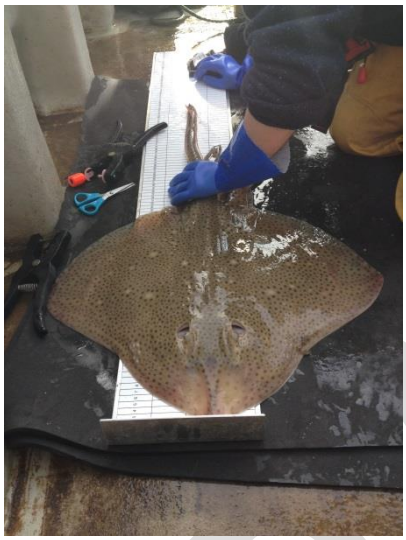
Habitat preferences and fisheries interactions of three commercially important ray species in North Devon, UK based on fishermen's knowledge

Devon and Severn IFCA contribution to Shark By-Watch UK 2



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Contents

1. Introduction

1.1 The Bristol Channel ray assemblage

The Bristol Channel is an important area for a number of elasmobranch species. Three species of Rajidae are particularly important to commercial trawlers working out of North Devon ports; thornback ray, *Raja clavata*; blonde ray, *Raja brachyura* and small-eyed ray, *Raja microocellata. R. clavata* is a Boreal species which occurs all around the British Isles whilst *R.brachyura* and *R.microocellata* are considered to be Southern species which are more abundant along the south-western coasts of the British Isles (Ellis et al. 2004). The area also seems to be important for juvenile rays of all three species, being one of only a few locations where juvenile *R.brachyura* have been recorded, albeit infrequently and showing relatively high abundances of young *R.clavata* and *R.microocellata* at least in the northern Bristol Channel (Ellis et al. 2004).

1.2 The Bristol Channel targeted fishery

The Bristol Channel is one of the few targeted skate fisheries in the UK with landings of ray from this area contributing about 20% by weight of the total skate landed by all English & Welsh fisheries (Catchpole & Enever 2007). The Bristol Channel skate fishery has an estimated annual value of approximately £1 million (Catchpole & Enever 2007). The main skate species caught by otter trawls and gill-nets in the Bristol Channel, and their proportions recorded in landings from otter trawls are: are *Raja clavata* (32%)*, R. brachyura* (28%) and *R. microocellata* (41%)*.* Small quantities of spotted ray *(Raja montagui)* are also caught by these fisheries*.* Beam trawls which operate further offshore have a different catch composition, with cuckoo ray *(Leucoraja naevus)* dominating catches. *R. brachyura*, *R. microocellata* and *R. montagui* are also caught, but *R. clavata* is caught in much smaller numbers.

Skate fisheries are currently managed by a multi-species quota, with TACs often covering large geographic areas. This is partly due to the historical reporting of landings of skates at the family level but this is improving and the proportion of skate landings reported to species level for UK (English and Welsh) fleets has increased from ca. 42% (2008) to ca. 92% (2010) (Ellis et al. 2012). A total allowable catch (TAC) was first introduced for skates in the Celtic seas ecoregion (which includes the Bristol Channel) in 2009. Initially the quota for this area was set at 15,748 tonnes with yearly reductions down to 9,915 tonnes in 2012 (Ellis et al. 2012). Historically quotas for skates were at or above the total landings however recent reductions in skate and ray quota are now restrictive to some fisheries.

Additional measures have also been implemented by the fishing industry in North Devon which strives to safeguard the sustainability of the skate fishery in the Bristol Channel through the North Devon Fisherman's Association. This includes the implementation of a voluntary seasonal closed area which covers an area of approximately 400 square km encompassing Lundy Island known as the 'ray box' which has been agreed by English and Belgian vessels. Larger mesh sizes and a voluntary minimum landing size initially of 38cm across the wing tips which has recently increased to 45cm (NDFA) have also been adopted. Around 500 tonnes of ray are caught per year in in the Bristol Channel fishery (Catchpole & Enever 2007).

The UK quota for skates and rays has steadily declined since 2009. In October 2014 many UK skate fisheries were closed as the UK ran out of the annual quota. This closure has had particularly severe

consequences for the targeted ray fishery in North Devon with many boats forced to move elsewhere or stop fishing, with serious knock-on effects for local fish processors and the North Devon economy.

ICES advice for 2015 and 2016 have suggested a 20% increase in *R. clavata* landings could be permissible in the Irish and Celtic Seas. However the advice for *R. brachyura*, small eyed ray, spotted ray and cuckoo ray suggests reductions in TAC of 20%, 36%, 4% and 34% respectively. Furthermore, many supermarkets have stopped stocking skate over concerns surrounding sustainability after pressure from a number of NGOs (ABPmer 2013).

There is also a lack of information on stock structure and basic ecology of rays in the Bristol Channel which could be used to explore alternative, possibly regional management. As part of a wider programme of work for the Shark By-Watch UK 2 project we therefore collated fishermen's knowledge on the location of rays within the Inner Bristol Channel and mapped them in GIS. This is displayed along with a qualitative description of fishermen's knowledge of ray distribution and habitat utilisation in the study area. Existing mapping data was collated in order to compare areas to those fished. In order to investigate whether ICES BTS locations are likely to be capturing true patterns of ray abundance in the Bristol Channel we compare ICES BTS survey stations with fishermen's knowledge. The information collected was then used to plan future survey work and direct other aspects of the project.

2. Methods

3.1 Fisheries activity mapping

Fishermen were given charts of the inner Bristol Channel and asked to draw the main areas that they fish, and for which species they fish. Where possible, hand-drawn charts were supplemented with co-ordinates supplied directly from the boats plotter. The study area included all areas from as far west as the most Westerly point of the D&S IFCA boundary and all areas east and north of this within the Inner Bristol Channel and Severn Estuary.

Three fishermen took part, representing the fishing knowledge of five boats that target the area, primarily for rays. Hand drawn charts were transferred manually to GIS, resulting in maps of approximate areas targeted for different species. Given the size of the areas and the use of seabed features depicted on the charts to map the edges of the areas this allowed for relatively accurate transfer into GIS and it is thought that this method is fit-for purpose for baseline data collection on the ecology and fisheries interactions in North Devon.

3.2 ICES BTS Trawl locations

Information on which survey data fed into stock assessments was taken from the 'Input Data' described in the ICES 2014 advice for each species. For two species (*Raja clavata* and *R. microocellata*) survey based trends were assessed from the UK Beam Trawl Survey (UK (E&W) VIIaf BTS) (ICES 2014a, b). For *R. brachyura* ICES advice was based upon landings data (2011-2013) with the UK BTS trawl used as stock size indicators for juveniles only (ICES 2014c). ICES BTS trawl locations UK (E&W) VIIa,f BTS were therefore downloaded from the ICES data centre: http://www.ices.dk/marine-data/dataset-collections/Pages/default.aspx and mapped in GIS.

3.3 Habitat maps

Predictive habitat maps were available for the study area from the EMODnet Seabed Habitats (EUSeaMap) project (http://www.emodnet-seabedhabitats.eu/). Two layers were deemed appropriate and downloaded: 'Predicted broad-scale EUNIS habitats - Atlantic area' and 'Predicted habitats - North Sea and Celtic Sea'. Both layers were then clipped to the Bristol Channel and Severn Estuary. More information on how these maps have been developed and the assumptions and limitations of the modelled outputs can be found here: http://www.emodnet-seabedhabitats.eu/PDF/426918_EU_Seamap_Exec_Summary_Phase_II_WEB_FINAL.pdf

3.4 Sidescan sonar survey preparation

Based upon information provided by the fishermen, a sidescan sonar survey plan was developed (Appendix B). Survey areas were chosen to best cover either areas thought to be important to a particular species or sites which could span a transition from an area supporting one species, to an area supporting another species. Selected sites were mapped against existing IFCA data on areas used for potting and netting as these activities can seriously jeopardise the ability to conduct a sidescan sonar in an area and adjusted where appropriate. Areas were restricted to <6.5km^2; the maximum area realistically surveyed in one day. Survey lines 150m apart were plotted within each survey area which were, as far as practicably possible, parallel to the primary flow of tide and along any major contours. The Environment Agency/ Briggs Marine Ltd vessel Severn Guardian was chartered to undertake the surveys and a series of possible weather windows during neap tides were identified. A recce on the Severn Guardian was undertaken to check for any pots and nets which had not already been taken account of and subsequently Site 4 was adjusted to avoid some previously unmapped pots.

3. Results and discussion

3.1. Distribution of ray species in North Devon from fishermen's knowledge

The distribution within the Inner Bristol Channel where the fishermen target rays reflects the nature of the fishing vessels and determines the primary target species. Smaller inshore boats (Fishermen 1&2) target inshore waters close to their home port of Bideford with *R. microocellata* a major component of their catch (Figure 1). Larger vessels work a larger area, with *R. microocellata* generally making up a smaller proportion of the catch (Figure 2). However there are areas of overlap in fishing grounds in Bideford Bay and south of Hartland Point on the border between Devon and Severn IFCA and Cornwall IFCA districts (Figure 3).

Fishermen reported that different species aggregate in different areas. They attributed these differences to changes in habitat or sediment type. All fishermen suggested that *R. clavata* are found on muddier and/ or coarser, more broken ground than the other two species and are not found in sympatry with either of the other two species (Figure 3). This agrees well with findings from the eastern English Channel, where species distribution modelling revealed that adult *R. clavata* were associated with hard sediments (gravels and pebbles) and coarse grounds with medium to strong tidal currents (Martin et al. 2012). This study also found a difference between adults and juveniles, with *R.clavata* juveniles preferring some inshore grounds where seabed sediments were comprised of mud, sand and gravel. The fishermen in this study did not note any difference between age and sex in the rays that they caught in different areas, but complimentary data collected by fishing

vessels during this project may shed some light on this. The distribution of *R. clavata* does not appear to correlate to any particular features of the habitat maps available, although the resolution of the mapping data and the degree to which it is modelled and extrapolated means that the existing data is not at an appropriate resolution for further use in this study (Figures 6 & 7). However one of the maps does show a patch of mud in the Southern end of Bideford Bay (Figure 7) which could indicate a change in ground in this area. Further fine-scale habitat mapping is required to address questions relating to habitat associations of rays in the inner Bristol Channel.

Whilst some fishermen reported some overlap in fishing grounds for blonde and *R. microocellata* (generally close inshore in Bideford Bay), there were also differences in the areas in which the fishermen targeted each species. Sandy and muddy sand areas close inshore were favoured by *R. microocellata*, with some *R. brachyura* also being found in these areas according to the fishermen's knowledge. However, the largest aggregations of *R. brachyura* were generally thought to be associated with large sand bank features, for example south east and south west of the Isle of Lundy (Figure 3). These sand bank features, reported by the fishermen, are not currently reflected in the habitat maps available (Figures 6 & 7), or on the hydrographic charts of the area. Therefore further work is required to provide finer-scale habitat maps of these areas (such as sidescan sonar imagery) in order to fully corroborate the fishermen's knowledge. In the eastern English Channel *R.brachyura* was found to prefer more coastal habitats with soft sediments (muddy sand, fine and coarse sands) located in shallower areas that were sheltered from strong tidal currents (Martin et al. 2012). This differs somewhat from the findings of this study where fishermen report that *R. brachyura* extend into highly tidal exposed areas. Fishermen's knowledge of the preferred fishing grounds for *R. microocellata* agreed well with the findings of Martin et al. (2012) with *R.microocellata* being associated with inshore grounds of muddy sand, fine and coarse sands.

The fishermen also noted that *Raja brachyura* are more temporally variable in distribution and abundance than either *R. clavata* or *R. microocellata* in the inner channel. Fishermen believed that *R. brachyura* move into and out of the area possibly moving out of the inner Bristol Channel in the winter months, with fishermen hypothesising that they were moving further offshore into warmer, deeper water. However they also noted that often movements were not as simple as predictable seasonal migrations and other factors may also affect the occurrence of *R.brachyura* in the inner Bristol Channel.

The scale at which habitat changes affect species composition is also of interest. Fishermen reported a change in species within a very small area, e.g. south of Hartland point over a distance of approximately 1km with only *R. brachyura* caught on one side of the 'bank' and only thornback on the other side of the bank (Figure 4). Again, this confirms the need for high resolution habitat mapping to assess whether differences in habitat are causing species to aggregate separately.

3.2 Potential causes of spatial separation of species

Based on the fisher's knowledge above we have assumed that changes in habitat type (generally described by sediment type) are the primary cause of reported aggregation by species in North Devon rays. However, a number of other factors relating to habitat type could be underlying the observed patterns. Habitat, food availability and temporal separation have all been identified as important mechanisms for resource partitioning in fish assemblages (Ross 1986).

