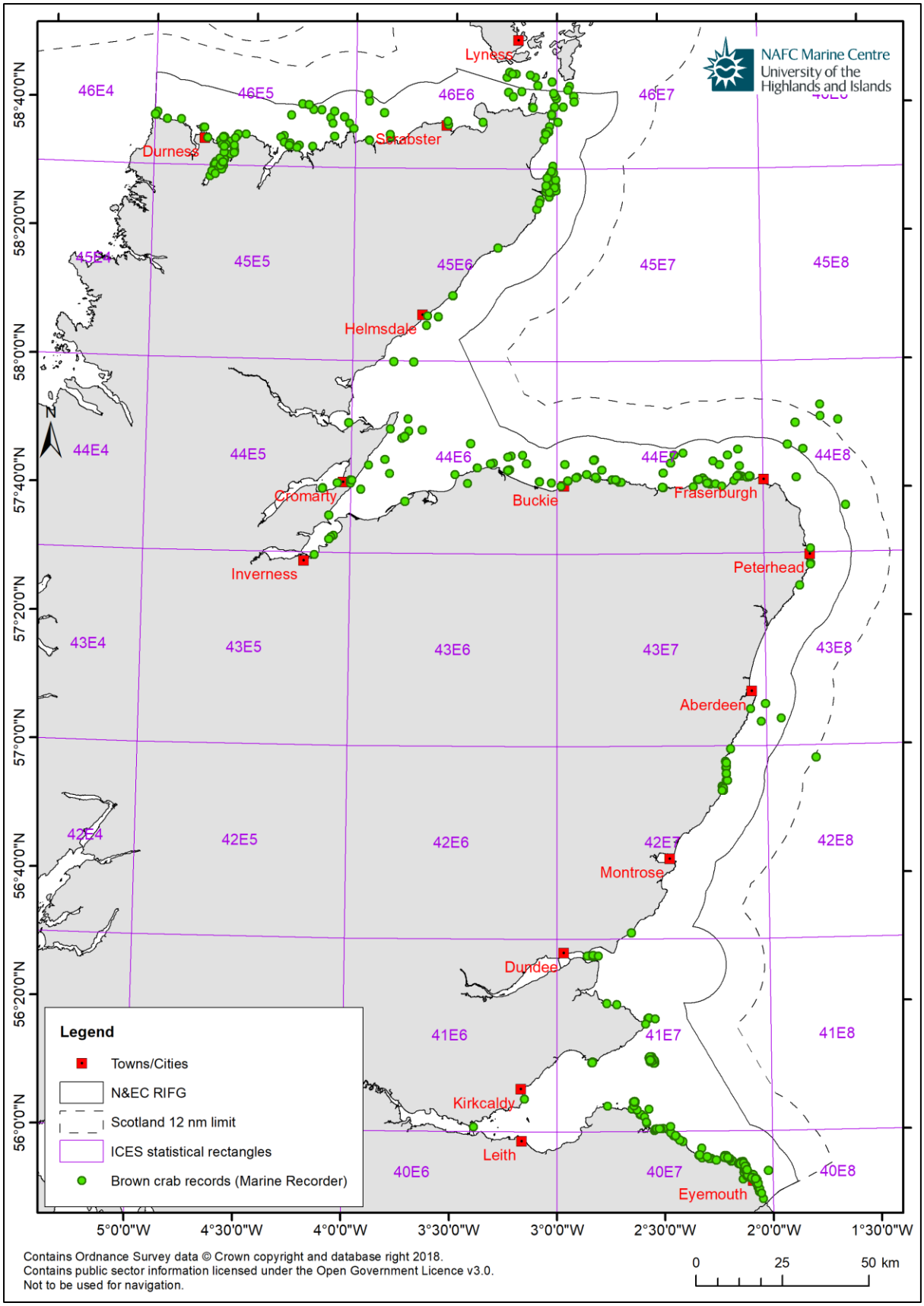

Figure 28 Brown crab records sourced from the Marine Recorder database.

