Multi-year intertidal Edible Crab (*Cancer pagurus*) survey

Final report for the 2021-2024 Intertidal Edible Crab Survey

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Glossary of Terms and abbreviations

BST	British Summer Time
Cefas	Centre for Environment, Fisheries and Aquaculture Science
CL	Carapace length
EOL	End of line
IFCA	Inshore Fisheries and Conservation Authority
SAC	Special Area of Conservation
SOL	Start of line
UTC	Universal Time Coordinated

1 Introduction

Cornwall Inshore Fisheries and Conservation Authority (IFCA) has been investigating ways to survey the abundance of edible crab (*Cancer pagurus*), also known as brown crab, within the Cornwall IFCA district. Shallow water, cobble nursery habitats are likely to represent a major source of recruitment to offshore fisheries (Robinson and Tully, 2000). In 2012, the Centre for Environment, Fisheries and Aquaculture Science (Cefas), carried out two shoreline surveys to sample juvenile edible crab in Cornwall. The Cefas surveys were carried out to examine the feasibility of shore-based sampling of juvenile edible crabs and the utility of the data collected as an abundance index, a source of information on crab growth and further analysis of length frequency data (Smith, 2012a and 2012b). Since then, two masters students have carried out separate studies: firstly O'Halloran (2015) looked at the nursery function of rockpools for commercially important species of crab, *C. pagurus*, velvet swimming crab (*Necora puber)* and Spider Crab (*Maja squinado)* in Jersey and secondly, Heraghty (2013) investigated the abundance, distribution and habitat use of juvenile *C. pagurus* of the intertidal zone around Anglesey and the Llŷn Peninsula, North Wales (UK).

Juvenile edible crabs, *C. pagurus* settle from July to September (Robinson and Tully, 2000) and inhabit the intertidal zone until they reach a carapace width of 60-70 mm before migrating to subtidal areas offshore after around three years (Robinson and Tully, 2000). The subtidal migration pattern varies between the sexes. Males have been observed migrating large distances, especially larger, older animals, but generally they are nomadic and move in fairly random localised patterns. Females move offshore to spawn then back inshore to mate and feed (Hunter *et al*., 2013). Mark and recapture studies have shown females in the English Channel travel on a westward axis. It is suggested that this western travel is a migration to spawning grounds, allowing the edible crab larvae to hatch and travel in the prevailing tidal currents returning them to settle in areas of their mother's origin (Hunter *et al*., 2013).

In 2020, Cornwall IFCA carried out two exploratory survey days at Prisk Cove, near Mawnan Smith on the south coast of Cornwall. This site was chosen due to high records of edible crab numbers during past Seasearch surveys (Matt Slater, pers. comm. 2020). These two surveys trialled different sampling methods: one using a 5 m^2 grid at different stages down the shoreline from the high-water mark to the low water mark and the other doing a walkover along the length of shore at the low water mark parallel to the shoreline. The walkover method proved more suitable to the survey and has been used by Cornwall IFCA in subsequent surveys presented in this report. Due to the low numbers of edible crabs at the Prisk Cove site from the two preliminary survey days, it was decided that repeating the survey at Greeb Point, Portscatho which is the location Cefas used for their surveys would be more beneficial.

Edible crabs are known to live in a wide range of habitats, from course to muddy sand, gravel and bedrock, under boulders and shingles and females prefer softer sandy substrates (FAO, 2021). The site at Greeb Point, Portscatho provides optimal habitat and shelter for juvenile edible crabs consisting of coarse sand, pebbles,

cobbles, boulders and bedrock with overhangs. In 2021, the survey area at Greeb Point was surveyed by Vertical Horizons Media using a UAV and a high-resolution mosaic of the image data collected was created to accurately show the habitat.

This report summarised the results from exploratory multiyear intertidal edible crab surveys, between 2021 and 2024, conducted at Greeb Point.

1.1 Aims and objectives

1.1.1 Aims

- To investigate the abundance of edible crab (*C. pagurus*) at Greeb point, located on the south coast of Cornwall, between 2021 and 2024.
- To use the Greeb point site to optimise the intertidal crab survey methodology.
- To create a tool that could be used in future to investigate the use of intertidal crab surveys as a proxy for monitoring crab abundance, and in turn potentially a recruitment index for edible crab fisheries in the future.

1.1.2 Objectives

- To photograph, measure and record the length (mm) of all edible crabs (*C. pagurus*) observed during the sampling period and compare results between years.
- To provide information on growth increment where moults were present with soft shelled specimens.
- To record any invasive species observed during the survey.
- To provide recommendations for future survey work.

2 Methodology

2.1 Survey location

The survey was carried out at Greeb Point, one mile south of Portscatho on the south coast of Cornwall. This location was sampled by Cefas in 2012 and provides an ideal habitat for juvenile edible crab. It comprises a rocky outcrop with gullies that are full of a mixture of coarse sand, stones, cobbles and small boulders (Figure 1). The location is accessed down a narrow, overgrown path and is therefore exposed to minimal human disturbance, as it is off the main coastal path. The survey site is situated within the Fal and Helford Special Area of Conservation (SAC).

Figure 1: Survey site at Greeb Point on the south coast of Cornwall.

2.2 Survey timing

Officers aimed for a 45 minute search either side of low tide to equal a 1 ½ hour survey time but some of the earlier surveys were a little longer (up to 2 hours 18 minutes). The survey was carried out covering as much ground as possible around the predicted spring low tide time between April 2021 and June 2024. Cornwall IFCA officers carried out fourteen survey days (between: April to October in 2021, March to July in 2022 and in March to June in 2023/24) to sample juvenile edible crabs at Greeb Point (Table 2). Timings of later year surveys were modified accordingly to account for findings from previous years surveys, to allow sampling when the crabs at the site were most abundant. Data from the 2021 (Jenkin *et al*., 2021), 2022 (Jenkin *et al*., 2023) and 2023 (Daniels *et al*., 2023) surveys has previously been reported by Cornwall IFCA.

2.3 Personnel

The survey was carried out by two scientific officers (apart from the surveys on 27th May 2021 [one scientific officer] and 21st March 2023 [three officers]).

2.4 Personal Protective Equipment (PPE)

Steel toe capped waterproof boots were worn while carrying out the surveys. Waterproofs, suncream and sunhats were used as required. A first aid kit and mobile phone were in possession of the officers at all times. There were no reported accidents or near misses during the surveys.

2.5 Survey methodology

The start of line (SOL) positions from the survey carried out by Cefas in 2012 was used as the SOL position in the Cornwall IFCA 2021, 2022, 2023 and 2024 surveys. The end of line (EOL) position was modified for all surveys from 2022 onwards due to time constraints and habitat type. Positions were loaded into a handheld Garmin GPS

60 unit using latitude and longitude and work mobile phones using the what3words app. All times were recorded as Universal Time Coordinated (UTC) unless otherwise stated. The SOL and EOL positions were recorded on a handheld Garmin GPS 60 unit for all surveys and an additional Garmin eTrex SE for one survey in 2024.

Officers initially recorded the weather and tide times into a log sheet (water temperature was also recorded for 2023/24 surveys) and then proceeded to the SOL position. Officers walked towards the EOL position covering as much ground as possible. At the given survey positions, stones, cobbles and boulders that were deemed safe (not too heavy or in an awkward position) were overturned and checked for edible crabs hiding underneath.

If crabs were found, these were picked up carefully and their abdomen was photographed with an Olympus Tough TG-5 or an Olympus Tough TG-6. The crabs were measured across the width of the carapace (mm) using vernier callipers and carapace width recorded on a log sheet. Determining the gender of immature edible crab is difficult as the differences in the abdominal flaps are not as distinct as in adult edible crabs (personal survey observation). As such crab gender was recorded as U (unsexed) for crabs <60 mm carapace width and recorded as either male or female if they were ≥60 mm and morphological features allowed a clear gender assignment. Once measured, the crabs were returned to the place they were found and the habitat was returned to as found, by replacing stones and cobbles to their original positions.

2.6 Data handling

Data was entered into a daily log sheet and then transferred to Microsoft Excel. All photographs taken during the survey were transferred to Cornwall IFCA's servers.

2.7 Data analysis

The survey metadata, GPS positioning and crab data were transferred into Excel. Length frequency and density, box and dot plots were created in R (using R studio version 4.3.2) to visualise trends in data. However, given the exploratory nature of this work the survey results have been compared with caution.

The GPS track for all survey days were plotted using MapInfo Professional Advanced (Version 17.0.4) over aerial footage from drone photography of the survey site supplied by Vertical Horizons Media and was used as a base layer for survey positional data.

3 Results

Fourteen intertidal edible crab surveys were carried out between March 2021 and June 2024 (Table 1 and Table 2). Given the exploratory nature of these surveys in determining the optimum intertidal crab survey protocol (in terms of time of year and sampling frequency) each year saw differing months surveyed (Table 1). Four surveys were conducted in both 2021 and 2022 and three surveys in 2023 and 2024.

Table 1: Visual spread of intertidal crab surveys from 2021 to 2024.

Year/ Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
2021				x	x	x				x		
2022			xx	x		x	x					
2023			x	x		x						
2024			x	x		x						

Table 2: Cornwall IFCA 2021 to 2024 Intertidal edible crab survey dates.

Year	Month	Date	SOL time	EOL time	Duration of survey	Number of surveyors
2021	April	29th April 2021	11:55	14:13	02:18	2
2021	May	27th May 2021	11:48	13:31	01:43	1
2021	June	23rd June 2021	09:37	11:23	01:46	2
2021	October	8th October 2021	12:17	14:27	02:10	2
2022	March	3rd March 2022	12:01	13:44	01:43	2
2022	March	31st March 2022	11:14	12:43	01:29	2
2022	June	15th June 2022	11:43	13:22	01:39	2
2022	July	14th July 2022	11:03	12:47	01:44	2
2023	March	21st March 2023	10:54	12:47	01:53	3
2023	April	20th April 2023	10:59	12:41	01:42	2
2023	June	5th June 2023	11:23	12:54	01:31	2
2024	March	11th March 2024	11:27	12:58	01:31	2
2024	April	23rd April 2024	10:56	12:31	01:35	2
2024	June	7th June 2024	11:43	13:10	01:27	2

3.1 Survey Narrative

All times are Universal Time Coordinated (UTC) unless stated otherwise.