Much effort has been placed in investigating the diets of sympatric elasmobranch species in order to better understand this axis of resource partitioning (Ellis, 1996, White et al. 2004, Farias et al. 2006, Domi et al. 2005). Studies in North European waters have found the main the primary prey for *R. clavata* to be shrimps and brachyuran crabs whilst for *R. brachyura* whilst shrimps were still important, bony fish were also a major component of the diet (Farias et al. 2006). More in-depth studies in Portuguese waters have found ontogenetic shifts in the diets of *R.clavata* at lengths of about 45−55 cm in both sexes. Smaller males and females of *R. clavata* fed mainly on polychaetes, mysids, and various other small crustaceans. Individuals larger than 45 cm were found to feed on cephalopods, bony fish and brachyuran crabs were the main prey. The study supported previous findings that fish are a major prey item for all sizes of *R. brachyura* but also noted differences between size classes and sexes: After bony fish, polychaetes were the most common food item for females with lengths from 45 to 65 cm. For small males (35-45cm) shrimps and brachyuran crabs dominated gut contents whilst cephalopods were the most important prey for both sexes for specimens larger than 50 cm (Farias et al. 2006).

However, Farias acknowledged that food preferences and habitat type were linked as ontogenetic shifts were related to a change from small to larger and faster prey which in turn was linked to a change from benthic to semi-pelagic feeding habits, and from a shift from shallow inshore to offshore waters and from crustacean-dominated diets to a more piscivorous diet (Farias et al. 2004).

Further work is required to better understand habitat associations, such as fine-scale habitat mapping of areas mapped as ray habitat, detailed biological data including, CPUE, sex ratios and maturity stages of rays associated with different habitats and gut content analysis in order to better understand the reasons for aggregation in different areas in North Devon

3.3 ICES BTS survey locations in relation to fisher knowledge

The UK (Cefas) Irish Sea and Bristol Channel Beam Trawl Survey is a standard survey covering the whole of ICES divisions VIIa, f &g and has been operating in its current format since 1993 (ICES 2009) . The current purpose of the survey is provide fisheries independent indices of abundance for all age groups of plaice, sole, cod and whiting in the Irish Sea, Bristol Channel and Western English Channel. The survey stations focus on areas known to be historically important for commercial plaice and sole fisheries and include 119 tows, 51 of which are in the Bristol Channel (ICES 2009). Although not designed for the purpose, data from the surveys also contributes to survey based trends which, along with landings data, is used to form the species –specific advice published by ICES for *R.clavata* and *R. brachyura*. In ICES advice published in 2012 data from the UK (Cefas) Irish Sea and Bristol Channel Beam Trawl Survey was also used to look inform stock assessments (ICES 2012). However ICES advice for this species only considered landings data, with the UK BTS being used only as an 'indicator' for juveniles (ICES 2014c). When displayed against fishermen's knowledge of ray distribution in the Inner Bristol Channel (Figure 5) it shows that certain species are likely to be sampled better than others in this area. For example the ICES BTS surveys appear to sample well in Bideford Bay, covering known *R. microocellata* grounds well. The ICES BTS trawl locations also appear to sample *R. clavata* areas known to fishermen around Hartland Point and on the Welsh coast. However they do not sample important Thornback ray ground in the southern half of Bideford Bay (Figure 5). This may be due to the occurrence of fixed gear, mostly pots, which appear seasonally and which could prevent systematic trawl surveys. Local fishermen work around the static gear by inputting the co-ordinates of the buffs into their plotter following daily placing the pots.

The ICES BTS surveys do not appear to target any of the ground known to the fishermen to be the most important areas for *Raja brachyura* in North Devon. Obviously to gain a full picture this exercise would need to be extended to the whole of ICES division VIIf but early indications are that blonde ray are likely to be under sampled in this area. ICES have acknowledged this by basing their most recent advice on landings only. The ICES BTS trawl data is still used as a stock indicator for juveniles, but it is not clear from the resolution of data collected so far whether this is a suitable method or not for this area.

4. Conclusions and future work

Fishermen fishing out of North Devon have an excellent knowledge of the locations where different species can be found. They also have a good understanding of the sediment characteristics and those sites and believe the two are related. Initial comparisons of mapped areas of ray distribution from fishermen's knowledge do not currently match closely with existing bottom sediment maps. These maps are largely modelled and only offer predicted habitat types. Therefore finer-scale habitat mapping is needed in order to corroborate fishermen's information on the habitat preferences of *Raja clavata*, *R. brachyura* and *R. microocellata*. This information will also help to corroborate the assumption that current ICES BTS surveys do not cover suitable ground for adult *Raja brachyura.* Further work with the fishermen could ask about distributions of adults and juveniles and incorporate seasonality with the mapping, something that was not possible within the time frame of this survey. Collection of CPUE, species composition and morphometric and life-history information from the areas mapped by the fishermen would also greatly expand our knowledge of ray ecology in North Devon. If possible an extension to working with Welsh fishermen would also greatly improve our knowledge of the Bristol Channel as a whole.

5. Acknowledgements

Many thanks to the Fishermen who shared their knowledge of the distribution of rays in North Devon; in particular to Steve Taylor, Scott Wharton and Dan Wharton. To IFCA officers who assisted with survey planning and the limited boat work that was possible within the time frame of the project; Sarah Clark, Steph Davies and Katherine Gray. To Devon and Severn IFCA chair Elaine Hayes and vice chair John Butterwith for their encouragement and guidance. To the North Devon Fishermen's Association for advice, assistance and participation.

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7.0 Figures

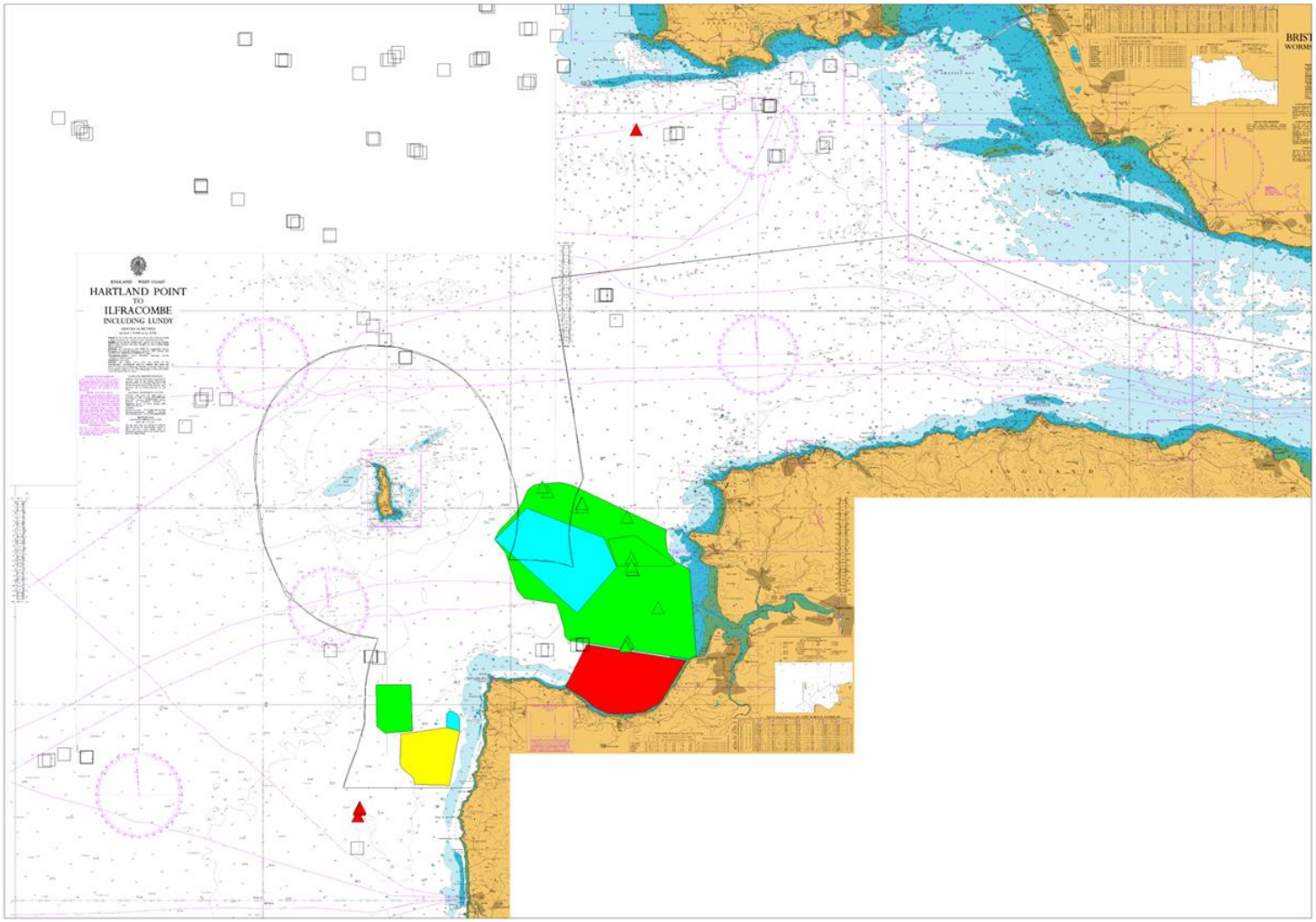

Figure 1. Fisher knowledge no. 1 - distributions of rays in the Inner Bristol Channel. Red polygons depict areas where *R. clavata* are found, light blue polygons for *R. brachyura*, yellow areas for *R. microocellata*. Green polygons highlight areas where *R. microocellata* dominate but *R. brachyura* may also be caught.

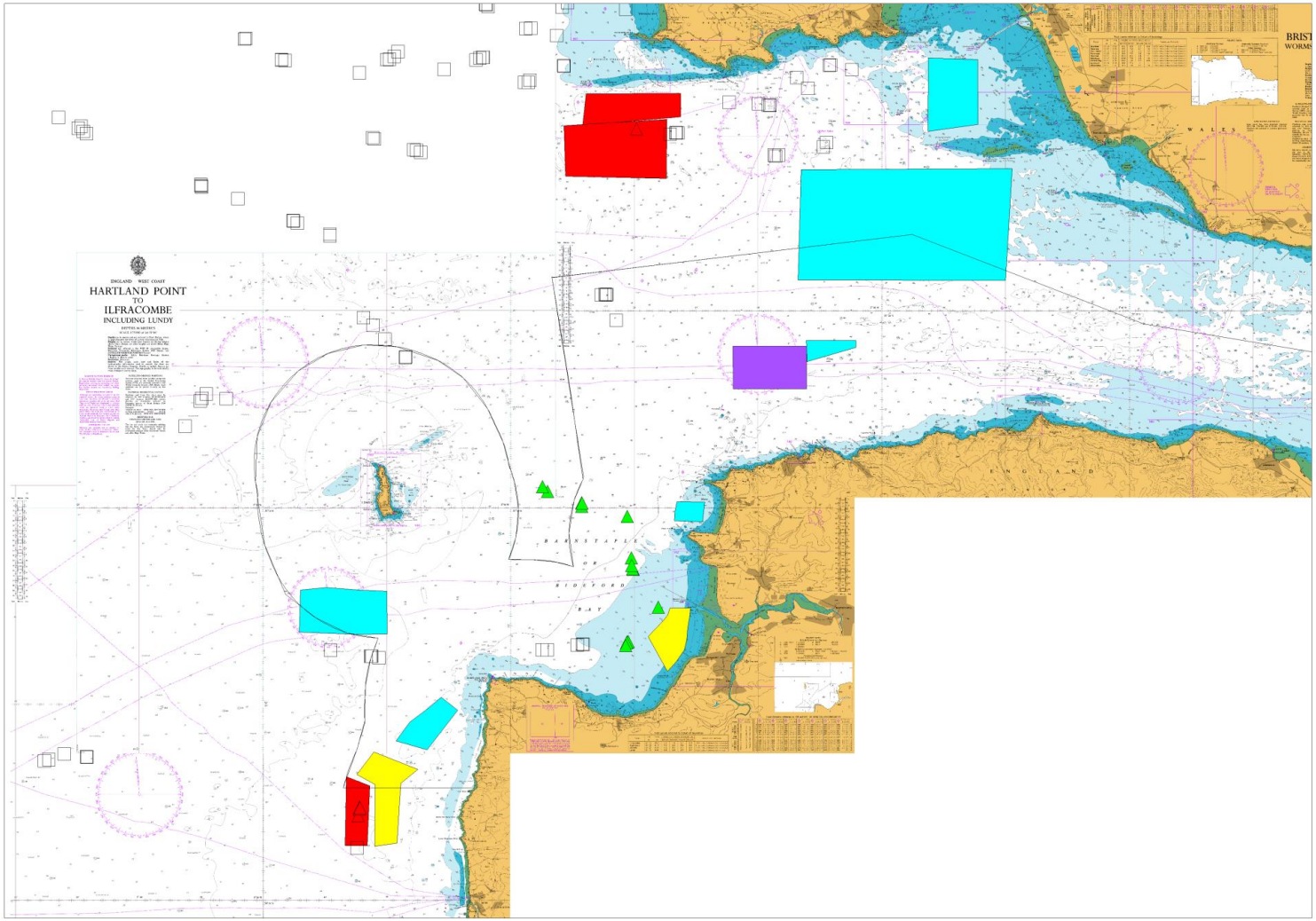

Figure 2. Fisher knowledge no. 2&3 - distributions of rays in the Inner Bristol Channel. Red polygons depict areas where *R. clavata* are found, light blue polygons for *R. brachyura*, yellow areas for *R. microocellata*. Green polygons highlight areas where *R. microocellata* dominate but *R. brachyura* may also be caught. Purple polygons are areas where blonde and *R. clavata* may be found.

