Crab Tile Surveys of Devon Estuaries 2020

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LP	16/03/2021	Draft report	0.1
	26/03/2021	Comments on first draft by J. Stewart	0.2
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1. Introduction

Crab tiling, also known as crab potting, is a method of collecting shore crabs (*Carcinus maenas*) for use as fishing bait by anglers. Like all other crustaceans, shore crabs moult their shells at intervals during their life cycle, during which they seek a refuge from predators. Crab tilers exploit this behaviour, providing artificial shelters such as roof tiles, guttering, drainpipes, chimney pots and tyres (Black, 2014). Whist sheltering under the tiles, the crabs are preparing to peel, and they release a hormone as part of the moulting process. The scent of the hormone produced is a powerful attractor to fish and this is why 'peelers' are one of the top baits used by anglers. However, this is also the reason it is necessary for crabs to find shelter during the peeling process. It is in this state that the crabs are collected for bait during low water when the tiles are exposed. Crabs are gathered early in the peeling process and stored in low temperature conditions that will holt or slow the process. Once the crabs have peeled and in a soft state the hormones are no longer present and therefore there are less attractive to fish. This method of bait collection has been used throughout Devon for generations.

Devon and Severn Inshore Fisheries and Conservation Authority (D&S IFCA) has a duty to manage the exploitation of sea fisheries resources under the Marine and Coastal Access Act 2009 (MaCCA) and this includes crab tiling. Every four years, surveys are carried out to determine the number and location of crab tiles on the intertidal zone of estuaries in the D&S IFCA's District. These surveys enable D&S IFCA to assess any potential impacts of crab tiling on sensitive estuary environments, and to inform the development of appropriate management. Crab tiles have the potential to change habitat complexity, benthic infaunal diversity and abundance, and bird behaviour over large areas (Sheehan et al., 2010). The 2020 survey results will feed into a hand gathering byelaw which D&S IFCA is currently developing.

In 2015, D&S IFCA trialled the use of an Unmanned Aerial Vehicle (UAV) to undertake the surveys. As this was successful, the methodology was adopted for all the estuaries, apart from the Axe, in 2020. The Axe was carried out on foot due to the small numbers of tiles in 2016.

2. Methodology

The aerial imagery company Vertical Horizons Media were chartered to carry out the work using an UAV. Surveys were carried out on the Axe, Dart, Teign, Exe, Taw Torridge, Tamar, Plym, and Salcombe and Kingsbridge estuary in May and June 2020. Some sites on the Dart and Taw Torridge had to be completed in September 2020. Surveys on the Dart were incomplete due to airspace restrictions and Covid-19, and the Axe was incomplete due to Covid-19 restricting the use of two officers on the muddy West side of the estuary. These will be completed when Covid-19 restrictions and officer time resources allow for it.

Surveys were carried out over a four-hour time frame, two hours either side of low water on spring tides. The UAV cannot be flown in the rain and is restricted by wind, with the maximum peak wind speed it can be flown being 23mph. Using the site maps produced from the past surveys, the operator programmed flight paths into the UAV for each location of the survey. The UAV then flew these pre-determined flight paths at an altitude of 20m, recording the GPS track, and taking photos every few seconds to achieve a target ground spacing distance of 1 pixel/cm. The flight was monitored by the operator who was able to manually override the UAV to compensate for obstacles and wind drift.

The images from the survey were then processed by the UAV operator using the processing software, Pix4D. The software stitches together the imaging and creates geo-tiles. These

geo-tiles are in a TIF format to allow them to be overlaid in QGIS mapping software to give the exact location of the images. The images could then be zoomed in on for the crab tiles to be counted and regions mapped. An example of crab tiles from the UAV imaging can be seen in Figure 1. In some instances, where there are rocks and weed, it may not be possible to distinguish between tiles and rocks. In these cases, other officers should check the images and joint decisions should be made with best personal judgement. They are more likely to be tiles if they are in an organised manner, such as rows, or if there are fresh footprints around them.

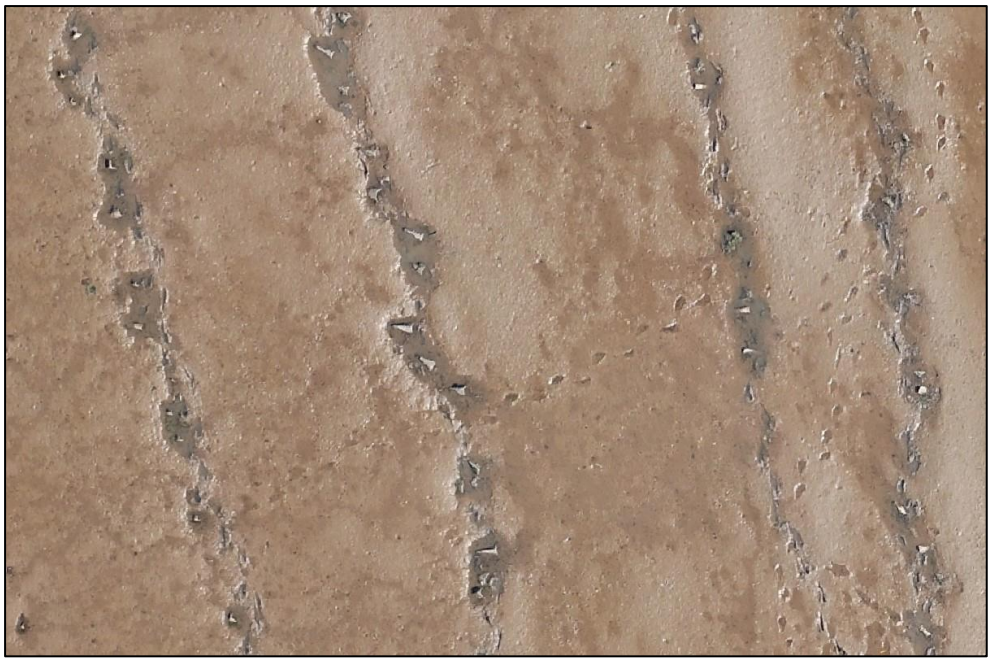

Figure 1 Example of crab tiles from UAV imaging

3. Results

3.1 Overall Results

The overall results of the 2020 survey are compared to those of previous years in Table 1. There was a 5% increase in tiles across the District since 2016, despite surveys being incomplete on the Axe and Dart. Although there has been an increase since 2016, this is still a decrease since surveys began in early 2000s. Comparison in number of tiles and percentage differences can be seen in Tables 2-11. Surveys were not undertaken on the River Erme, Otter, Sid or Yealm in 2020 due to no tiles being present in previous years. The River Avon was not surveyed as no tiles have been present since 50 were observed in 2003/04.

*Table 1 – Comparisons of crab tile counts in each estuary in the Devon and Severn IFCA's District. [1]Devon and Severn IFCA's District only, *West bank still to survey due to Covid-19 restrictions, **two sites still to survey due to air space restrictions and Covid-19, which restricted activity.*

Estuary	2020	2016 (Davies, 2017)	2012 (Noble, 2013a&b)	2011 (unknown)	2008 (Lockett, 2008)	2003/04 (Black, 2004)	2000/01 (Black, 2004)
Avon	-	0	-	-	-	50	0
Axe	245*	263	-	-	-	0	0
Dart	4,674**	5,484	-	-	-	11,904	11,794
Exe	21,146	23,835	20,997	-	26,488	30,302	26,796
Plym	4,251	2,019	1,710	-	-	2,729	2,956
Tamar[1]	3,916	3,570	4,929	-	-	2,646	3,412
Taw-Torridge	3,751	3,704	-	2,213	-	3,741	4,864
Teign	16,412	12,865	-	-	-	22,722	21,001
Salcombe & Kingsbridge	118	105	-	-	-	193	534
Total	54,513	51,845	-	-	-	74,287	71,357

3.2 River Axe

Crab tiles were first recorded in 2016 for the River Axe, with a total of 263. Surveys were carried out on foot on the east side in 2020, however the west side is yet to be surveyed due to Covid-19 restrictions limiting surveys and the requirement of two officers due to muddy conditions. A total of 245 tiles have been observed so far. When removing the west bank tiles numbers from the 2016 results and comparing these results with 2020, there has been a 46% increase in tiles. This figure may increase further if there are still tiles on the west bank when surveyed. Figure 2 shows the location of crab tiles on the River Axe, comparing 2016 and 2020.

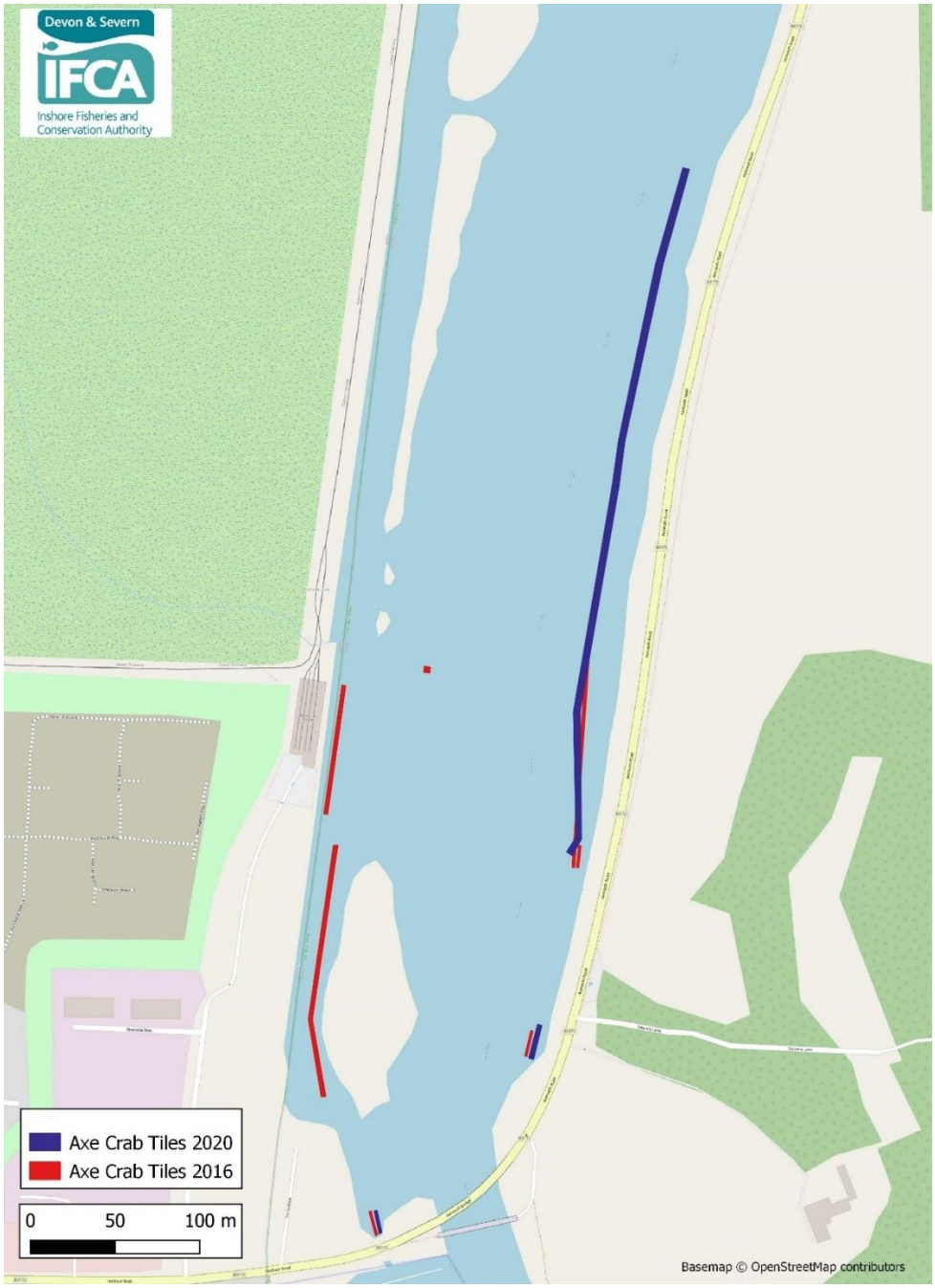

Figure 2 - Crab tiles on the River Axe. Comparison of 2016 and 2020 counts. Base map © OpenStreetMap contributors

3.3 River Dart

Crab tile surveys on the River Dart were carried out with the UAV in 2020. Two sites on the lower Dart could not be surveyed with the UAV due to air space restrictions near the Naval College. These two sites will be surveyed once Covid-19 restrictions allow. When excluding these two sites from both the 2016 and 2020 results there has been a 14% increase since 2016. Table 2 shows changes in tile numbers since 2000/01.

Figure 3 to Figure 6 show the location of crab tiles on the River Dart. Since 2003 in the Galmpton area (Figure 5), while some areas have remained consistent, there are large areas of tiles that are no longer present.

Table 2 –Comparison of crab tile counts from previous surveys on the River Dart. [1]Including all areas surveyed in 2016. [2]Excludes areas from 2016 not surveyed in 2020.

Survey	Number of crab tiles	Difference	Percentage difference
2020	4674	-810[1] +590[2]	-15%[1] +14%[2]
2016	5,484[1] 4,084[2]	-6,420	-54%
2003/04	11,904	+110	+1%
2000/01	11,794	-	-

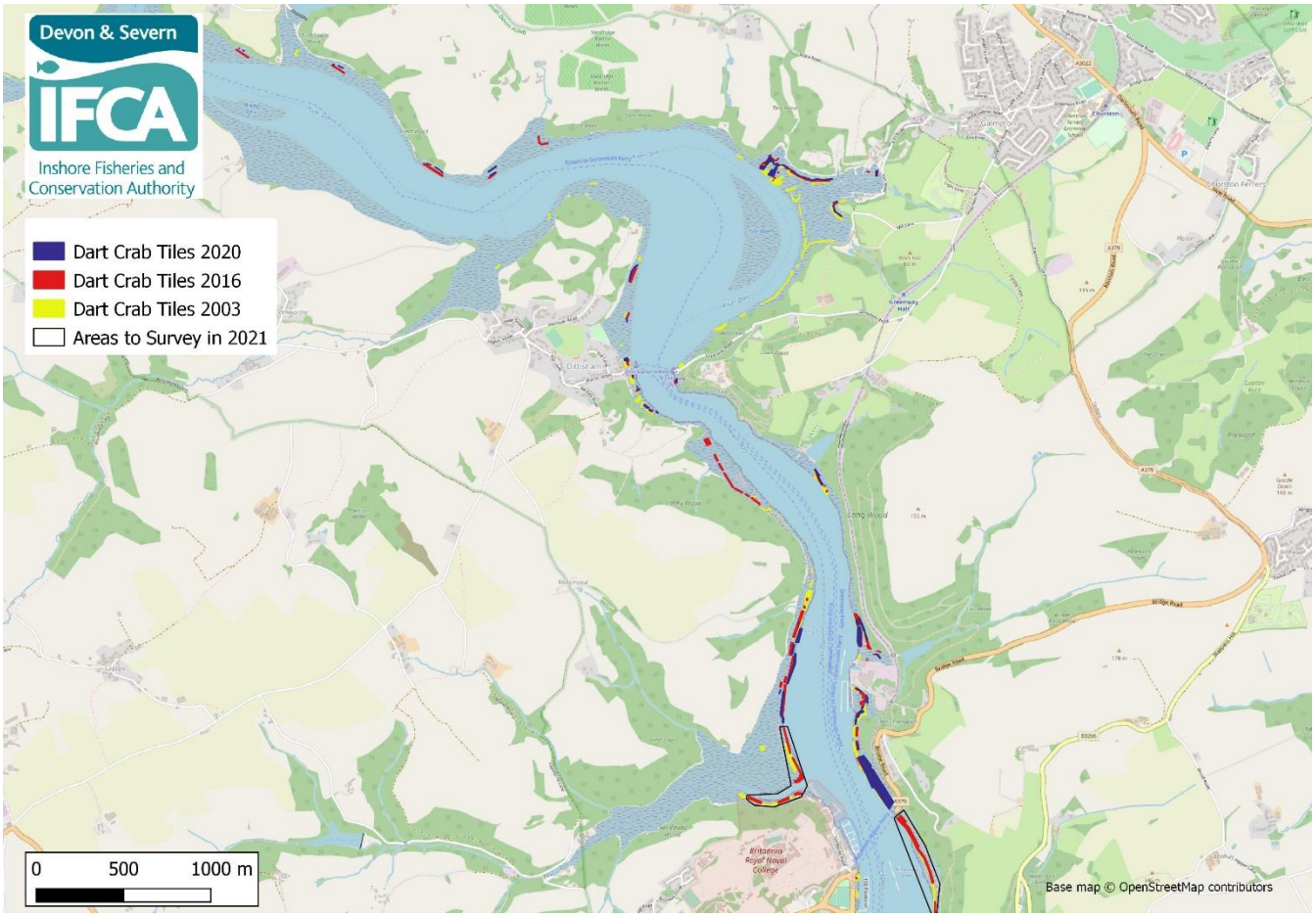

Figure 3 – Overview of crab tiles on the River Dart comparing 2003, 2016 and 2020 surveys. Base map © OpenStreetMap contributors

