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Analysis of inshore Vessel Monitoring System data from scallop vessels fishing in Welsh waters between 2012 and 2015

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We work to support Wales' economy by enabling the sustainable use of natural resources to support jobs and enterprise. We help businesses and developers to understand and consider environmental limits when they make important decisions.

We work to maintain and improve the quality of the environment for everyone and we work towards making the environment and our natural resources more resilient to climate change and other pressures.

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Contents

About Natural Resources Wales.....	2
Evidence at Natural Resources Wales	3
Distribution List (core)	4
Distribution List (others)	4
Recommended citation for this volume:	4
Crynodeb Gweithredol	6
Executive Summary.....	6
Background	7
Methodology	9
Areas on interest.....	9
Assumptions and caveats with the iVMS data analysis.....	10
GIS Analyses	11
Results.....	12
iVMS analysis	12
Annual summary of Cardigan Bay and Conwy box activity.	19
Analysis of vessel characteristics.....	21
Discussion	23
Conclusion.....	24
References	24

Crynodeb Gweithredol

Ceir dwy Ardal Cadwraeth Arbennig (ACA) yn nyfroedd Cymru, gyda'r dolffin trwyn potel wrth sail eu dynodiad. Mae gan Lywodraeth Cymru a CNC gyfrifoldebau statudol i reoli'r safleoedd hyn yn unol â'u hamcanion cadwraethol; yn hyn o beth, mae CNC yn rhoi cyngor addas yn ymwneud â gwarchod natur. Er 2010, ceir pryder bod treillio am gregyn bylchog yn effeithio ar adnoddau prae dolffiniaid trwyn potel mewn dwy ardal arbennig y tu allan i'r ACA: ardal Conwy ac ardal Bae Ceredigion. Aeth yr adroddiad hwn ati i geisio mesur gweithgareddau'r fflyd cregyn bylchog yn y ddwy ardal, gan gyflwyno'r wybodaeth hon yng nghyd-destun pysgodfa cregyn bylchog Cymru gyfan.

Er 2012, mae wedi bod yn orfodol gosod system arbennig o'r enw "Succorfish SC2 inshore Vessel Monitoring System" (iVMS) ar longau treillio sy'n gweithredu ym mhysgodfa cregyn bylchog Cymru. Mae'r system yn nodi'n fanwl ble a phryd y mae'r llongau wedi bod yn gweithio. Aethpwyd ati i gynnal dadansoddiadau meintiol a GIS ar y data a oedd yn berthnasol i'r ddwy ardal.

Mae'r canlyniadau'n awgrymu amrywiad o dymor i dymor yn y gweithgarwch. Mae lefel y gweithgarwch yn y ddwy ardal dan sylw yn gymharol isel o'u cymharu ag ardaloedd eraill a gaiff eu pysgota gan y fflyd cregyn bylchog. O ran yr ymdrech bysgota dybiedig, nid ystyrir ardal Conwy nac ardal Bae Ceredigion yn ardaloedd pwysig yn eu rhinwedd eu hunain o safbwynt treillio am gregyn bylchog..

Executive Summary

There are two Special Areas of Conservation (SAC) in Welsh waters that have Bottlenose dolphin as a qualifying feature. The Welsh Government and NRW have statutory responsibilities to manage these sites in line with their conservation objectives; NRW provide appropriate nature conservation advice in this respect. Since 2010 there has been a concern that scallop dredging may impact the prey resources of Bottlenose dolphins in two specific areas outside of the SACs: the Conwy box and Cardigan Bay box. This report sought to quantify the activities of the scallop fleet in both these areas and to present this information in the context of the entire Welsh scallop dredge fishery.

It has been a mandatory requirement to install the Succorfish SC2 inshore Vessel Monitoring System (iVMS) on scallop vessels prosecuting the Welsh scallop fishery since 2012. The system details exactly where and when the vessels have been operating. Quantitative and GIS analyses of these activity data were carried out relative to the two areas.

The results suggest season-by-season variation in activity. The level of activity in both areas of concern is relatively low compared to other areas fished by the scallop fleet. In terms of assumed fishing effort the Conwy box and Cardigan Bay box are not considered important scalloping grounds in their own right.

Background

The Scallop Dredging Tracking Devices Wales Order 2012 requires all vessels engaged in the Welsh scallop fishery to have an inshore Vessel Monitoring System (iVMS) installed. The technology is provided by Succorfish Ltd and records the location of the vessel, its course and speed at regular ten minute intervals and transmits that data to a server in real time. Three years of data have been generated to date. The data are used to monitor the fleet during the fishing season in terms of regulation and can be further analysed to identify the possible overlap of potential fishing effort with protected features.

The Scallop Fishing (Wales) (No2) Order 2010 prohibits scallop fishing in the majority of Welsh European Marine Sites. The Atlas of Marine Mammals of Wales (Baines & Evans 2012) identified two areas with high densities of Bottlenose dolphins outside of the areas afforded protection under the Scallop Order 2010. These areas are located north of Conwy and Southwest of Cardigan Bay, which for the purposes of this report are referred to as the 'Conwy box' and the 'Cardigan Bay box' respectively. Given the high density of Bottlenose dolphins in these areas, there is a potential for scallop fishing to have an effect on this species. However, both areas have remained open to scallop fishing since 2010.

The areas currently closed to scallop fishing under the Scallop Fishing (Wales) (No.2) Order 2010 and both the Conwy and Cardigan Bay boxes are shown in Figure 1.

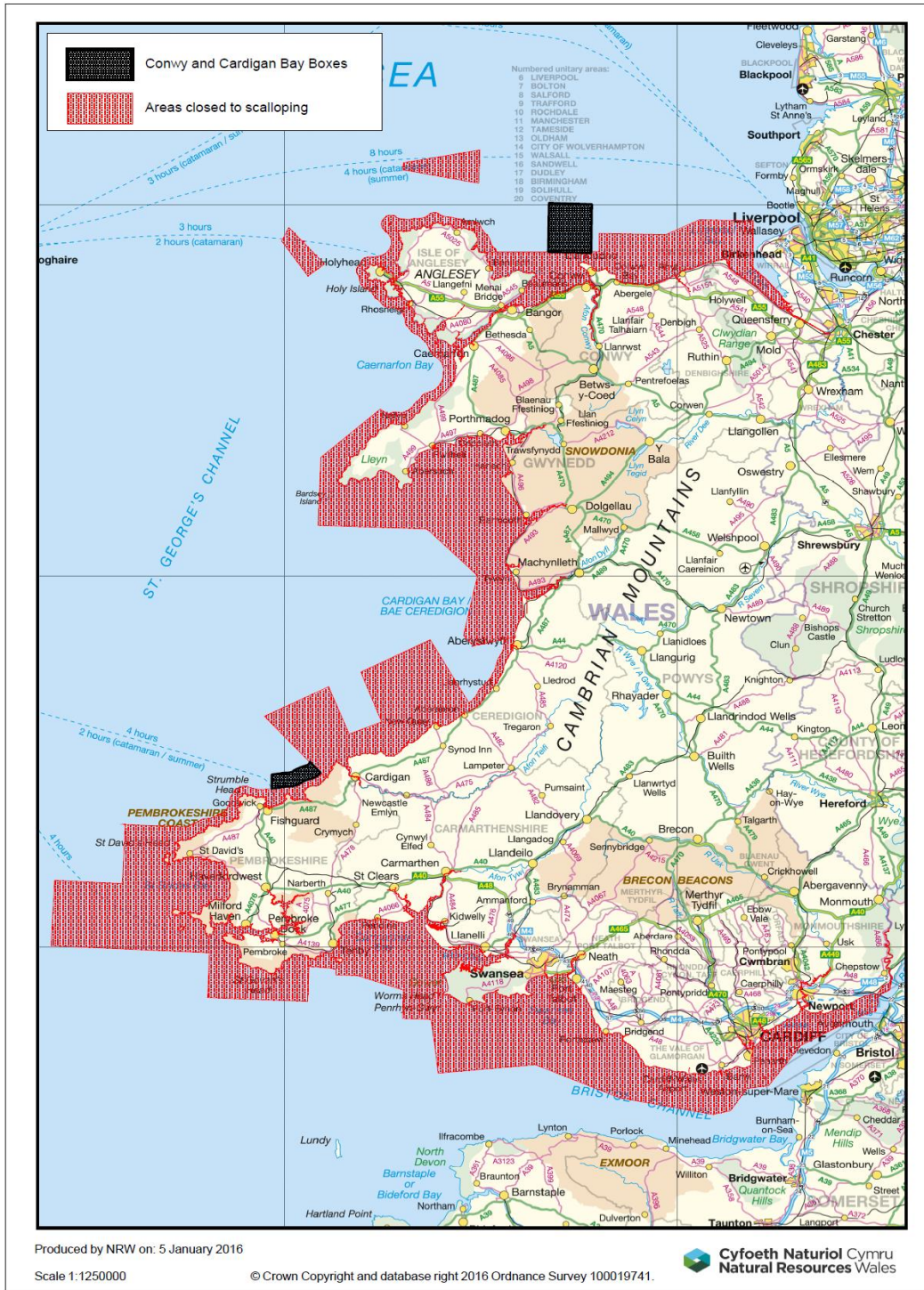


Figure 1. Map of Welsh Government closed areas to scallop fishing (red) with the Conwy and Cardigan Bay boxes shown (black).