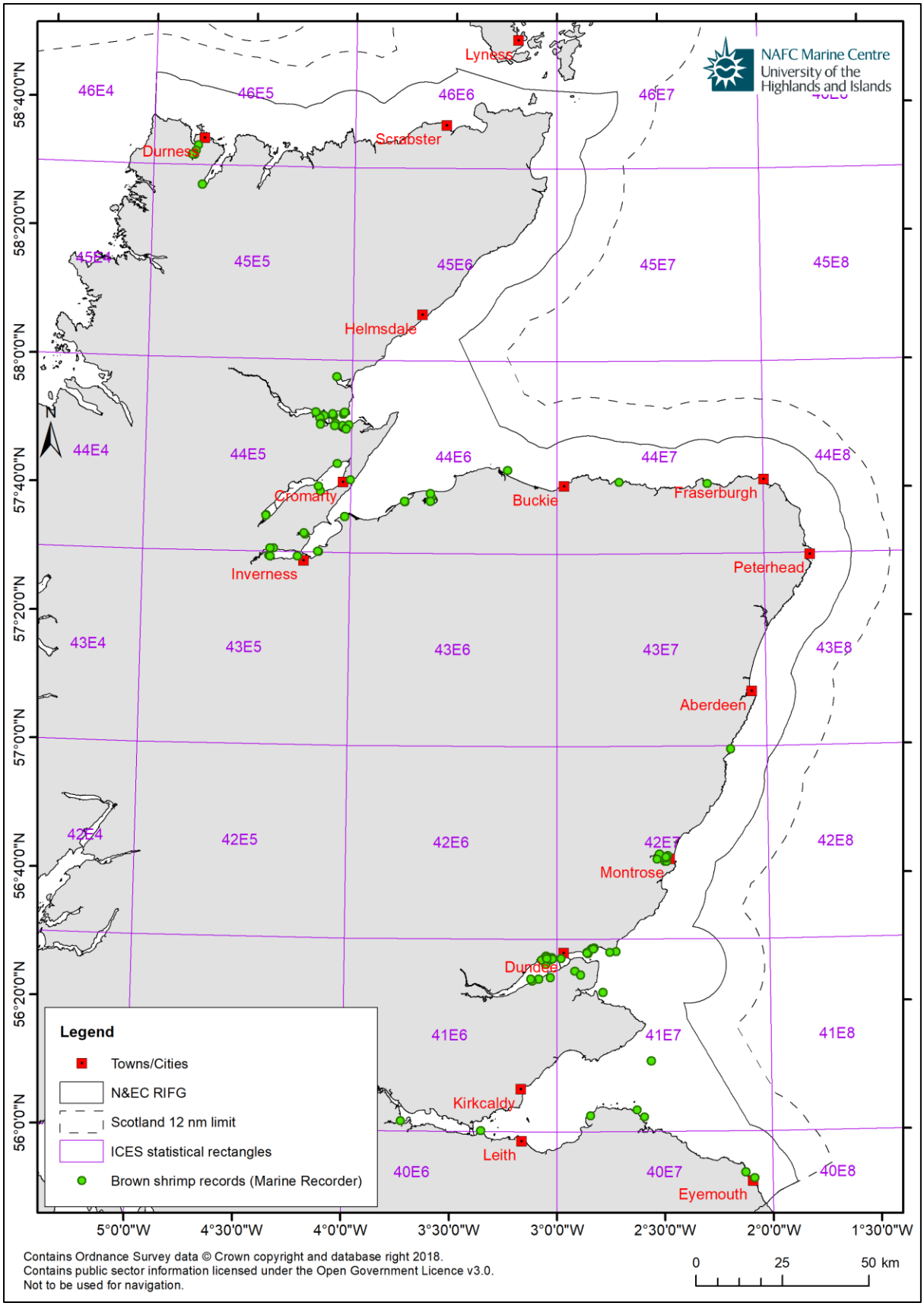

Figure 29 Brown shrimp records sourced from the Marine Recorder database.