Figure 4 –Crab tiles on the upper Dart Estuary comparing 2003, 2016 and 2020 surveys. Base map © OpenStreetMap contributors

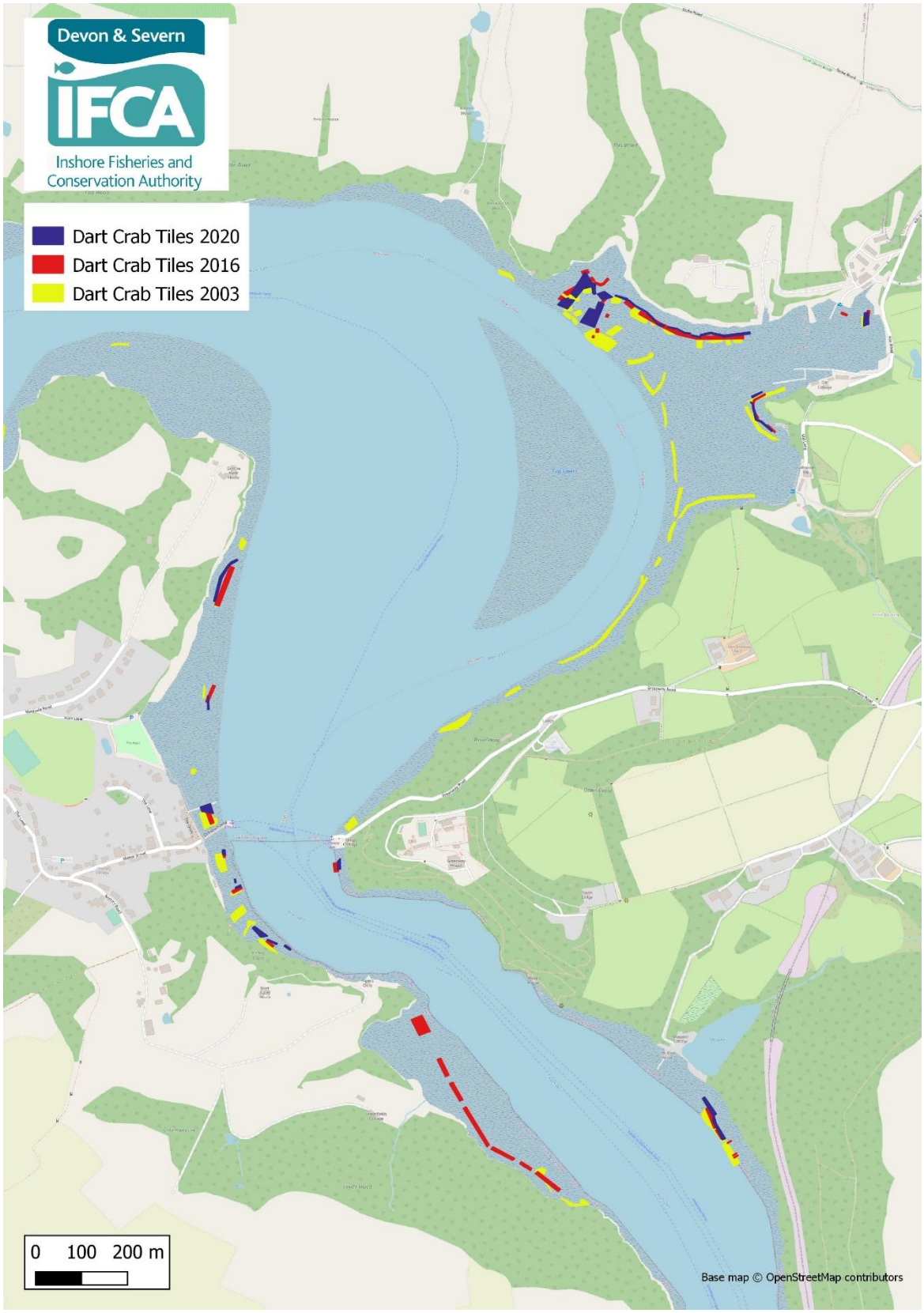

Figure 5 - Crab tiles near Galmpton and Dittisham, Dart Estuary comparing 2003, 2016 and 2020 surveys. Base map © OpenStreetMap contributors

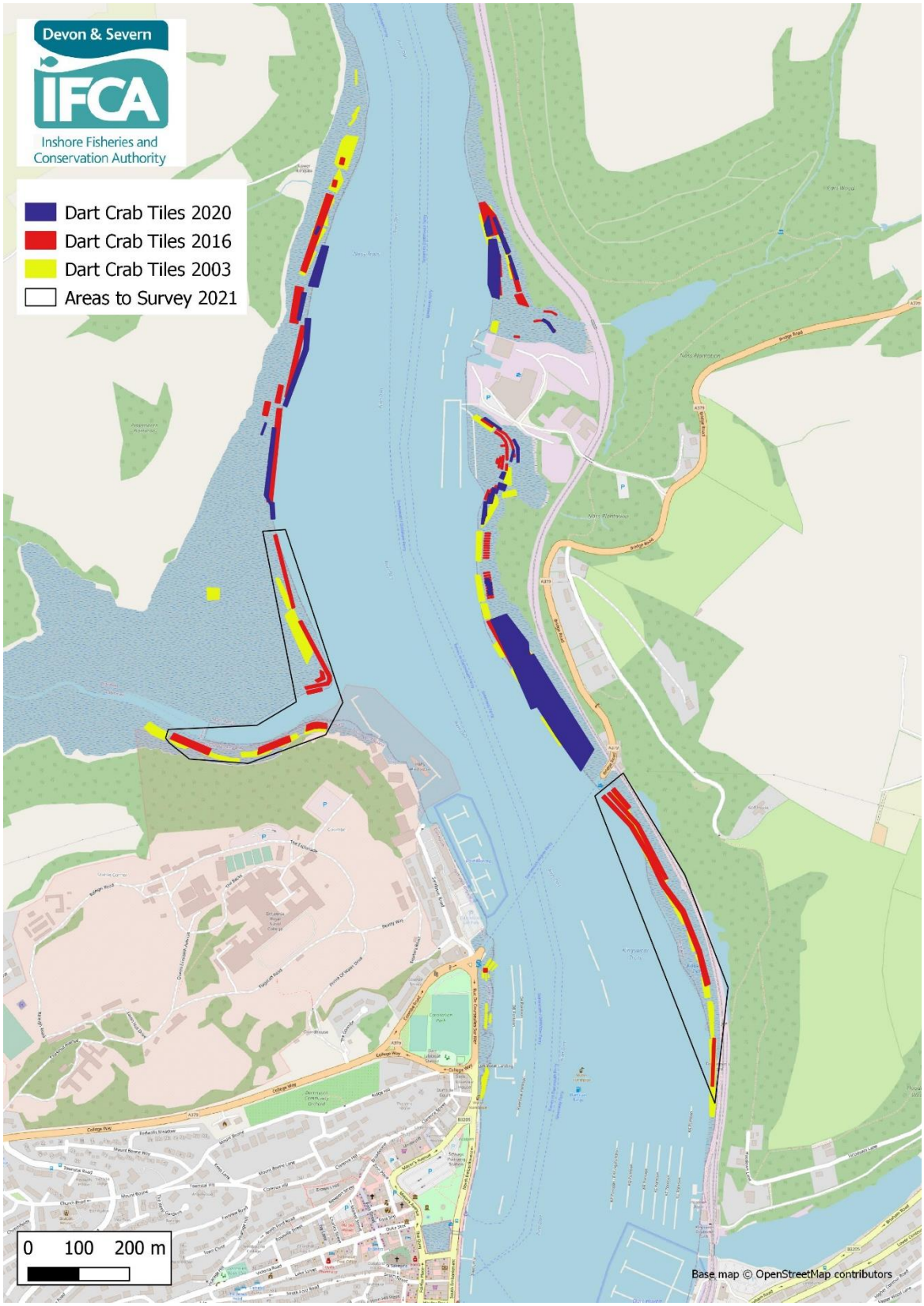

Figure 6 - Crab tiles on the lower Dart Estuary comparing 2003, 2016 and 2020 surveys. Areas not surveyed in 2020 outlined by black polygons. Base map © OpenStreetMap contributors

3.4 Exe Estuary

Crab tiles were counted on the Exe Estuary using an UAV in 2020, this site was also surveyed with an UAV in 2016. A total of 21,146 crab tiles were counted in 2020. This is a 11% decrease since 2016, but more in line with the 2012 count (Table 3). Table 4 shows the breakdown of crab tiles in different areas of the Exe Estuary compared to previous years. There was a decrease in five out of the nine areas surveyed, with the largest decrease of 28% in area Exe08. Although there were increases in four of the sites, these were minimal. The largest increase of 19% was in area Exe19. Figure 7 to Figure 14 show the location of crab tiles on the Exe Estuary, the 2008 layers were not available at the time of writing this report and so are not included in the maps.

Table 3 - Comparison of crab tile counts from previous surveys on the Exe Estuary

Survey	Number of crab tiles	Difference	Percentage difference
2020	21,146	-2,689	-11%
2016	23,835	+2,838	+14%
2012	20,997	-5,451	-21%
2008	26,488	-3,814	-13%
2003/04	30,302	+3,506	+13%
2000/01	26,796	-	-

Table 4 - Breakdown of crab tile numbers and distribution on the Exe Estuary

Location	Area	2020	2016	2012	2008	2003/04	1999/00
Dawlish Warren	EXE 04	82	93	148	152	410	0
	EXE 05	3,684	5,073	4,406	6,054	4,573	1,135
Cockwood-Starcross	EXE 06	5,452	5,237	3,188	4,720	6,375	3,400
North of Starcross	EXE 07	5,728	6,760	7,338	6,313	8,468	8,450
South of Powderham	EXE 08	1,661	2,317	1,757	2,765	3,303	4,876
North of Powderham	EXE 09	-	0	0	0	0	150
North of Lympstone	EXE 17	652	584	330	384	420	1,165
South of Lympstone	EXE 18	916	1,231	1,123	1,472	1,580	900
Middle of Exmouth and Lympstone	EXE 19	2,641	2,226	2,463	4,022	4,218	5,820
Exmouth	EXE 20	330	314	244	606	955	900

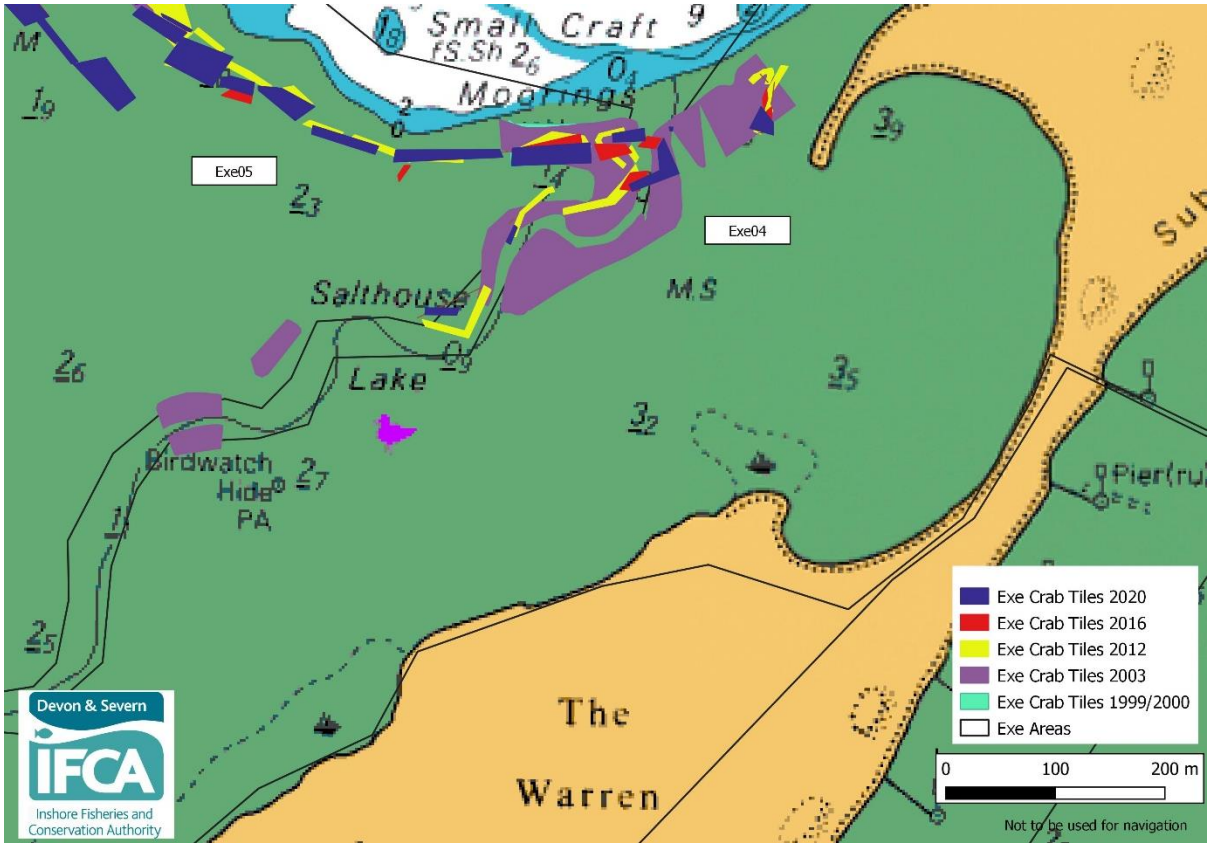

Figure 7 – Crab tiles on the Exe Estuary, comparing each survey year in Area Exe04