3.1.1 2021

29th April 2021

The weather conditions were favourable with light winds from the NW of 10 mph and overcast skies with cloud coverage of 8/8. Cornwall IFCA officers arrived on site at 11:15, conducted a brief preliminary inspection to determine the habitat of edible crabs, and identified the location of Cefas's previous survey positions. During the preliminary inspection a large number of edible brown crabs were discovered so the survey started earlier than planned at 11:55. The survey ended at 14:13 and IFCA officers departed the site at 14:45. Low tide on the day was 0.14 m at 13:15 as recorded in Falmouth (UTC). 65 brown crabs were recorded as part of the survey (62 live and 3 dead).

27th May 2021

The weather conditions were favourable with light winds from the SSE of 10-14 mph and partially overcast skies with cloud coverage of 5/8. A Cornwall IFCA officer arrived on site at 11:45 and started the survey at 11:48. The survey ended at 13:31 and the IFCA officer departed the site at 13:45. Low tide on the day was 0.25 m at 12:15 as recorded in Falmouth (UTC). 37 brown crabs were recorded as part of the survey (36 live and 1 dead). A noticeable increase in velvet swimming crabs and Montagu's crab were observed compared to the previous survey.

23rd June 2021

The weather conditions were favourable with light winds from the NE of 6-10 mph and sunny skies with low cloud coverage of 1/8. Cornwall IFCA officers arrived on site at 09:25 and started the survey at 09:37. The survey ended at 11:23 and IFCA officers departed the site at 11:55. Low tide on the day was 0.72 m at 10:11 as recorded in Falmouth (UTC). 35 brown crabs were recorded as part of the survey. Cornwall IFCA officers observed a noticeable increase in algal coverage of rocks, as well as a higher abundance of Montagu’s crabs and larger velvet swimming crabs.

8th October 2021

The weather conditions were favourable with light winds from the SE of 10-13 mph and sunny skies with low cloud coverage of 1/8. Cornwall IFCA officers arrived on site at 11:55 and started the survey at 12:17. The survey ended at 14:27 and IFCA officers departed the site at 14:40. Low tide on the day was 0.29 m at 12:49 as recorded in Falmouth (UTC). 18 brown crabs were recorded as part of the survey. A noticeable increase in brown algae coverage over rocks from previous surveys in 2021.

3.1.2 2022

3rd March 2022

The weather conditions were favourable with moderate winds from the NW of 17-25 mph and overcast skies with cloud coverage of 6/8. Cornwall IFCA officers arrived on site at 11:55 and started the survey at 12:01. The survey ended at 13:44 and IFCA officers departed the site at 14:10. Low tide on the day was 0.10 m at 12:30 as recorded in Falmouth (UTC). 44 brown crabs were recorded as part of the survey (43 live and 1 dead).

31st March 2022

The weather conditions were unfavourable with a strong, cold ENE wind of 20-35 mph blowing across the survey site making it hard to see in some of the rockpools. The skies were mostly clear with cloud coverage of 3/8. Cornwall IFCA officers arrived on site at 11:00 and started the survey at 11:14. The survey ended at 12:43 and IFCA officers departed the site at 13:15. Low tide on the day was 0.56 m at 11:26 as recorded in Falmouth (UTC). 56 brown crabs were recorded as part of the survey.

15th June 2022

The weather conditions were favourable with light winds from the NW of 10 mph and mostly clear skies with low cloud coverage of 3/8. Cornwall IFCA officers arrived on site at 11:30 and started the survey at 11:43. The survey ended at 13:22 and IFCA officers departed the site at 13:35. Low tide on the day was 0.49 m at 12:11 as recorded in Falmouth (UTC). 41 brown crabs were recorded as part of the survey. There was a noticeable increase in green algal coverage over rocks since the last survey.

14th July 2022

The weather conditions were favourable with moderate winds from the N of 20 mph and sunny skies with low cloud coverage of 1/8. Cornwall IFCA officers arrived on site at 10:50 and started the survey at 11:03. The survey ended at 12:47 and IFCA officers departed the site at 13:25. Low tide on the day was 0.58 m at 12:04 as recorded in Falmouth (UTC). 29 brown crabs were recorded as part of the survey. The green algal cover found on the 15th June was still present on the rocks.

3.1.3 2023

21st March 2023

The weather conditions were favourable with moderate winds from the SW of 17-23 mph and overcast with high cloud coverage of 7/8. Cornwall IFCA officers arrived on site at 10:40 and started the survey at 10:54. The survey ended at 12:47 and IFCA officers departed the site at 13:10. Low tide on the day was 0.10 m at 11:40 as recorded in Falmouth (UTC). 37 brown crabs were recorded as part of the survey (35 live and 2 dead). Four empty carapaces were also noted.

20th April 2023

The weather conditions were favourable with moderate/high winds from the E of 15-30 mph and mostly clear skies with low cloud coverage of 2/8. Cornwall IFCA officers arrived on site at 10:24 and started the survey at 10:59. The survey ended at 12:41 and IFCA officers departed the site at 13:10. Low tide on the day was 0.09 m at 11:58 as recorded in Falmouth (UTC). 46 live brown crabs were recorded as part of the survey. A lot more sand and stones were noticeable at the survey site after strong winds in comparison to previous surveys. The underside of some rocks looked cleaner e.g. less keel worms.

5th June 2023

The weather conditions were favourable with moderate winds from the E of 11-15 mph and clear sunny skies with low cloud coverage of 1/8. Cornwall IFCA officers arrived on site at 10:50 and started the survey at 11:23. The survey ended at 12:54 and IFCA officers departed the site at 13:21. Low tide on the day was 0.65 m at 12:21 as recorded in Falmouth (UTC). 34 live brown crabs were recorded as part of the survey. IFCA officers noticed an increase in algal coverage in the area (wracks and *Sargassum* spp).

3.1.4 2024

11th March 2024

The weather conditions were favourable with light winds from the NW of 8-15 mph and overcast with cloud coverage of 4/8. Cornwall IFCA officers arrived on site at 11:05 and started the survey at 11:27. The survey ended at 12:58 and IFCA officers departed the site at 14:00. Low tide on the day was -0.11 m at 12:36 as recorded in Falmouth (UTC). 33 live brown crabs were recorded as part of the survey. 149 Montagu's crab (*Xantho hydrophilus*) and 11 Risso's crab (*Xantho pilipes*) were also counted.

23rd April 2024

The weather conditions were favourable with low winds from the N of 5-10 mph and cloud coverage of 4/8. Cornwall IFCA officers arrived on site at 10:05 and started the survey at 10:56. The survey ended at 12:31 and IFCA officers departed the site at 13:00. Low tide on the day was 0.72 m at 11:29 as recorded in Falmouth (UTC). 66 brown crabs were recorded as part of the survey (64 live and 2 dead). 126 Montagu's crab (*X. hydrophilus*) and 2 Risso's crab (*X. pilipes*) were also counted.

7th June 2024

The weather conditions were favourable with moderate winds from the WSW of 12-15 mph and overcast with cloud coverage of 6/8. Cornwall IFCA officers arrived on site at 11:20 and started the survey at 11:43. The survey ended at 13:10 and IFCA officers departed the site at 13:50. Low tide on the day was 0.64 m at 12:10 as recorded in Falmouth (UTC). 28 live brown crabs were recorded as part of the survey and 17 dead carapace

shells were found scattered across the survey site. 131 Montagu's crab (*X. hydrophilus*) and 0 Risso's crab (*X. pilipes*) were also counted.

3.1.5 Survey location

The SOL and EOL positions (WGS 84) are shown in Table 3.

Table 3: Positions of the start of line (SOL) and end of line (EOL) for each of the survey days from 2021 to 2024.

Date	SOL position		EOL position	
	Latitude (dd.dddddd)	Longitude (dd.dddddd)	Latitude (dd.dddddd)	Longitude (dd.dddddd)
2021				
29th April 2021	50.164500	-4.972300	50.165050	-4.972050
27th May 2021	50.164250	-4.972283	50.164483	-4.972350
23rd June 2021	50.164233	-4.972250	50.165417	-4.972350
8th October 2021	50.164250	-4.972233	50.164567	-4.972550
2022				
3rd March 2022	50.164250	-4.972250	50.164467	-4.972233
31st March 2022	50.164250	-4.972300	50.164550	-4.972467
15th June 2022	50.164250	-4.972267	50.164500	-4.972433
14th July 2022	50.164133	-4.972317	50.164533	-4.972483
2023				
21st March 2023	50.164267	-4.972317	50.164517	-4.972400
20th April 2023	50.164250	-4.972300	50.164433	-4.972267
5th June 2023	50.164433	-4.972333	50.164267	-4.972250
2024				
11th March 2024	50.164267	-4.972317	50.164433	-4.972283
23rd April 2024	50.164083	-4.972400	50.164367	-4.972267
7th June 2024	50.164300	-4.972283	50.164517	-4.972383

The GPS SOL, EOL positions and the track for each survey day are shown in Annex 1 – GPS Track positions.

3.2 Edible Crabs (*Cancer pagurus*)

The total number (including live and dead), minimum size (mm), maximum size (mm) and average size (mm) of edible crabs, for each of the survey days, are shown in Table 4. The carapace size (mm), sex and any comments for individual crabs, for each survey day, are shown in Annex 2.

Table 4: Descriptive statistics for edible crabs (*Cancer pagurus*) by year between 2021 and 2024.

Number recorded	2021	2022	2023	2024
Sample size (n)	155	170	117	127
Live (n)	151	169	115	125
Dead (n)	4	1	2	2
Mean	37.85	44.81	45.33	34.90

Median	35	40	42	27
Maximum	102	156	93	108
Minimum	12	11	10	10
Range	90	145	83	98
Standard deviation	17.70	22.04	22.96	20.46
Variance	313	486	527	419
Standard Error	1.42	1.69	2.12	1.82

3.2.1 Abundance

The abundance of edible crab across the survey period is displayed in Table 5. Edible crab abundance throughout the survey period ranged from 18 to 66 crabs.

Table 5: Descriptive statistics for edible crabs (*Cancer pagurus*) for each of the survey days between 2021 and 2024.