The purpose of this report is to conduct an analysis of the scallop fishery iVMS data in Welsh waters with a particular focus on the Conwy and Cardigan Bay boxes described above.

Methodology

Succorfish were required to examine the distribution and temporal patterns of likely fishing effort of the scallop fishery in Wales with particular emphasis on the two areas of concern. The following methodological objectives were defined:

1. Filter raw iVMS data for vessels assumed to be fishing
2. Provide Kernel Density Estimates to highlight core fishing areas at a Welsh scale.
3. Provide Kernel Density Estimates for the Conwy box and Cardigan Bay box
4. Quantify the number and period of visits by scallop vessels into the Cardigan and Conwy boxes
5. Carry out simple fleet analysis on the participating fishing vessels.

Areas on interest

The Conwy box (Figure 2) and Cardigan Bay box (Figure 3) were geo-fenced on the Succorfish iVMS software system from the coordinates provided by NRW in Table 1. A geo-fence is a virtual barrier created by a user of the Succorfish software which allows the user to set up 'breaches' when a vessel enters (or exits) the boundaries defined by the geo-fence. These breaches are then saved in a structured database and data can be extracted at a later date.

Table 1. Coordinates of the Cardigan Bay and Conwy boxes

Cardigan box						Conwy box	
Lat	Long	Lat	Long	Lat	Long	Lat	Long
52.0793	-4.968	52.085058,	-4.79169	52.063602,	-4.874602	53.483	-3.99888
52.08236	-4.93466	52.082015,	-4.798446	52.061605,	-4.877164	53.483	-3.83633
52.08347	-4.91696	52.079394,	-4.805717	52.058772,	-4.881603	53.3653	-3.83633
52.08669	-4.90131	52.077195,	-4.813674	52.055931,	-4.885625	53.3653	-3.99888
52.09347	-4.88453	52.077423,	-4.822662	52.053722,	-4.890676		
52.09878	-4.86878	52.076384,	-4.83165	52.052894,	-4.89666		
52.10165	-4.85507	52.075979,	-4.840981	52.052903,	-4.901883		
52.10493	-4.84411	52.073885,	-4.849625	52.052326,	-4.906813		
52.10938	-4.83263	52.072108,	-4.858012	52.052278,	-4.910197		
52.1134	-4.8287	52.068643,	-4.865712	52.048983,	-4.93875		
52.0881	-4.78871	52.065599,	-4.870837	52.0459,	-4.9649		



Figure 2. Conwy box



Figure 3. Cardigan box

Quantitative analyses involved a bulk download of the Conwy box and Cardigan box geofence activities for season 2013-14 and season 2014-15. The geofenced areas were only created after season 2012-13 had elapsed so it was not possible to download the activities for the first season. However, GIS data exist for the 3 years analysed in this report. The data were downloaded into an Excel spreadsheet and pivot tables created in order to undertake the analysis. These data were combined with lists of all vessels engaged in the fishery and were tagged with their country of registration and their registered overall length.

For the purpose of analysing the geo-fence breaches any breach below 60 minutes was deemed to be transiting rather than fishing. This is based on the most likely courses taken by vessels 'cutting through' both areas on their way to and from ports/fishing grounds, allowing up to 60 mins transiting at between speeds of 6 and 12 knots.

The report only presents aggregated and anonymised data in order to protect the interests of fishermen.

Assumptions and caveats with the iVMS data analysis

Fishing speed

Over the course of the fishing season, the Succorfish iVMS software records the location of all scallop fishing vessels in Welsh waters every 10 minutes and records the entry and exit of fishing vessels into the two geo-fenced areas. The iVMS system is not capable of monitoring whether a vessel is fishing or not. Instead, speed of travel is used to ascertain potential fishing activity. To extract this information, a filter was applied to the data based on a speed rule. Under normal circumstances while a vessel is at sea it will do one of two things, either steam to and from the fishing grounds or tow its gear. Steaming speeds for a scallop vessel will vary by boat, the weight of load on board and weather conditions. Normally a vessel would be expected to be steaming at speeds between 6 and 12 knots. The authors experience indicates that when scallop dredging, a vessel will normally tow at speeds of between 3 -4 knots (Howarth & Stewart 2014) and slow down to a stop when hauling. Based on these values, all activity that occurred outside the fishing ports of speeds between 0 and 4 knots were assumed to be fishing activity. This assumption is broad and will be incorrect in some instances, such as when a vessel breaks down or if it is passing through a strong tidal area.

Fishing season and activity

The Scallop season in Welsh water extends over the 6 month period (181 days) from November 1- April 30. Only data generated within the scallop season were used in the analysis for those vessels with a permit to fish for scallops. Not all the vessels fished for scallops throughout the season and some will have used other gears and/or fished in other locations. It is not possible to separate out data for non-scallop fishing activity, so for the purpose of this report it was assumed that all the activity was scallop fishing. Any data indicating activity outside the Welsh jurisdiction were removed in the analysis. Additionally, data from the Bangor University 2014 experimental scallop fishing intensity trial¹ were removed from the data set so as not to skew the analysis.

¹<http://fisheries-conservation.bangor.ac.uk/wales/reports.php.en?menu=1&catid=10722&subid=10805> See reports 59, 60 & 61

GIS Analyses

The analyses were undertaken within a GIS system (ArcMap 9.3.1). The Succorfish SC2 units used in this project generated 18 Comma Separated Values (CSV) files (one per month) to generate iVMS data. The iVMS data include latitude and longitude values of vessel positions during the fishing season for the period 1 Nov 2012 – 30 March 2015. Vessel positions were represented as point data within the GIS and used as the basis for Kernel Density Estimation (KDE). KDE calculates the magnitude of data points per unit area to create a surface of density across a defined area. By presenting the data in a kernel density plot the user can discern the relative concentration of activity based on a colour scale.

iVMS data were grouped together for the fishing seasons for three periods (2012 - 2013, 2013 – 2014 and 2014 – 2015) and collated together in one file containing all of the data. The raw iVMS output can be seen as grey points in Figure 4. The fishing speed assumption described above was then used to identify the fishing only data and this can be seen in Figure 5. Further analysis was carried out on the iVMS data set based on seasonal activity and variable data resolution.

Figures 7, 8 and 9 exclude data generated by the vessels participating in the Bangor School of Ocean Science experimental fishery in April 2014. It was not possible to filter the data based on the individual vessels activity. Rather all the activity from individual vessels participating in both the experimental fishery and the public fishery were removed from the data set. As a consequence an amount of activity by vessels participating in the public fishery were removed.

Results

iVMS analysis

The total raw iVMS data for the whole of Wales for each year and for all years combined is displayed in Figure 4. This does not indicate fishing vessel activity, only their position at the time of reporting. Each point on the map represents a position report with some areas having multiple reports.