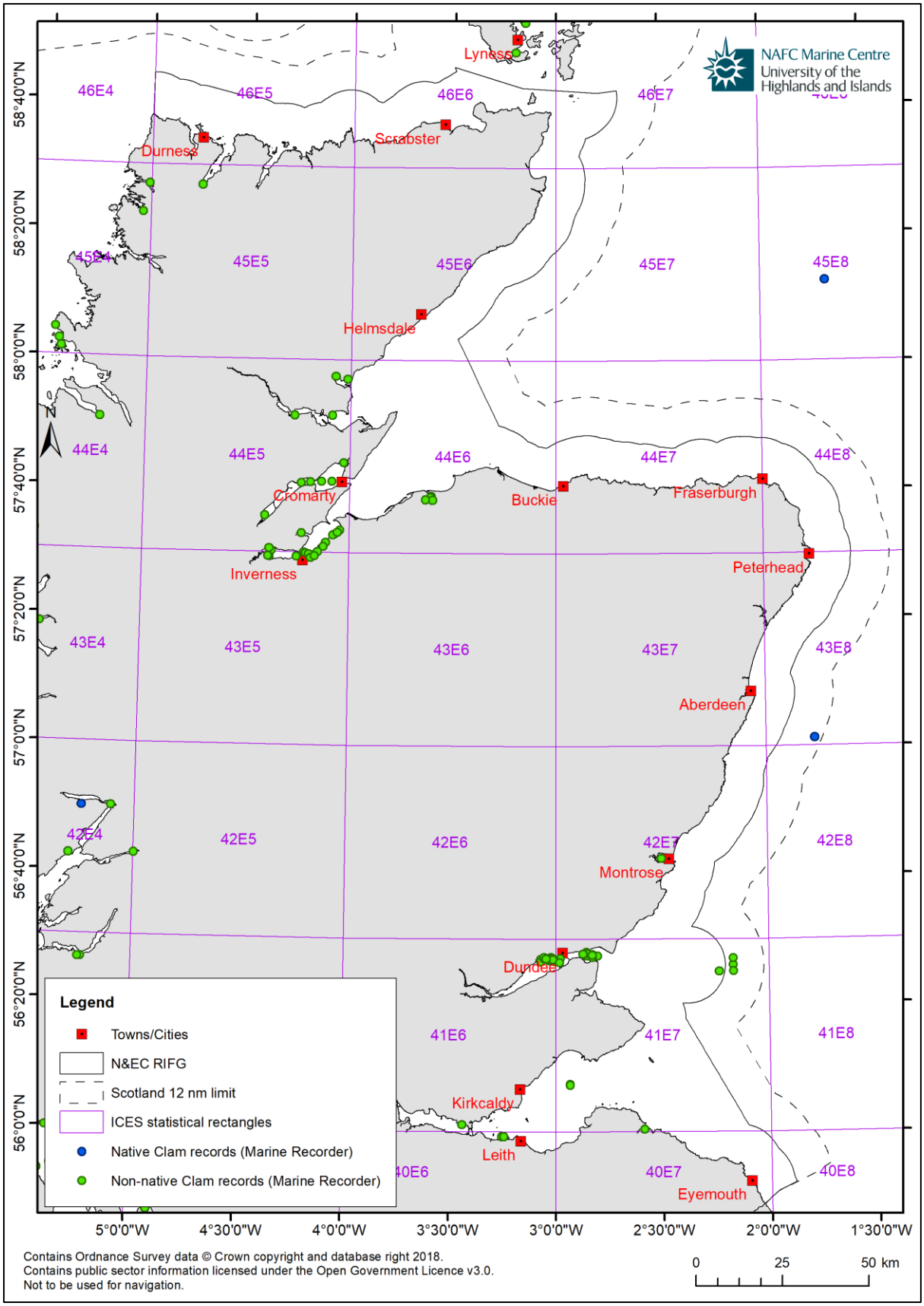

Figure 30 Clam (native and non-native) species records sourced from the Marine Recorder database.

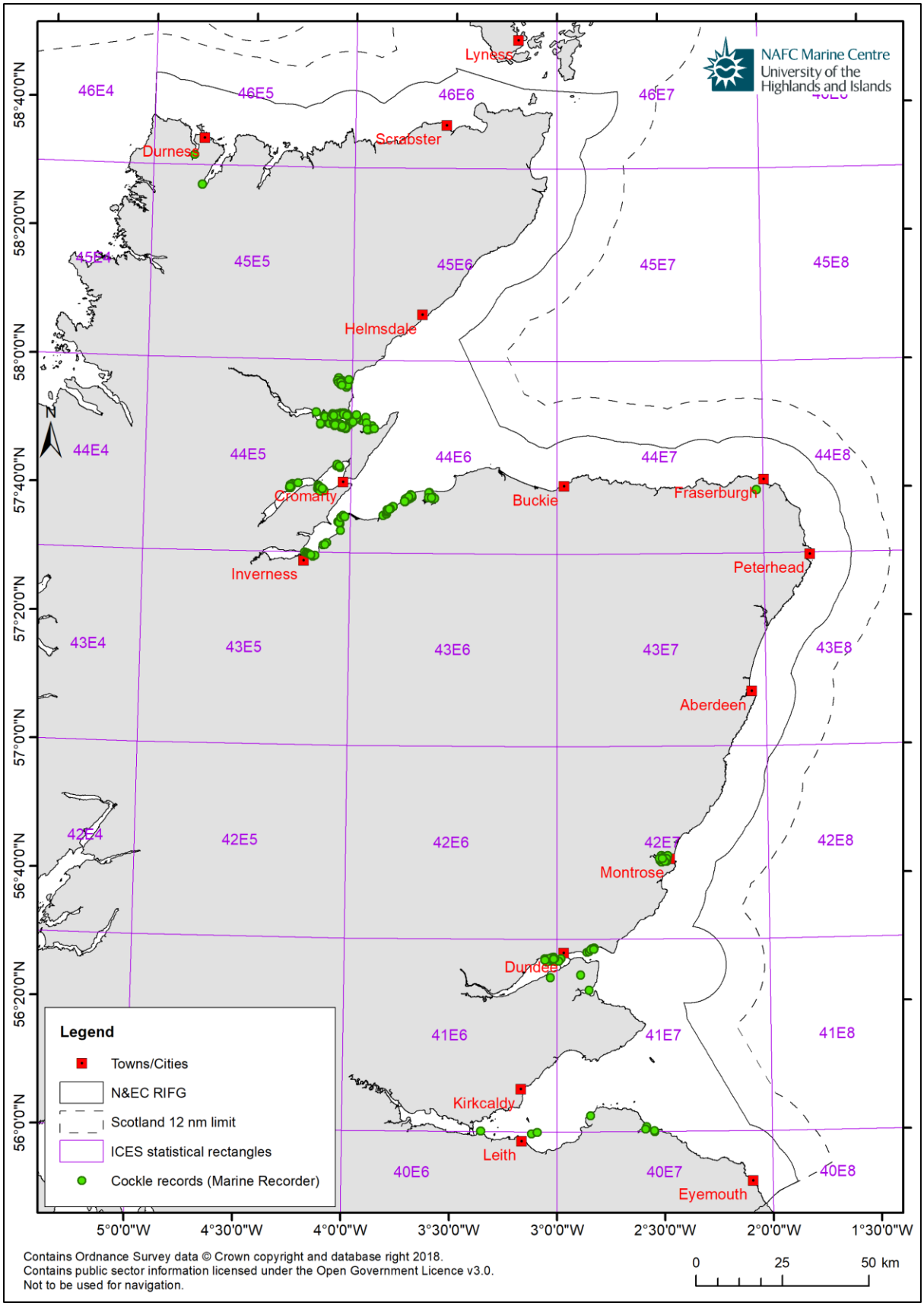

Figure 31 Cockle records sourced from the Marine Recorder database.