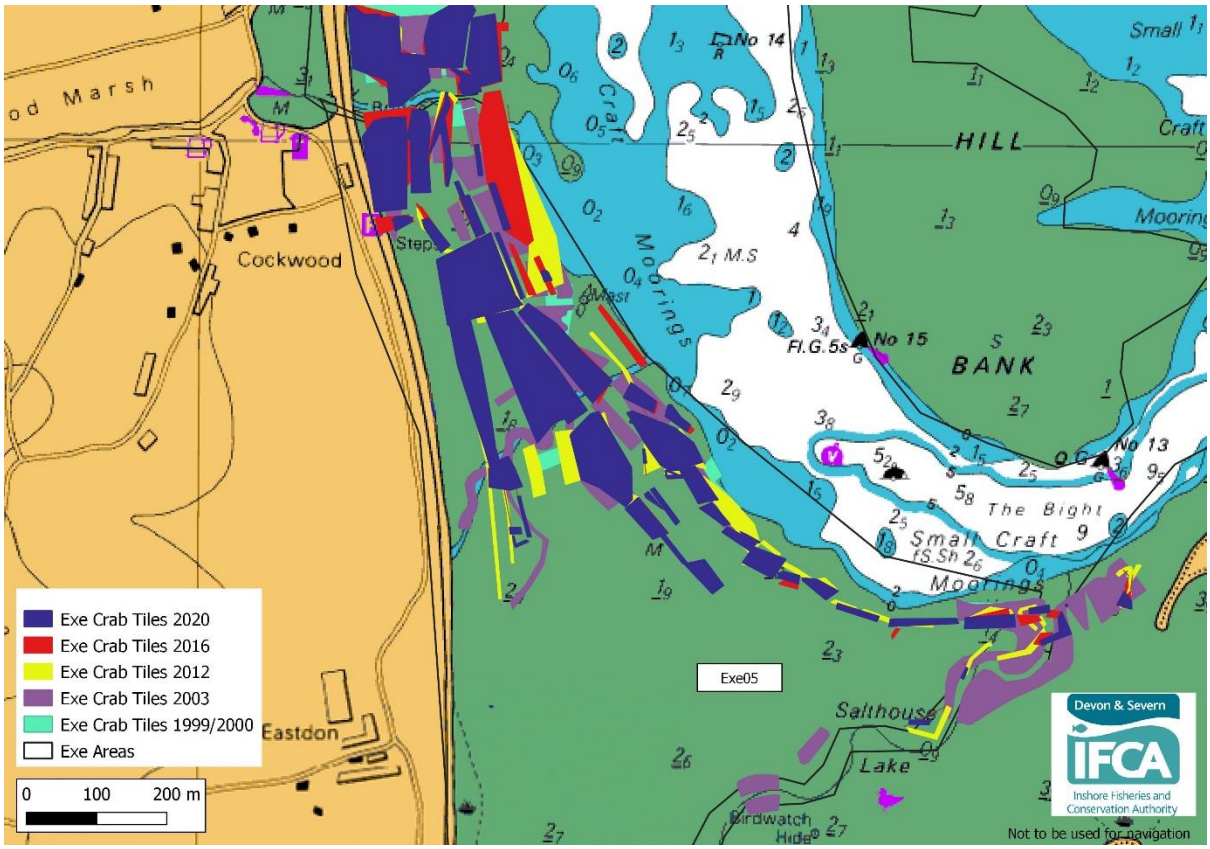

Figure 8 - Crab tiles on the Exe Estuary, comparing each survey year in Area Exe05

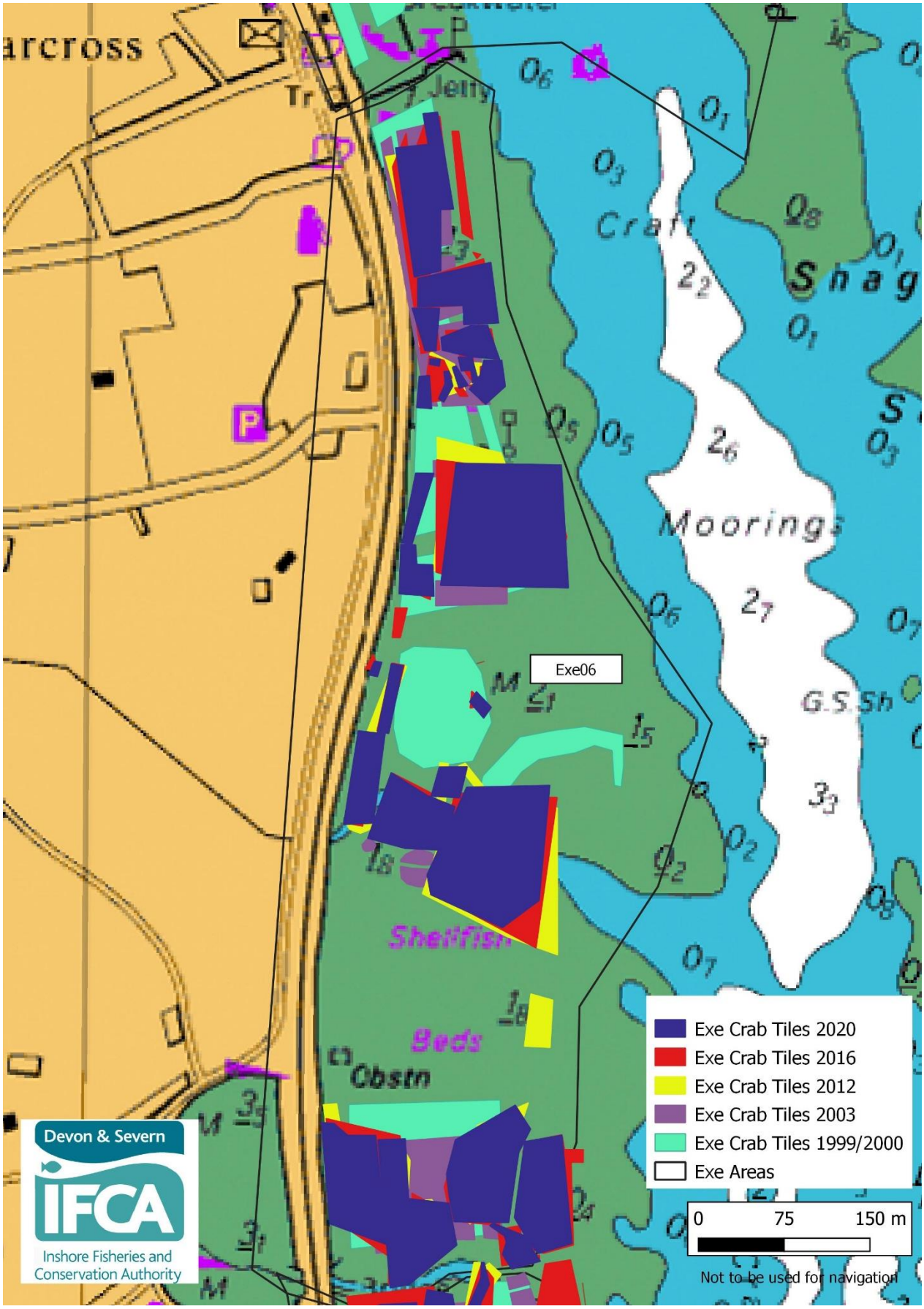

Figure 9 - Crab tiles on the Exe Estuary, comparing each survey year in Area Exe06

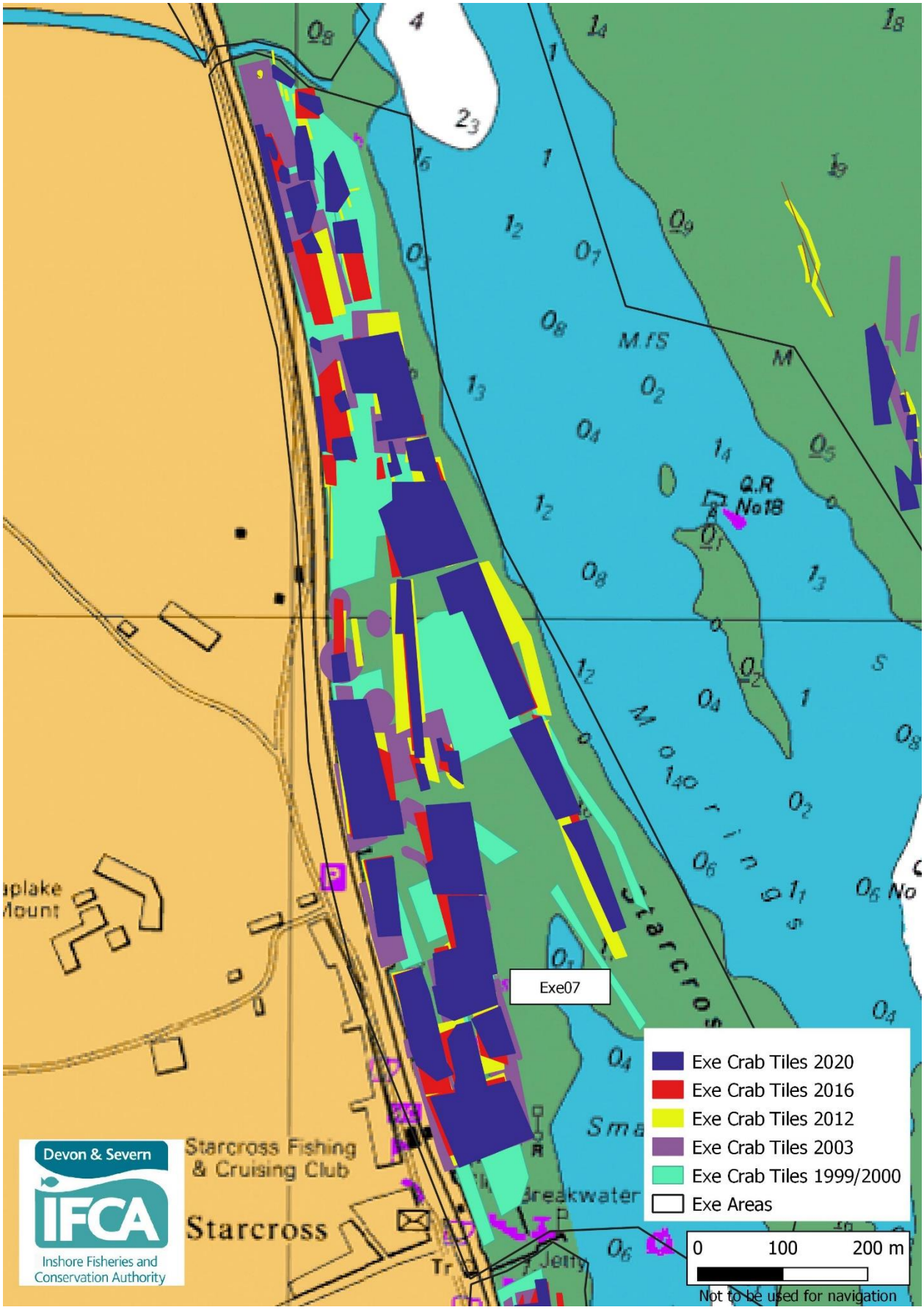

Figure 10 - Crab tiles on the Exe Estuary, comparing each survey year in Area Exe07

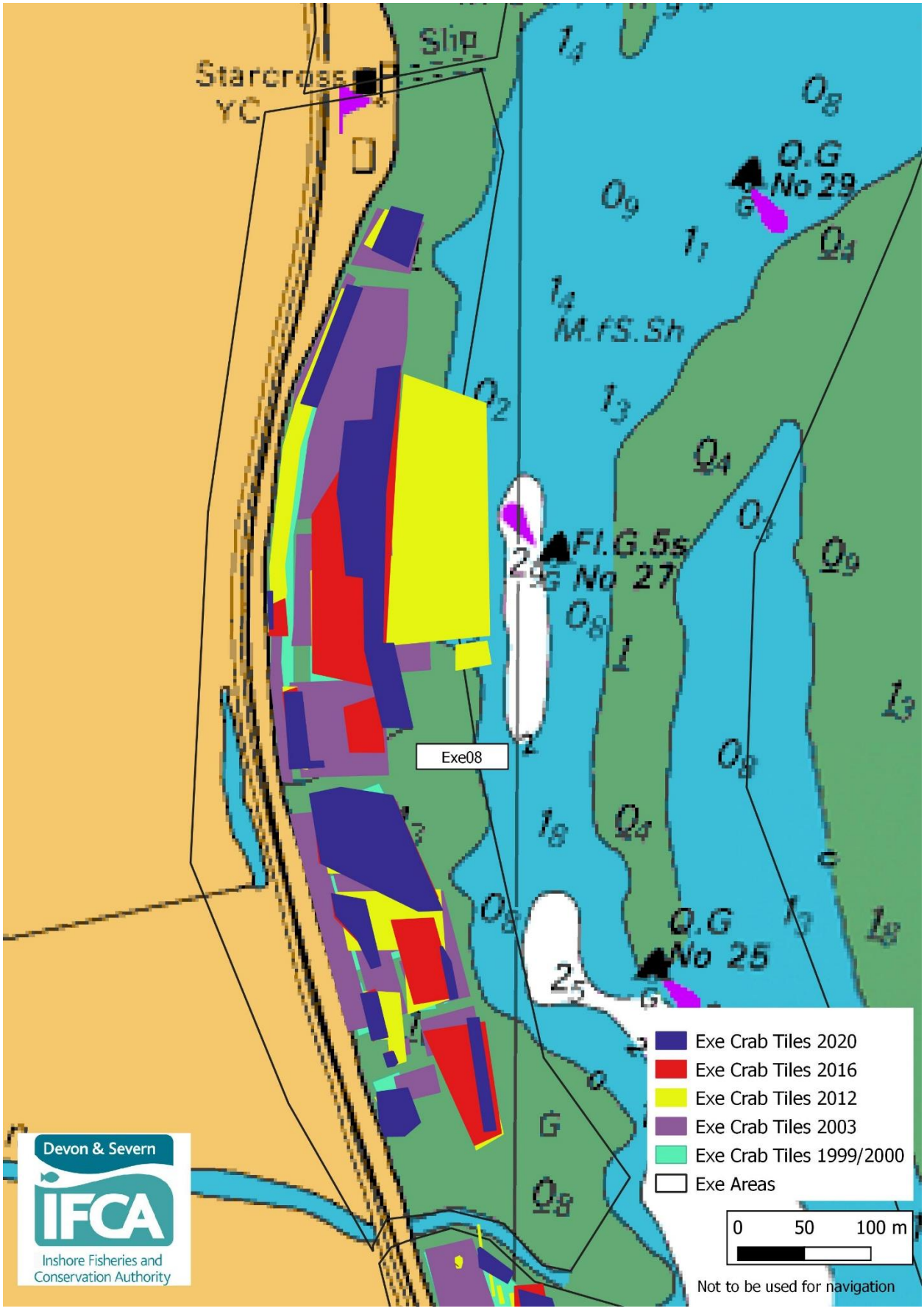

Figure 11 - Crab tiles on the Exe Estuary, comparing each survey year in Area Exe08

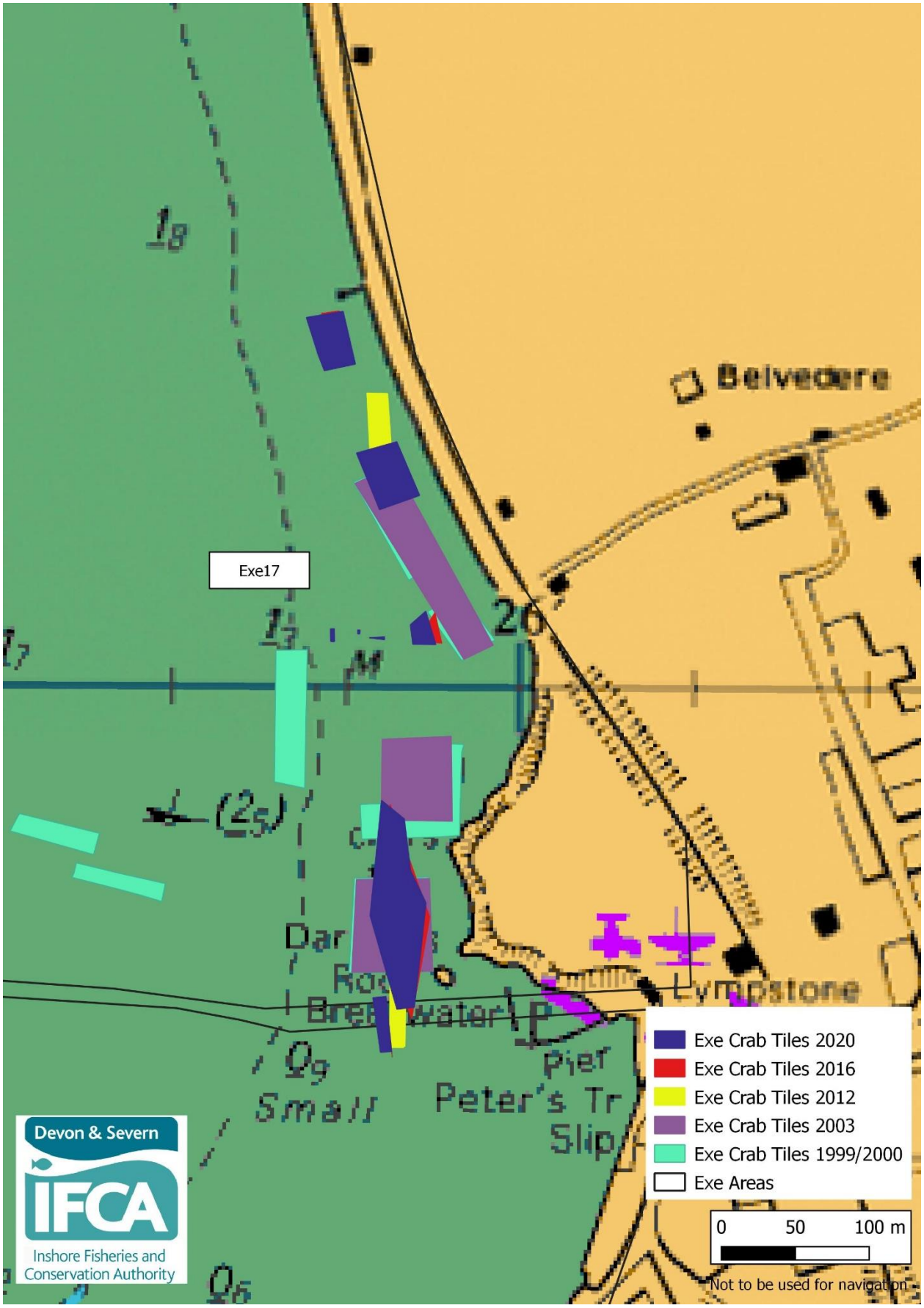

Figure 12 - Crab tiles on the Exe Estuary, comparing each survey year in Area Exe17