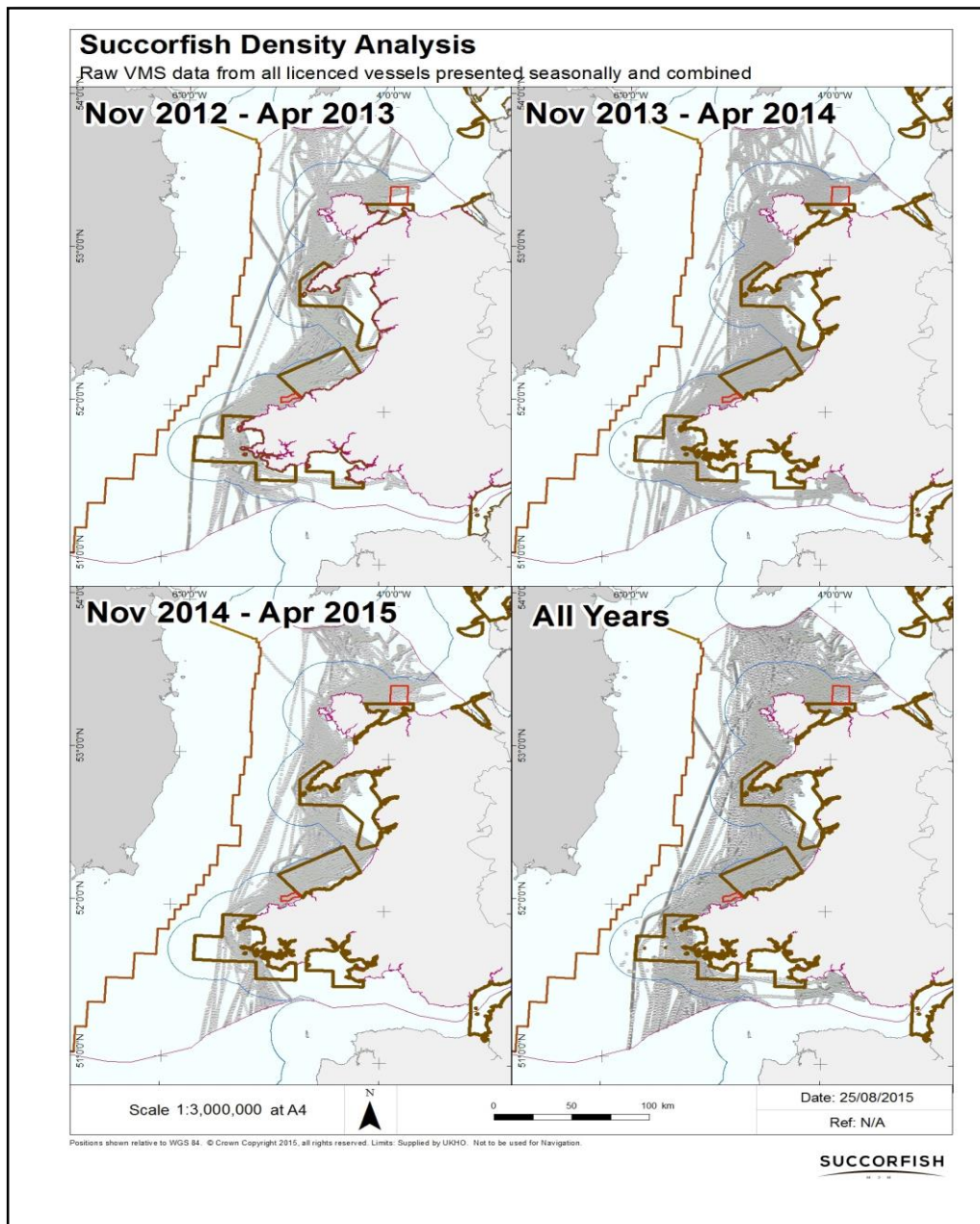


Figure 4. Raw iVMS data from scallop vessels presented annually and combined. Each data point (grey) represents a vessel position but not whether that vessel was fishing. Activity displayed at 1km resolution.

Assumed fishing activity was based on vessel fishing at speeds of less than 4 knots. Figure 5 shows the locations of probable fishing activity annually and cumulatively over the 3 years, based on this assumption of fishing speed. The resolution of these data is displayed at 1km / point and multiple data points are overlaid (concentration of fishing activity is therefore not represented).

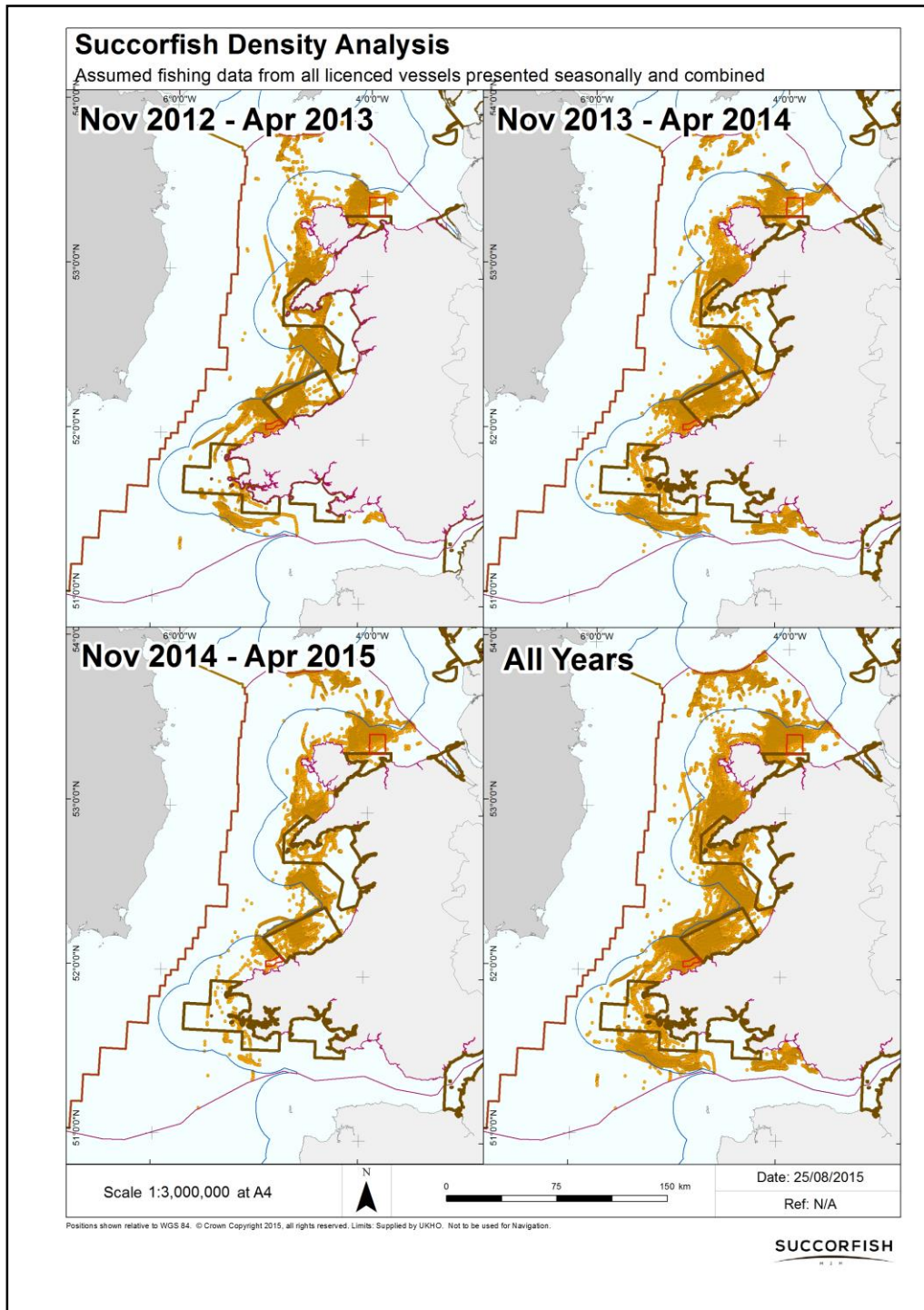


Figure 5. Assumed fishing activity (vessel speeds <4 knots) from raw iVMS data for all licenced scallop fishing vessels. Three years of fishing effort are presented annually and combined. Activity displayed at 1km resolution.

By overlaying the data of Figure 5 on top of that of Figure 4, we get an indication of where the main fishing grounds are located relative to the operation of the fleet (Figure 6). Routes to and from the grounds become clear for Welsh waters. However none of these figures (Figures 4-6) give an indication of fishing intensity.