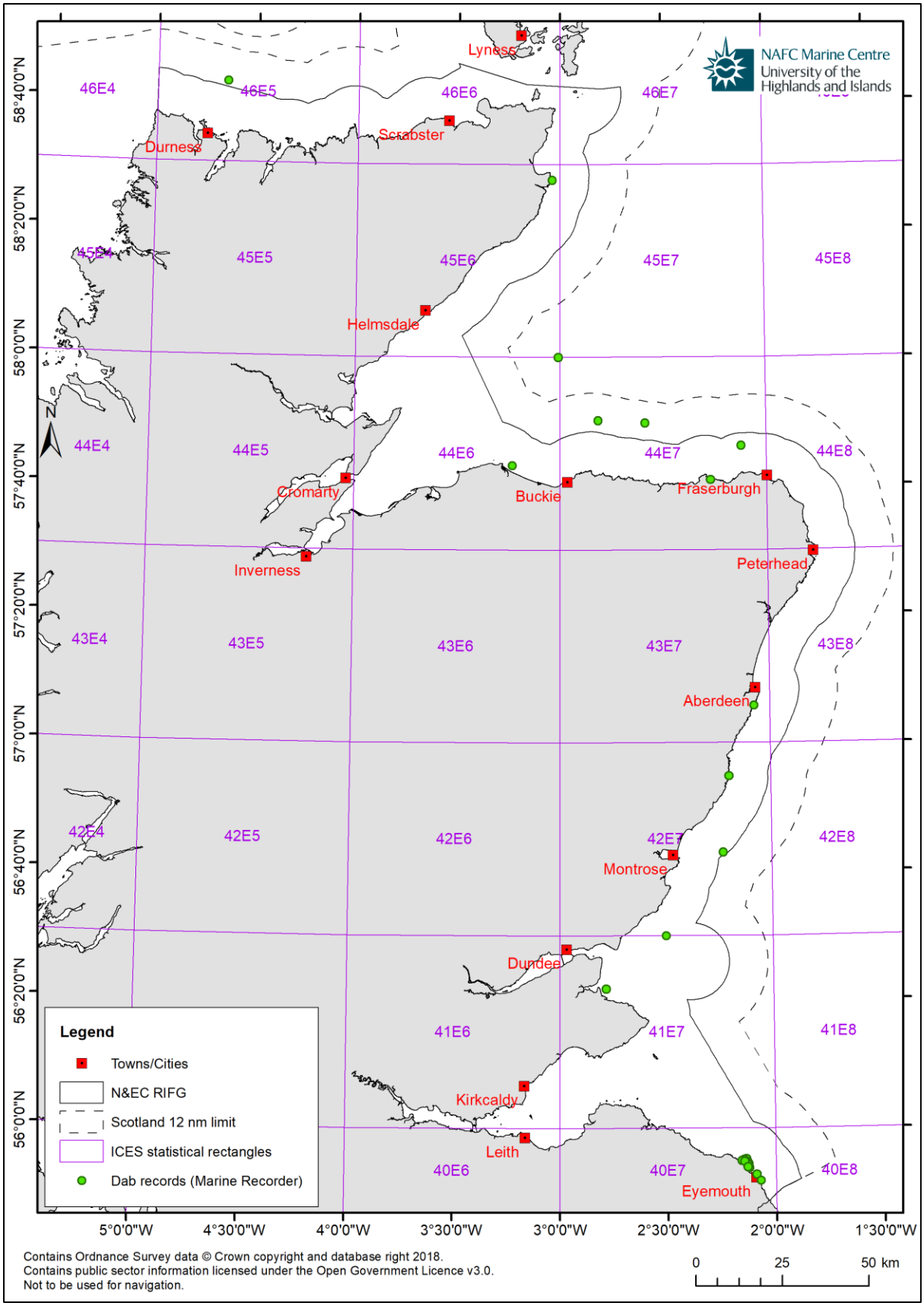

Figure 32 Dab records sourced from the Marine Recorder database.