Descriptive statistics/ date	29.04.2021	27.05.2021	23.06.2021	08.10.2021	03.03.2022	31.03.2022	15.06.2022	14.07.2022	21.03.2023	20.04.2023	05.06.2023	11.03.2024	23.04.2024	07.06.2024
Sample size (n)	65	37	35	18	44	56	41	29	37	46	34	33	66	28
Live (n)	62	36	35	18	43	56	41	29	35	46	34	33	64	28
Dead (n)	3	1	0	0	1	0	0	0	2	0	0	0	2	0
Mean size (mm)	32.5	37.4	43.4	47.4	32.5	37.2	50.7	57.7	42.4	43.2	51.5	25.6	32.5	42.5
Median	30	30	42	51	33	32	46	58	40	42	47	21	29	37
Minimum size (mm)	12	16	16	19	12	11	21	24	12	10	11	14	10	10
Maximum size (mm)	92	77	102	73	156	94	86	97	91	88	93	65	100	108
Range	80	61	86	54	144	83	65	73	79	78	82	51	90	98
Standard deviation	15.5	18.1	17.9	18.3	25.4	20.9	17.4	17.0	21.9	22.7	23.8	12.4	20.3	24.6
Variance	239	327	321	335	644	436	302	290	481	517	568	154	414	605
Standard Error	1.9	3.0	3.0	4.3	3.8	2.8	2.7	3.2	3.6	3.4	4.1	2.2	2.5	4.6

The boxplot of crab abundance (Figure 2) reveals yearly variation in the number of edible crabs. From 2021 to 2022, both the mean and median increased slightly, indicating a rise in crab abundance. In 2023, there was a sharp decline in both metrics, reflecting a drop in crab abundance. Interestingly, while the mean was highest in 2024, the median fell to its lowest level across all four years. Additionally, variability (as shown by the interquartile range) was greatest in 2024.

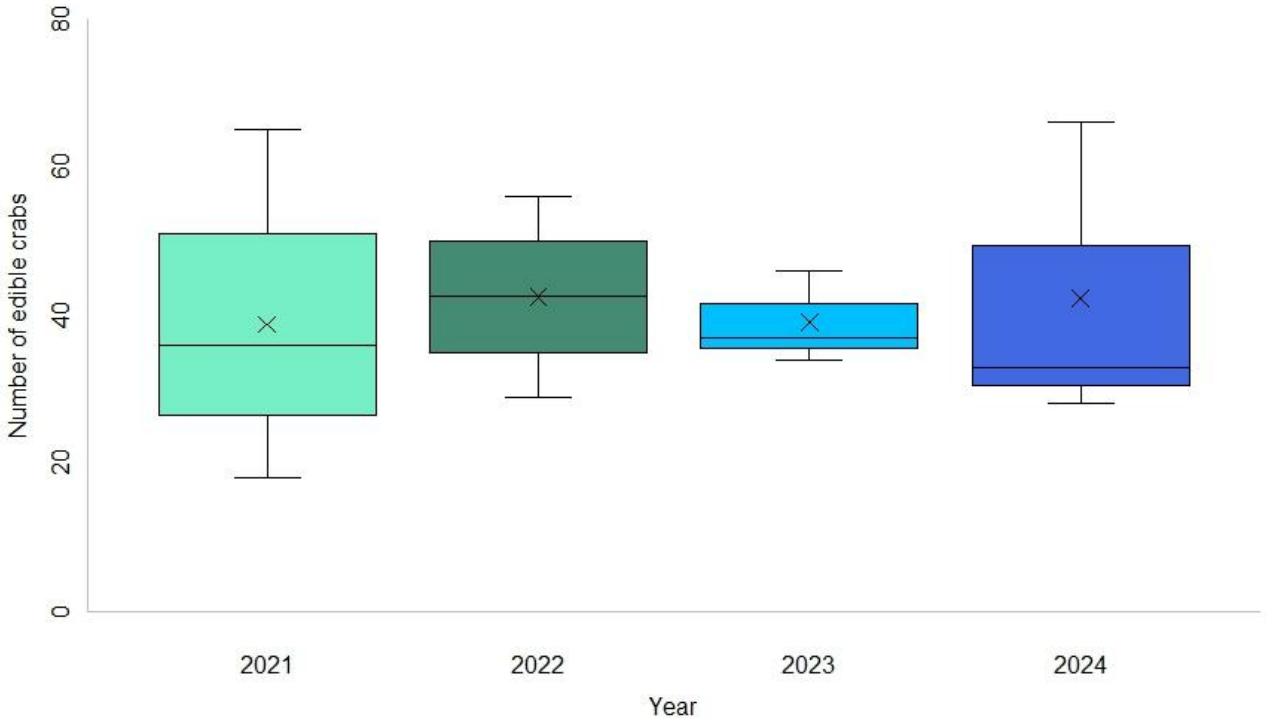


Figure 2: Edible crab (*Cancer pagurus*) survey abundance (number of crabs) over the 2021- 2024 intertidal surveys at Greeb point, grouped by year. The cross represents the mean, the solid line represents the median, boxes represent the interquartile range, whiskers represent 1.5 x interquartile range, and the filled circles represent outliers.

Figure 3 illustrates the abundance of edible crab from 2021 to 2024, with data spanning March to October each year. Across all four years, a consistent declining trend in crab abundance is observed from early spring through to autumn. This pattern suggests a seasonal decrease in crab presence as the year progresses as shown by the negative correlations in Figure 3. While the overall trend is similar across years, the magnitude of abundance and the shape of the decline vary slightly, with 2021 showing relatively higher early-season numbers compared to subsequent years. The GLM smoothing lines, accompanied by 95% confidence intervals, highlight this trend and also reveal greater variability in crab counts during the early (April to June) and late (October) months, as indicated by the wider confidence bands during these periods.

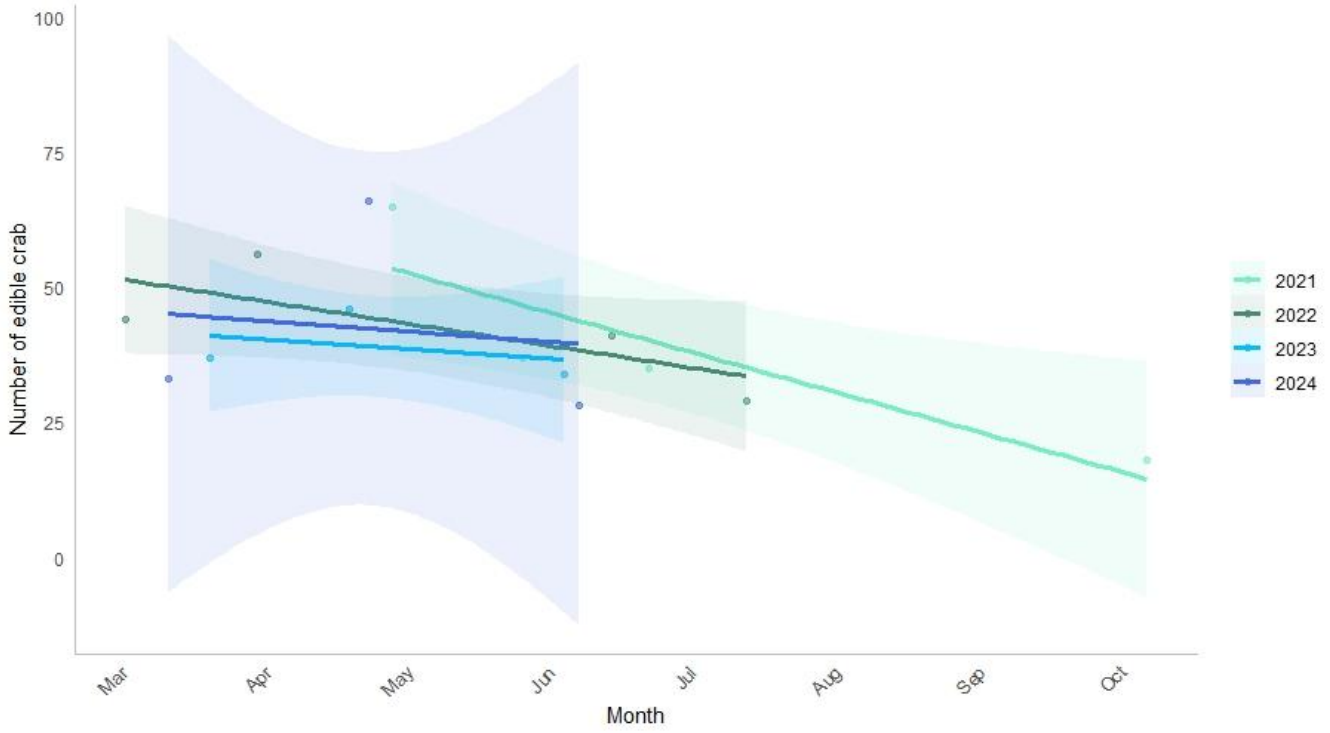


Figure 3: Edible crab (*Cancer pagurus*) abundance across the days of the year for the 2021- 2024 (2021 = light green, 2022 = dark green, 2023 = light blue, 2024 = dark blue) during the intertidal surveys at Greeb Point. Yearly GLM smoothing line (in corresponding colours) with 95% confidence intervals shown in corresponding colours

3.2.2 Size Distribution

Average carapace width (mm) of edible crab for each survey day ranged from 25.6 mm to 57.7 mm (Table 5) and crab width (mm) throughout the surveys ranged from 10 mm to 156 mm (Table 5).The distribution of edible crab sizes, across the survey period is displayed in the histograms of carapace width distributions (mm) for six months from March to October from 2021 to 2024 (Figure 4). A clear seasonal trend is observed: smaller carapace widths (approximately 20–60 mm) are more frequently recorded in the early months of the year, particularly in March and April. In contrast, mid-year months such as June and July show a shift toward larger carapace widths (approximately 40–100 mm), suggesting growth over time. These patterns are consistent across the four years. It should be noted that May, July and October had few observations with only one survey carried out for each month.