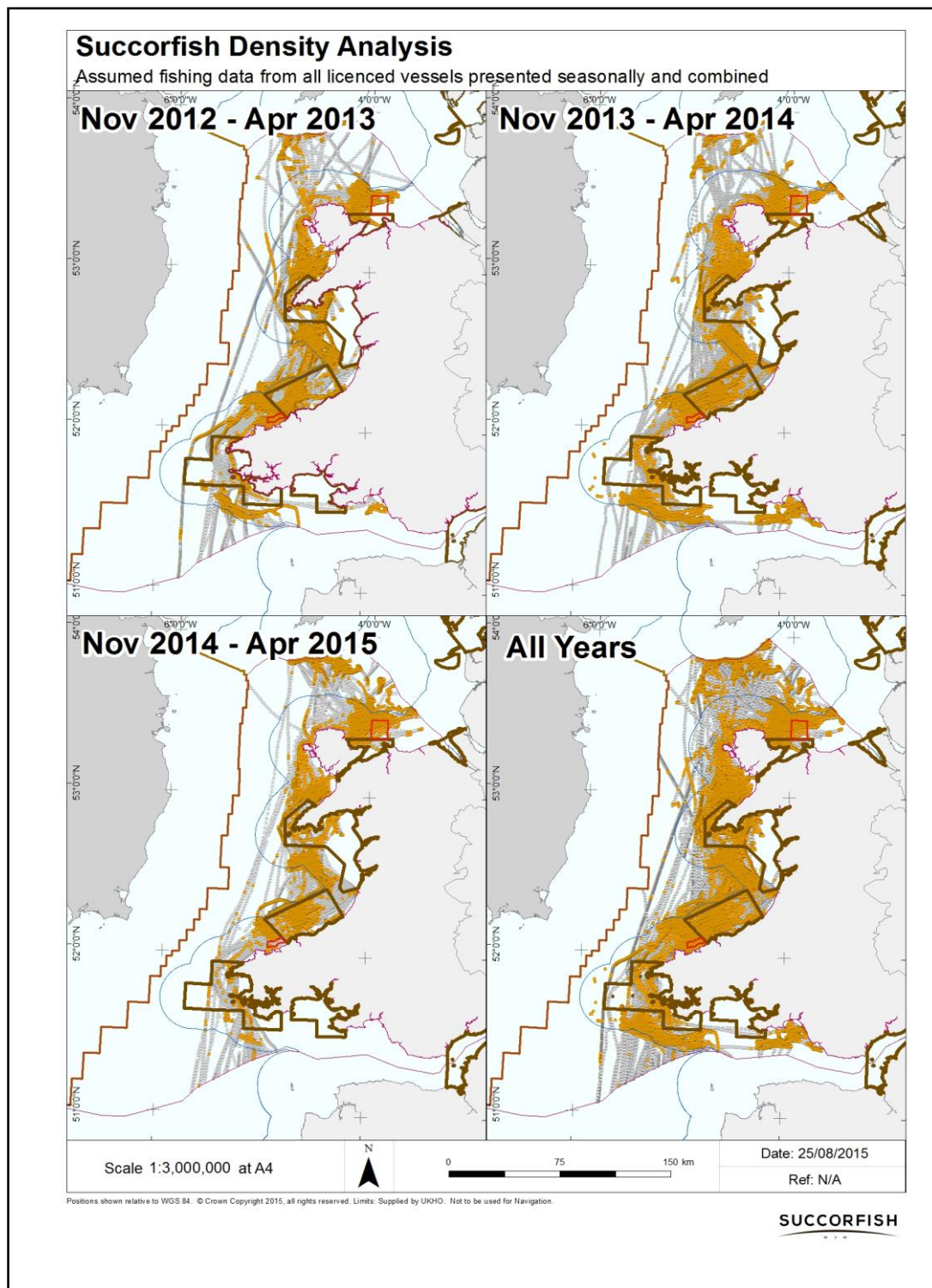


Figure 6. Overlay of assumed fishing data (orange) on vessel location data (grey) in Welsh waters. Data presented seasonally and combined and displayed at 1km resolution.

The KDE of the assumed fishing data indicates the concentration (intensity) of activity based on a colour scale (also called a heat map). Data resolution can have a significant impact on the interpretation of the graphical outputs. Figure 7, including data from the Bangor School of Ocean Science experimental fishery in April 2014 clearly presents the difference between resolutions (from 500m, 100m to 10m) and indicates the increasing accuracy and frequency of data points with higher resolution data.

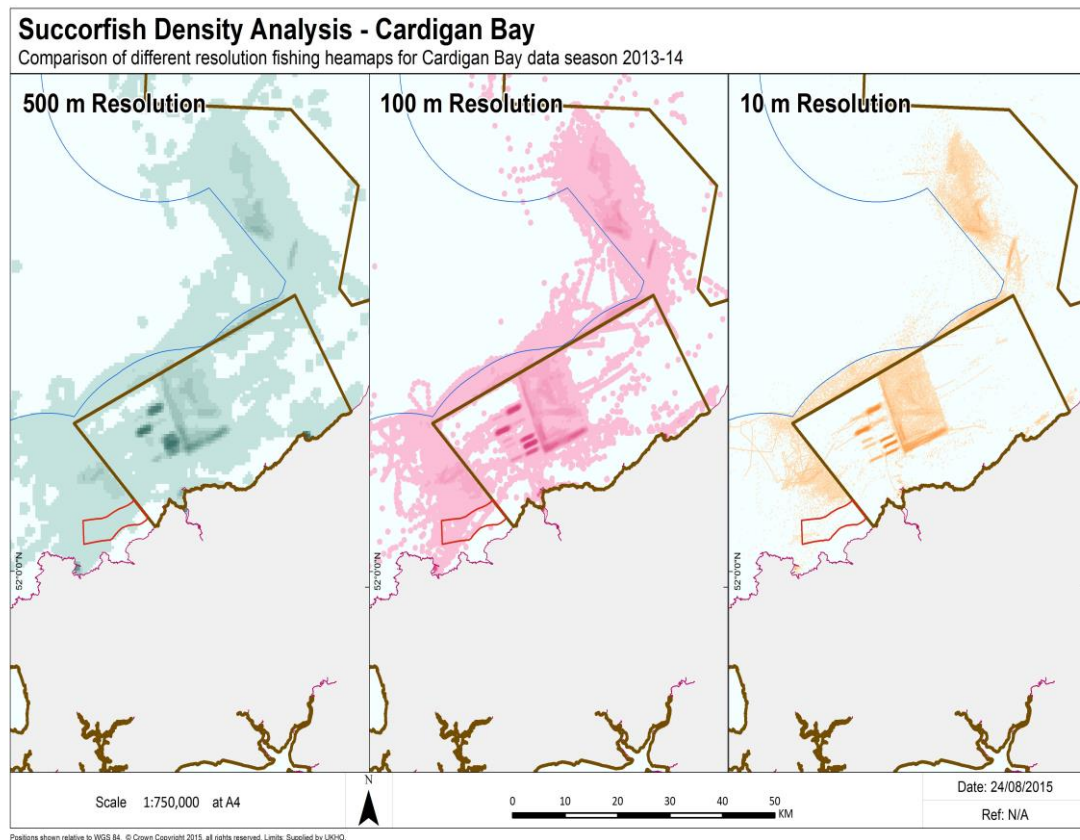


Figure 7. Comparison of different resolutions of kernel density plots (heat maps) for assumed fishing data in Cardigan Bay during the season 2013-14. Here, data includes the Bangor University, School of Ocean Sciences experimental fishery data.

Utilising the 10m resolution, areas of potential fishing activity can be identified at a Welsh scale (Figure 8) and within the Cardigan Bay (Figure 9) and the Conwy (Figure 10) boxes.