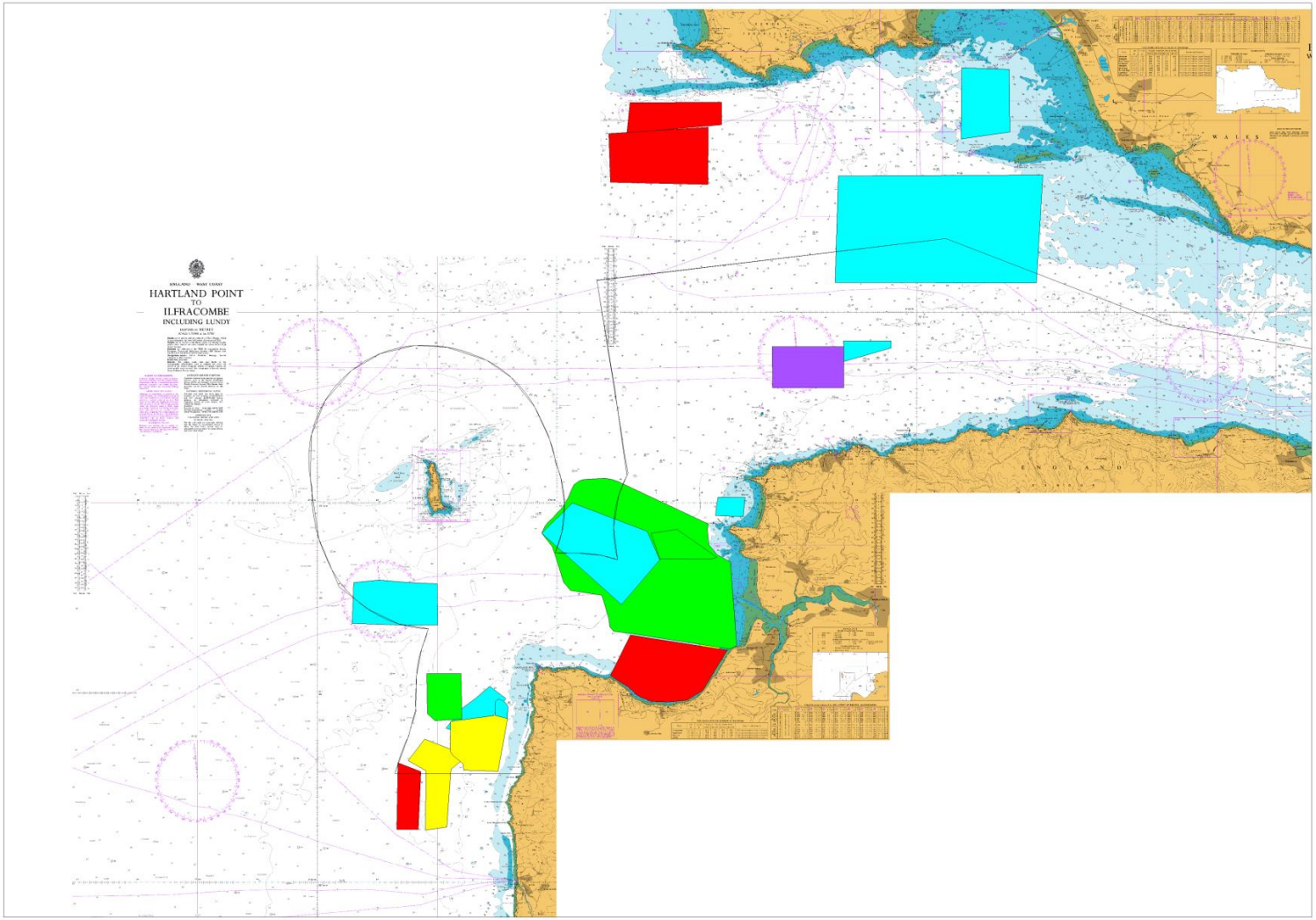

Figure 3. Ray distribution in the Inner Bristol Channel based on all fisher knowledge. Red polygons depict areas where *R. clavata* are found, light blue polygons for *R. brachyura*, yellow areas for *R. microocellata*. Green polygons highlight areas where *R. microocellata* dominate but *R. brachyura* may also be caught. Purple polygons are areas where blonde and *R. clavata* may be found.

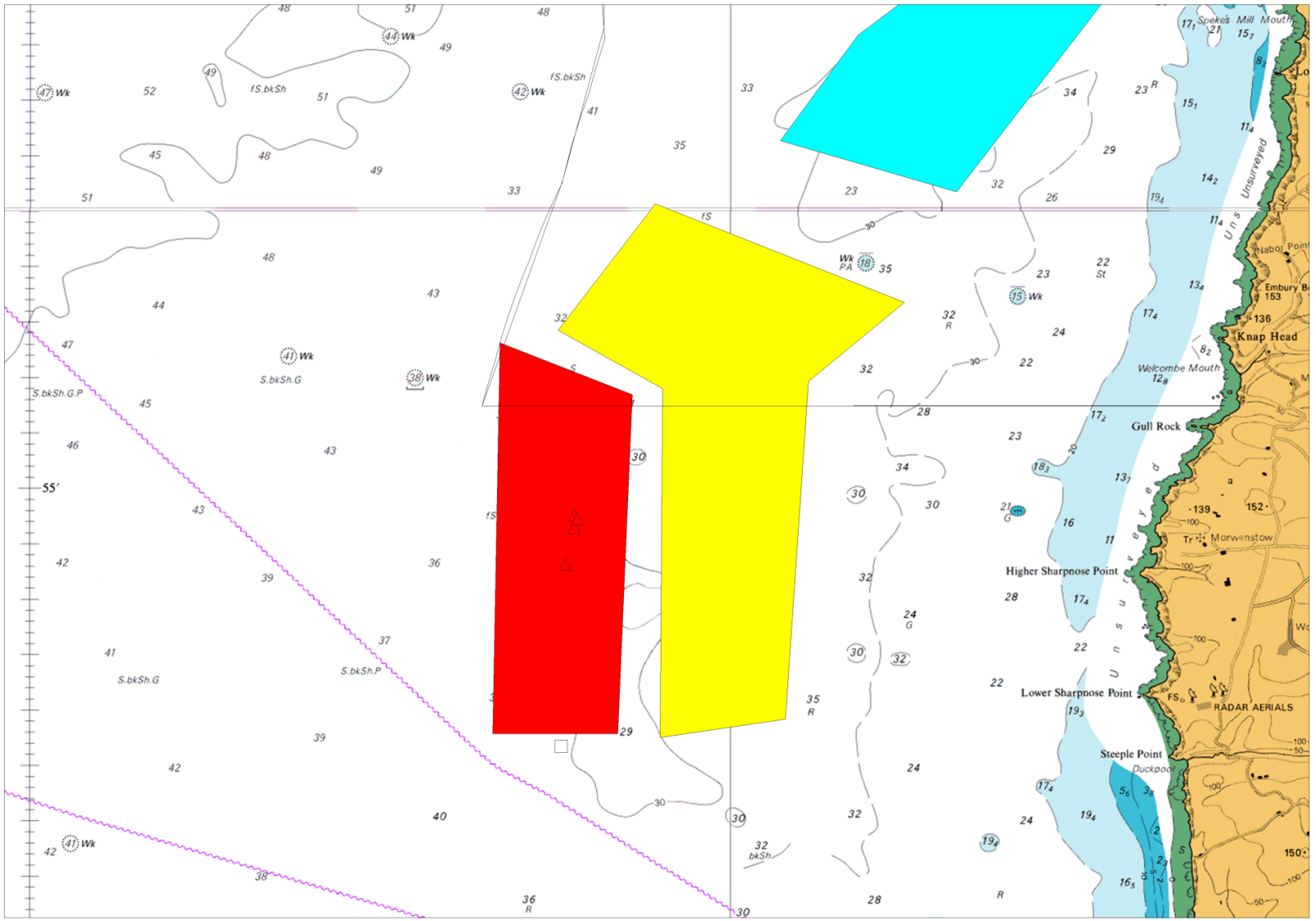

Figure 4. Polygons showing areas where fishers encounter *R. clavata* (red) and *R. microocellata* (yellow) in close proximity, thought to be on either side of a 'bank' southwest of Hartland Point.

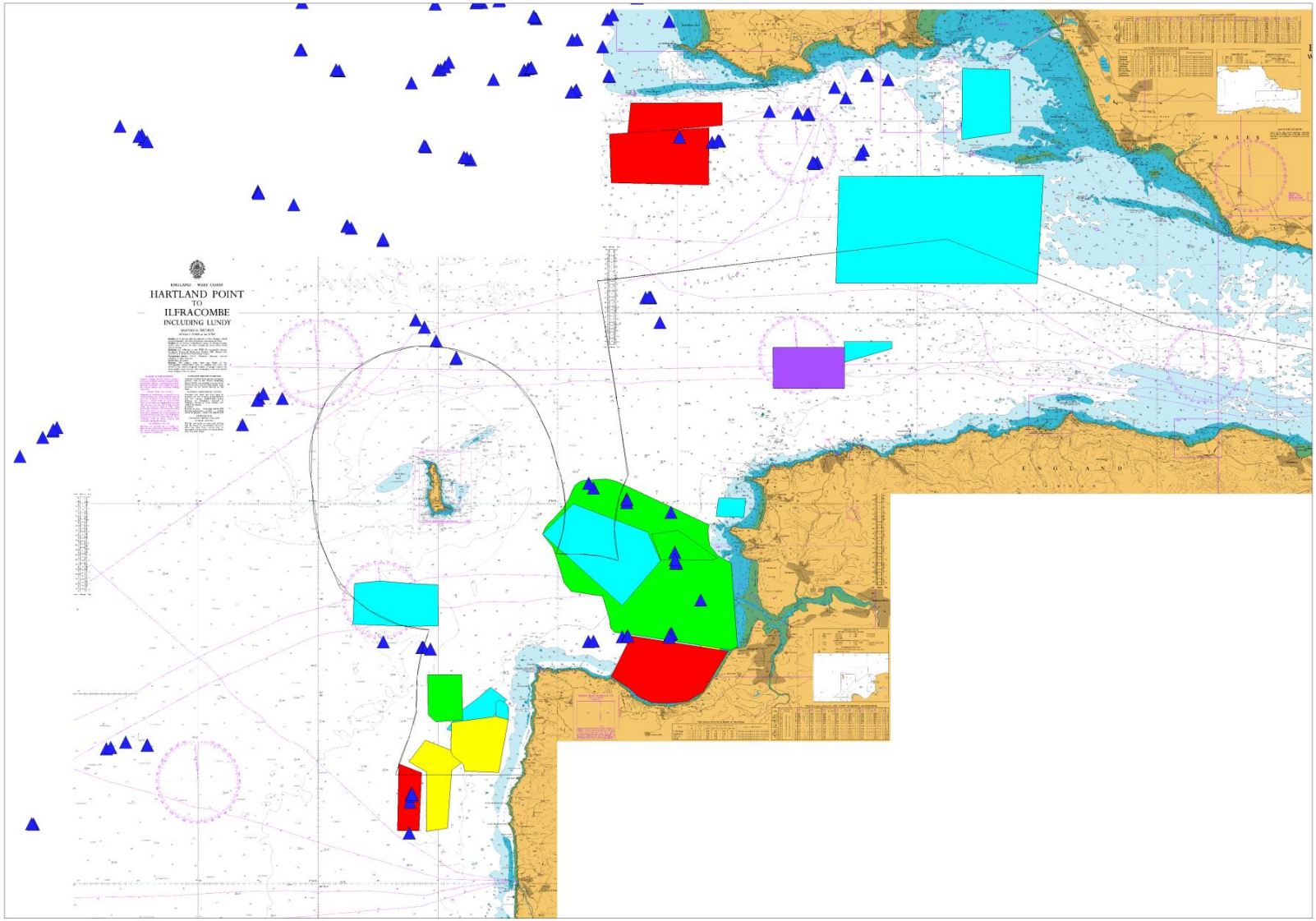

Figure 5. Locations of ICES BTS survey stations (blue triangles) against known ray habitat. Shoot locations only shown in relation to areas important for different species.