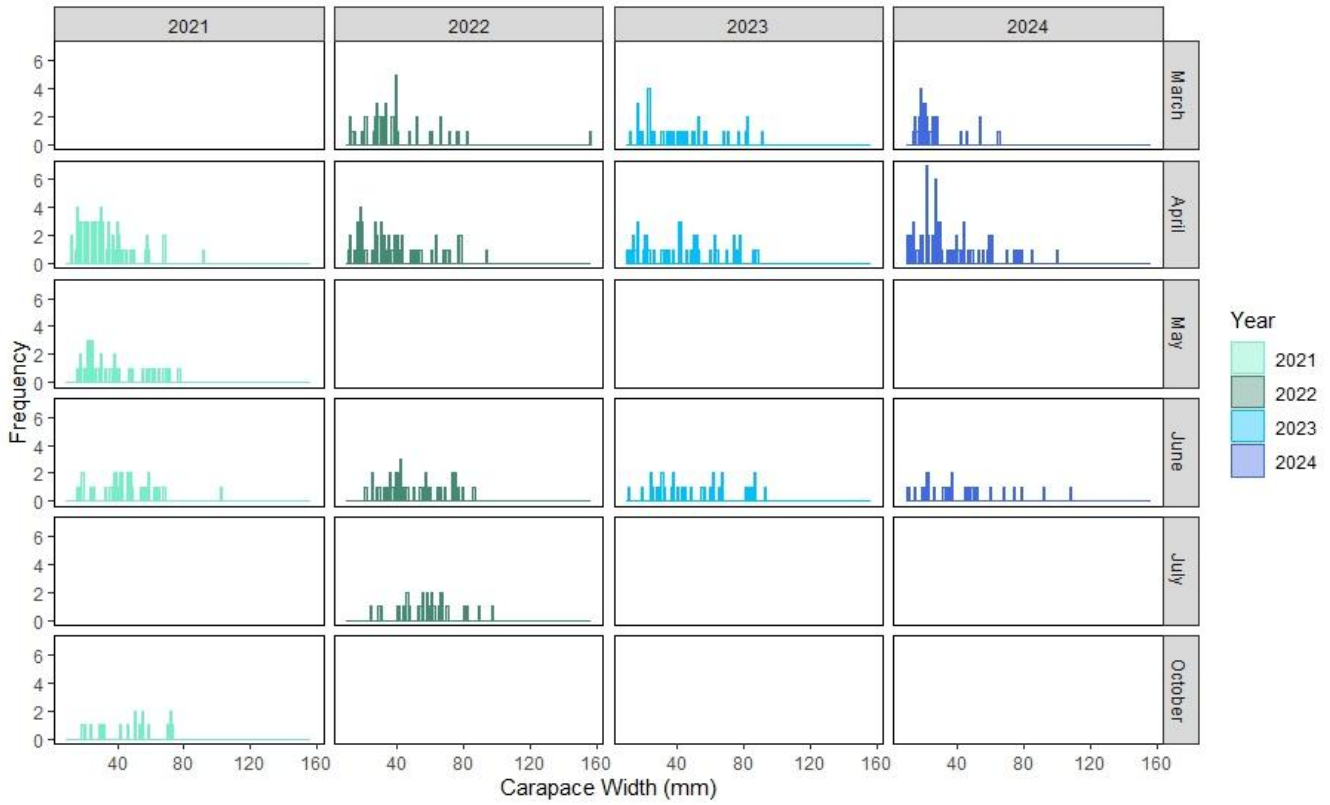


Figure 4: Edible crab (*Cancer pagurus*) carapace width/frequency distribution (for the 1 mm size classes) separated by year and month of survey, with years shown in different colours (2021 = light green, 2022 = dark green, 2023 = light blue and 2024 = dark blue)

The distribution of carapace widths varied across the four-year period (Figure 5). From 2021 to 2023, both the mean and median increased slightly, indicating a slightly larger carapace sizes recorded. Increased variability was recorded from 2021 to 2022 and remained similar in 2023. In 2024, the mean and median decreased with a shift towards smaller crab sizes with less spread showing that the sizes were more consistent.

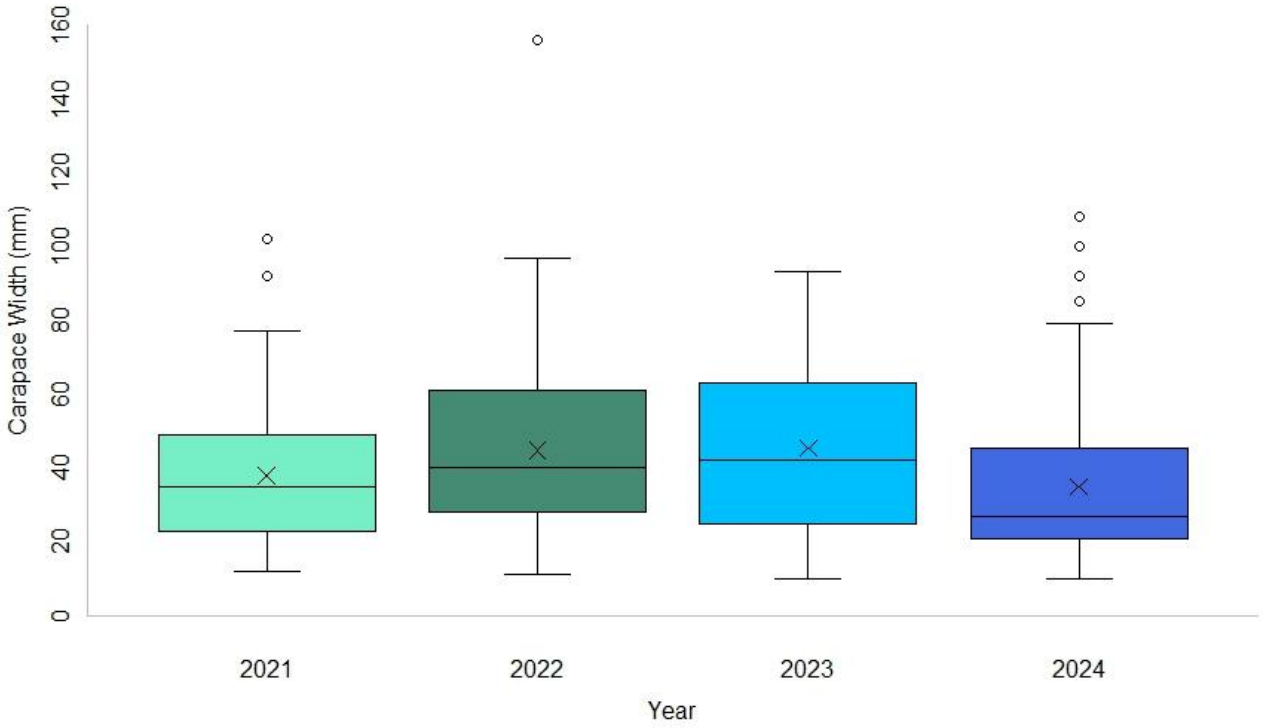


Figure 5: Edible crab (*Cancer pagurus*) carapace width (mm) over the 2021- 2024 intertidal surveys at Greeb point, grouped by year. The cross represents the mean, the solid line represents the median, boxes represent the interquartile range, whiskers represent 1.5 x interquartile range, and the circles represent outliers.

Figure 6 represents boxplots of carapace width (mm) from March to October over the years 2021 to 2024. A general upward trend in median carapace width was evident across most months, suggesting a consistent increase in size over time and by season. March, April and June displayed a clear year-on-year increase in median values from 2021 to 2023 with a decrease observed in 2024. More pronounced outliers were recorded in 2024 in March and April. Larger edible crab were present in the June, July and October surveys and smaller edible crab present in March, April and May compared by individual year.

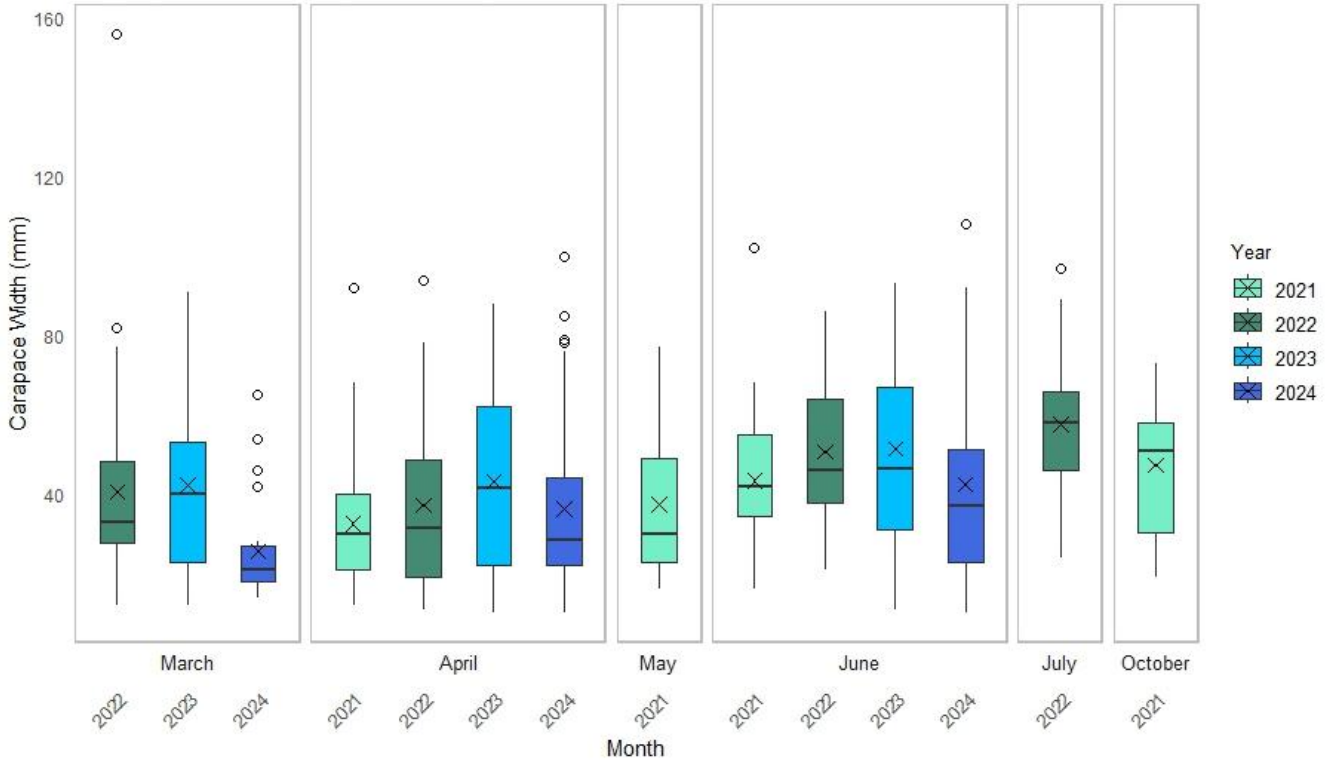


Figure 6: Edible crab (*Cancer pagurus*) carapace width (mm) over the 2021- 2024 intertidal surveys at Greeb point by month and year (2021 = light green, 2022 = dark green, 2023 = light blue, 2024 = dark blue) The cross represents the mean, the solid line represents the median, boxes represent the interquartile range, whiskers represent 1.5 x interquartile range, and the filled circles represent outliers.