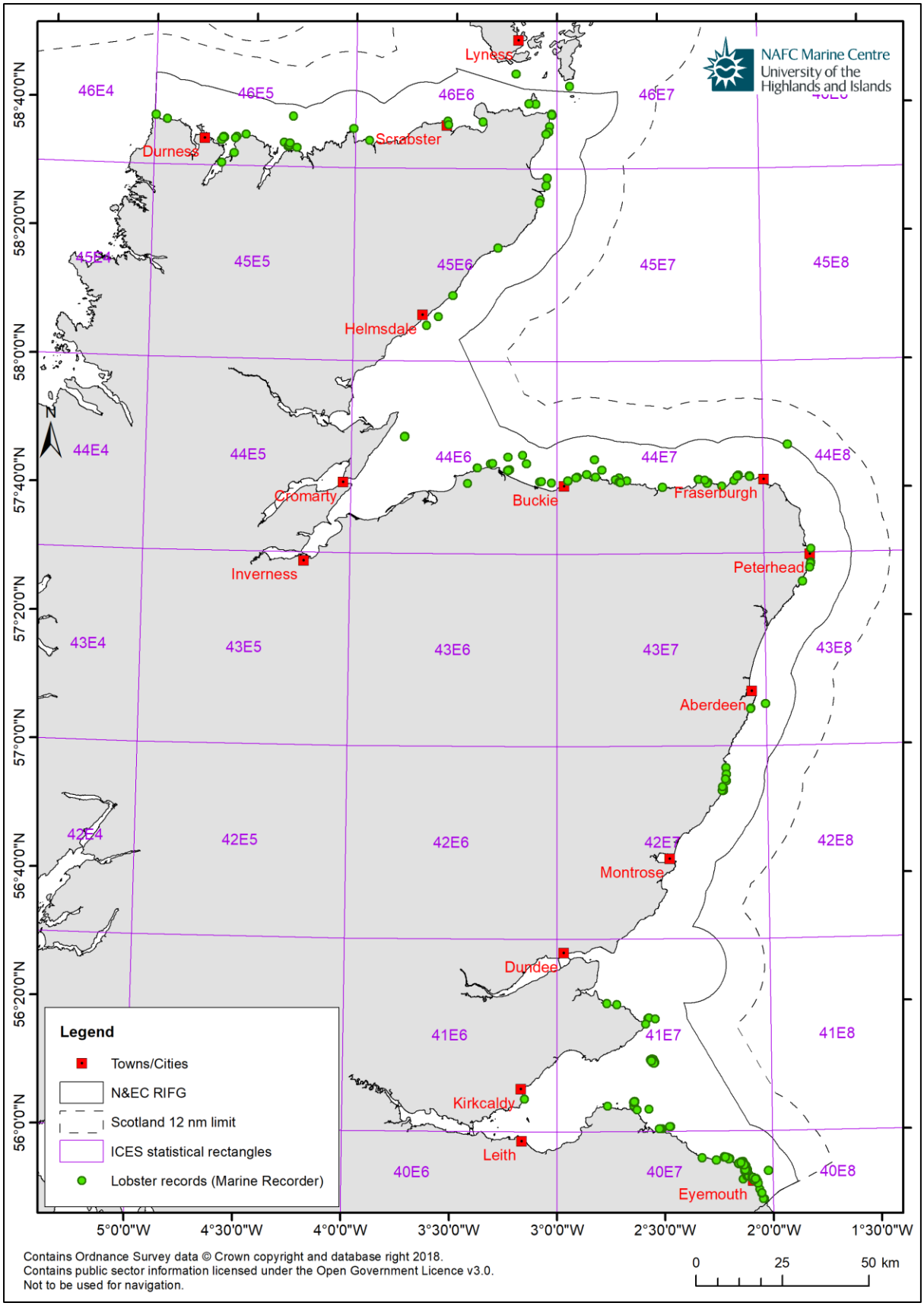

Figure 33 Lobster records sourced from the Marine Recorder database.