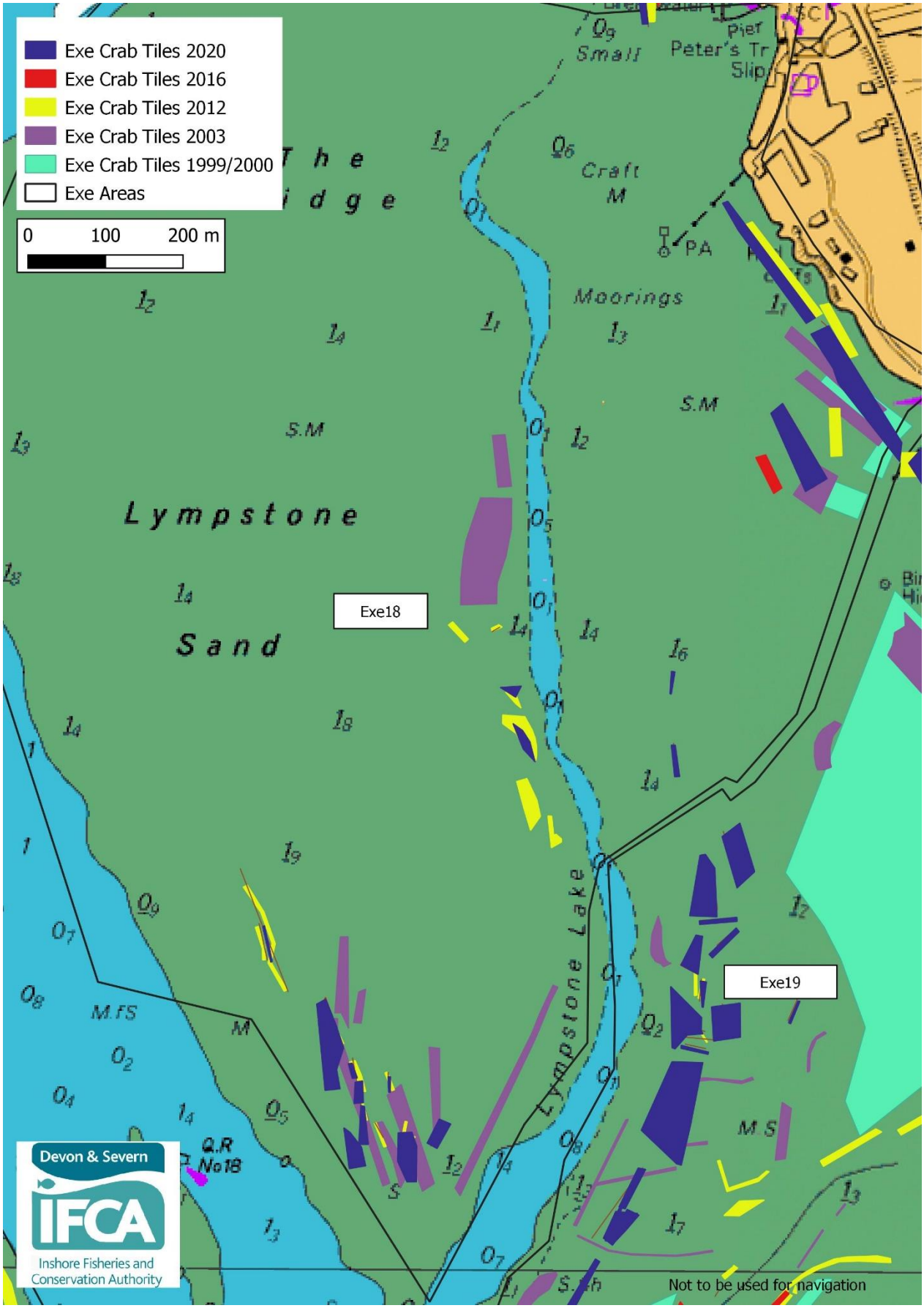

Figure 13 - Crab tiles on the Exe Estuary, comparing each survey year in Area Exe18

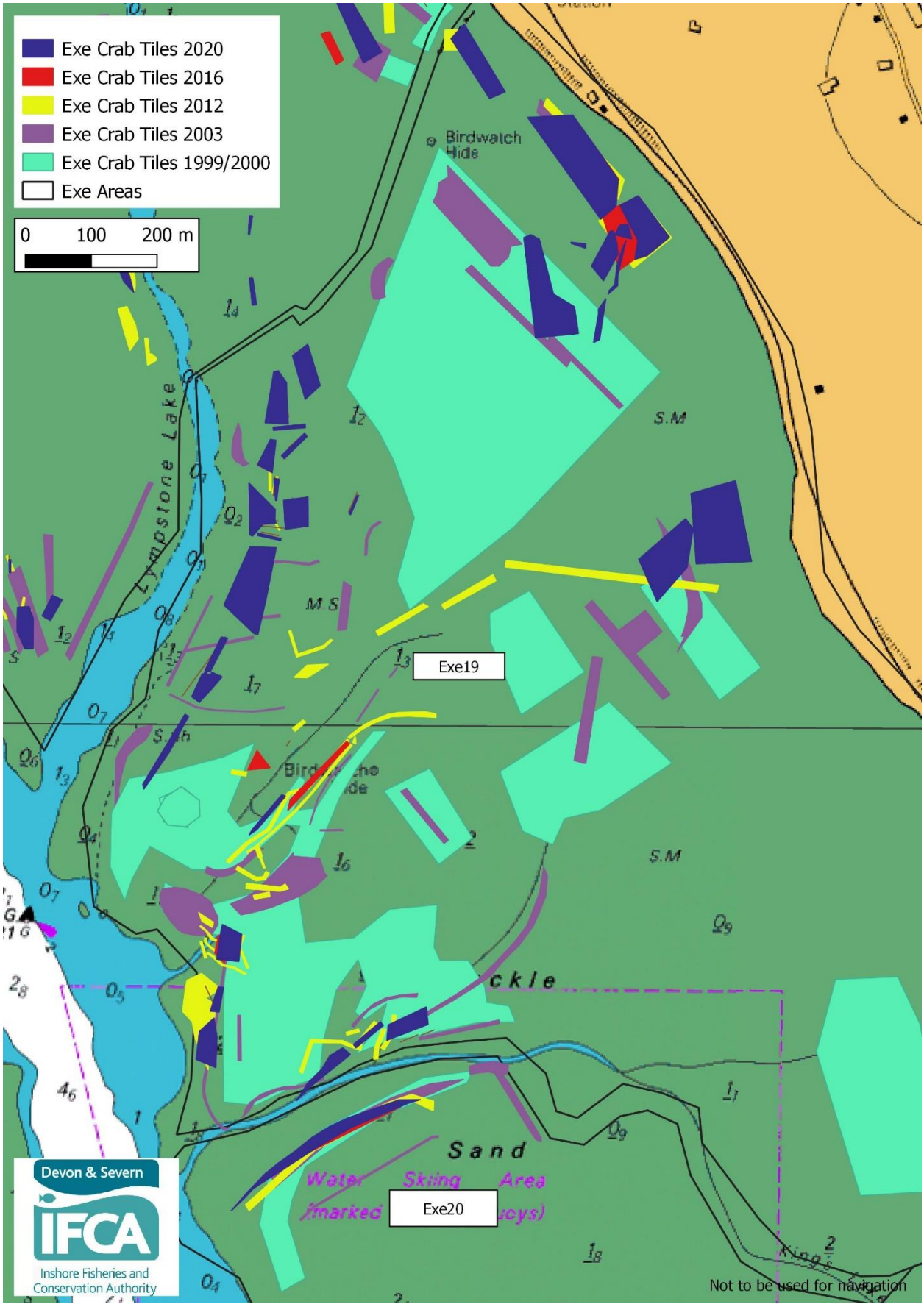

Figure 14- Crab tiles on the Exe Estuary, comparing each survey year in Areas Exe 19 and Exe20

3.5 River Plym

Crab tile surveys on the River Plym were carried out with the UAV in 2020. A total of 4,251 crab tiles were counted. This was a 102% increase from the 2016 survey (Table 5). Figure 15 shows the location of crab tiles on Hooe Lake and Figure 16 shows crab tiles on the River Plym. Table 6 shows the breakdown of crab tiles on the Plym compared to previous years. TAM19 contributed the most to the increase with an extra 1,123 crab tiles north of Laira Bridge compared to 2016. There was also a large increase in TAM21 with just over double the number of tiles in 2020 as in 2016.

Table 5 - Comparison of crab tile counts from previous surveys on the River Plym.

Survey	Number of crab tiles	Difference	Percentage difference
2020	4,251	+2,147	+102%
2016	2,104	+394	+23%
2012	1,710	-1,019	-37%
2003/04	2,729	-227	-8%
2000/01	2,956	-	-

Table 6 – Breakdown of crab tile numbers and distribution on the River Plym.

Location	Area	2020	2016	2012	2003/04	2000/01
Plym (West side)	TAM18	251	60	50	560	176
	TAM19	2,040	897	495	1247	1125
Plym (East side)	TAM20	126	80	0	0	288
	TAM21	1,001	495	655	620	714
	TAM22	663	452	360	302	653
Hooe Lake	TAM36	170	120	150	0	0

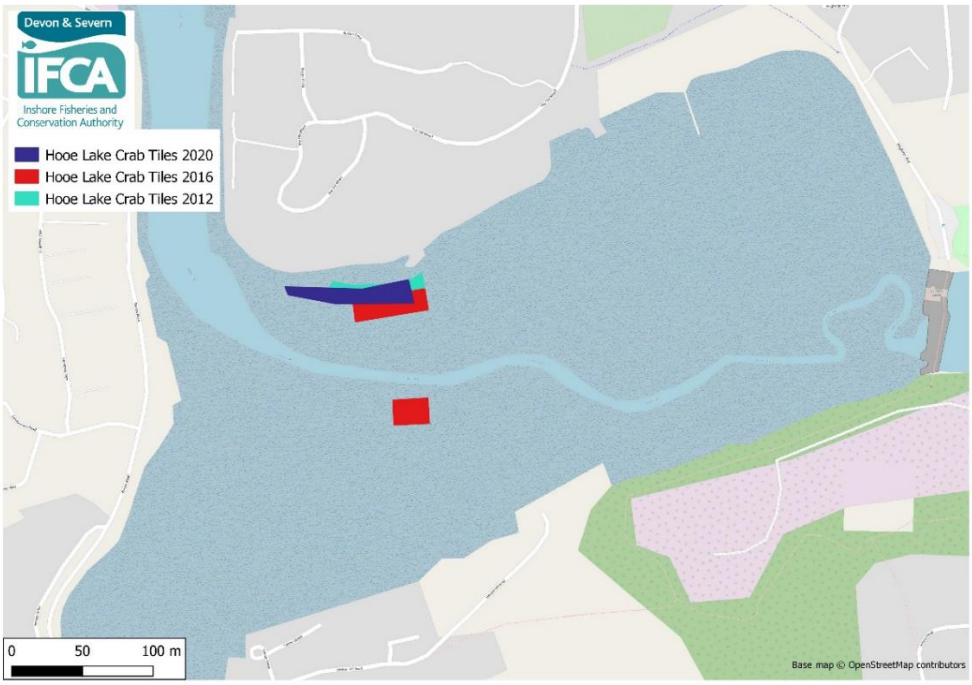

Figure 15 - Crab tiles on Hooe Lake comparing 2012, 2016 and 2020 surveys. Base map © OpenStreetMap contributors

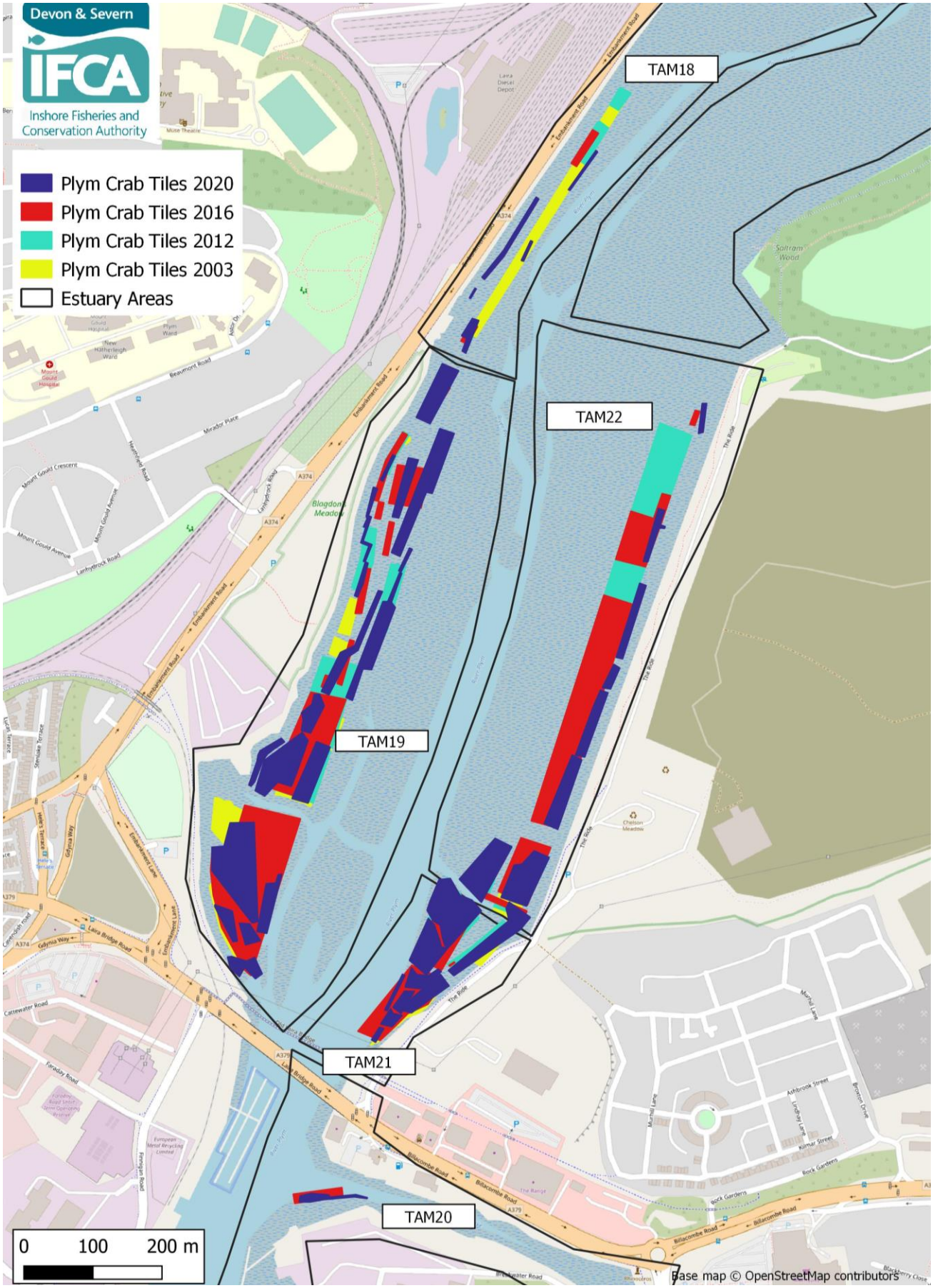

Figure 16 - Crab tiles on the River Plym comparing 2003, 2012, 2016 and 2020 surveys. Base map © OpenStreetMap contributors

3.6 River Tamar

Crab tile surveys on the River Tamar (D&S IFCA District only) were carried out by UAV in 2020. A total of 3,916 crab tiles were counted, this is a 10% increase from the 2016 survey (Table 7). A small section of Kiln Bay could not be surveyed by the UAV due to air space restrictions. However, there were only 20 tiles seen in this section in 2016 and is therefore not deemed to have impacted the results significantly. Figure 17 to 19 shows the location of crab tiles on the River Tamar. Table 8 shows the breakdown of crab tiles on the Tamar compared to previous years. There was a 24% decrease in tiles in the Tamerton Lake (TAM10) area, and a 21% decrease in area TAM09. There was an 107% increase North of Ernesettle Pier (TAM 12). All other areas were broadly consistent in numbers.