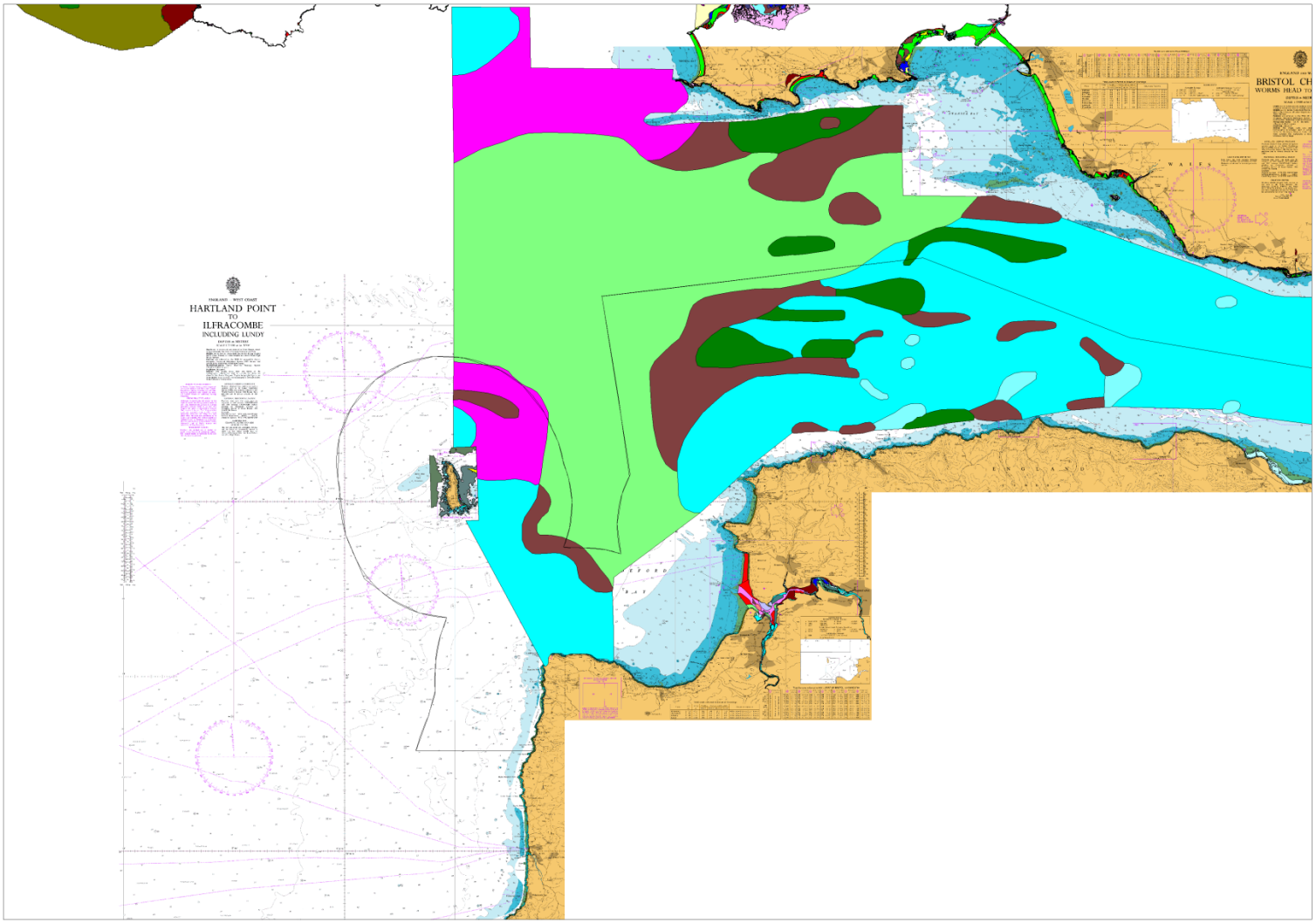

Figure 6. Predicted broad-scale EUNIS habitats from http://www.emodnet-seabedhabitats.eu/

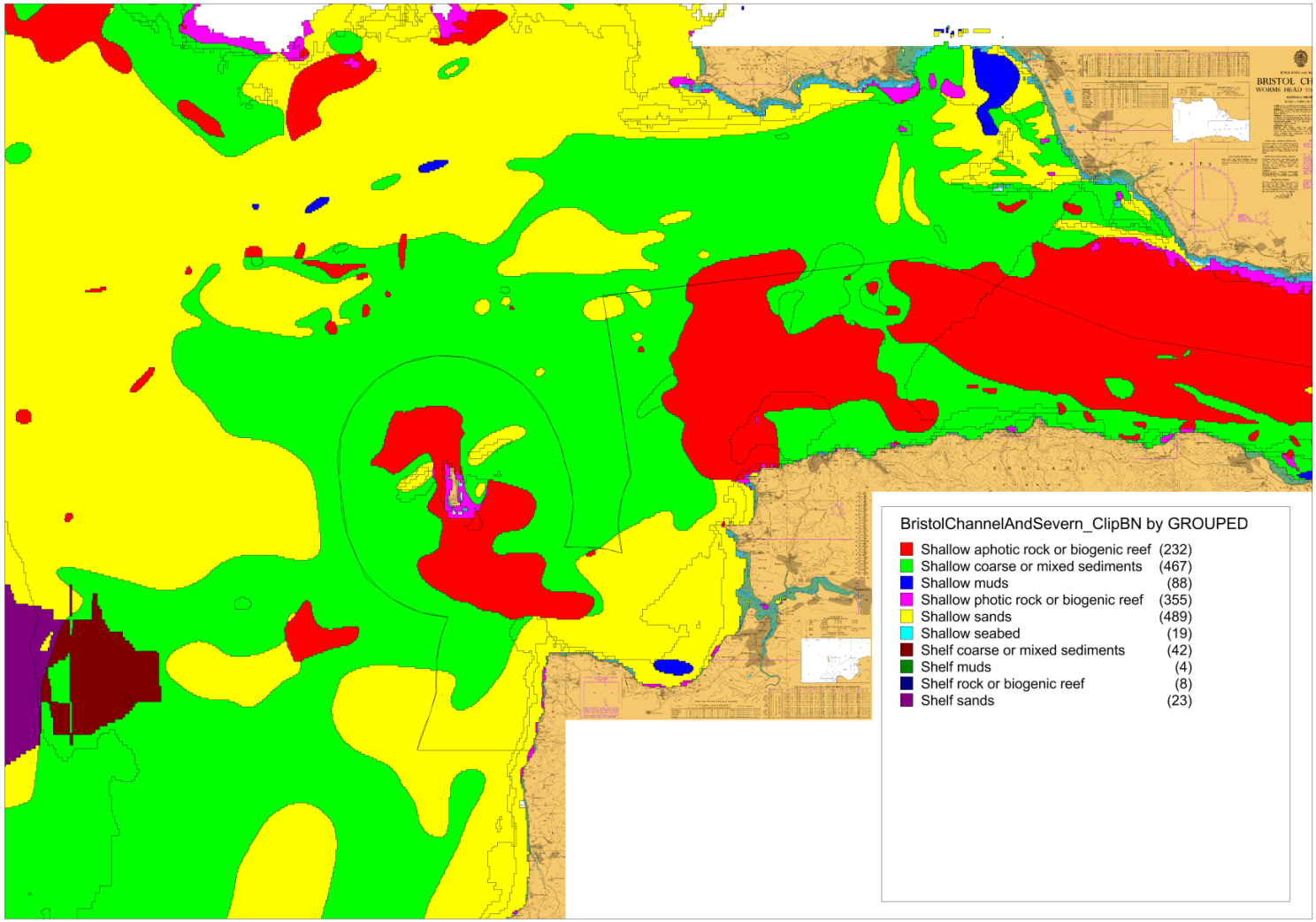

Figure 7. Predicted habitats - North Sea and Celtic Sea from http://www.emodnet-seabedhabitats.eu/

Appendices

Appendix A – Research Questions

Research questions developed following the North Devon Skate Pilot Project workshop to be addressed by Shark ByWatch UK 2 and future scientific/monitoring work are found below. Those currently being addressed as part of the Shark By-Watch UK 2 project are highlighted in yellow. Those that will be in-part addressed by data collected by the data storage tags are highlighted in green.

Should rays in the Bristol Channel be considered as a separate management unit?

- What are the home range sizes of the most commercially important ray species?
- Are populations of rays in the Bristol Channel part of widely distributed, panmictic populations with high levels of interchange or are they spatially restricted? (NB similar question to above)?
- What is the appropriate spatial scale of management for commercially important ray species in the Bristol Channel?
- Are populations of rays species in the Bristol Channel genetically distinct from populations of the same species outside the Bristol Channel and should they be considered as separate Evolutionary Management Units?

What are the habitat preferences of different ray species in the Bristol Channel & Severn Estuary?

- Do rays in the Bristol Channel show seasonal movements and are these the same across species and sexes?
- Do rays display species-specific habitat preferences in the Bristol Channel and how do these vary seasonally?
    - Could split it down based on fisher knowledge
- Do rays display aggregating behaviour within habitat types in the Bristol Channel and how does this vary seasonally?
- Do rays reproduce within the Bristol Channel and which habitats are important for key life-history stages?
- Does the ray-box protect important habitat for rays and if so, which species and during which life-history stages?

Sustainability of the fishery

- Are there large areas of the Bristol Channel which are naturally unsuitable for the operation of towed gear?
- Are these habitats suitable for rays and thus offer a natural protection from fishing activity?
- Has CPUE been relatively stable over time and what can and can't landings data tell us about the sustainability of the fishery?
- Does the towed gear closed-area in the Severn Estuary SAC provide important habitat & therefore protection for any ray species?
- Do current survey methodologies which inform stock assessments target the correct habitats at the correct time of year for the most commercially important species of ray in the Bristol Channel?

Devon & Severn IFCA
Inshore Fisheries and Conservation Authority

Habitat mapping of ray fishery locations in North Devon

Contribution to Shark ByWatch UK 2

Survey Plan

September 2015

Site 1: Ilfracombe		
Rationale: Area encompasses adjacent areas fished for *R. brachyura* and *R. clavata*, stays within depth contours and avoids obstacles.		
Area	**Depth range**	**Obstacles**
5.2 sq. km	Approx. 29-33m	Compass Rose BD78 & Greeneye BD88 pots to North of area. Possibly rocky/ coarse sea floor habitats.
Habitat EUNIS composite map: A5.2 Sublittoral sand; A.4 Circalittoral rock and other hard substrate within survey site; A5.14 – Circalittoral coarse sediment in vicinity. EU SeaMap: Aphotic rock or biogenic reef throughout		

Line No.	Start Latitude	Start Longitude	End Latitude	End Longitude	Line Length (km)
SB_Site1_ 001	51° 16.9695' N	004° 5.4397' W	51° 16.9685' N	004° 8.4811' W	3.525
SB_Site1_ 002	51° 17.0202' N	004° 5.4398' W	51° 17.0192' N	004° 8.4811' W	3.525
SB_Site1_ 003	51° 17.0708' N	004° 5.4399' W	51° 17.0699' N	004° 8.4812' W	3.525
SB_Site1_ 004	51° 17.1215' N	004° 5.4399' W	51° 17.1206' N	004° 8.4812' W	3.525
SB_Site1_ 005	51° 17.1723' N	004° 5.4400' W	51° 17.1713' N	004° 8.4813' W	3.525
SB_Site1_ 006	51° 17.2230' N	004° 5.4400' W	51° 17.2220' N	004° 8.4814' W	3.525
SB_Site1_ 007	51° 17.2737' N	004° 5.4401' W	51° 17.2727' N	004° 8.4814' W	3.525
SB_Site1_ 008	51° 17.3244' N	004° 5.4401' W	51° 17.3234' N	004° 8.4815' W	3.525
SB_Site1_ 009	51° 17.3751' N	004° 5.4402' W	51° 17.3741' N	004° 8.4815' W	3.525
SB_Site1_ 010	51° 17.4258' N	004° 5.4403' W	51° 17.4248' N	004° 8.4816' W	3.525
SB_Site1_ 011	51° 17.4765' N	004° 5.4403' W	51° 17.4755' N	004° 8.4817' W	3.525
SB_Site1_ 012	51° 17.5272' N	004° 5.4404'W	51° 17.5262' N	004° 8.4817' W	3.525
SB_Site1_ 013	51° 17.5779' N	004° 5.4404'W	51° 17.5769' N	004° 8.4818' W	3.525
SB_Site1_ 014	51° 17.6286' N	004° 5.4405'W	51° 17.6276' N	004° 8.4818' W	3.525
SB_Site1_ 015	51° 17.6793' N	004° 5.4406'W	51° 17.6783' N	004° 8.4819' W	3.525
SB_Site1_ 016	51° 17.7300' N	004° 5.4406'W	51° 17.7290' N	004° 8.4819' W	3.524