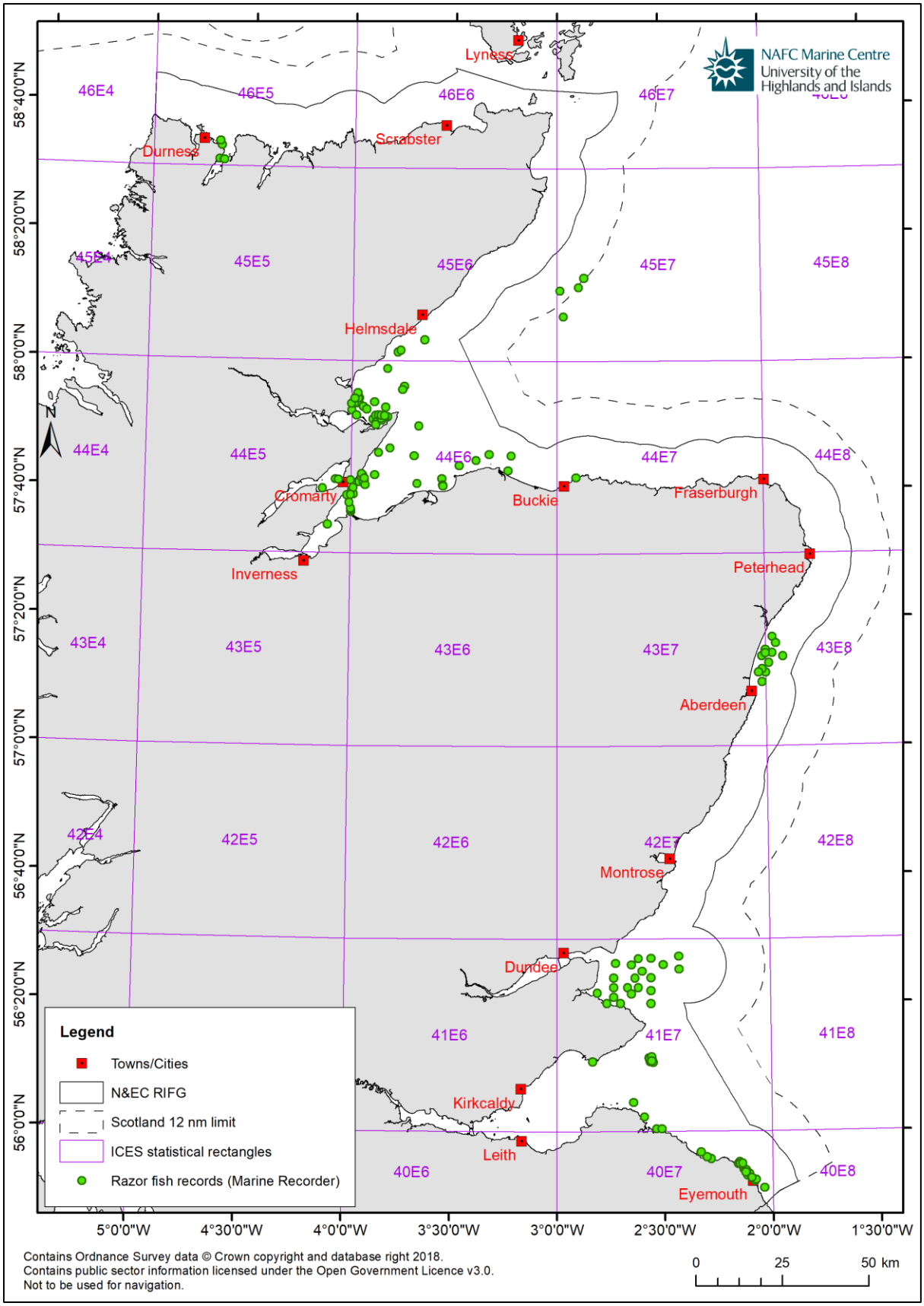

Figure 34 Razor fish records sourced from the Marine Recorder database.

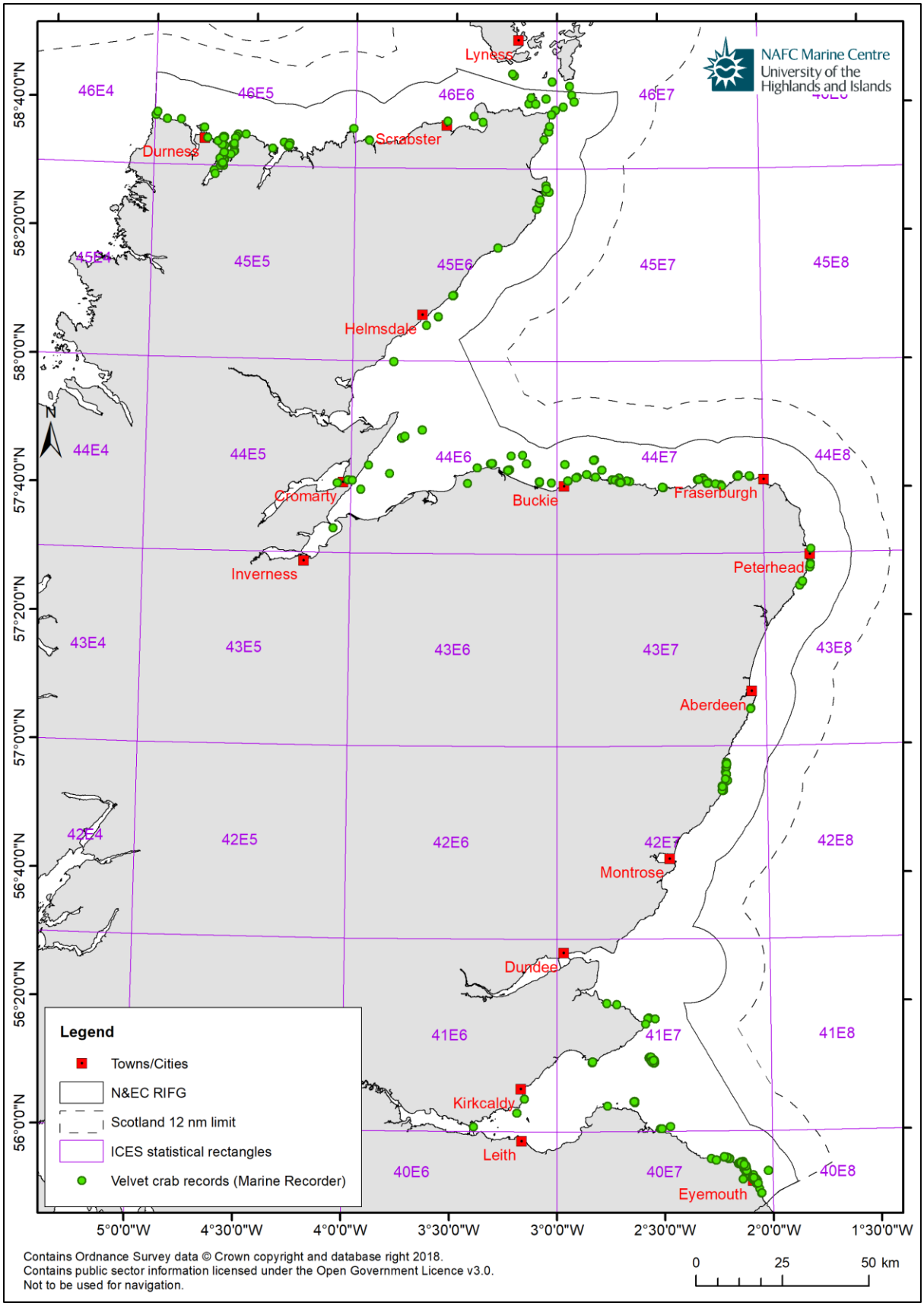

Figure 35 Velvet crab records sourced from the Marine Recorder database.