Table 7 - Comparison of crab tile counts from previous surveys on the River Tamar.

Survey	Number of crab tiles	Difference	Percentage difference
2020	3,916	+346	+10%
2016	3,570	-1,359	-28%
2012	4,929	+2,283	+86%
2003/04	2,646	-766	-22%
2000/01	3,412	-	-

Table 8 - Breakdown of crab tile numbers and distribution on the River Tamar.

Location	Area	2020	2016	2012	2003/04	2000/01
Tavy river mouth	TAM07	0	0	0	0	20
	TAM08	184	184	181	360	284
	TAM09	573	726	816	980	442
Tamerton Lake	TAM10	858	1,129	938	470	490
	TAM11	0	0	0	0	112
North of Ernesettle Pier to Tamerton Lake	TAM12	1,452	701	1,581	344	1,068
North of Tamar Bridge to South of Ernesettle Pier	TAM13	444	425	810	281	475
South of Tamar Bridge	TAM14	84	78	191	211	227
Kiln Bay	TAM15	321	327	412	0	294

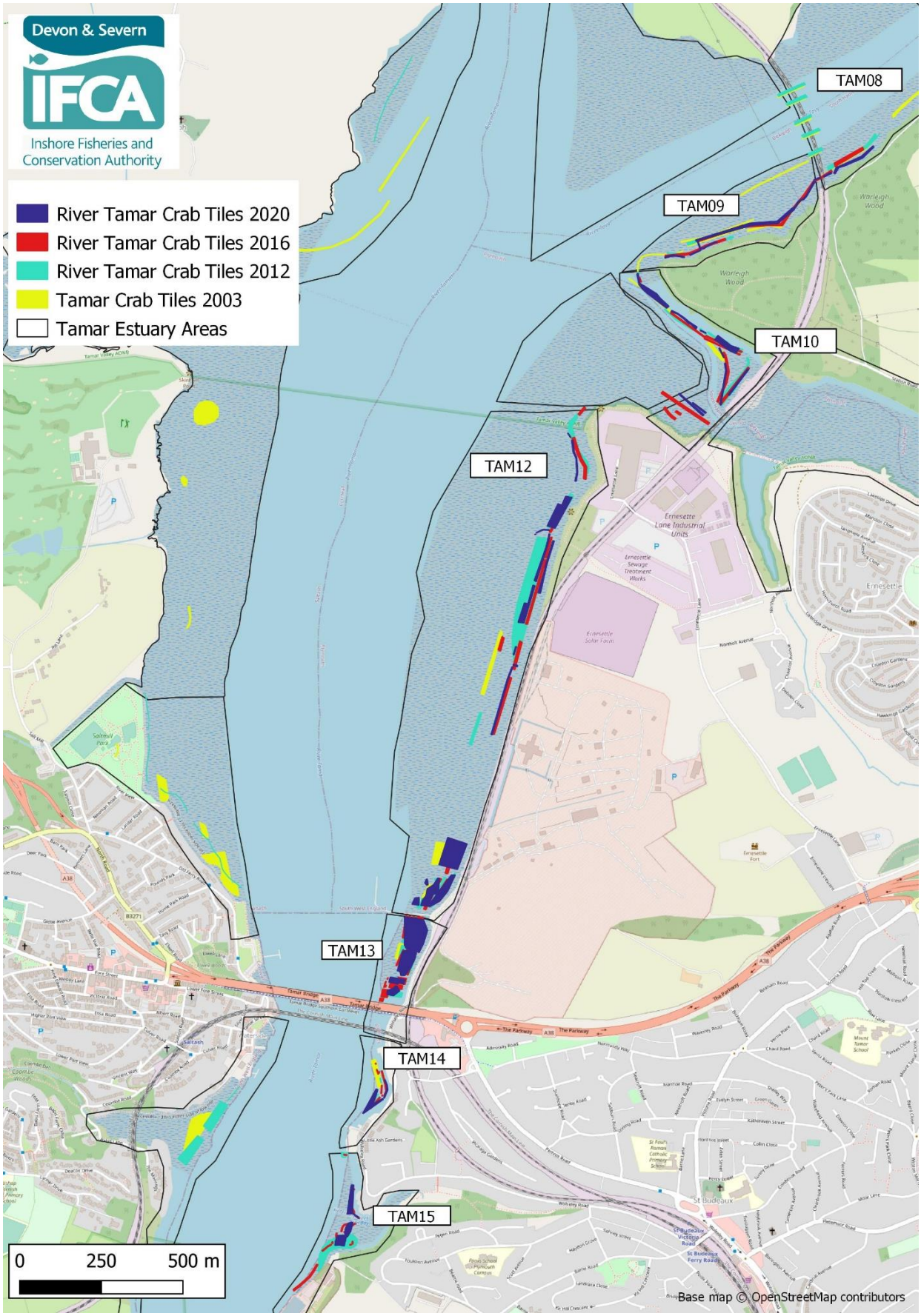

Figure 17 – Overview of crab tiles on the River Tamar comparing 2003,2012, 2016 and 2020 surveys. (N.B. Cornwall IFCA data not included since 2012). Base map © OpenStreetMap contributors

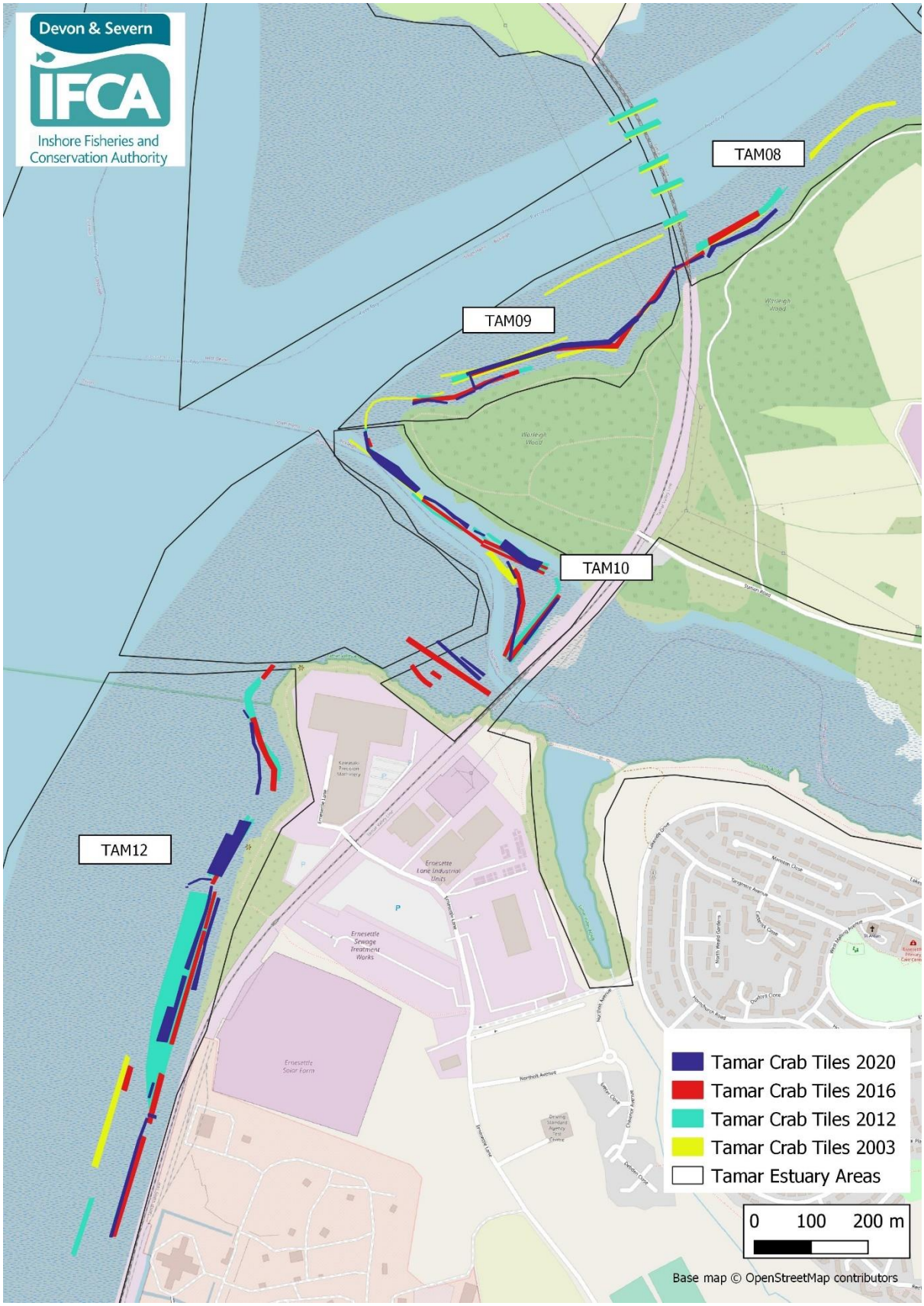

Figure 18- Crab tiles in the north section of the River Tamar comparing 2003,2012, 2016 and 2020 surveys. Base map © OpenStreetMap contributors

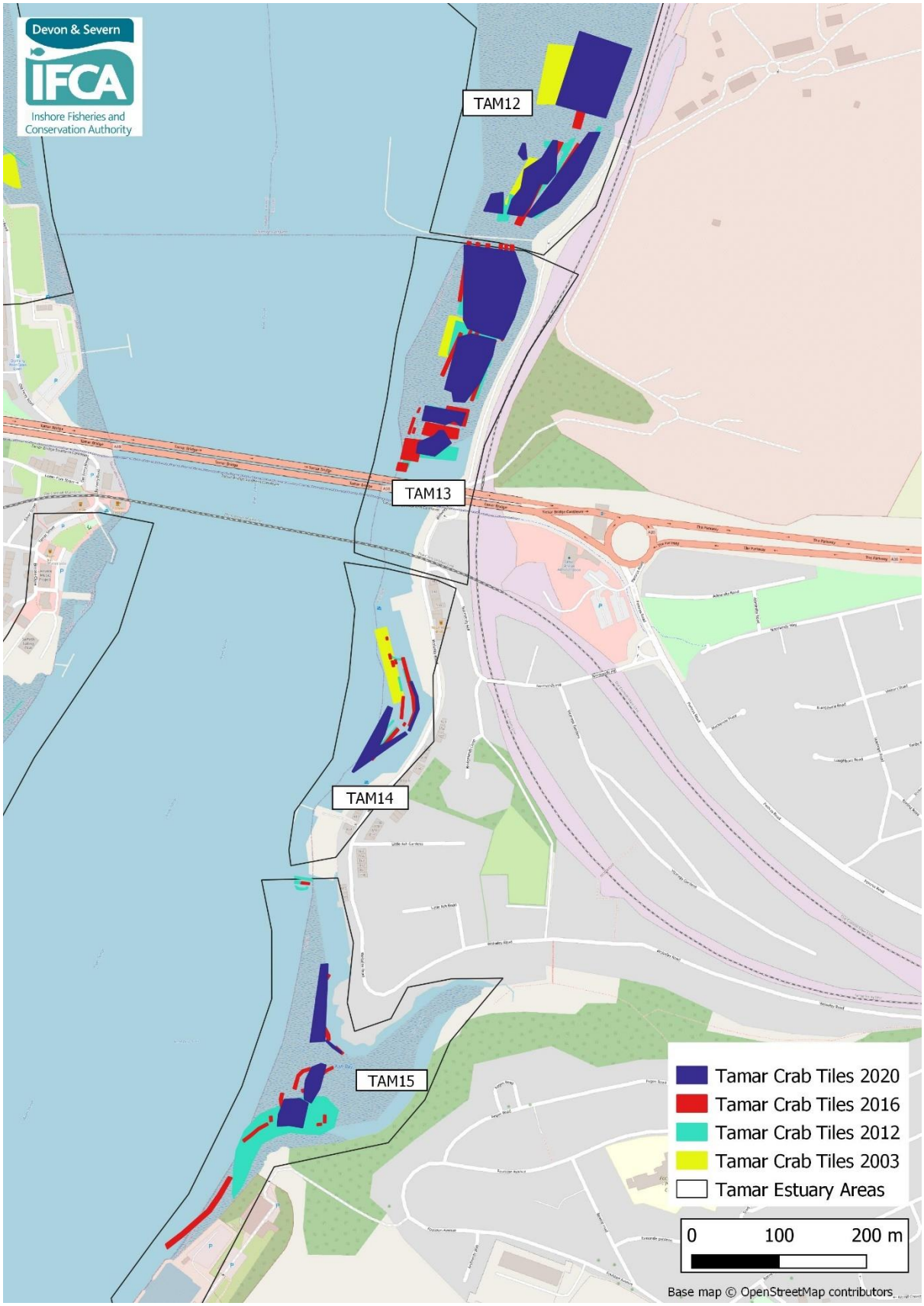

Figure 19- Crab tiles in the south section of the River Tamar comparing 2003,2012, 2016 and 2020 surveys. Base map © OpenStreetMap contributors

3.7 River Teign

Crab tile surveys on the River Teign were carried out by UAV in 2020. A total of 16,412 crab tiles were counted. This was a 28% increase from the 2016 survey (Table 9). Locations of crab tiles can be seen in Figure 20 to Figure 22.

Table 9 - Comparison of crab tile counts from previous surveys on the River Teign.