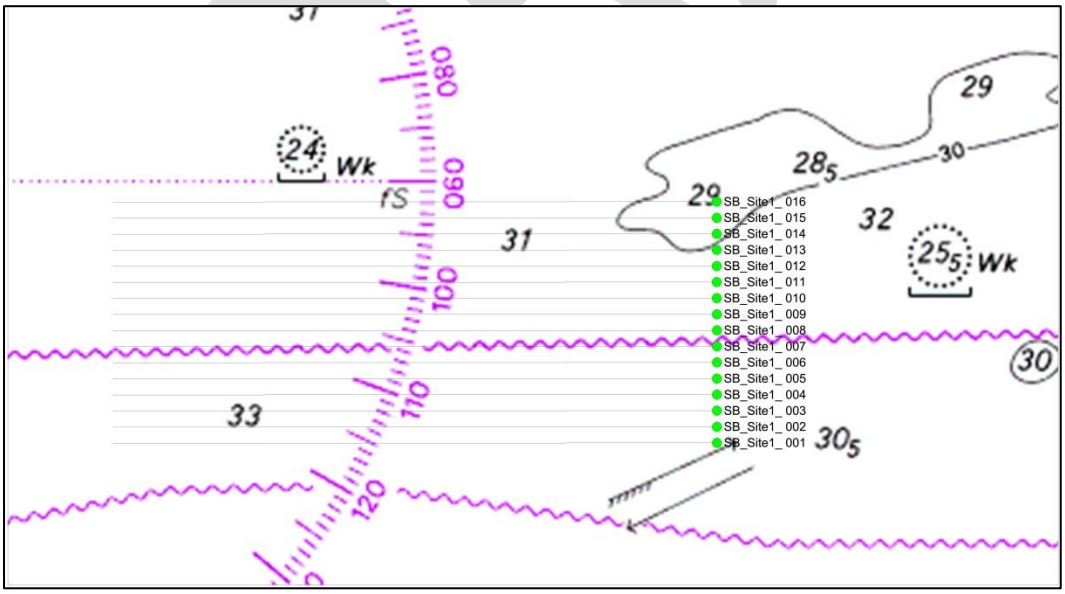

Figure 1. Start points of 150m spaced survey lines. Lines may be completed in either direction and out of order (for example every other line completed then return and fill in the gaps) depending on survey conditions, sidescan stability and vessel safety considerations.

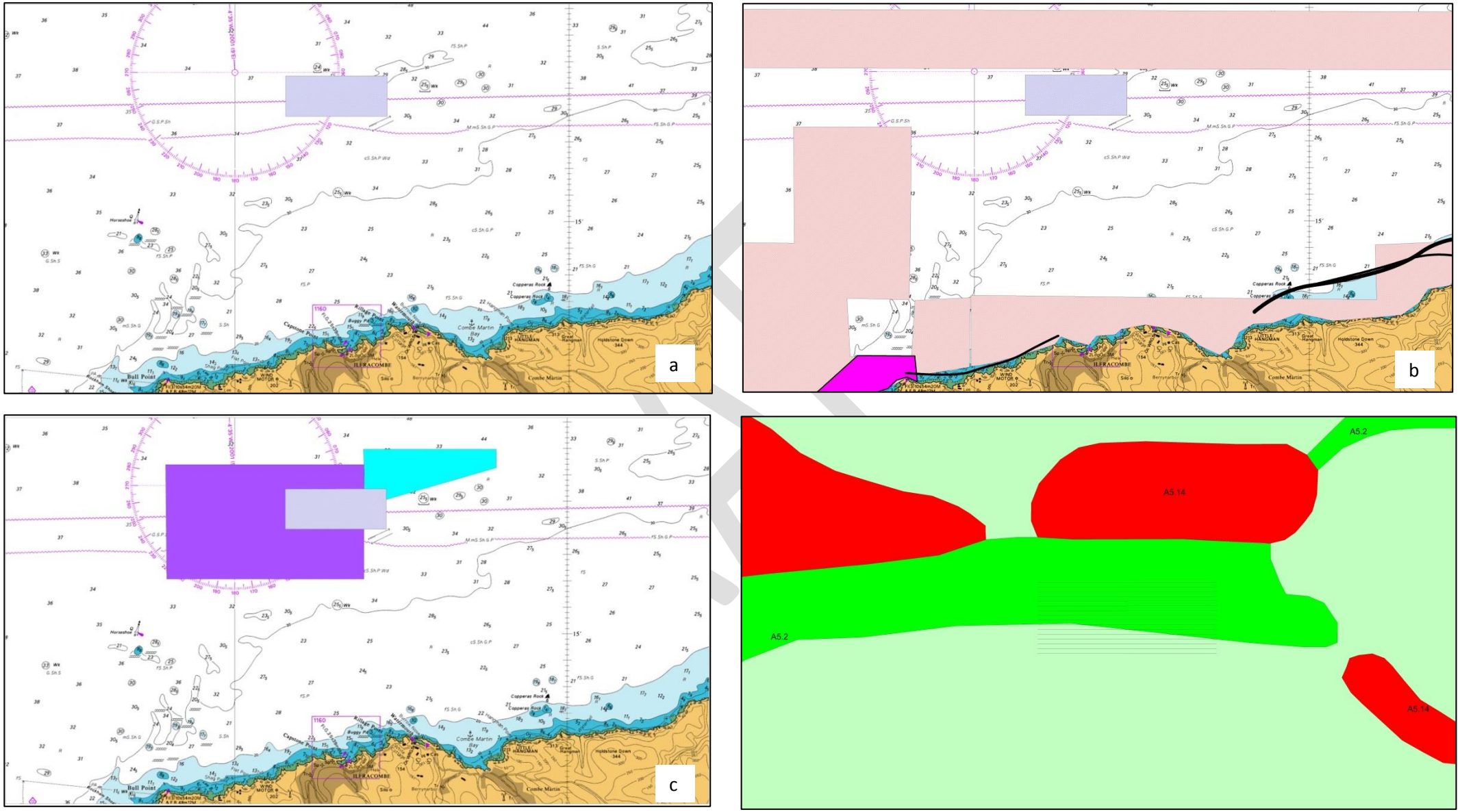

Figure 2. Location, rationale and factors to be considered on survey; (a) Location of Site 1 relative to Ilfracombe; (b) Position of Site 1 relative to important areas for ray fishing - purple area is fished for both *R. clavata* and *R. brachyura* and the blue section is fished only for *R. brachyura*; (c) Known locations of pots as reported in D&S IFCA potting and netting survey 2014/2015.

Site 2: Bideford Bay North a + b		
Rationale: Both sites are partially situated within the area define by fisherman as being some of his most important ground. *Split into two sub-sites due to change in water depth*. Site 2a covers an area fished primarily for *R. microocellata* but also for *R. brachyura*. Encompasses ICES BTS tow location. Site 2b covers an area fished primarily for *R. microocellata* but also for *R. brachyura*. Slightly deeper.		
Area	**Depth range**	**Obstacles**
2.7 sq. km	21-25m	Set-nets around Baggy point September to December but nothing recorded within survey area
Area	**Depth range**	**Obstacles**
2.3 sq. km	34-36m	Set-nets around Baggy point September to December but nothing recorded within survey area

Line number	**Start Latitude**	**Start Longitude**	**End Latitude**	**End Longitude**
SB_Site2a_001	51° 08.4035' N	004° 22.4119' W	51° 09.0517' N	004° 21.3814' W
SB_Site2a_002	51° 08.3675' N	004° 22.3547' W	51° 09.0158' N	004° 21.3241' W
SB_Site2a_003	51° 08.3316' N	004° 22.2975' W	51° 08.9798' N	004° 21.2670' W
SB_Site2a_004	51° 08.2957' N	004° 22.2403' W	51° 08.9439' N	004° 21.2098' W
SB_Site2a_005	51° 08.2597' N	004° 22.1831' W	51° 08.9080' N	004° 21.1526' W
SB_Site2a_006	51° 08.2238' N	004° 22.1260' W	51° 08.8720' N	004° 21.0955' W
SB_Site2a_007	51° 08.1878' N	004° 22.0688' W	51° 08.8361' N	004° 21.0383' W
SB_Site2a_008	51° 08.1519' N	004° 22.0116' W	51° 08.8001' N	004° 20.9811' W
SB_Site2a_009	51° 08.1159' N	004° 21.9544' W	51° 08.7642' N	004° 20.9239' W
SB_Site2a_010	51° 08.0800' N	004° 21.8972' W	51° 08.7283' N	004° 20.8667' W
SB_Site2a_011	51° 08.0440' N	004° 21.8400' W	51° 08.6923' N	004° 20.8096' W
SB_Site2a_012	51° 08.0080' N	004° 21.7829' W	51° 08.6564' N	004° 20.7524' W
SB_Site2a_013	51° 07.9720' N	004° 21.7257' W	51° 08.6204' N	004° 20.6952' W
SB_Site2a_014	51° 07.9361' N	004° 21.6685' W	51° 08.5845' N	004° 20.6380' W
SB_Site2a_015	51° 07.9002' N	004° 21.6113' W	51° 08.5486' N	004° 20.5808' W

Line number	Start Latitude	Start Longitude	End Latitude	End Longitude
SB_Site2b_001	51° 07.1932' N	004° 21.2585' W	51° 07.8755' N	004° 20.1743' W
SB_Site2b_002	51° 07.1572' N	004° 21.2014' W	51° 07.8395' N	004° 20.1172' W
SB_Site2b_003	51° 07.1212' N	004° 21.1442' W	51° 07.8035' N	004° 20.0600' W
SB_Site2b_004	51° 07.0852' N	004° 21.0870' W	51° 07.7675' N	004° 20.0028' W
SB_Site2b_005	51° 07.0492' N	004° 21.0298' W	51° 07.7315' N	004° 19.9456' W
SB_Site2b_006	51° 07.0132' N	004° 20.9726' W	51° 07.6955' N	004° 19.8884' W
SB_Site2b_007	51° 06.9772' N	004° 20.9154' W	51° 07.6595' N	004° 19.8313' W
SB_Site2b_008	51° 06.9412' N	004° 20.8583' W	51° 07.6235' N	004° 19.7741' W
SB_Site2b_009	51° 06.9052' N	004° 20.8011' W	51° 07.5875' N	004° 19.7169' W
SB_Site2b_010	51° 06.8692' N	004° 20.7439' W	51° 07.5515' N	004° 19.6597' W
SB_Site2b_011	51° 06.8332' N	004° 20.6868' W	51° 07.5155' N	004° 19.6025' W
SB_Site2b_012	51° 06.7972' N	004° 20.6296' W	51° 07.4795' N	004° 19.5454' W
SB_Site2b_013	51° 06.7612' N	004° 20.5724' W	51° 07.4435' N	004° 19.4882' W
SB_Site2b_014	51° 06.7252' N	004° 20.5153' W	51° 07.4075' N	004° 19.4311' W
SB_Site2b_015	51° 06.6892' N	004° 20.4581' W	51° 07.3715' N	004° 19.3739' W
SB_Site2b_016	51° 06.6532' N	004° 20.4010' W	51° 07.3355' N	004° 19.3167' W
SB_Site2b_017	51° 06.6172' N	004° 20.3438' W	51° 07.2995' N	004° 19.2596' W

Site 3: Bideford Bay Banks		
Rationale: Area defined by fishermen as good for *R. brachyura* and also small eyed. Area of pronounced sandbanks.		
Area	**Depth range**	**Obstacles**
4.3 sq. km	Approx. 33-38m	No nearby records of pots and nets