This pattern of increasing carapace width as the year progresses is clearer when looking at carapace width against the day of the year (positive correlation for all years shown in Figure 7). The figure illustrates the relationship between the day of the year and carapace width (mm) from 2021 to 2024, each represented by a distinct colour. A positive trend is observed in all years, indicating that carapace width generally increases as the year progresses. However, the strength of this relationship is weak, as reflected by the low R^2 values (ranging from 0.03 to 0.11). Among the years, 2024 exhibits the steepest increase in carapace width over time (slope = 0.193), suggesting more rapid growth or size accumulation compared to other years. In contrast, 2021 shows the shallowest slope (0.099), indicating a slower rate of increase. The year 2023, despite having a relatively high intercept (31.2), has the weakest correlation ($R^2 = 0.03$), implying high variability in the data. Overall, while a general growth trend is evident, the variability and low explanatory power of the models suggest that other factors may also influence carapace width.

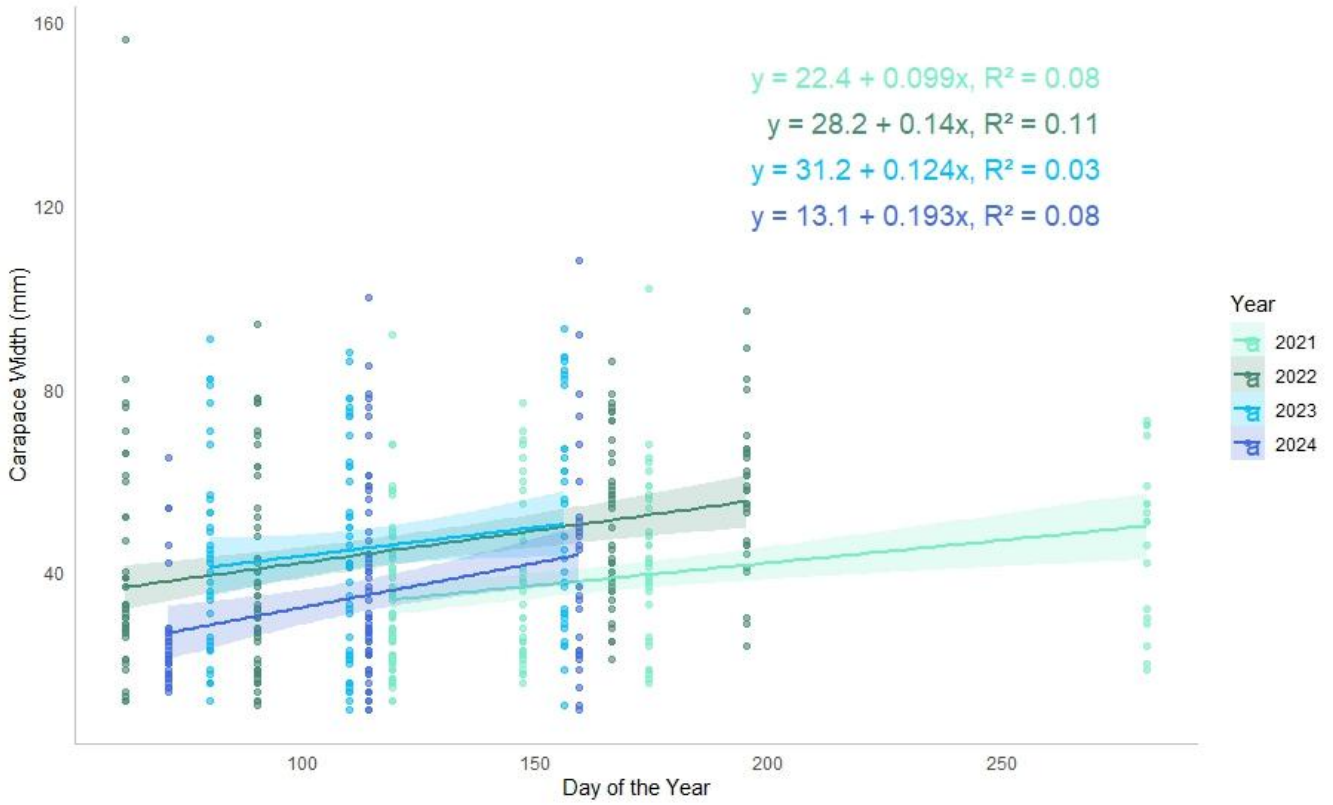


Figure 7: Edible crab (*Cancer pagurus*) carapace width (mm) across the days of the year for the 2021- 2024 (2021 = light green, 2022 = dark green, 2023 = light blue and 2024 = dark blue) during the intertidal surveys at Greeb Point. Yearly linear regression lines plotted (in corresponding colours) with 95% confidence intervals in corresponding colours. Line equation and R_2 represented.

3.2.3 Gender

It was not possible to assign gender to 468 of the 569 crabs across the surveys. Of the crabs that were ≥60 mm CL that it was possible to assign gender to (101 individuals), 61.4% were females and 38.6% were males (Table 6 and Table 7). Examples of cases where clear gender assignment was possible can be seen in Table 8. Examples of crabs observed with carapace width < 60 mm, across the years are shown in Table 9, with possible males on the left and females on the right but all were recorded as unsexed.

Table 6: Gender assignment of crabs throughout the surveys recorded in number of crabs (n) and % of gender assigned crabs (for Male and Female) and % of total crabs measured (for unsexed crabs).

		Male assignment		Female assignment		Unsexed	
Date	Total crabs measured	n	% of crabs assigned male	n	% of crabs assigned female	n	% of crabs unsexed
29th April 2021	65	1	1.5	2	3.1	62	95.4
27th May 2021	37	4	10.8	2	5.4	31	83.8
23rd June 2021	35	2	5.7	3	8.6	30	85.7
8th October 2021	18	2	11.1	2	11.1	14	77.8
3rd March 2022	44	3	6.8	5	11.4	36	81.8
31st March 2022	56	3	5.4	8	14.3	45	80.4
15th June 2022	41	5	12.2	7	17.1	29	70.7
14th July 2022	29	5	17.2	8	27.6	16	55.2

21st March 2023	37	1	2.7	6	16.2	30	81.1
20th April 2023	46	4	8.7	8	17.4	34	73.9
5th June 2023	34	2	5.9	3	8.8	29	85.3
11th March 2024	33	1	3.0	0	0.0	32	97.0
23rd April 2024	66	4	6.1	4	6.1	58	87.9
7th June 2024	28	2	7.1	4	14.3	22	78.6
Totals	**569**	**39**		**62**		**468**	

Table 7: The proportion of male, female and unsexed edible crabs from 2021 to 2024

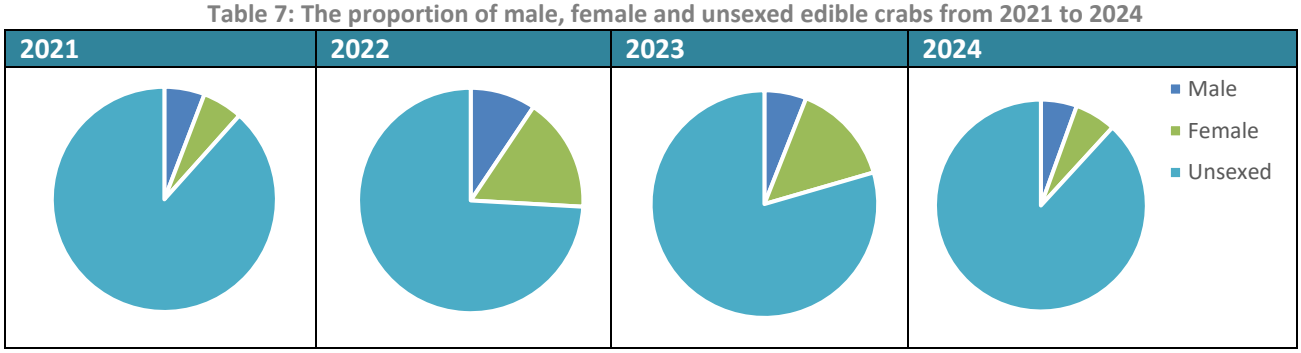


Table 8: Images of the underside of edible crab (*Cancer pagurus*) as recorded during the intertidal edible crab surveys between 2021 and 2024. Pictures represent specimens >60 mm Carapace width where clear male (left) and female (right) gender assignment was possible.

Gender assigned: Carapace width >=60 mm	
Male	**Female**
	

Table 9: Images of the underside of edible crab (*Cancer pagurus*) as recorded during the intertidal edible crab surveys between 2021 and 2023. Pictures represent examples from 2021, 2022 and 2023 of crabs with carapace width <60 mm, where gender differentiation was unclear.

No gender assigned		
2021	**2022**	**2023**
		

The temporal trend of the number of female, male and unsexed crabs from 2021 to 2024 is shown in Figure 8. The majority of crabs recorded were unsexed. The number of female and male crabs have followed a similar trend with a peak in 2022 and gradual decline to 2024.

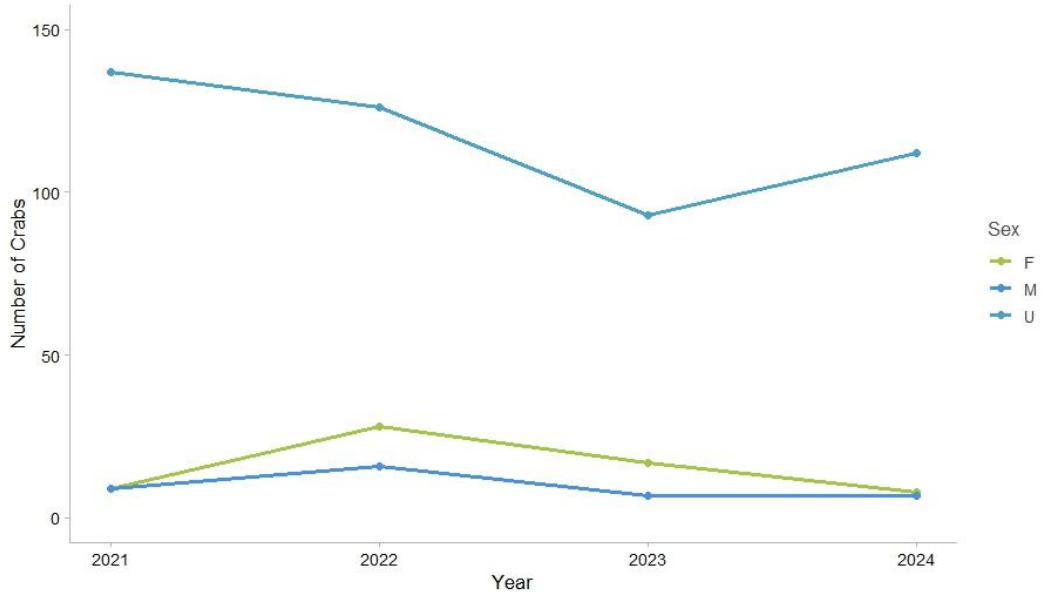


Figure 8: The number of female, male and unsexed crabs from 2021 to 2024

The temporal trend of the average carapace size (mm) of female, male and unsexed crabs from 2021 to 2024 is shown in Figure 9. Female crabs exhibited an upward trend in size indicating an increasingly larger size of female

crab recorded during the surveys over time. Male crabs stayed relatively similar in size from 2021 to 2023 and decreased in 2024. The unsexed crabs steadily increased from 2021 to 2023 then decreased in 2024.