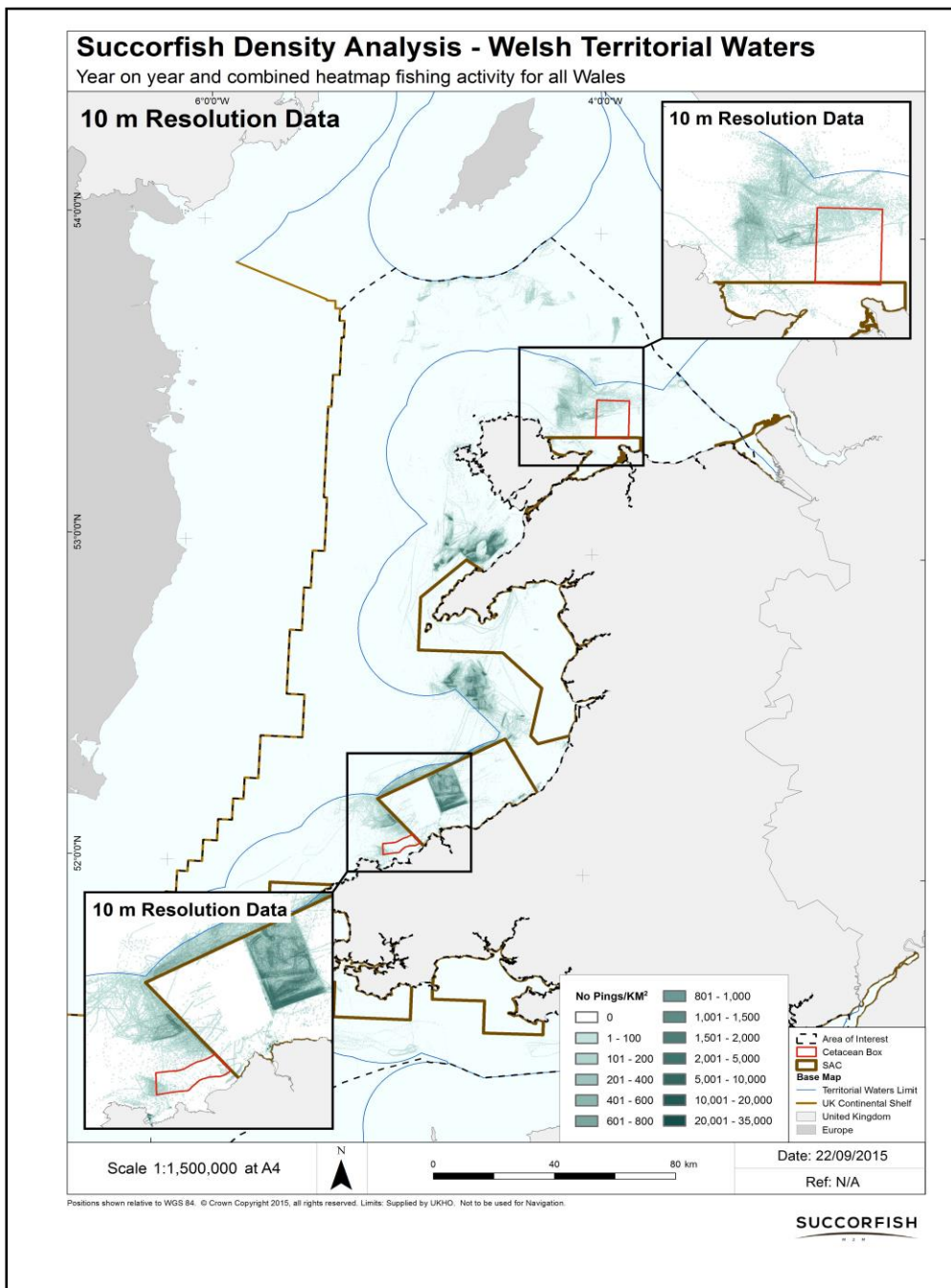


Figure 8. KDE of assumed fishing effort (vessel speeds <4 knots and excluding experimental fishery data) for all years combined at a resolution of 10m.

The KDE for the Cardigan Bay box is presented in Figure 9. All assumed fishing data relating to the areas of the Bangor University 2014 experimental scallop fishing intensity trial² were removed from the data set so as not to skew the analysis. The GIS analysis of 2012-2015 data shows relatively light fishing activity year on year with a small concentration of assumed fishing activity in the SW corner of the Cardigan Bay box for the 2012-13 season. This activity is relatively light when compared to the more heavily fished areas outside of the Cardigan Bay box.

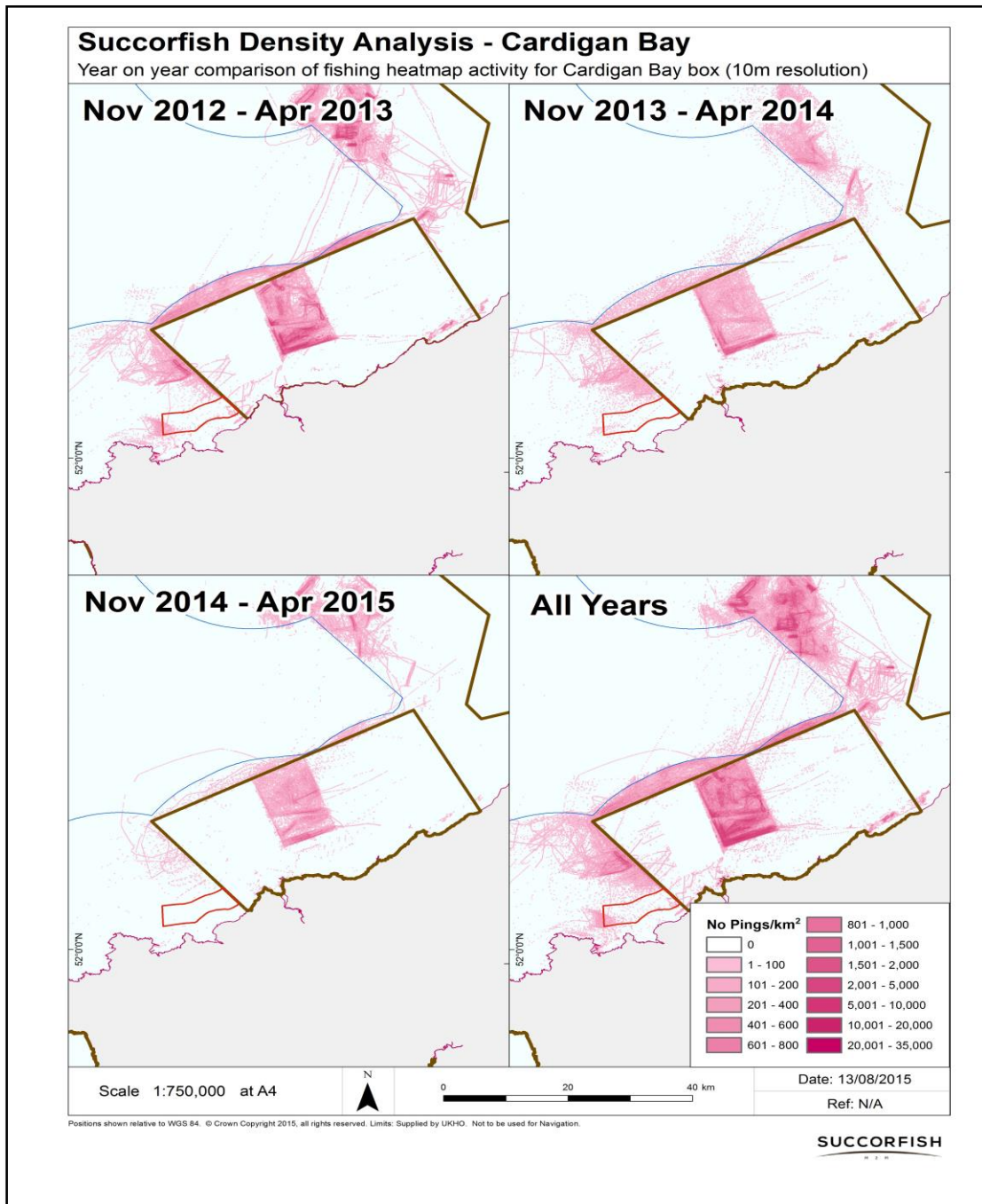


Figure 9. Kernel Density Estimate of assumed fishing activity (vessel speed <4 knots and excluding experimental fishery data) for Cardigan Bay area by year and all years combined at 10m resolution.

²<http://fisheries-conservation.bangor.ac.uk/wales/reports.php.en?menu=1&catid=10722&subid=10805> See reports 59, 60 & 61

The KDE for the Conwy box is presented in Figure 10. The illustration clearly presents the year on year assumed fishing activity occurs in the northern half of the Conwy box. However most activity occurs outside of the Conwy box to the east of Anglesey but at the same intensity as that within the box.