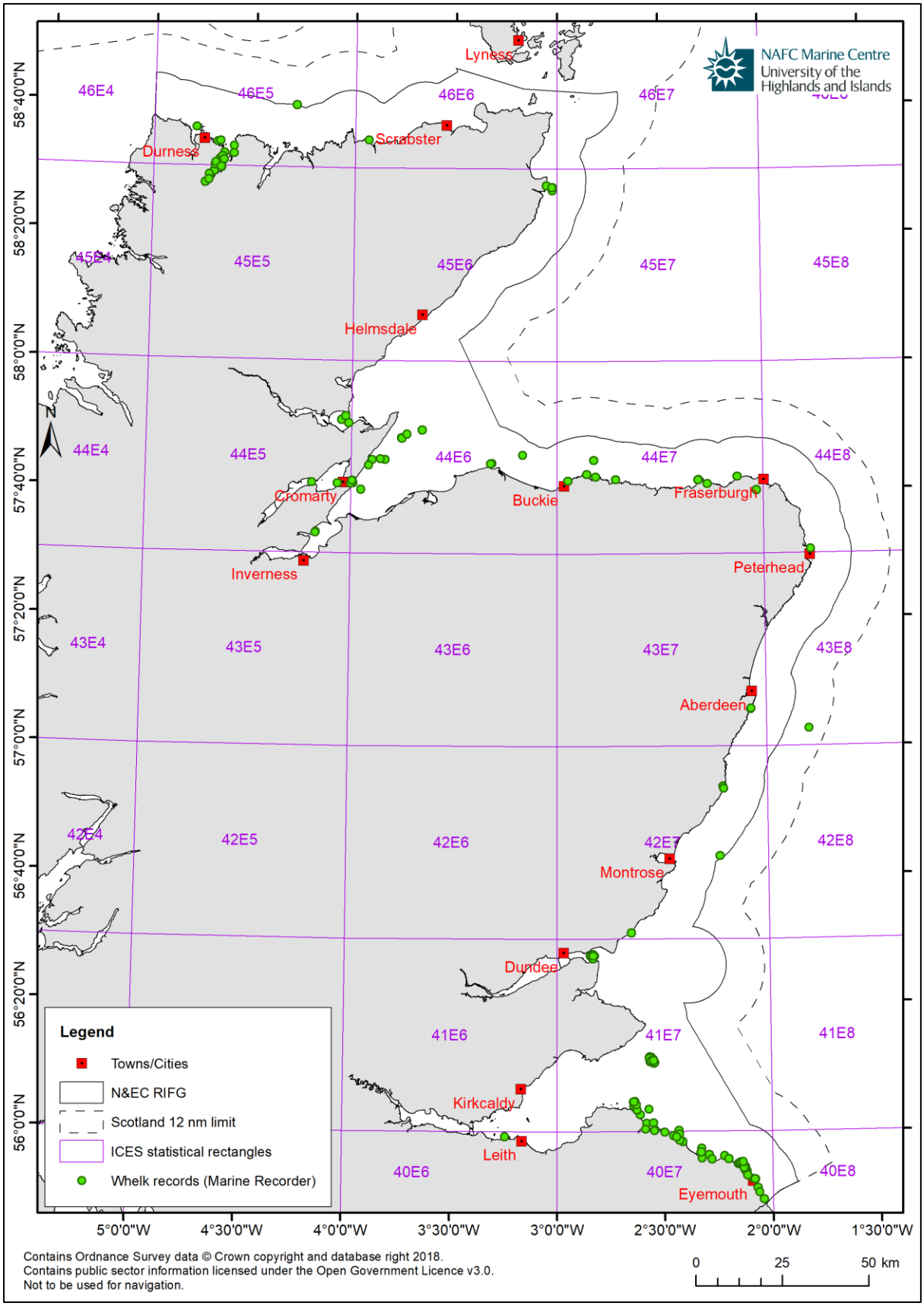

Figure 36 Whelk records sourced from the Marine Recorder database.

Appendix D Scientific analysis

D1 Fisheries location data

There were three main sources of fisheries location data, Automatic Identification System (AIS) tracks available from the Marine Management Organisation (MMO), AIS position data from an EFF Marine Scotland project, gridded Vessel Monitoring System (VMS) data available from ICES, and processed global AIS fishing location grids from Global Fishing Watch. The analysis of each of these data sets were treated separately and are detailed below. Additional fishing location information were also available through surveys from the ScotMap project, a Creel Fishing Effort Study, and the Scottish Marine Recreation and Tourism Survey 2015 with the latter containing information on sea angling from shore and boats.

D1.1 Fishing grounds based on AIS fishing vessel tracks

The annual MMO's vessel track data and the EFF vessel position data were processed to create fishing ground locations.

Annual AIS track information (sourced from MMO) consisted of the first seven days of each month, rather than a complete annual data set. In order to produce a more complete picture of fishing vessel activity, it was appropriate to combine the information from all five available years (2011 to 2015). Vessel speed along the track was not available so it was not possible to automatically identify fishing areas or activity. It was necessary to remove vessel tracks originating from ports (associated with vessel movement and not fishing) in order to better view fishing activity.