Survey	Number of crab tiles	Difference	Percentage difference
2020	16,412	+3,547	+28%
2016	12,865	-9,857	-43%
2003/04	22,722	+1,721	+8%
2000/01	21,001	-	-

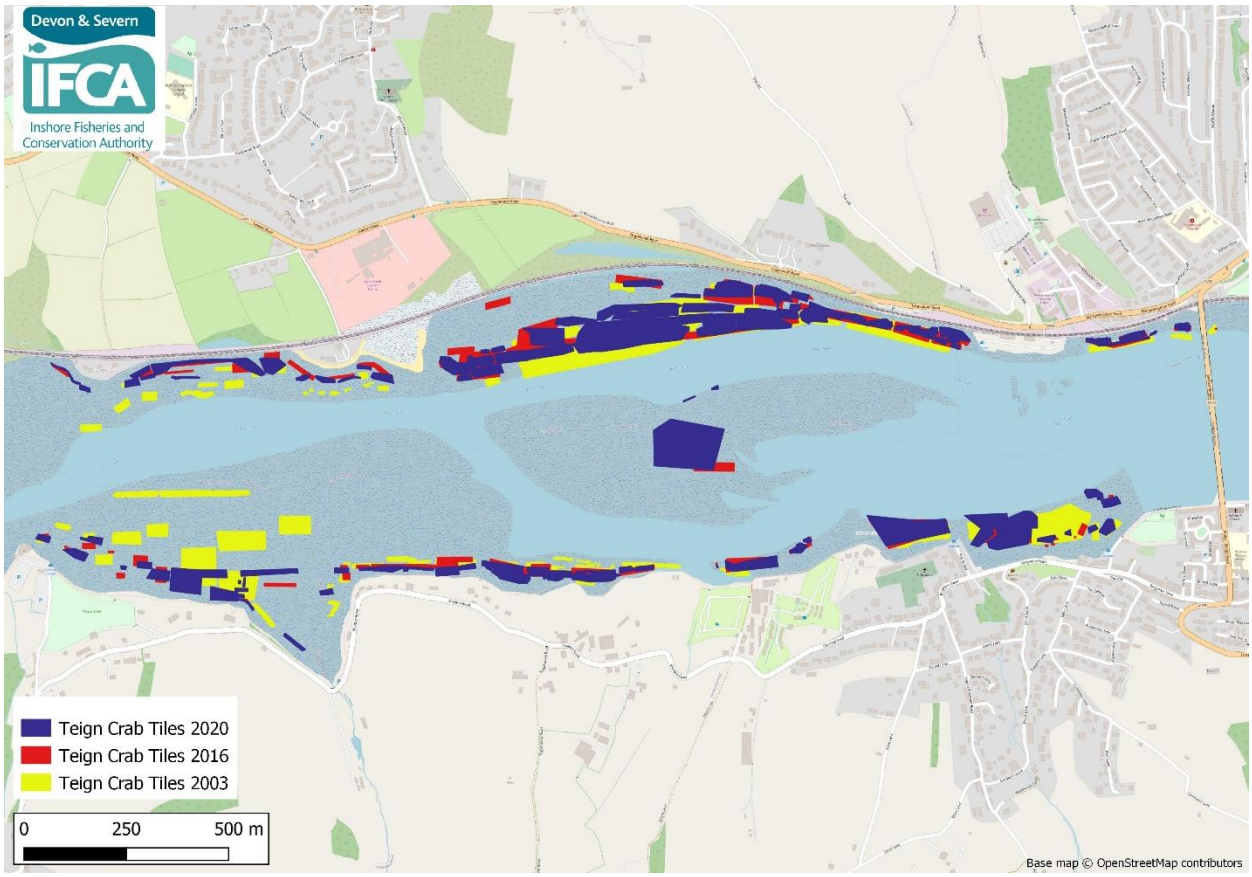

Figure 20 – Overview of crab tiles on the River Teign comparing 2003, 2016 and 2020 surveys. Base map © OpenStreetMap contributors

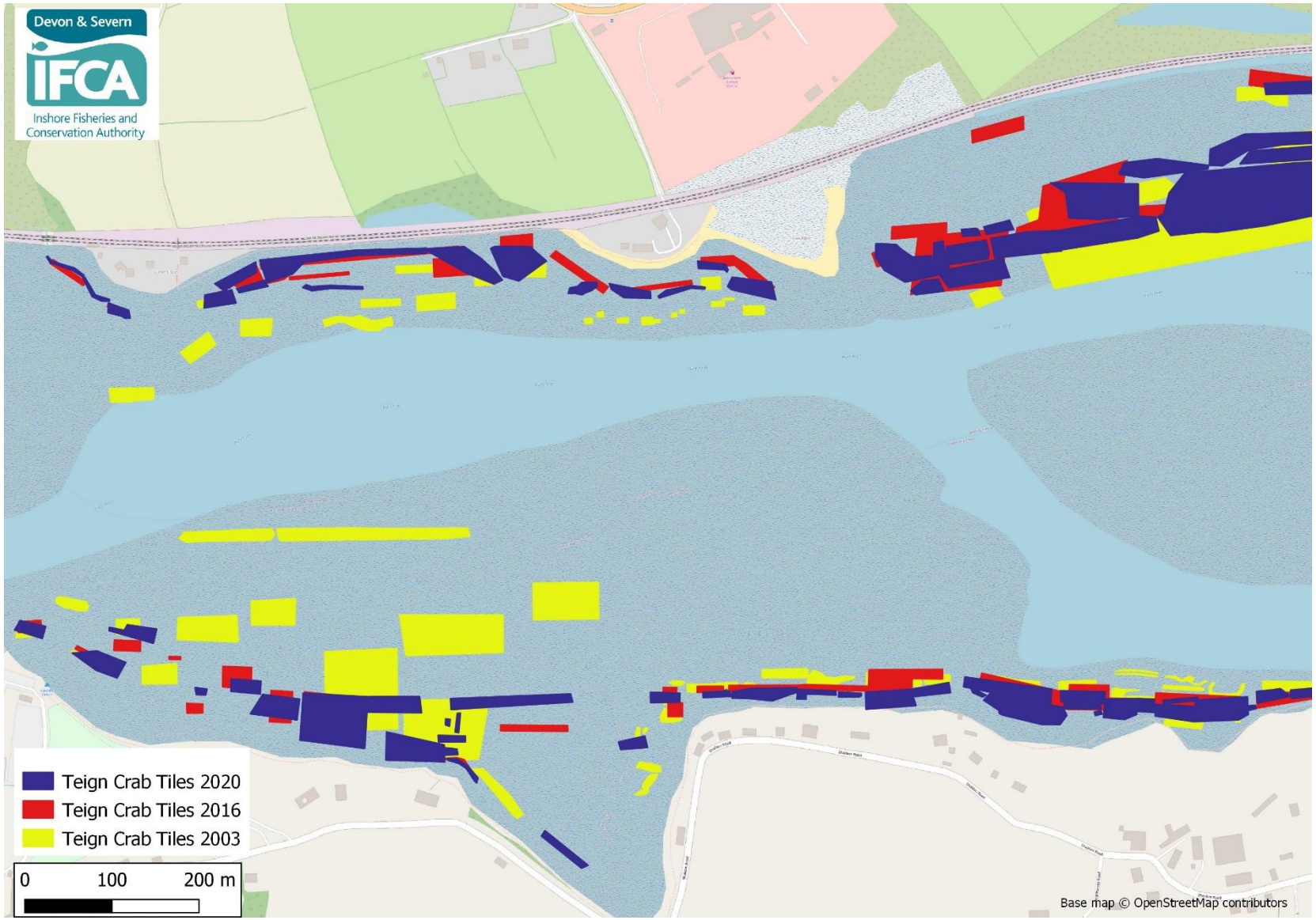

Figure 21 - Crab tiles to the west on the River Teign comparing 2003, 2016 and 2020 surveys. Base map © OpenStreetMap contributors

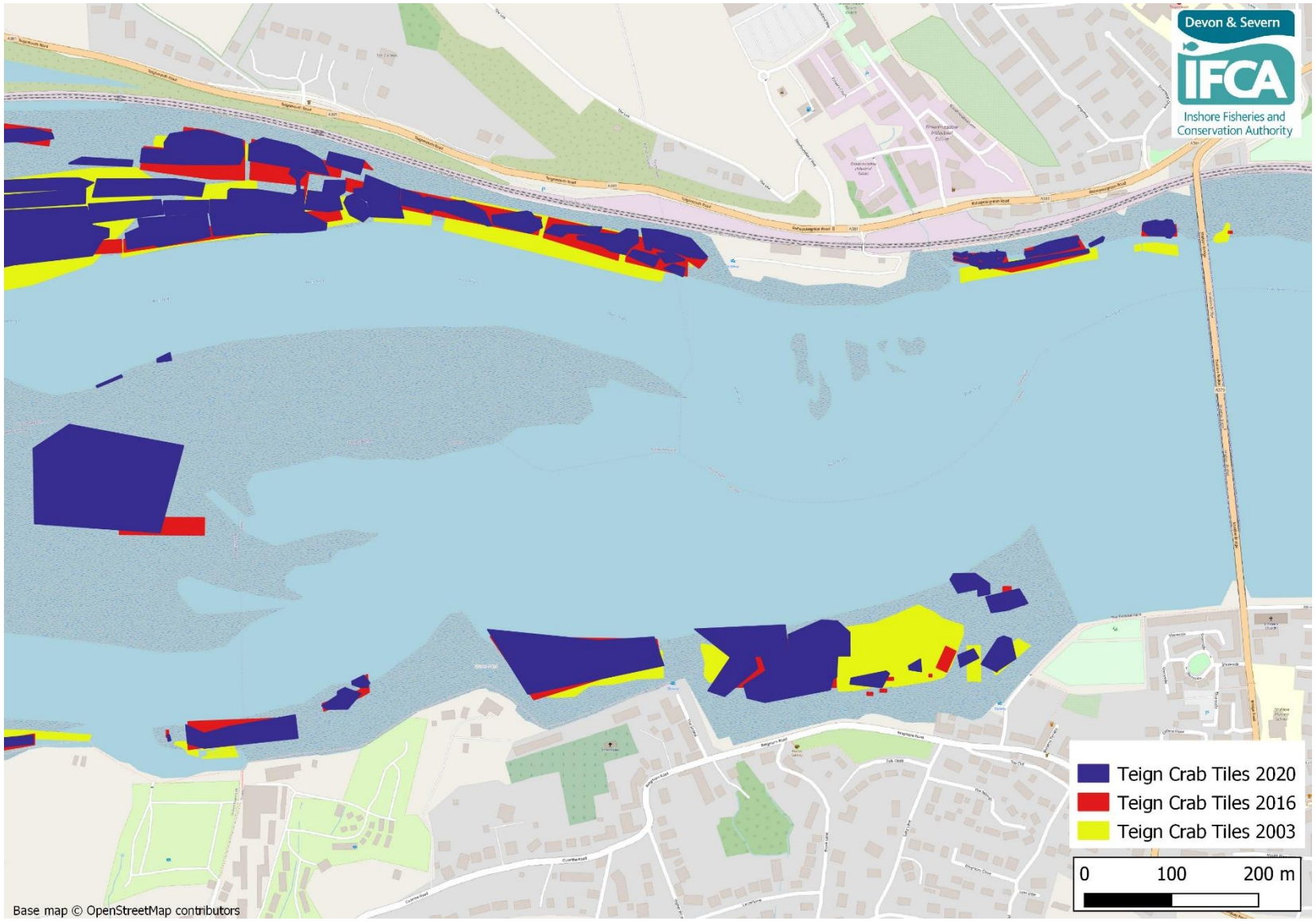

Figure 22 - Crab tiles to the east on the River Teign comparing 2003, 2016 and 2020 surveys. Base map © OpenStreetMap contributors

3.8 Salcombe and Kingsbridge Estuary

Crab tiles in the Salcombe and Kingsbridge Estuary were surveyed by UAV in 2020. A total of 118 crab tiles were counted. All of these were in the Kingsbridge Estuary. The 55 tiles observed in The Bag area of Salcombe in 2016 seem to have been removed. These were also not present in the 2003 survey. Crab tile locations on Kingsbridge Estuary can be seen in Figure 23. These are south of Bowcombe Creek Bridge, by West Charleton.

Table 10 - Comparison of crab tile counts from previous surveys on Salcombe and Kingsbridge Estuary.

Survey	Number of crab tiles	Difference	Percentage difference
2020	118	13	+12%
2016	105	-88	-46%
2003/04	193	-341	-64%
2000/01	534	-	-

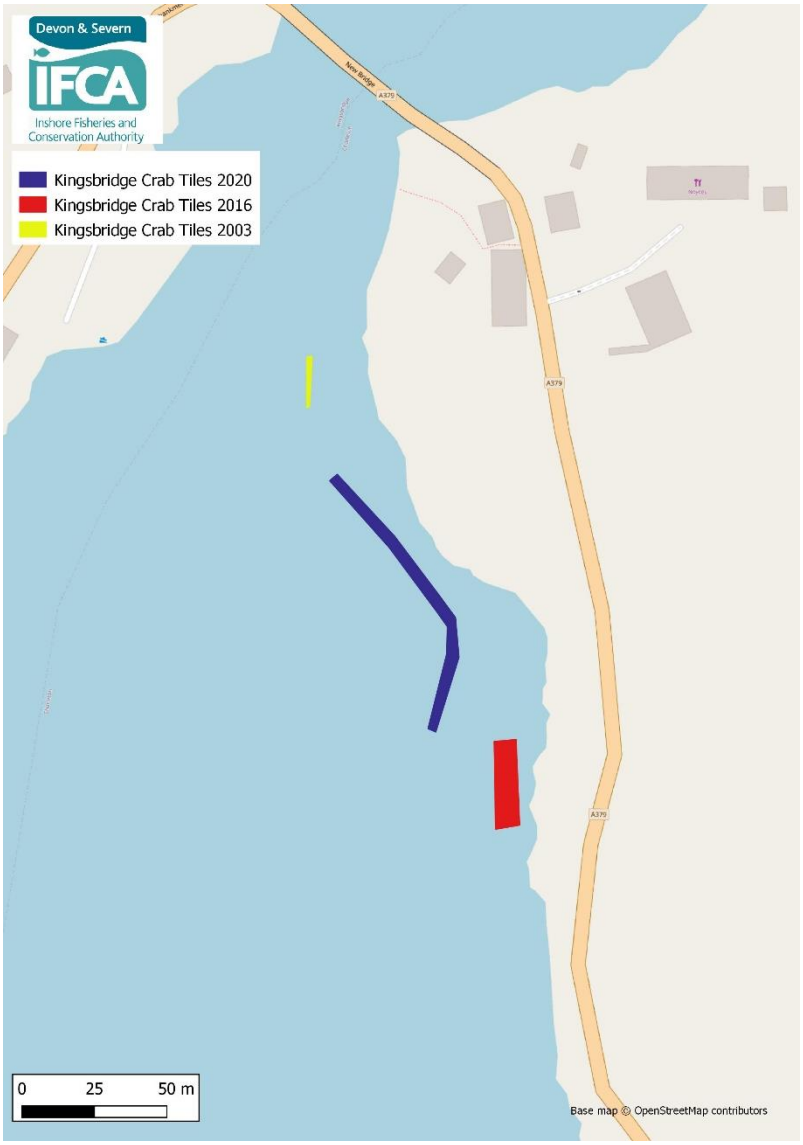

Figure 23 - Crab tiles on Kingsbridge Estuary comparing 2003, 2016 and 2020 surveys. Base map © OpenStreetMap contributors

3.9 Taw Torridge

Crab tiles in the Taw Torridge Estuary were surveyed by UAV in 2020; this estuary was also surveyed by UAV in 2015. A total of 3,751 crab tiles were counted in 2020 which is 47 more tiles than 2015 (Table 11), suggesting that the numbers on the Taw Torridge have been stable since 2015 when the UAV was first used.

Crab tile locations on the Taw Torridge can be seen in Figure 24 to Figure 31.