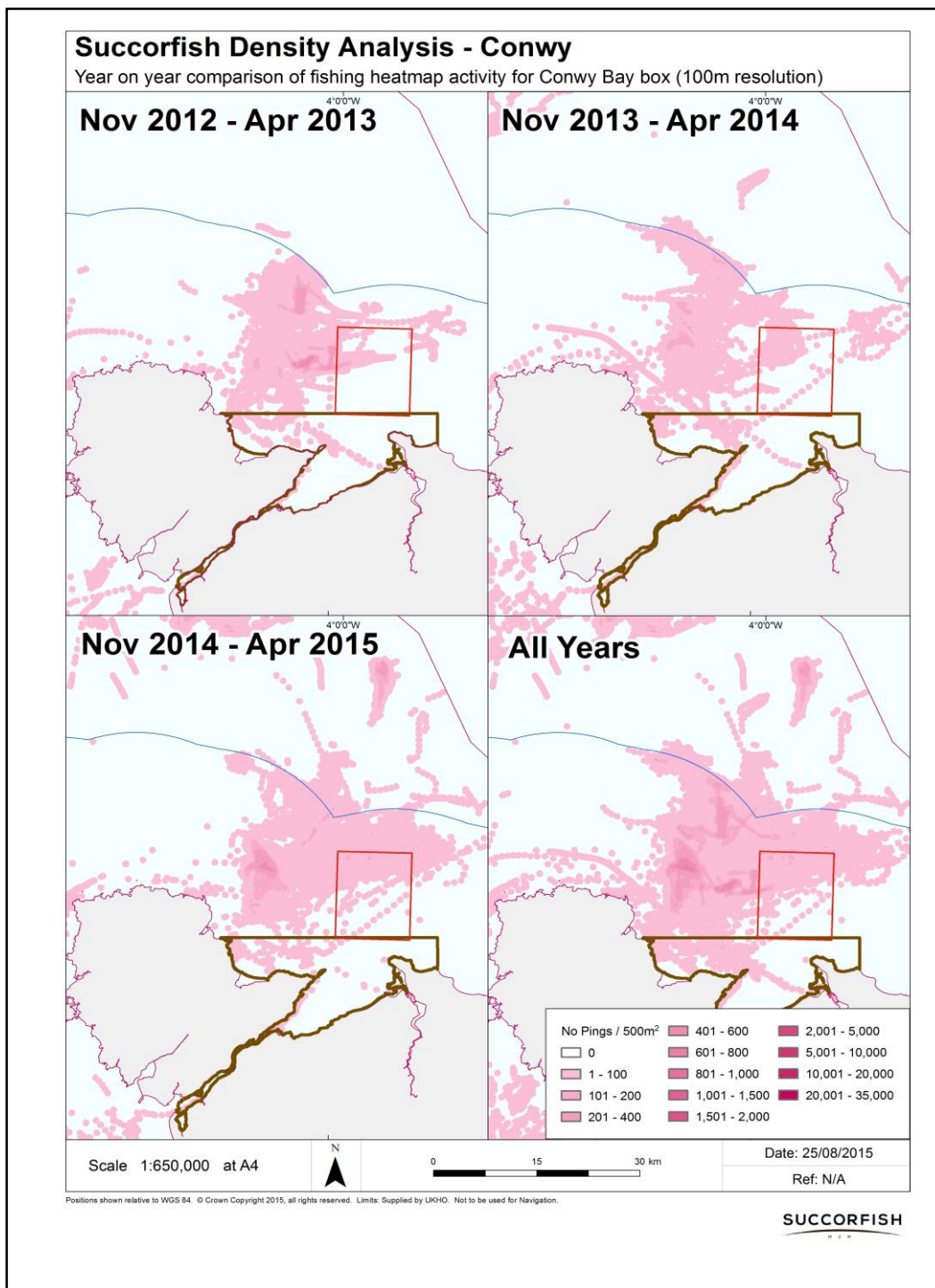


Figure 10. Kernel Density Estimate of assumed fishing activity (vessel speed < 4 knots) for Conwy box area by year and all years combined at 100m resolution.

By only presenting the combined seasonal activity, there is a risk that important patterns that occur within a given season are lost. Figure 11, illustrates the fishing activity on a pan Wales basis for each month of the 2014/15 season and shows variation in fishing intensity over time. However, there are areas (scallop beds) that are targeted year-round: east Anglesey, north Llyn and the permissible fishing area in Cardigan Bay SAC.

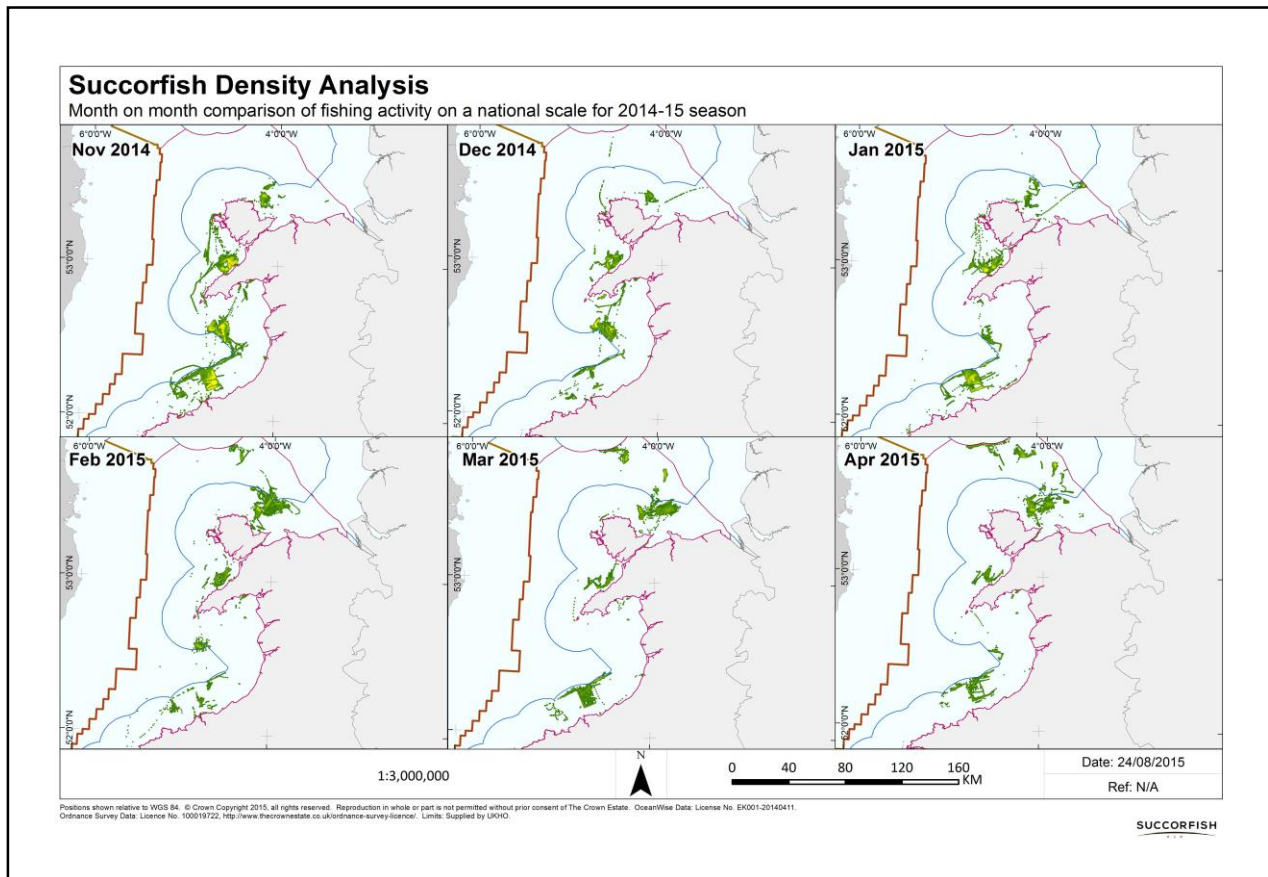


Figure 11. Month on month comparison of fishing activity on a national scale for 2014-15 season at 500m resolution. Increasing fishing activity is represented by a colour ramp from green (low) to orange (high).