AIS position data (sourced from the EFF project) was extracted for the N&EC RIFG region and available from July 2015 to January 2016. The data for this region included 144 inshore vessels. Position data was converted to track data for each vessel with straight line speed and distance values calculated. High speed vessel track sections were removed from the analysis to enable a clearer picture of fishing activity.

Each area of fishing activity in and around the N&EC RIFG region was mapped with each fishing area assigned a likelihood and occurrence score. Likelihood scores were classed as 'low', 'moderate', or 'high' based on the ease of defining fishing activity. Occurrence scores ('low', 'medium', or 'high') were based on the number of vessel tracks within a fishing area. A final score was assigned to each defined fishing area based on the combination of the Likelihood and Occurrence values, combined with information available from other sources, such as the Global AIS data set, VMS, ScotMap, and Creel Fishing Effort Study data. This Overall category ('low', 'medium', or 'high') was a reflection on the confidence of the interpretation.

The three Overall categories were assigned values of 1 (low), 2 (medium), and 3 (high). These values were used with other available data sets to obtain a series of maps that combined all the available information for fishing activity (see Section D1.5).

D1.2 VMS data for bottom contact gear types

Gridded VMS fishing information was available from 2009 to 2016 for the whole UK EEZ. Information was extracted for all ICES statistical rectangles within the N&EC RIFG and out to the 12 nm limit. The information was predefined based on the species caught and gear used (termed "species/gear type class"). Each type class for each year were merged and the associated summary statistics calculated.

Five categories were defined, using Jenks (a scientific way of grouping data), to display each species/gear type class. The top three categories of each layer were exported in order to provide a summary for that species/gear type class. The different gear types targeting cod were merged to one layer, which resulted in five species group summaries (cod and flatfish, Norway lobster and shrimps, scallops, sprat, and other species).

Each species/gear type class was also defined to three categories, using Jenks, of mean annual hours fished. Each category was assigned a value of 1, 2, or 3 with three relating to areas of high fishing effort and one to areas of low fishing effort. This information was combined with other available data sets to obtain a series of maps that combined all the available information for each species/gear type class (see Section D1.5).

D1.3 Global AIS

Global AIS fishing vessel information was downloaded as daily .csv files for 2012 to 2016. The information was pre-processed with perceived fishing activity being assigned a value of 'fishing hours'. However, it should be noted that perceived fishing hours may also include other activities, such as guard duties. AIS fishing tracks from the MMO were available up to 2015. For this reason, only 2016 Global AIS data were analysed. Point shapefiles (a file used in mapping which holds information on specific locations of each vessel over time) were created from the daily .csv files and all points remaining within the Scottish EEZ were extracted. These points were then merged to one point shapefile for fishing vessel activity within the Scottish EEZ and converted to a UTM30N projection. Only point information with fishing hours attributed to it was gridded at a resolution of 1×2 km. Gridded data were displayed using Jenks, which was found to be the most appropriate for highlighting fishing activity.

D1.4 Survey information

Three sources of survey data were used: ScotMap (Kafas*, et al.*, 2014), a Creel Fishing Effort Study[9], and the Scottish Marine Recreation and Tourism Survey 2015[10]. All survey data within the N&EC RIFG region were extracted and displayed to three categories using Jenks. Each category was assigned a value of 1 (low), 2 (medium), or 3 (high) before combining with fishing activity (see Section D1.5).

[9] Creel Fishing Effort Study, further information at: www.spatialdata.gov.scot/geonetwork/srv/eng/catalog.search?node=srv#/metadata/Marine_Scotland_FishDAC_1988

[10] Scottish Marine Recreation and Tourism Survey, further information at: https://data.marine.gov.scot/dataset/scottish-marine-recreation-and-tourism-survey-2015

D1.5 Combined fishing activity

Fishing areas defined from AIS vessel track data (MMO and EFF), EU VMS information, and survey information from ScotMap, Creel Fishing Effort Study, and Marine Recreation and Tourism Survey were used to produce a series of combined fishing activity maps. Each combined map was based on three values of 1 (low), 2 (medium), and 3 (high) for each available gear type and species. It was necessary to transform the data in this way to enable adding of the data layers. Each data set was converted to an integer raster and summed using Cell Statistics. This provided a series of simplified heat maps of the summed values. It should be noted, however, that the resulting maps are limited by the input data and the extent of each input data set.

D2 Requested fisheries data

A request for information was submitted to Marine Scotland's Fisheries Statistics. The aim of the request was to compile information held within the FISH1 Forms which have recently incorporated a section for fishers to provide information on the start location (latitude/longitude coordinates) of their fishing activity and the related catch and value information. Unfortunately, at the time of producing this report, the available data required further quality control and was therefore not available for use. The only remaining fishing data information was from the Scottish sea fisheries statistics which is based on ICES statistical rectangles and provides information on landings and value for all Scottish vessels and effort information for all vessels over 10 m in length.

D3 Species records

Species records were sourced from the JNCC Marine Recorder database, which was downloaded as a Snapshot in September 2018. The Snapshot was queried to export all records of the species listed with each species exported to an Excel file for conversion to a GIS shapefile. Species which already had information on their critical habitat (see Section 3.3) were not included.