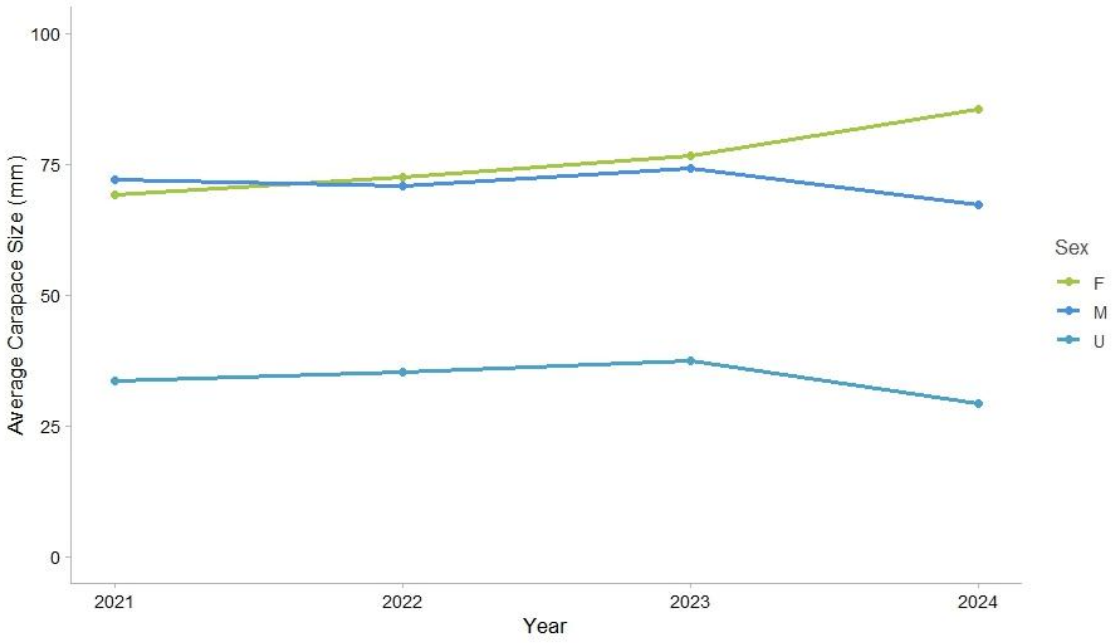


Figure 9: The average carapace size (mm) of edible crabs from 2021 to 2024

3.2.4 Growth Increment

A total of ten soft shelled crabs were recorded next to exuvae (moults) over the survey period, which allowed record and calculation of the growth increment (Table 10). The average growth increment (mm) across the years was 11.9 mm and 28.6% increase in size at moult (with a minimum of 22.2 % increase in size at moult and a maximum = 38.5% increase in size at moult). Examples of soft-shelled crabs and their respective moults are shown in Figure 10.

Table 10: Edible crab (*Cancer pagurus*) growth increment data collected from 2021 to 2024.

Date measured	Premoult width (mm)	Postmoult width (mm)	Increment (mm)	Increment (% increase)
29th April 2021	71	92	21	29.6
27th May 2021	45	55	10	22.2
27th May 2021	17	22	5	29.4
8th October 2021	56	70	14	25.0
8th October 2021	24	30	6	25.0
14th July 2022	35	46	11	31.4
14th July 2022	69	89	20	29.0
21st March 2023	13	18	5	38.5
11th March 2024	18	23	5	27.8
23rd April 2024	78	100	22	28.2

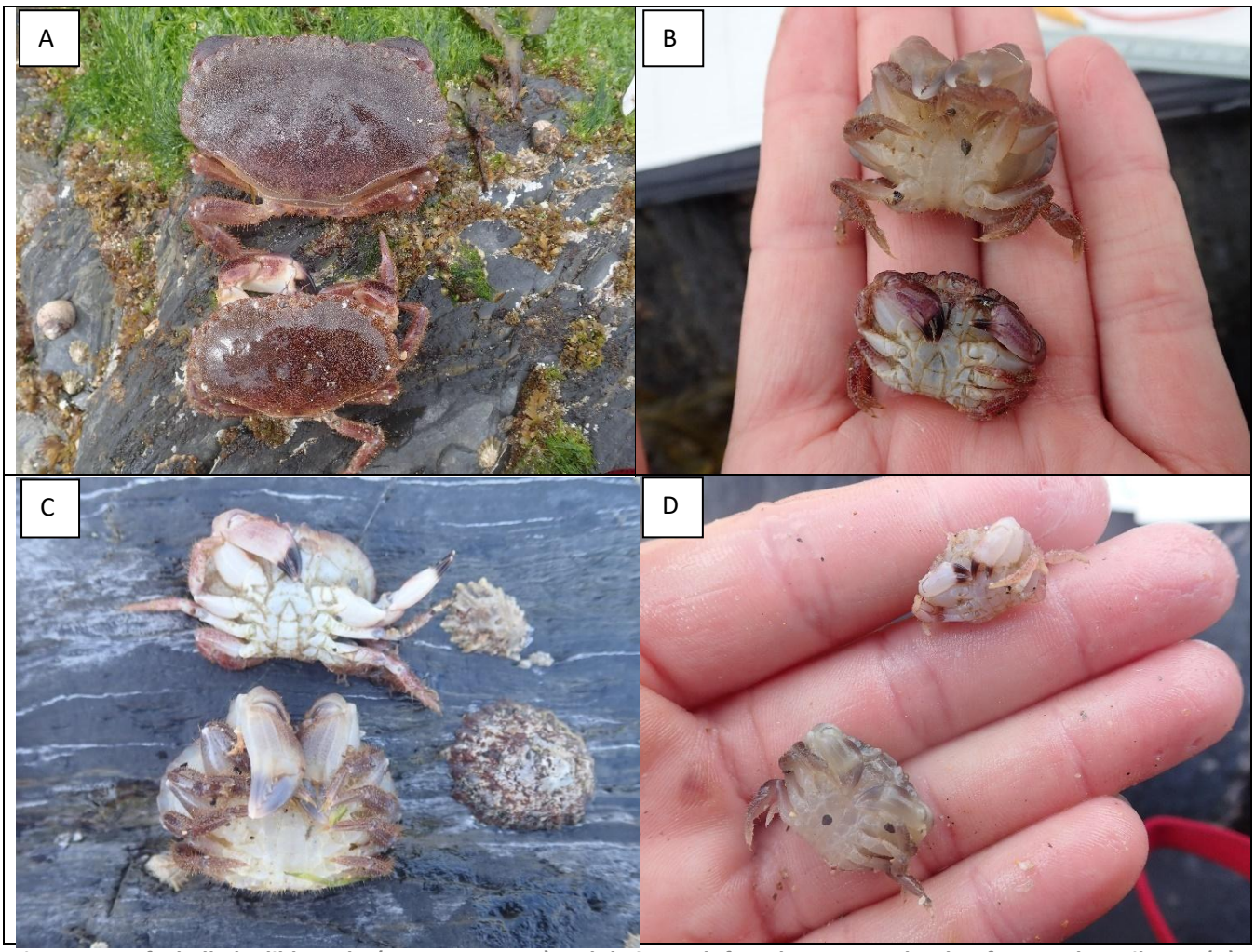
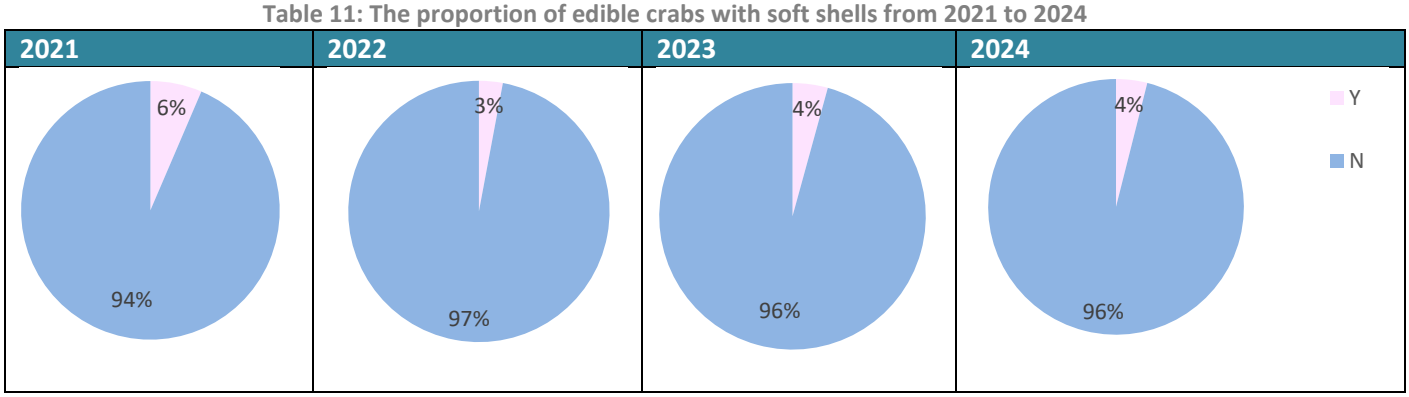


Figure 10: Soft shelled edible crabs (*Cancer pagurus*) and their moult found next to each other from 29th April 2021 (A), 8th October 2021 (B), 14th July 2022 (C) and 21st March 2023 (D) respectively.

The proportion of soft shell crabs has remained fairly similar from 2021 to 2024 (Table 11).