Annual summary of Cardigan Bay and Conwy box activity.

An analysis of entries and exits to the Cardigan Bay and Conwy geo-fenced boxes totalled 74 and 278 respectively over the 6 month fishing season of 2014-15. In the previous season (2013-2014), there were 187 and 36 entries, respectively. In the Cardigan Bay box for the 2014-15 season there was a reduction in entries of the geo-fence by 60% on the previous year. However in the Conwy box there was an increase in entries of the geo-fence by 87%, (Figure 12). In total, 20 of 32 vessels that participated in the fishery were found to enter at least one of the geo-fenced areas in the 2014/15 season.

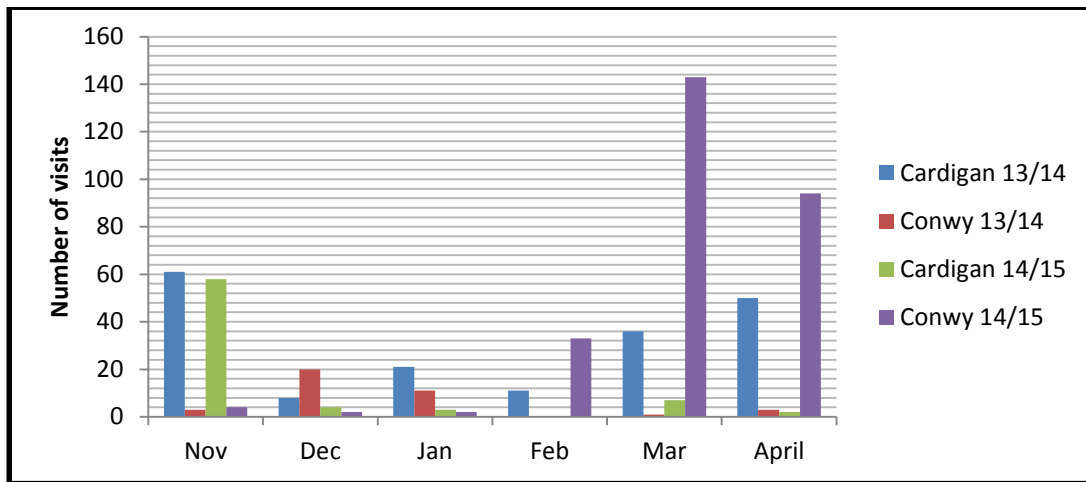


Figure 12. Breakdown of geo-fence entries by area and by month for the fishing season 2013/14 and 2014/15

In the Cardigan box, the geo-fence breaches for 2014/15 were all for an hour or less (Figure 13)

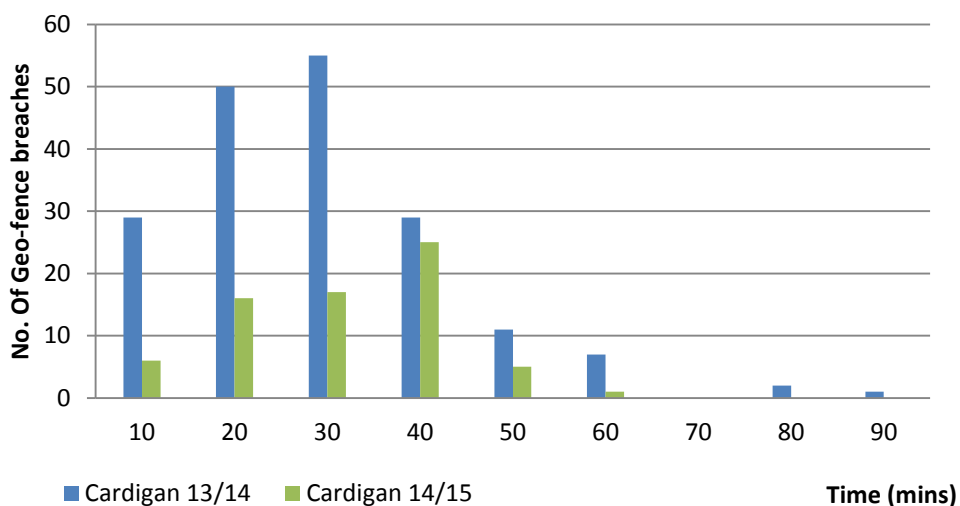


Figure 13. Cardigan Bay geofence breaches by duration (minutes) for the 2013-14 and 2014-15 seasons.

In contrast to the Cardigan Bay box, there were a much higher proportion of longer visits found in the Conwy box with activity increasing substantially in the 2014/15 season. The period of time spent in the Conwy box varied from a few minutes to almost 16 hours constant occupation (Figure 14).

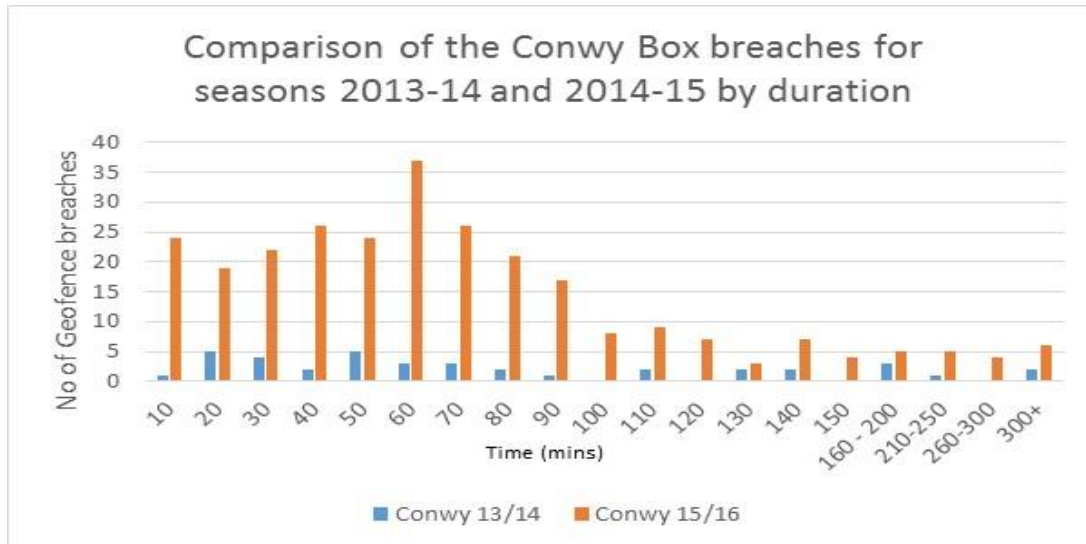


Figure 13. Breakdown of Conwy box geo-fence breaches by duration for the 2013-14 and 2014-15 seasons.

The total time spent by the 20 vessels in both boxes for the entire 14/15 season, irrespective of their activity, was 17.25 days which amounts to 0.28% of the available time for these vessels throughout the season. One vessel alone during the 2014/15 season accounted for 9.5 days (55%). The assumed fishing time for both boxes was calculated at 0.21% of the available fishing time for all 32 vessels in the season.

Analysis of vessel characteristics

Since the Scallop Dredging Operations (Tracking Devices) (Wales) Order 2012 was introduced in 2012, 75 vessels have at one time or another fished for scallops in Welsh waters. Figure 15 shows the breakdown of vessels by home country and by size (either greater than or less than 10m). 44% of the vessels are registered in Wales, 32% from England, 12 % from Scotland, 11% from Northern Ireland and 1% from the Isle of Man. The majority of Welsh vessels are small inshore vessels (<10m) while the majority of non-Welsh vessels are larger (>10 m) (Figure 15).