Line number	Start Latitude	Start Longitude	End Latitude	End Longitude
SB_Site3_001	50° 08.9726' N	004° 23.9875' W	51° 07.9961' W	004° 25.1722' W
SB_Site3_002	50° 08.9417' N	004° 23.9232' W	51° 07.9653' W	004° 25.1080' W
SB_Site3_003	50° 08.9109' N	004° 23.8590' W	51° 07.9345' W	004° 25.0437' W
SB_Site3_004	50° 08.8801' N	004° 23.7947' W	51° 07.9036' W	004° 24.9794' W
SB_Site3_005	50° 08.8492' N	004° 23.7305' W	51° 07.8728' W	004° 24.9152' W
SB_Site3_006	50° 08.8184' N	004° 23.6662' W	51° 07.8419' W	004° 24.8509' W
SB_Site3_007	50° 08.7875' N	004° 23.6019' W	51° 07.8111' W	004° 24.7867' W
SB_Site3_008	50° 08.7567' N	004° 23.5377' W	51° 07.7803' W	004° 24.7224' W
SB_Site3_009	50° 08.7259' N	004° 23.4734' W	51° 07.7494' W	004° 24.6581' W
SB_Site3_010	50° 08.6950' N	004° 23.4092' W	51° 07.7186' W	004° 24.5939' W
SB_Site3_011	50° 08.6642' N	004° 23.3449' W	51° 07.6877' W	004° 24.5296' W
SB_Site3_012	50° 08.6333' N	004° 23.2806' W	51° 07.6568' W	004° 24.4653' W
SB_Site3_013	50° 08.6025' N	004° 23.2164' W	51° 07.6260' W	004° 24.4011' W
SB_Site3_014	50° 08.5717' N	004° 23.1521' W	51° 07.5951' W	004° 24.3368' W
SB_Site3_015	50° 08.5408' N	004° 23.0879' W	51° 07.5643' W	004° 24.2726' W
SB_Site3_016	50° 08.5100' N	004° 23.0236' W	51° 07.5334' W	004° 24.2083' W
SB_Site3_017	50° 08.4791' N	004° 22.9593' W	51° 07.5025' W	004° 24.1441' W
SB_Site3_018	50° 08.4483' N	004° 22.8951' W	51° 07.4717' W	004° 24.0798' W
SB_Site3_019	50° 08.4175' N	004° 22.8308' W	51° 07.4408' W	004° 24.0155' W
SB_Site3_020	50° 08.3866' N	004° 22.7666' W	51° 07.4099' W	004° 23.9513' W
SB_Site3_021	50° 08.3558' N	004° 22.7023' W	51° 07.3791' W	004° 23.8870' W
SB_Site3_022	50° 08.3250' N	004° 22.6380' W	51° 07.3483' W	004° 23.8228' W
SB_Site3_023	50° 08.2941' N	004° 22.5738' W	51° 07.3174' W	004° 23.7585' W
SB_Site3_024	50° 08.2633' N	004° 22.5095' W	51° 07.2865' W	004° 23.6942' W
SB_Site3_025	50° 08.2324' N	004° 22.4453' W	51° 07.2557' W	004° 23.6300' W

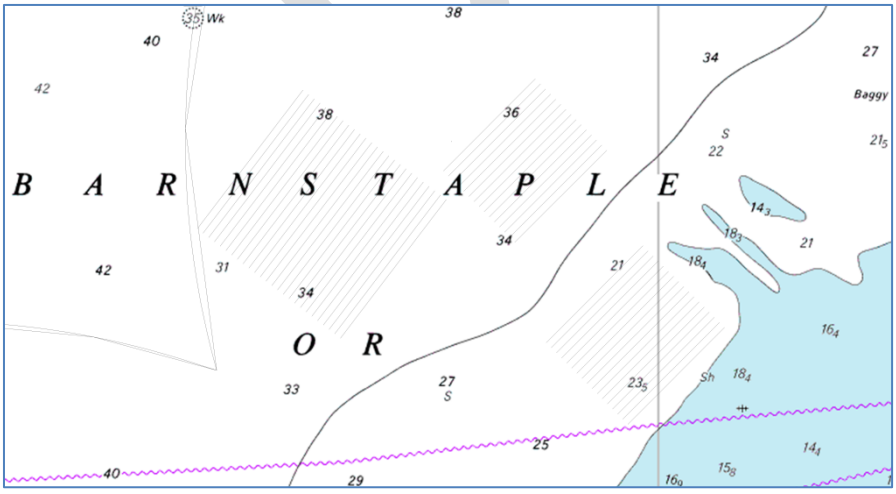

Figure 3 Water depth at survey sites 2 & 3

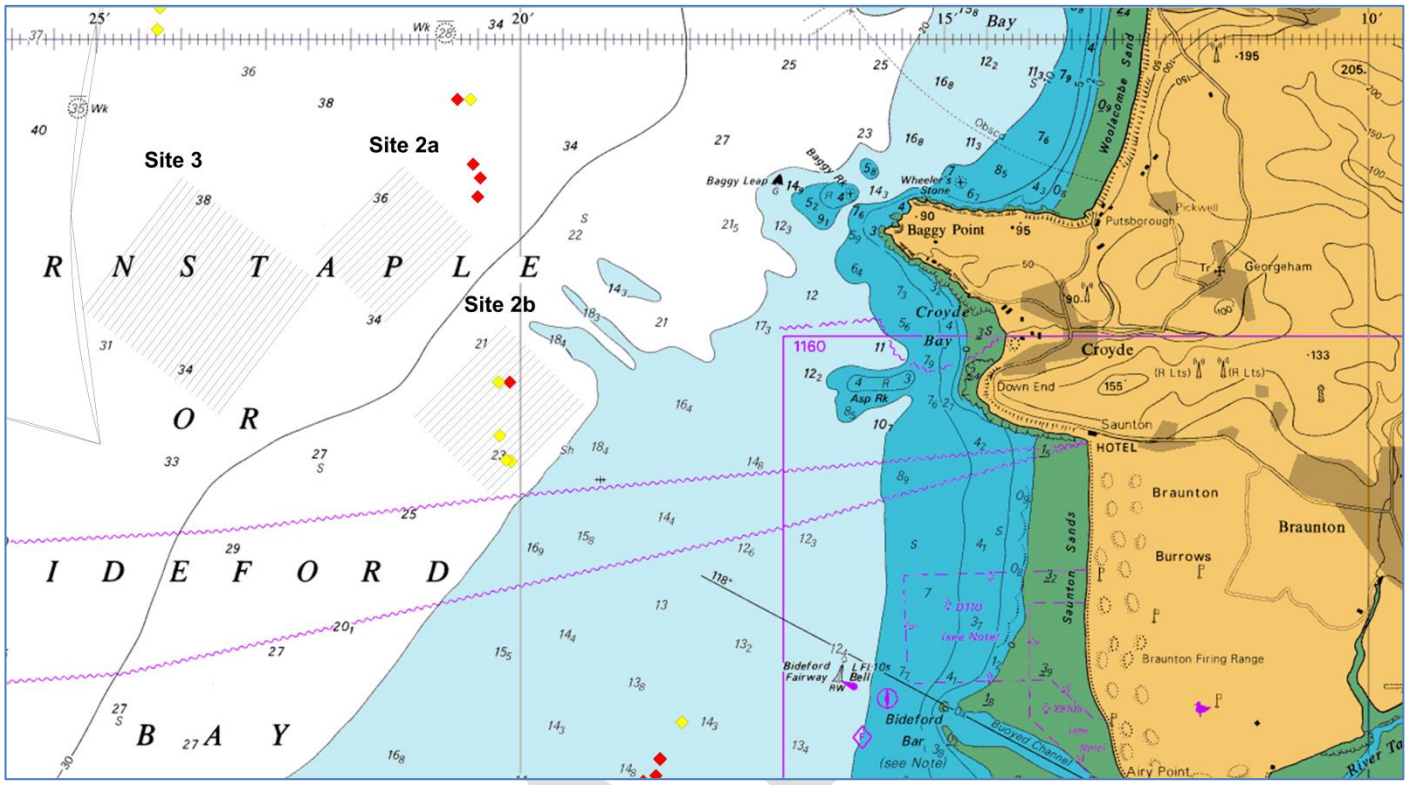

Figure 4 Locations of site 2a, 2b and 3 in Bideford Bay

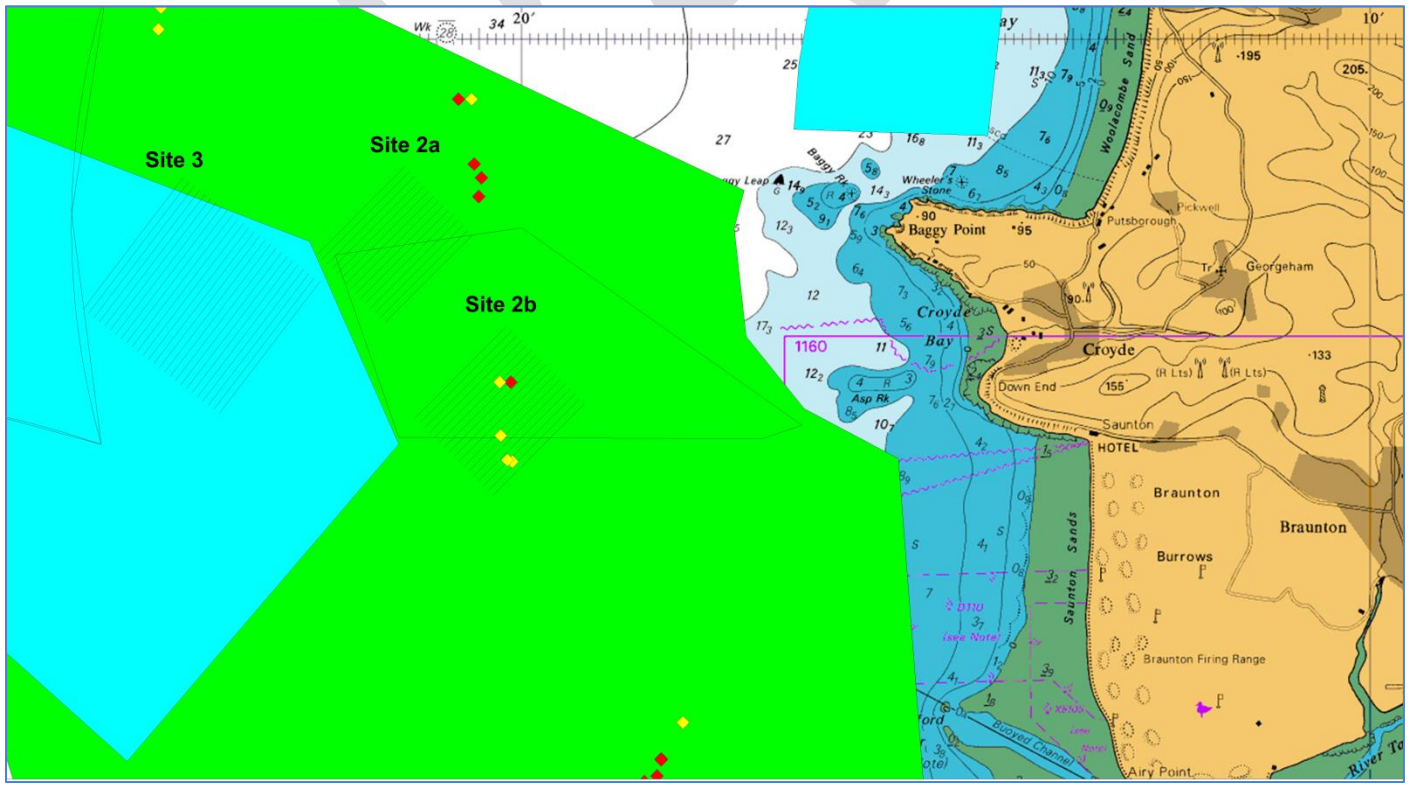

Figure 5 Locations of surveys sites in relation to areas fished for *R. brachyura* (blue) and primarily *R. microocellata* and some *R. brachyura* (green) ICES trawl location start and end points are denoted by yellow and red diamonds