Table 11: The proportion of edible crabs with soft shells from 2021 to 2024



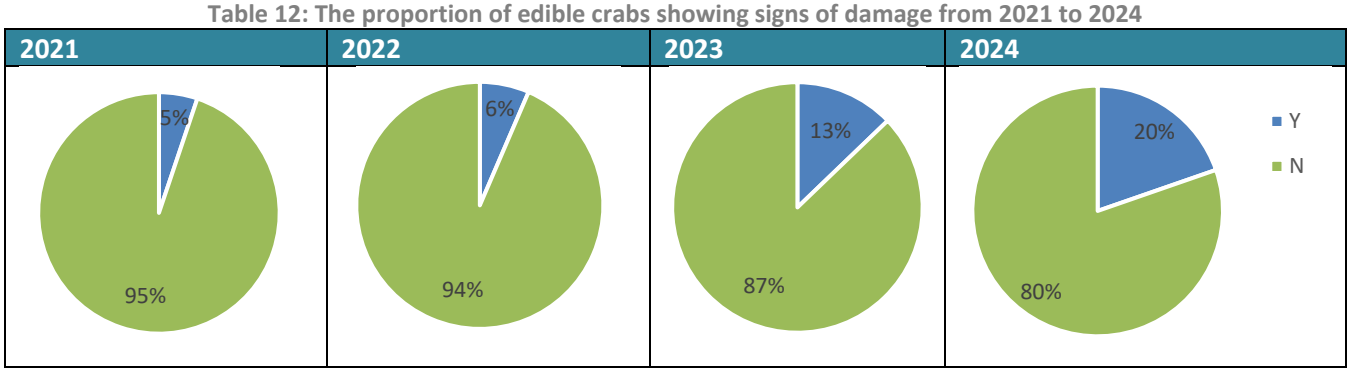
3.2.5 Damage

The majority of edible crabs recorded were not damaged, however there were signs of damage. This included crabs with one claw (1C), a broken carapace (BC), no claws (NC), legs missing (LM), LCM (legs and claw missing),

regrowing claw (RC), damaged claw (DC), broken carapace and one claw (BC1C), broken carapace and deformed flap (BCDF) (abdominal flap) and one claw and deformed flap (1CDF) (abdominal flap).

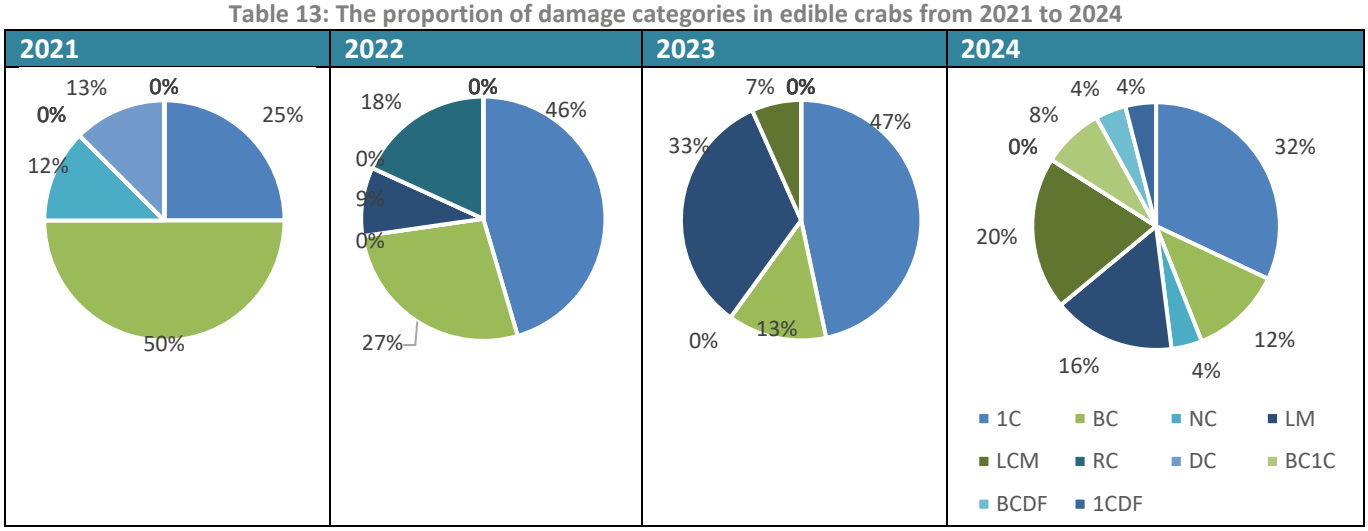
The proportion of crabs with damage increased from 2021 to 2024 (Table 12), although this is likely due to officers recording more information as the survey progressed.

Table 12: The proportion of edible crabs showing signs of damage from 2021 to 2024



In 2021, the dominant type of damage was broken claws and from 2022 to 2024 the dominant damage was crabs with one claw (Table 13).

Table 13: The proportion of damage categories in edible crabs from 2021 to 2024



3.3 Environmental Conditions

The water temperature (°C) of a rockpool was recorded for surveys in 2023 and 2024. Figure 10 illustrates the relationship between rockpool water temperature (°C) and the average size (mm) of edible crabs from 2021 to 2024. The data revealed an apparent trend with a higher average size recorded when water temperatures were warmest, however the temperature doesn't dip when the average size was smallest. Although there is an apparent relationship between crab size and temperature, it is not significant (Table 14). The pattern suggests that warmer water conditions may support or accelerate growth in edible crabs, possibly due to increased metabolic rates, moulting activity, or food availability during warmer months.

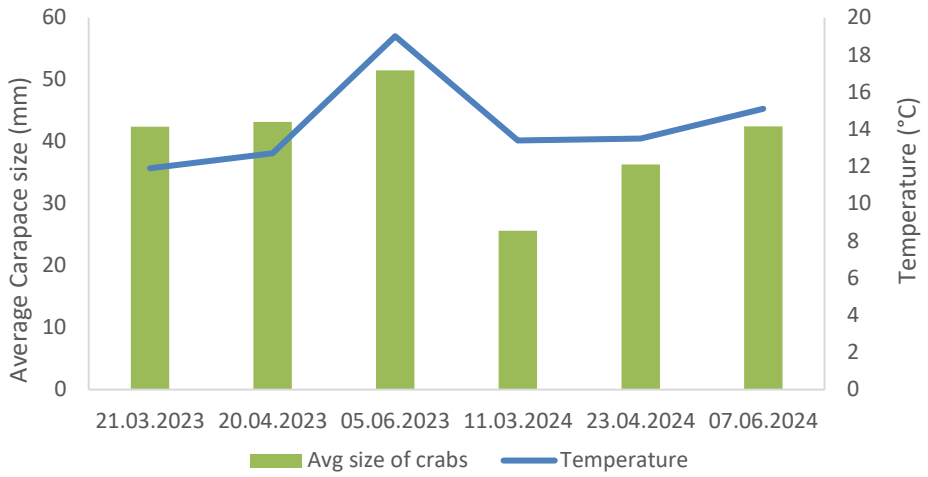


Figure 11: Rockpool water temperature (°C) and the average size (mm) of edible crabs from 2021 to 2024

The same trend is less obvious when split into gender categories Figure 12, with female and male crabs showing a less obvious trend with temperature, however, unsexed crabs had a larger average carapace size (mm) when water temperatures were higher indicating a possible trend with rockpool temperature (°C).

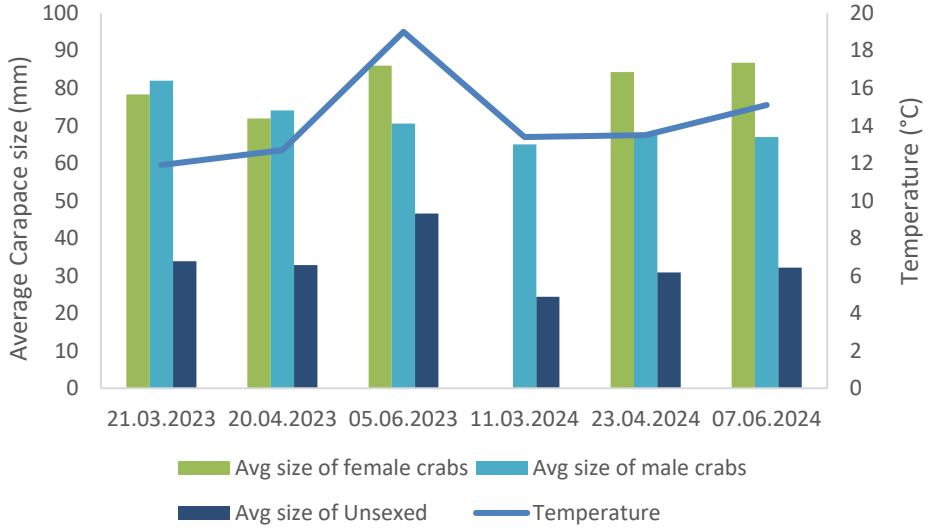


Figure 12: Rockpool water temperature (°C) and the average size (mm) of female, male and unsexed edible crabs from 2021 to 2024

Linear regressions were carried out to explore the influence of environmental variables on edible crab abundance and carapace size (Table 14). The cloud cover, wind direction and wind speed are unlikely to influence the crab carapace size, however, may influence the crab abundance on any particular day due to potential behavioural changes and have been included. All relationships were not statistically significant, indicating weak or no consistent associations. Temperature showed low explanatory power for both abundance ($R^2 = 0.0970$, $p = 0.5485$) and carapace size ($R^2 = 0.3030$, $p = 0.2581$). Ideally, a greater number of samples would be collected to improve the statistical analysis.

Table 14: Summary of linear regression analyses examining the effects of environmental variables (temperature, cloud cover, wind direction, and wind speed) on edible crab abundance and carapace size (significance level ($p < 0.05$).

Dependent	Independent	R^2	p-value	n	d.f.	Significance Level
Temperature	Crab Abundance	0.0970	0.5485	6	4	Not significant
Temperature	Carapace Size	0.3030	0.2581	6	4	Not significant
Cloud cover	Crab Abundance	0.1700	0.1432	14	12	Not significant
Wind Direction	Crab Abundance	0.0000	0.9914	14	12	Not significant
Wind Speed	Crab Abundance	0.0125	0.7037	14	12	Not significant

3.4 Other crab species - Montagus and Risso's crabs

In 2024, the number of Montagus crabs (*X. hydrophilus*) and Risso's Crab (*X. pilipes*) were also recorded alongside the number of edible crabs for three survey days (March to June) (Figure 13 and Figure 14). Montagu's crabs were consistently the most abundant, though their numbers declined slightly in April. Risso's were present in smaller numbers and showed a marked decrease with none recorded in June.