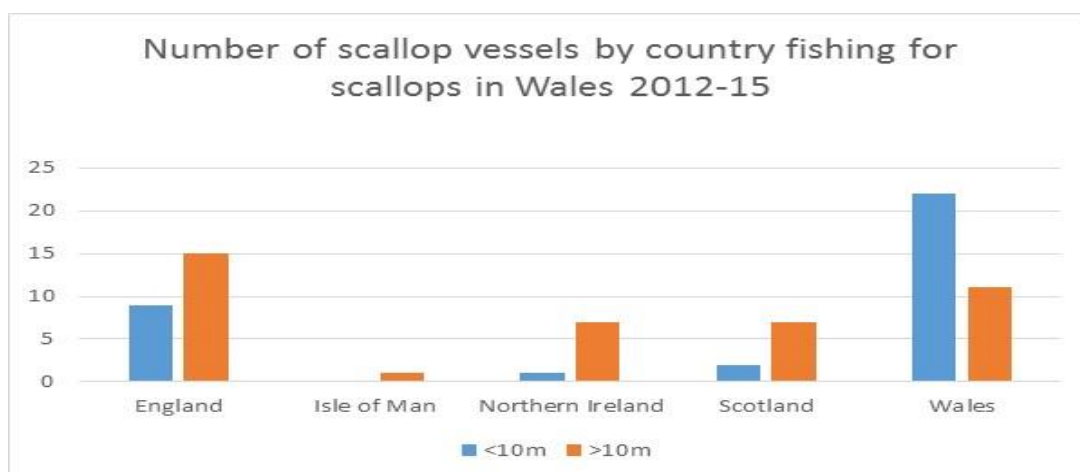


Figure 15. Breakdown of all participating vessels to date by size and country of origin.

During the 2014-15 season, the analysis of iVMS indicated that 27 of the 33 active vessels fished over the first two weeks of the season and by the last 2 weeks of the fishing season only 5 of the 33 vessels remained actively fishing.

Over the 3 years, the number of vessels from England, Isle of Man, Northern Ireland and Scotland targeting the scallop fishery has decreased by an average of 74% (SD 29%), while the reduction in Welsh vessels was 9% (calculated from the difference between 2012/13 and 2014/15) (Figure 16). However, the number of scallop vessels increased by 9% and 12% for Wales and England respectively from 2012/13 to 2013/14 indicating the number of vessels in the fleet in any one year varies. Patterns and trends in fleet dynamics cannot be interpreted further without longer term data.

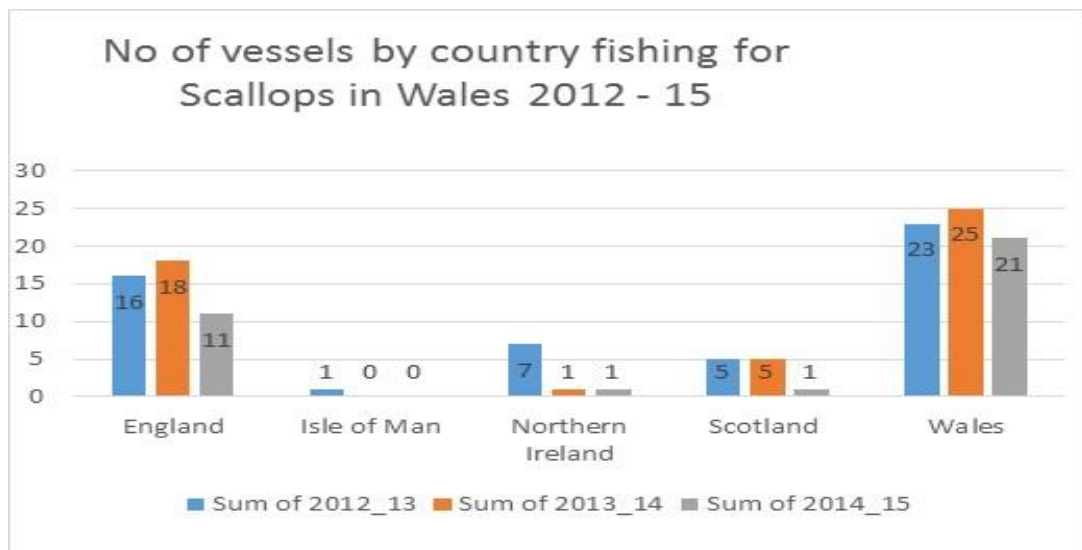


Figure 16. The number of active scallop vessels by country and fishing season.

Discussion

The purpose of this report was to understand how much fishing activity (subject to the assumptions outlined) took place in both the Cardigan Bay and Conwy boxes over the 2014-15 scallop fishing season and to compare this to past seasons.

Scalping is an economic activity and is influenced by a number of factors, many of which are outside the control of fishermen. The 2013-14 season was severely affected by poor weather, leading to over 50% of the activity taking place during the first and last months of the season. Similarly, the fleet activity was significantly less in the 2014-15 season compared to earlier seasons in the Cardigan Bay box area. In 2014/15 the catches peaked in the first two months while in 2012/13 the catch was spread more evenly across all 6 months of the season³, illustrating that each season has its own particular characteristics.

It is clear from the analyses presented that there has been fishing activity in the two geo-fenced boxes, although it was at a much lower level than witnessed in other areas. In particular the GIS plot for the Conwy box shows that the majority of the fishing activity is concentrated in the NW corner of the box (Figure 9), an important detail impossible to identify from geo-fence breach analysis alone.

The analysis presented is reliant on well-reasoned assumptions regarding the fishing activity of the individual vessels, which in some cases may be incorrect. Figure 10, relating to the Conwy box (November 13 to April 14) illustrates an instance when fishing speed (<4 knots) from a single vessel travelling from SW to NE is used to assume the vessel to be fishing. The vessel skipper was contacted directly and confirmed that the track was as a result of mechanical failure and not fishing. The data analysis would benefit from having clear descriptors of when a vessel is fishing to provide increased certainty and confidence in the data. The Welsh Government plans to trial a technology system that will record depth and temperature data once fishing gear is in the water, by doing so this would capture the exact time period fishing gear is deployed as well as collect valuable physical data.

Currently, the data set does not distinguish between scallop fishing and other types of fishing. Although scallop vessels are licensed to fish using scallop dredges, they may sometimes fish for other species using other gear. However, iVMS would not detect a change of gear: concurrent analysis of logbooks would be required, acknowledging that not all vessels are statutorily obliged to complete logbooks. Figure 5, suggests that there was scallop fishing activity in the mouth of the Severn where scallop fishing is prohibited. The vessel skipper was contacted directly and confirmed that the vessel was engaged in net fishing and not scalloping.

The analysis carried out in this report is unique, in that the Succorfish iVMS system is accurate to 2m with a frequency of reporting between 1 and 10 minutes. This permits the spatial resolution of the data to be increased to 10m. Normally, VMS data required by the EU is presented at a 5000m resolution due to its 100m accuracy and 2 hour frequency.

Consideration was given to the commercial sensitivity of the data and particularly at high resolution when it may be possible to pinpoint a particular vessel or favoured fishing area. The report presented aggregated and anonymised data in order to protect the interests of

³UK official landings statistics, <https://www.gov.uk/government/collections/monthly-uk-sea-fisheries-statistics>

the fishermen. Nevertheless, the plots do show the key areas of scallop fishing in Welsh waters over the past three years as well as the relatively low levels of fishing activity in the two geo-fenced areas.

The GIS and Kernel Density analyses gave a valuable and relatively realistic insight into the operation of the fleet each season. This information would have been impossible to obtain prior to the introduction of iVMS tracking using the Succorfish SC2 system.

Conclusion

- The Succorfish SC2 systems and associated GUI software proved effective in assessing the scallop fishing effort in the two areas of interest; The Cardigan Bay and the Conwy boxes.
- Analysis of the geo-fence activity shows a reduction in activity in the Cardigan Bay box in 2014-15 in comparison to previous years
- All the Cardigan Bay box activity was below 60 minutes in duration for the 2014/15 season, therefore it is concluded that there was little to no fishing in this area in 2014/15 season. This conclusion is supported by the GIS analysis.
- There was a significant increase in activity in the Conwy box for the 2014-15 season as compared to the previous seasons. Much of this activity was assumed fishing activity with the Kernel Density Estimation analysis showing that this activity was mostly concentrated in the Northwest corner of the area.
- Comparing the fished areas of the Cardigan Bay open area and the beds north of the Llyn Peninsula with the northwest corner of the Conwy geo-fenced area show the intensity of activity is relatively low in the Conwy box.
- The total time spent by 20 of the 32 vessels, irrespective of their activity, in both boxes was 17.25 days which amounts to 0.28% of the available time for these vessels throughout the season

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Monthly UK sea fisheries statistics - <https://www.gov.uk/government/collections/monthly-uk-sea-fisheries-statistics>

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