Table 11- Comparison of crab tile counts from previous surveys on Taw Torridge Estuary

Survey	Number of crab tiles	Difference	Percentage difference
2020	3751	+47	+1%
2015	3,704	+1,491	+67%
2011	2,213	-1,528	-40%
2003/04	3,741	-1,123	-23%
2000/01	4,864	-	-

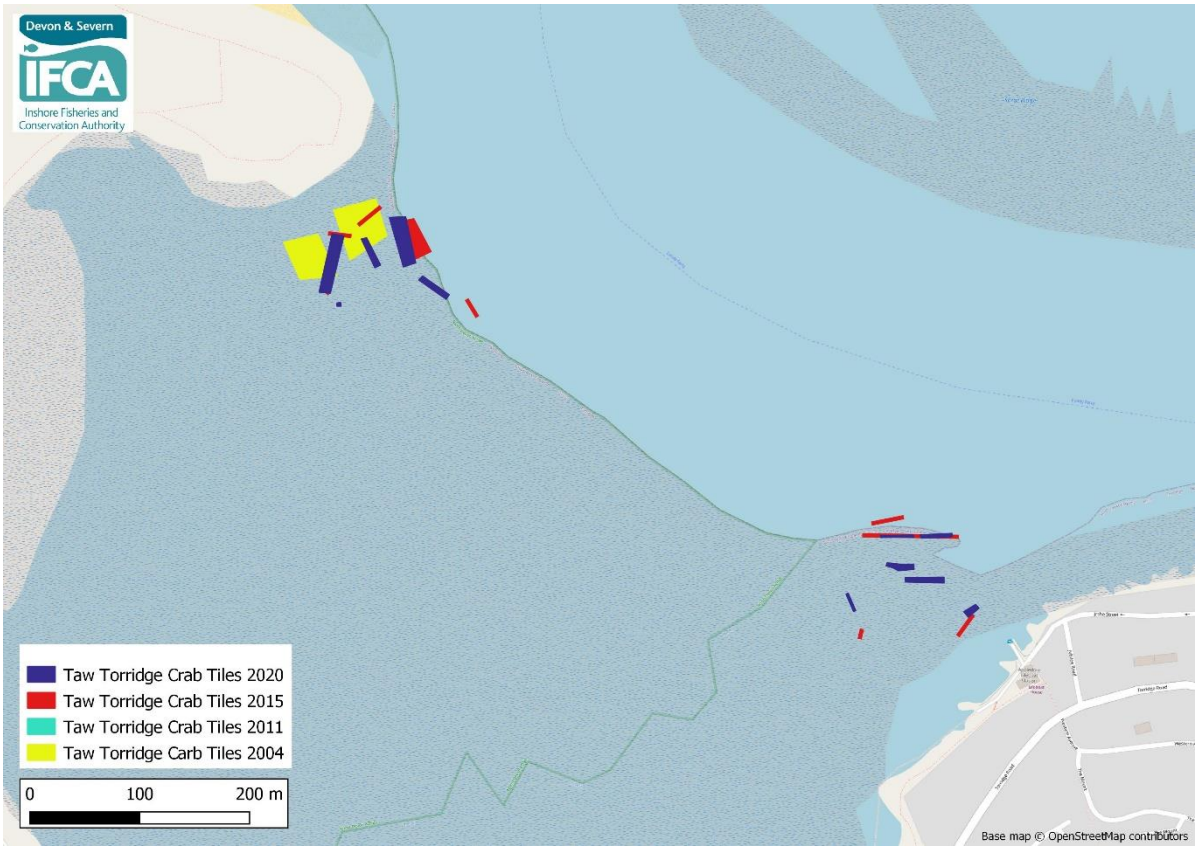

Figure 24- Crab tiles on the Taw Torridge Estuary, Skern and Lifeboat slip areas, comparing 2004, 2011, 2015 and 2020 surveys. Base map © OpenStreetMap contributors

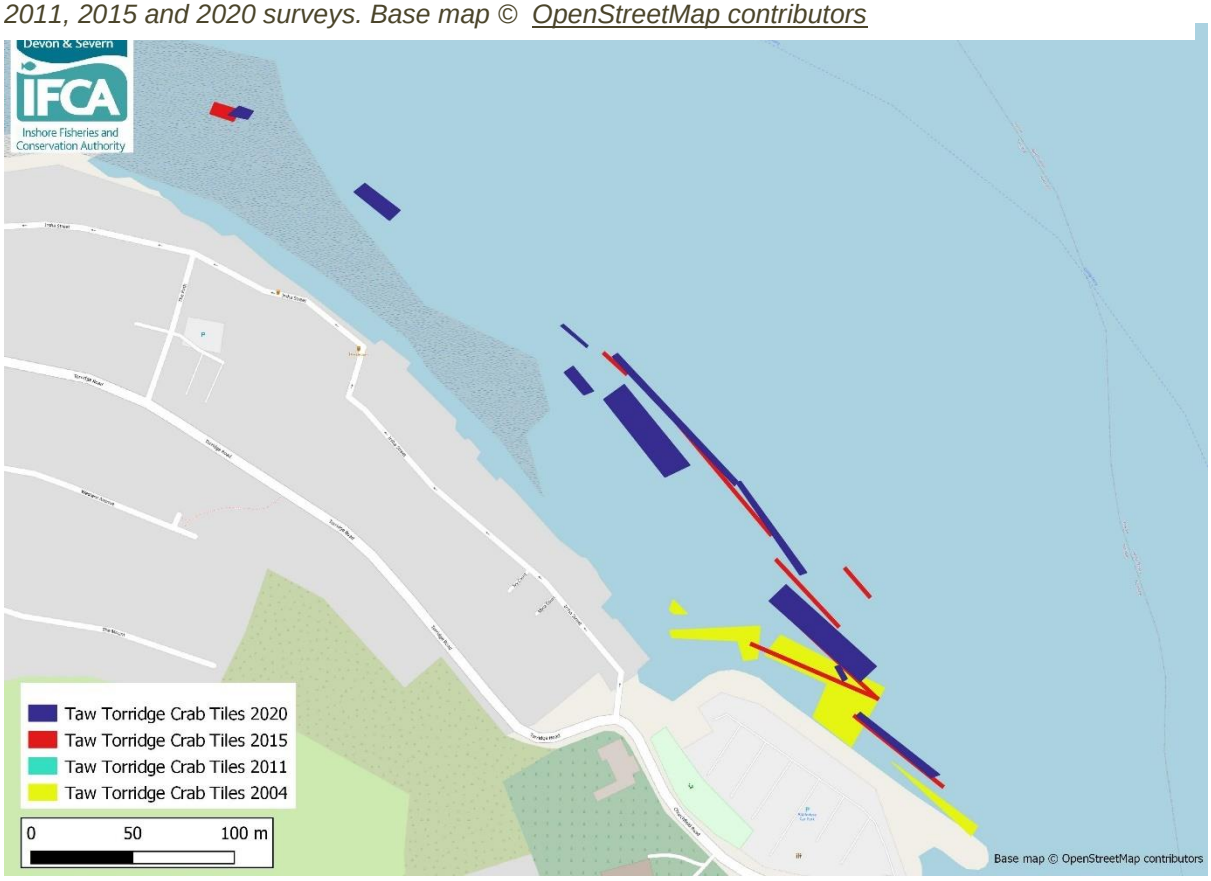

Figure 25- Crab tiles on the Taw Torridge Estuary, West Quay area, comparing 2004, 2011, 2015 and 2020 surveys. Base map © OpenStreetMap contributors

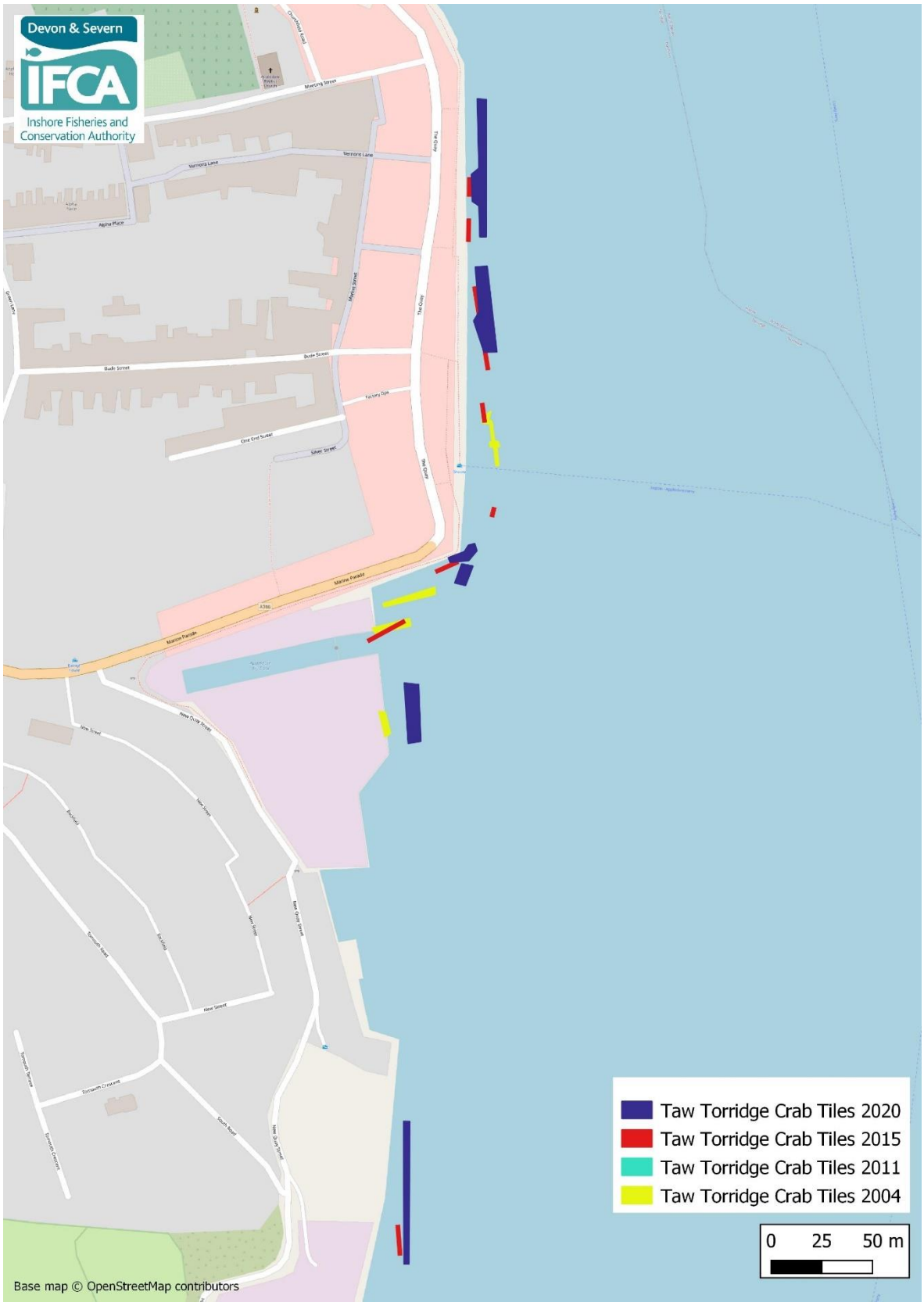

Figure 26- Crab tiles on the Taw Torridge Estuary, Appledore Quay area, comparing 2004, 2011, 2015 and 2020 surveys. Base map © OpenStreetMap contributors

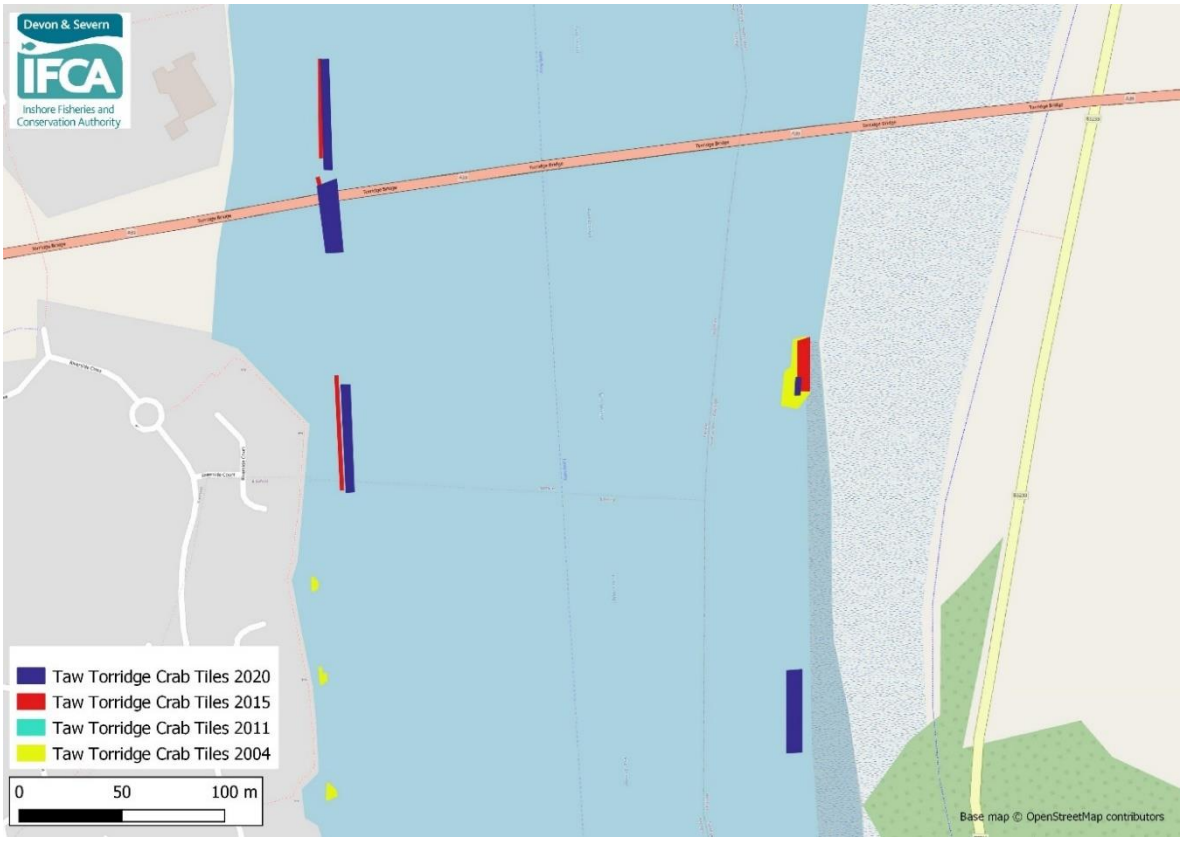

Figure 28- Crab tiles on the Taw Torridge Estuary, Bideford West, and East areas, comparing 2004, 2011, 2015 and 2020 surveys. Base map © OpenStreetMap contributors

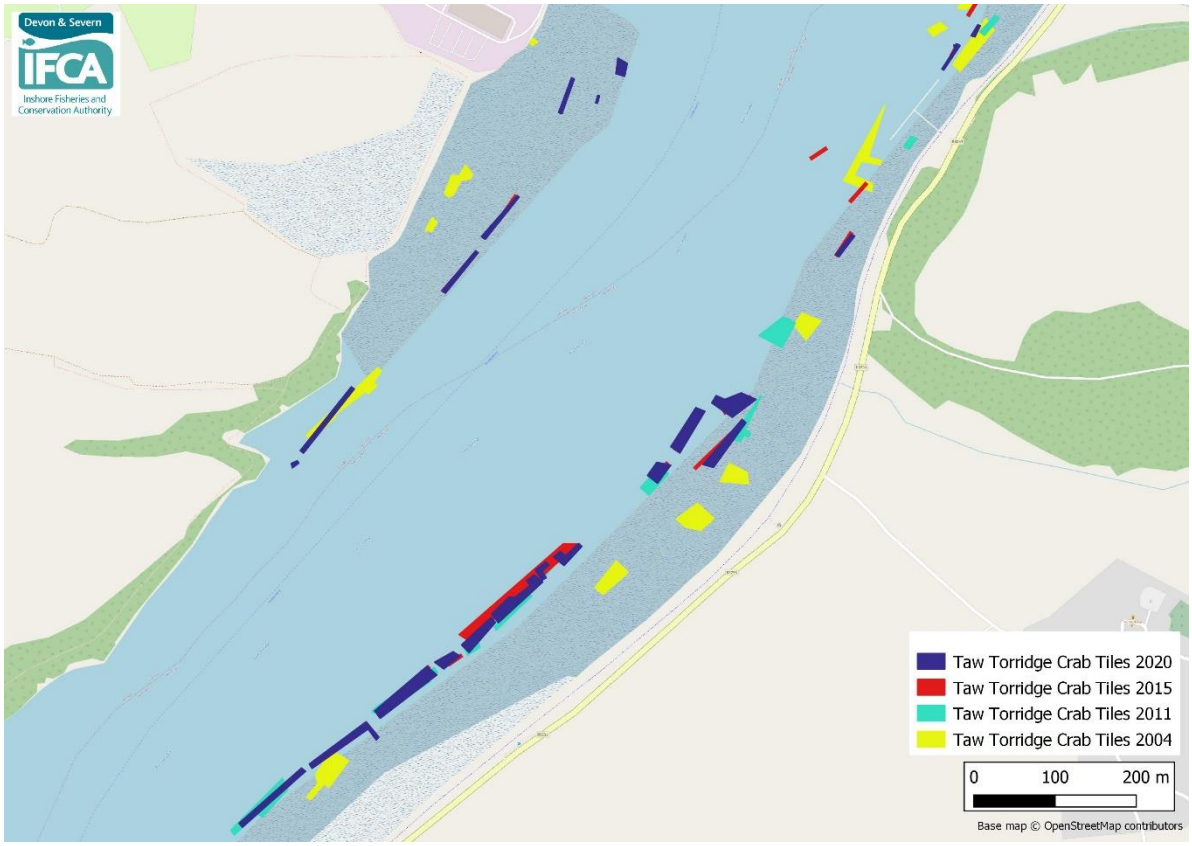

Figure 27- Crab tiles on the Taw Torridge Estuary, Appledore Yard and Westleigh South, comparing 2004, 2011, 2015 and 2020 surveys. Base map © OpenStreetMap contributors