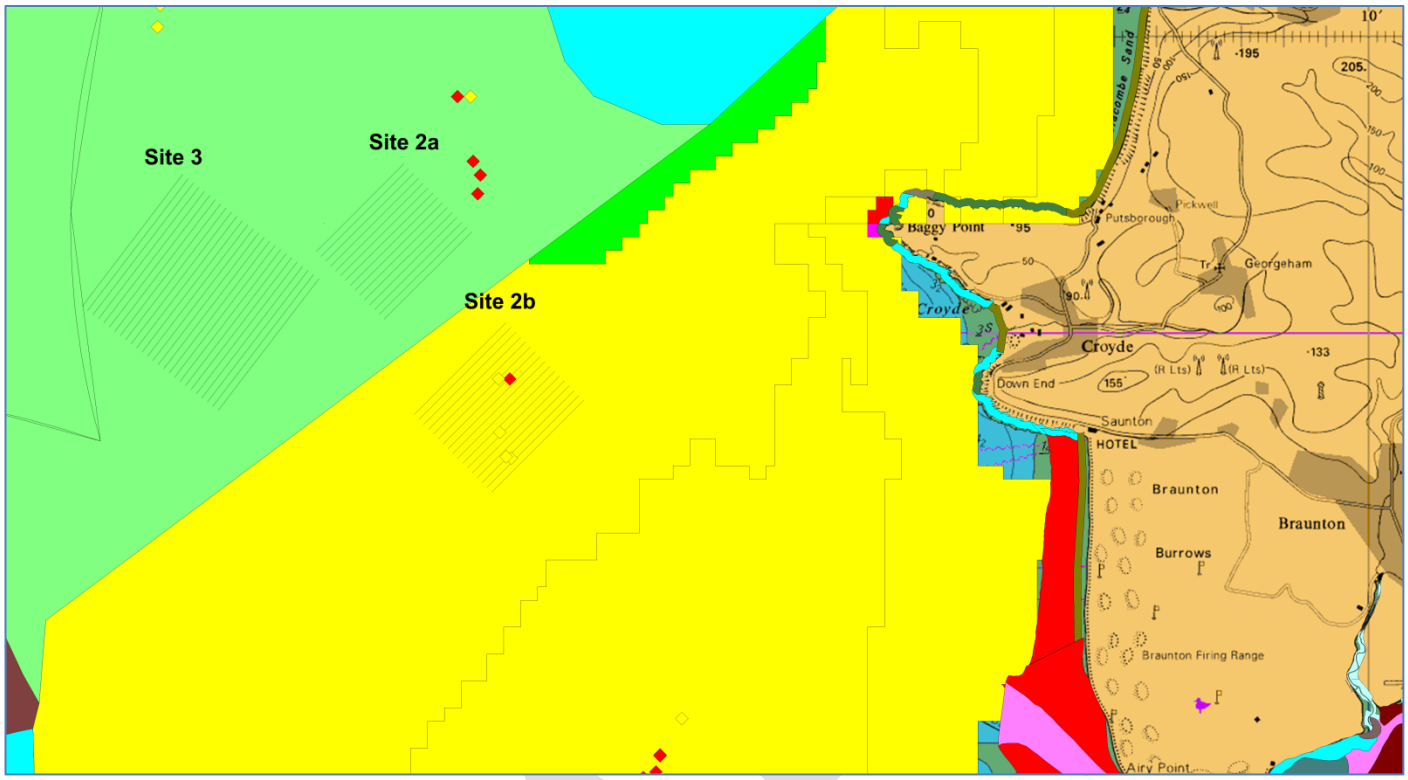

Figure 6 survey sites in relation to predicted habitats. Original legend unreliable so produced simply to show possible areas of change

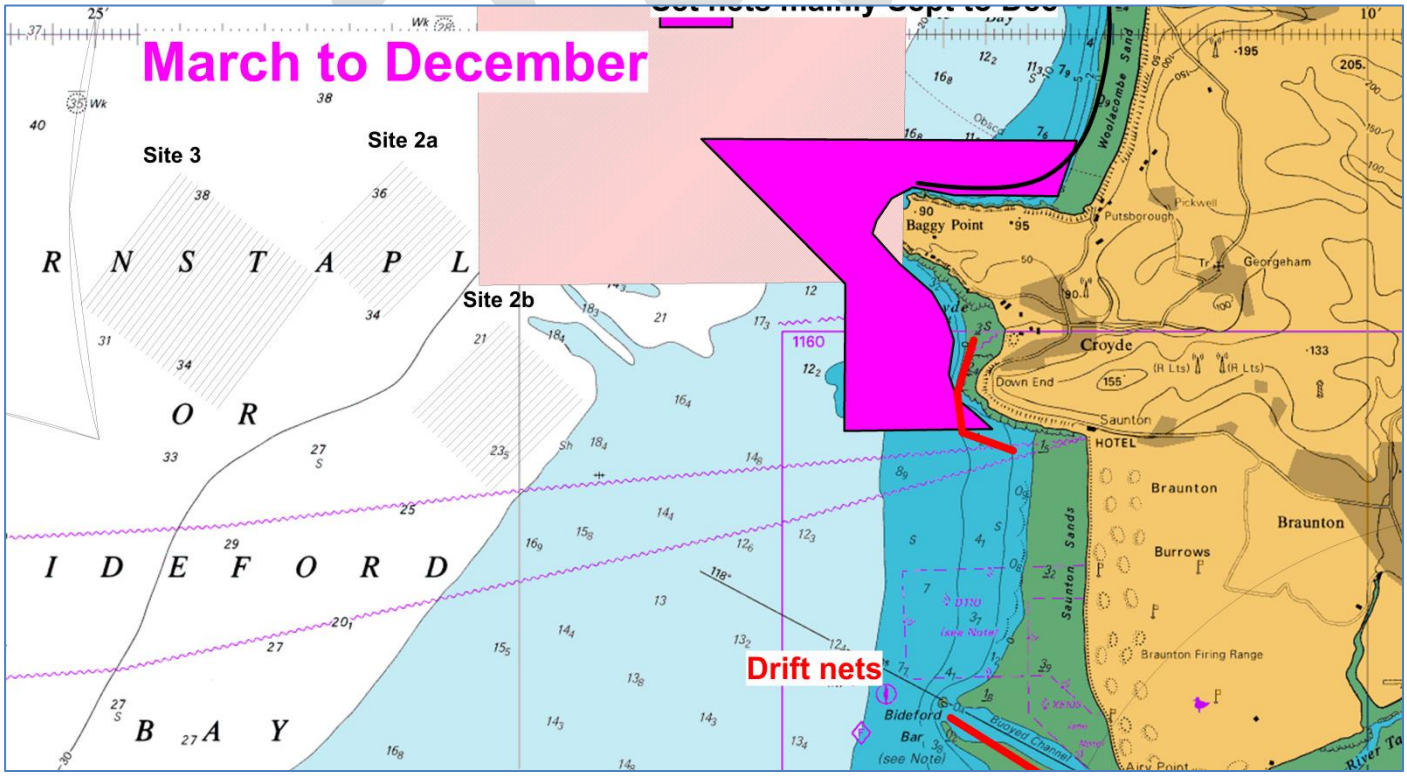

Figure 7 Possible obstructions in the water in the form of nets and pots that could affect the survey. Recce of survey site found it to be clear in September 2015

Site 4: Westward Ho!		
Rationale: Transitional area defined by fishermen as good for *R. microocellata* (northerly 1/3) and *R. clavata* (bottom 2/3). ICES BTS survey location in top 1/3.		
Area	**Depth range**	**Obstacles**
5.7 Sq. km	14-18m	Pots and nets south, east and west of survey location but nothing recorded within survey area.

Line number	Start Latitude	Start Longitude	End Latitude	End Longitude
SB_Site 4_001	51° 02.8498' N	004° 19.3604' W	51° 1.7309' N	004° 0.3523' W
SB_Site 4_002	51° 02.8859' N	004° 19.4176' W	51° 1.7669' N	004° 0.3532' W
SB_Site 4_003	51° 02.9219' N	004° 19.4747' W	51° 1.8030' N	004° 0.3542' W
SB_Site 4_004	51° 02.9580' N	004° 19.5319' W	51° 1.8390' N	004° 0.3551' W
SB_Site 4_005	51° 02.9941' N	004° 19.5890' W	51° 1.8751' N	004° 0.3561' W
SB_Site 4_006	51° 03.0301' N	004° 19.6462' W	51° 1.9112' N	004° 0.3570' W
SB_Site 4_007	51° 03.0662' N	004° 19.7033' W	51° 1.9472' N	004° 0.3580' W
SB_Site 4_008	51° 03.1022' N	004° 19.7605' W	51° 1.9833' N	004° 0.3590' W
SB_Site 4_009	51° 03.1383' N	004° 19.8177' W	51° 2.0194' N	004° 0.3599' W
SB_Site 4_010	51° 03.1744' N	004° 19.8749' W	51° 2.0554' N	004° 0.3608' W
SB_Site 4_011	51° 03.2104' N	004° 19.9321' W	51° 2.0910' N	004° 0.3618' W
SB_Site 4_012	51° 03.2465' N	004° 19.9892' W	51° 2.1275' N	004° 0.3627' W
SB_Site 4_013	51° 03.2825' N	004° 20.0464' W	51° 2.1636 ' N	004° 0.3637' W
SB_Site 4_014	51° 03.3186' N	004° 20.1036' W	51° 2.1997' N	004° 0.3646' W
SB_Site 4_015	51° 03.3547' N	004° 20.1608' W	51° 2.2357' N	004° 0.3655' W
SB_Site 4_016	51° 03.3907' N	004° 20.2180' W	51° 2.2718' N	004° 0.3665' W
SB_Site 4_017	51° 03.4267' N	004° 20.2751' W	51° 2.3078' N	004° 0.3675' W
SB_Site 4_018	51° 03.4628' N	004° 20.3323' W	51° 2.3439' N	004° 0.3685' W
SB_Site 4_019	51° 03.4988' N	004° 20.3895' W	51° 2.3800' N	004° 0.3694' W
SB_Site 4_020	51° 03.5348' N	004° 20.4467' W	51° 2.4160' N	004° 0.3704' W
SB_Site 4_021	51° 03.5708' N	004° 20.5039' W	51° 2.4521' N	004° 0.3713' W

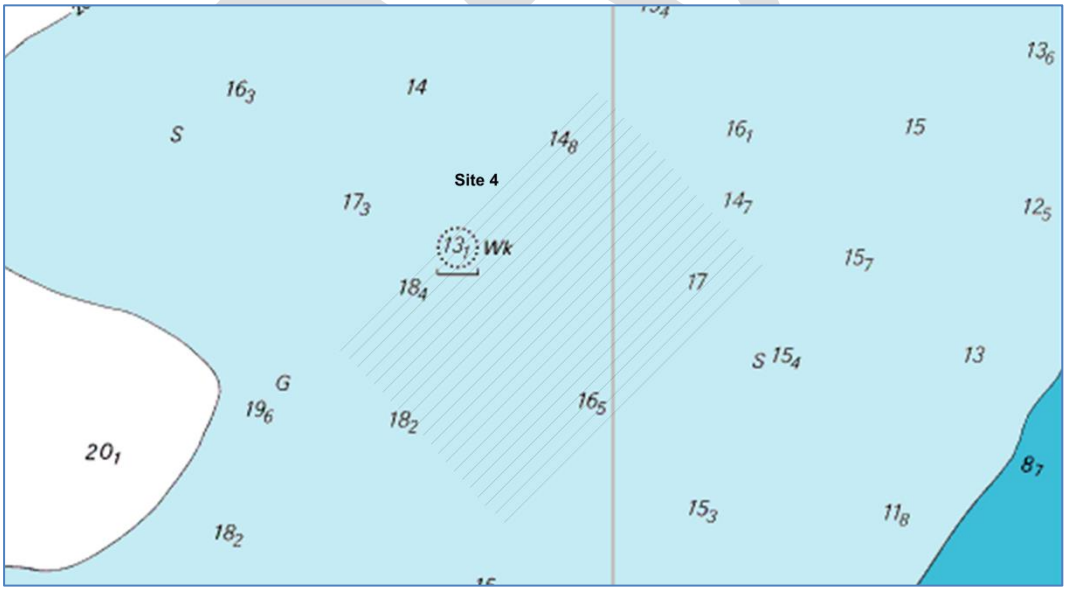

Figure 8 Water depth at survey site 4

Site 4 Option 2: Westward Ho!		
Rationale: Transitional area defined by fishermen as good for *R. microocellata* (northerly 1/3) and *R. clavata* (bottom 2/3). ICES BTS survey location in top 1/3. BUT avoiding pots recorded on recce		
Area	**Depth range**	**Obstacles**
5.7 Sq. km	14-18m	Pots and nets south, east and west of survey location but nothing recorded within survey area.