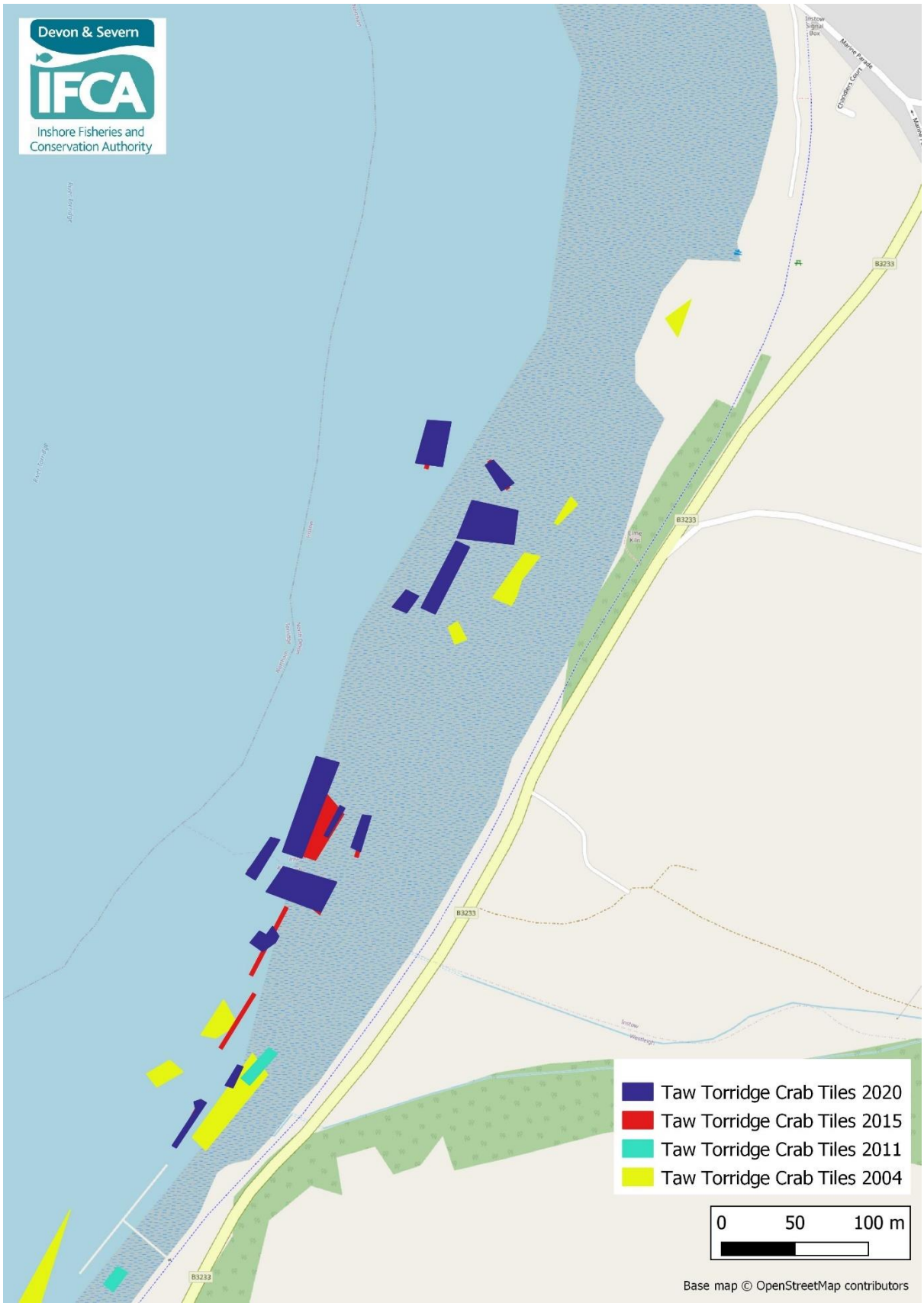

Figure 29- Crab tiles on the Taw Torridge Estuary, Westleigh North, comparing 2004, 2011, 2015 and 2020 surveys. Base map © OpenStreetMap contributors

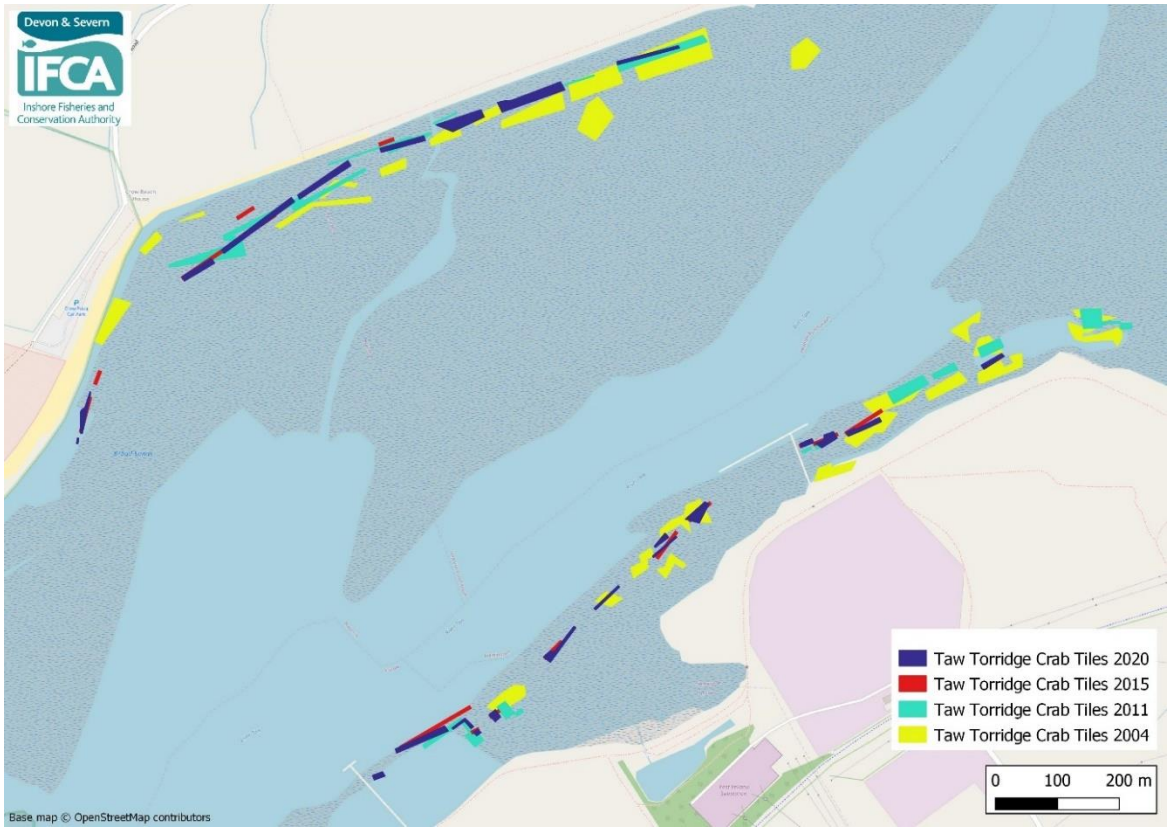

Figure 30- Crab tiles on the Taw Torridge Estuary, Crow and Yelland, comparing 2004, 2011, 2015 and 2020 surveys. Base map © OpenStreetMap contributors

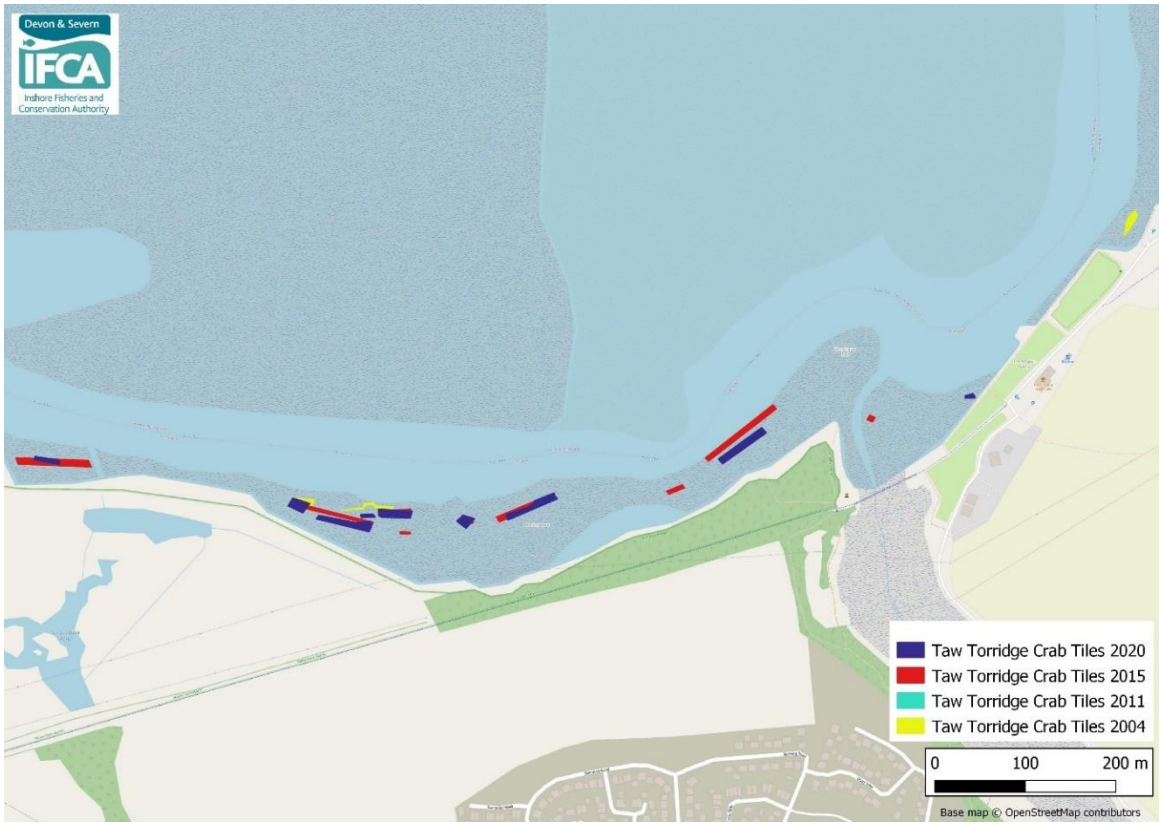

Figure 31- Crab tiles on the Taw Torridge Estuary, Fremington Quay, comparing 2004, 2011, 2015 and 2020 surveys. Base map © OpenStreetMap contributors

4. Discussion

4.1 Tile counts and perceived changes over time

This was the first year all the surveys were undertaken with an UAV, bar the Axe. The results from the trial on the Taw Torridge in 2015 (Parkhouse, 2016) indicate that this method is more accurate than counting by foot or from the boat, where estimates of locations and numbers are made with personal judgement, often from a distance with binoculars. Using the UAV allows for accurate counts of individual tiles and exact GPS locations of tiled areas from the geotagged images. It is therefore likely that the 2020 results are more accurate than the 2016 surveys.

Overall, there has been a slight increase of 5% in tile numbers across the District. However, there have been increases and decreases on the individual estuaries. This 5% may change slightly once the Dart and Axe surveys have been completed.

There was a 13% increase of crab tiles in Salcombe and Kingsbridge estuary, though this increase was just in the Kingsbridge area. Previous tiles observed in the Salcombe area appear to have been removed. Crab tile numbers had been steadily decreasing in the River Plym from 2000/01 to 2012, but numbers increased in 2016 by 23% and another large increase of 102% in 2020. This increase in 2020 could be due to the use of the UAV. The Plym is a very muddy estuary and previous surveys were carried out from the shoreline using estimates of tiles observed through binoculars. This traditional method may have underestimated the numbers. There was a 10% increase of tiles across the River Tamar. The Tamerton Lake area, which had seen an increase in 2016, has now decreased again by 24%. There was an 107% increase North of Ernesettle Pier since 2016 however, the 2020 numbers are similar to the 2012 numbers. The reason for these fluctuations on the Tamar could be due to errors in estimates in 2016 when surveying by foot. There was a 28% increase on the Teign. This again is a difficult estuary to survey by foot, with counts and locations being estimated from a distance. Therefore, the increase could be due to the accuracy of the counts by UAV.

The Taw Torridge estuary numbers appear to have remained stable between UAV surveys in 2015 and 2020, with an increase of just 47 tiles (1% increase on 2015).

There was a 11% decrease in crab tiles overall on the Exe Estuary. The cause of decline in crab tile numbers is unknown, although it may be that tilers have ceased fishing their tiles and therefore, they have become buried by the sediment over time. As the Exe was surveyed by UAV in 2016 and 2020, the change is unlikely to be due to accuracy of counts, but this cannot be ruled out.

The Dart and the Axe surveys will be completed when Covid-19 restrictions, and officer time resources allow. Currently there is a 14% increase on the Dart and 46% increase on the Axe when excluding the numbers from the 2016 surveys in the areas which could not be surveyed in 2020. If there are still tiles in these areas when surveys completed, there will be more of an increase. A supplementary report will be produced once these surveys are completed.

Except for the Plym, and to a lesser extent the Teign, there was no marked increase in tile numbers within the District. As discussed, these increases could be due the accuracy of the UAV counts compared to traditional foot surveys on these particularly muddy and difficult-to-survey estuaries. There is a territorial consensus between crab tilers, with a set area of crab tiles generally worked by one individual who owns them. Additionally, there is a limit to the number of crab tiles that can be placed on one estuary due to space. This may impose a carrying capacity on effort in the fishery and may explain why there are no marked increases in the total number of crab tiles between surveys (Davies, 2017).

4.2 Data limitations

Although it is considered that the counts are more accurate overall with the UAV than by foot or boat, there might still be some errors in counts. These errors can occur when tiles are covered with seaweed and close to small rocks with seaweed, as it can be difficult to discern between them in some cases. They are more likely to be tiles if they are in an organised formation, such as rows, or if there are footprints surrounding them. Other officers should check the images, and joint decisions can then be used using best personal judgement.

4.3 Future work

As reported in 2017 (Davies, 2017) there are currently no statutory management measures for crab tiling in place on the rivers and estuaries (apart from a closed area on the Exe Estuary) in D&S IFCA's District. Voluntary Codes of Conduct are in place on the Exe Estuary, Teign and Taw Torridge. D&S IFCA is progressing with the development of a hand gathering byelaw, which these results will feed into. It is important that future surveys of crab tile numbers and their distribution are continued every four years to feed into any byelaw reviews. It is recommended that the surveys are carried out with the UAV in the future to ensure consistency going forward.

5. References

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