Line number	**Start Latitude**	**Start Longitude**	**End Latitude**	**End Longitude**
SB_Site 4(2)_001	51° 03.8264' N	004° 20.1035' W	51° 002.7078' N	004° 21.8787' W
SB_Site 4(2)_002	51° 03.7937' N	004° 20.0394' W	51° 002.6750' N	004° 21.8146' W
SB_Site 4(2)_003	51° 03.7582' N	004° 19.9822' W	51° 002.6395' N	004° 21.7574' W
SB_Site 4(2)_004	51° 03.7184' N	004° 19.9242' W	51° 002.5996' N	004° 21.6993' W
SB_Site 4(2)_005	51° 03.6829' N	004° 19.8695' W	51° 002.5641' N	004° 21.6447' W
SB_Site 4(2)_006	51° 03.6486' N	004° 19.8088' W	51° 002.5297' N	004° 21.5840' W
SB_Site 4(2)_007	51° 03.6114' N	004° 19.7542' W	51° 002.4926' N	004° 21.5294' W
SB_Site 4(2)_008	51° 03.5758' N	004° 19.7006' W	51° 002.4570' N	004° 21.4758' W
SB_Site 4(2)_009	51° 03.5398' N	004° 19.6435' W	51° 002.4209' N	004° 21.4186' W
SB_Site 4(2)_010	51° 03.4988' N	004° 19.5863' W	51° 002.3800' N	004° 21.3614' W
SB_Site 4(2)_011	51° 03.4617' N	004° 19.5316' W	51° 002.3429' N	004° 21.3067' W
SB_Site 4(2)_012	51° 03.4219' N	004° 19.4767' W	51° 002.3030' N	004° 21.2519' W
SB_Site 4(2)_013	51° 03.3825' N	004° 19.4277' W	51° 002.2636' N	004° 21.2029' W
SB_Site 4(2)_014	51° 03.3464' N	004° 19.3731' W	51° 002.2276' N	004° 21.1483' W
SB_Site 4(2)_015	51° 03.3071' N	004° 19.3160' W	51° 002.1882' N	004° 21.0911' W
SB_Site 4(2)_016	51° 03.2695' N	004° 19.2613' W	51° 002.1506' N	004° 21.0364' W
SB_Site 4(2)_017	51° 03.2349' N	004° 19.2069' W	51° 002.1161' N	004° 20.9820' W
SB_Site 4(2)_018	51° 03.1923' N	004° 19.1547' W	51° 002.0735' N	004° 20.9299' W
SB_Site 4(2)_019	51° 03.1563' N	004° 19.1055' W	51° 002.0374' N	004° 20.8807' W
SB_Site 4(2)_020	51° 03.1221' N	004° 19.0349' W	51° 002.0032' N	004° 20.8100' W
SB_Site 4(2)_021	51° 03.0830' N	004° 18.9718' W	51° 001.9641' N	004° 20.7470' W

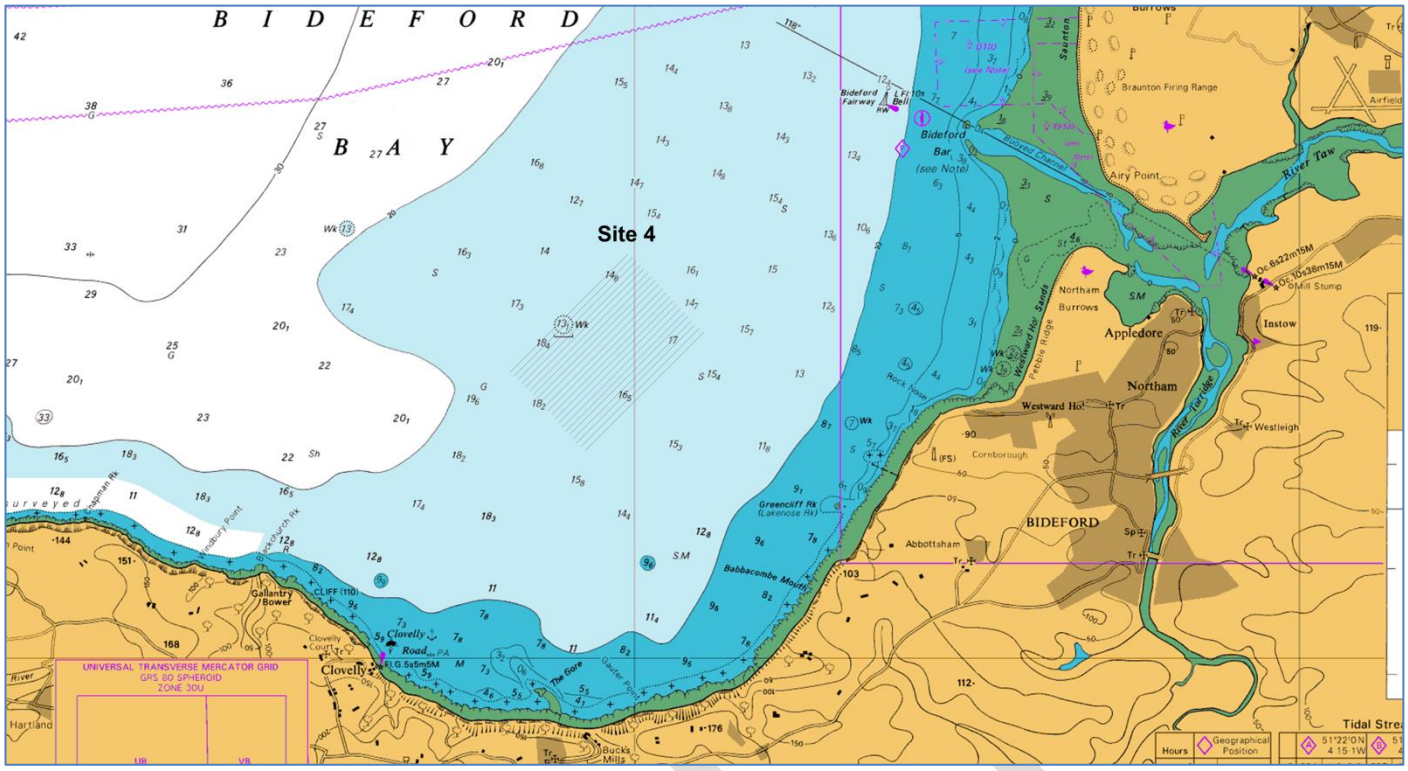

Figure 9 Location of site 4 in Bideford Bay

Figure 10 Locations of survey site in relation to areas fished for *R. clavata* (red) and primarily *R. microocellata* and some *R. brachyura* (green) ICES trawl location start and end points are denoted by yellow and red diamonds

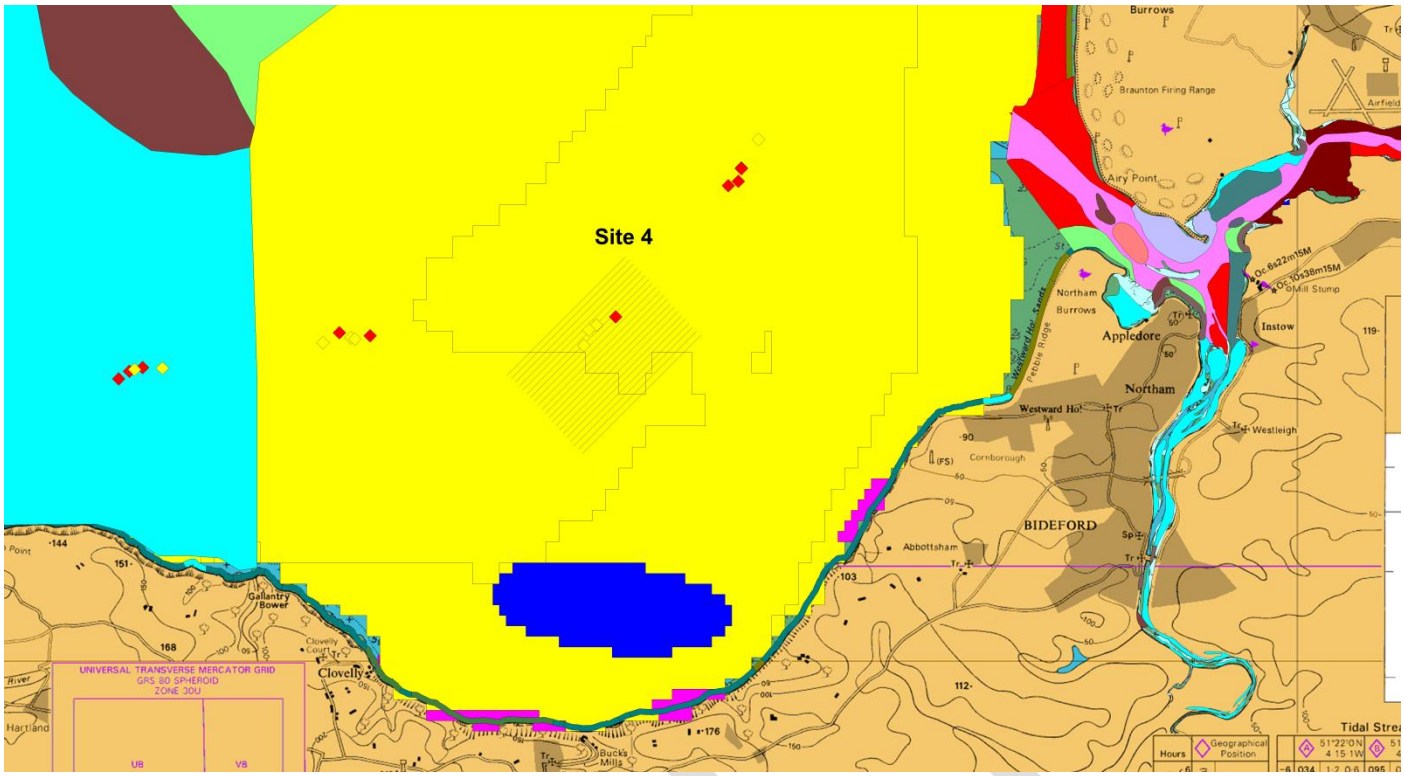

Figure 11 Location of survey site in relation to predicted habitats. Original legend unreliable so produced simply to show possible areas of change

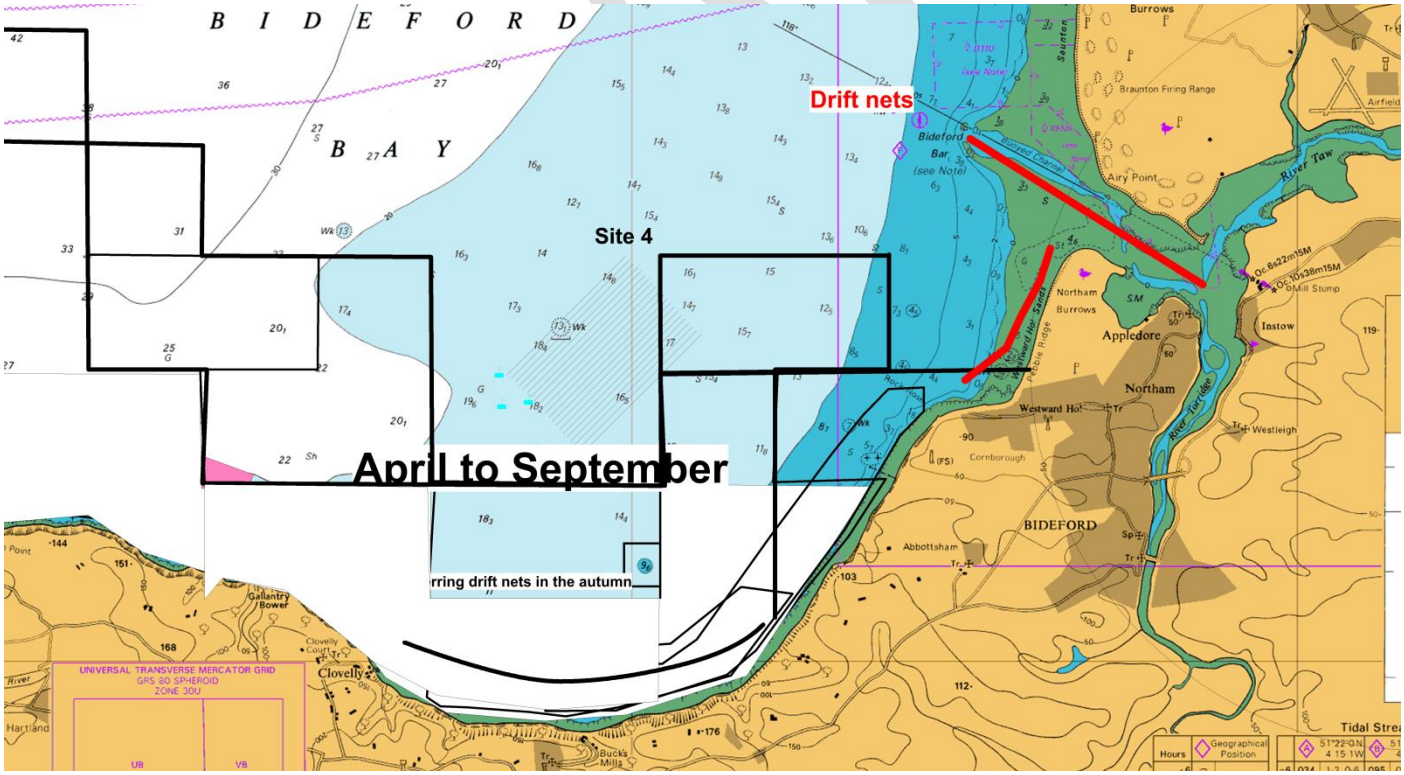

Figure 12 Possible obstructions in the water in the form of nets and pots that could affect the survey. Recce of surveysite found some pots in the Southern half in September 2015, hence the alternative co-ordinates provided.