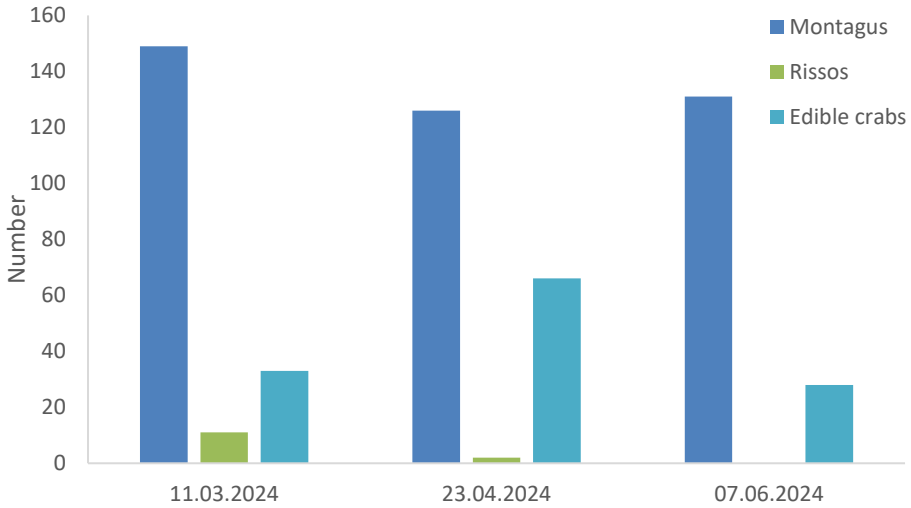


Figure 13: The number of edible crabs (*Cancer pagurus*), Montagus crabs (*Xantho hydrophilus*) and Risso's crabs (*Xantho pilipes*) recorded in 2024

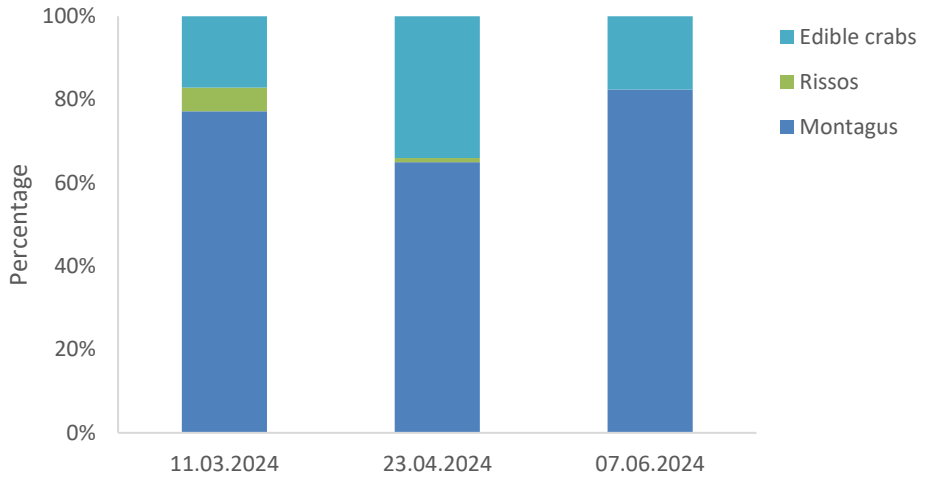


Figure 14: The proportion of edible crabs (*Cancer pagurus*), Montagus crabs (*Xantho hydrophilus*) and Risso's crabs (*Xantho pilipes*) recorded in 2024

3.5 Non-native species

Scientific officers were focused on finding and recording edible crabs therefore the observing and recording of non-native species was a minor part of the survey. However, a large amount of Japanese wireweed (*Sargassum muticum*), was noted covering the pools throughout the surveys, particularly when the air temperature was warmer.

4 Discussion

The 2021 to 2024 intertidal edible crab surveys at Greeb Point successfully demonstrated the presence and seasonal dynamics of pre-recruit edible crabs (*C. pagurus*) in a nursery habitat. Pre-recruit (<150 mm carapace width female and <160 mm carapace width male), edible crabs were found in abundance at this survey site during all surveys.

4.1 Seasonal patterns in abundance and size

A consistent seasonal trend was observed across all years with crab abundance highest in early spring (March–April) and declined through summer and autumn. This pattern likely reflects the seasonal movement of juvenile crabs, with individuals leaving the intertidal zone as they grow or in response to environmental changes such as temperature or increased algal cover (Figure 15). The positive correlation between carapace width and day of the year supports this, indicating growth over the warmer months with smaller crabs present early in the year (March to May) and larger crabs present later in the year (June, July and October).

4.2 Habitat and environmental influences

Crabs were predominantly found under cobbles and boulders in coarse sand within gullies, microhabitats that offer shelter and foraging opportunities (Figure 16). The presence of dense algal cover in June and July (Figure 15) likely reduced detectability and may have influenced crab behaviour, potentially driving them deeper into crevices or further down the shore. This may explain why the current survey does not appear to capture settlement of juvenile crabs into the intertidal habitat which we would expect to see between June and October (Robinson and Tully, 2000).

Figure 15: Example of June and July observations where the tidal pools were full of algae

Water temperatures were noticeably warmer later in the year. Although water temperature showed a weak correlation with crab size and abundance, the trend of larger crabs in warmer months suggests a possible link to increased metabolic and moulting rates. However, the limited sample size for environmental data restricts robust conclusions. The influence of the warmer conditions were not investigated further but it's possible that the crabs buried deeper to find cooler conditions or moved to deeper intertidal positions on the shore, which was observed during the surveys with a greater number of larger crabs recorded further down the shore.

Figure 16: Examples of the type of habitat surveyed during the Cornwall IFCA intertidal edible crab survey.

4.3 Growth and recruitment indicators

The observation of soft-shelled crabs alongside moults allowed for direct measurement of growth increments along this stretch of coastline, averaging a 28.6% increase in carapace width. This aligns with an edible crab tagging study in the South West of England (Bennett, 1974) and supports the use of intertidal surveys to monitor growth dynamics. However, the freshly moulted crabs felt very soft and were likely to be recently moulted but it is unknown if they had completed taking on water before hardening, therefore their post moult size may be an underestimation if this process was not complete.

4.4 Gender assignment

When looking at the ratios of males to females in the intertidal population, the results of this survey relate closely to that found during crustacean catch sampling onboard fishing vessels in the Cornwall IFCA District between 2003 and 2006, which showed males to represent 39% of the population and females to represent 61% of the population (Davis, 2007). These results are the same as this survey with males representing 39% and females 61% of edible crabs which could be gender assigned. This suggests consistency in population structure across life stages.

4.5 Survey method

The walkover survey method is effective for detecting juvenile edible crabs in the intertidal zone. The refinement of the survey timing and positioning over the years has improved the consistency of the data and the comparability over the years. Some challenges still remain which include reduced visibility when algal cover is high, inability to measure crabs in deep crevices and possibly observer variability in crab detection.

The current three-year survey has shown that this type of sampling could be suitable as a proxy for long term trends in abundance on a local scale (in a given survey area). The 2021 survey methodology was refined in 2022 and 2023, with the resulting method (used from 2023) providing a repeatable survey for future years. The current four-year survey provides a baseline against which future surveys can be compared. However, to scale

it up to monitor intertidal crab abundance across the Cornwall IFCA district would take a considerable amount of time and effort and would depend on time and resource constraints.

5 Limitations

- An abundance of algae during periods of hot weather could have limited officers being able to find crabs, as the pools were covered by the algae.
- A low number of edible crabs were seen in nooks and crevices but could not be measured as there was no easy way to extract them without damaging them.
- The size of the freshly moulted crab could be misrepresentative. Crabs take up water from the environment after moulting before the exoskeleton hardens at a larger size and it is unknown at what stage in this process the crabs were sampled.
- As 2021 and 2022 were exploratory years to determine the best practice in field data collection (which was applied in 2023 and 2024), annual comparisons in this report are made with a degree of caution.
- The surveys undertaken do not provide enough continuous data collected using standardised protocols to make comparisons with permit returns (landings) data from the vicinity. Further surveys are required to enable making such comparisons and in turn to understand potential for surveys to help understand recruitment in the district.
- The data of these surveys was not directly compared to the findings of Smith (2012a and 2012b) conducted at the same site, as the exact route surveyed is not known for that study and the methodology varied slightly to allow the current survey to record additional information on the individual crabs. Due to the scoping nature of this work, the data presented in this report has also been compared with caution between the years due to the variability in survey timings, positioning and the number of officers sampling during the sample events. However, clear similarities were observed between years with a greater number of larger crabs recorded later in the year and a decrease in crab numbers through the year.
- The temperature in the pools is likely to be higher than the sea temperature on any given day due to how shallow the pools are.

6 Recommendations

- Cornwall IFCA officers agree that repeating surveys in the same months, March, April and June, as surveyed in 2023 and 2024, would be the best practice for a longer-term study, to ensure comparisons can be made across years with confidence. However, survey planning should consider resource and time constraints from the outset to ensure yearly surveys are repeatable and therefore comparable.

- Extension of the survey to include further suitable intertidal edible crab survey sites of different geographical location within the Cornwall IFCA district (north or west coast) would be beneficial, depending on resource and time constraints. If resources are restrictive then possibly conducting one survey annually at each site, in the month that gave constantly high abundance records (April), would be worth considering.
- Taking photos, though more time consuming, provides a reference point for gender assignment and clarity for future comparisons.
- Alternatively, or in addition to intertidal surveys, pre-recruit assessments could be conducted through current crustacean catch survey work across the district (smallest edible crab recorded in recent pot surveys = 60 mm carapace width).
- Use longer term datasets gathered using the intertidal crab surveys to start understanding the relationships between landings and juvenile abundance on intertidal crab grounds, with the intention of helping to predict recruitment into the edible crab fishery in the district.
- Records of water temperature from the surveys and or sea surface temperature records should be used in future to compare young of year settlement against to look for correlations.
- Use of sea surface temperature records (instead of the tidal pool temperature) for the area could be used to model against crab abundance and size.
- It would be worth separating out abundance data across different year classes of edible crabs found on intertidal surveys to help predict future trends in recruitment to the fishery for different years.
- Continue to record the abundance of the furrowed crab (*X. hydrophilus*) and the Risso's Crab (*X. pilipes*) to look at long term trends in potential correlations between species abundance.
- If data is continued to be collected annually using the standardised 2023/ 2024 methodology, it would be interesting to compare local LPUE in the fishery (examples of data available from 2022 and 2023 can be found in Street *et al*., 2023 and 2025) to look for any trend between the datasets. For example, links between LPUE and intertidal crab abundance at ~2/3 years apart (the approximate time they spend in the intertidal before moving to deeper water [Thrupp *et al*., 2015]). Such correlations may allow the use of these intertidal surveys as a proxy for determining potential recruitment into the fishery for the species in the Cornwall IFCA district when linked with growth increment data for the species.

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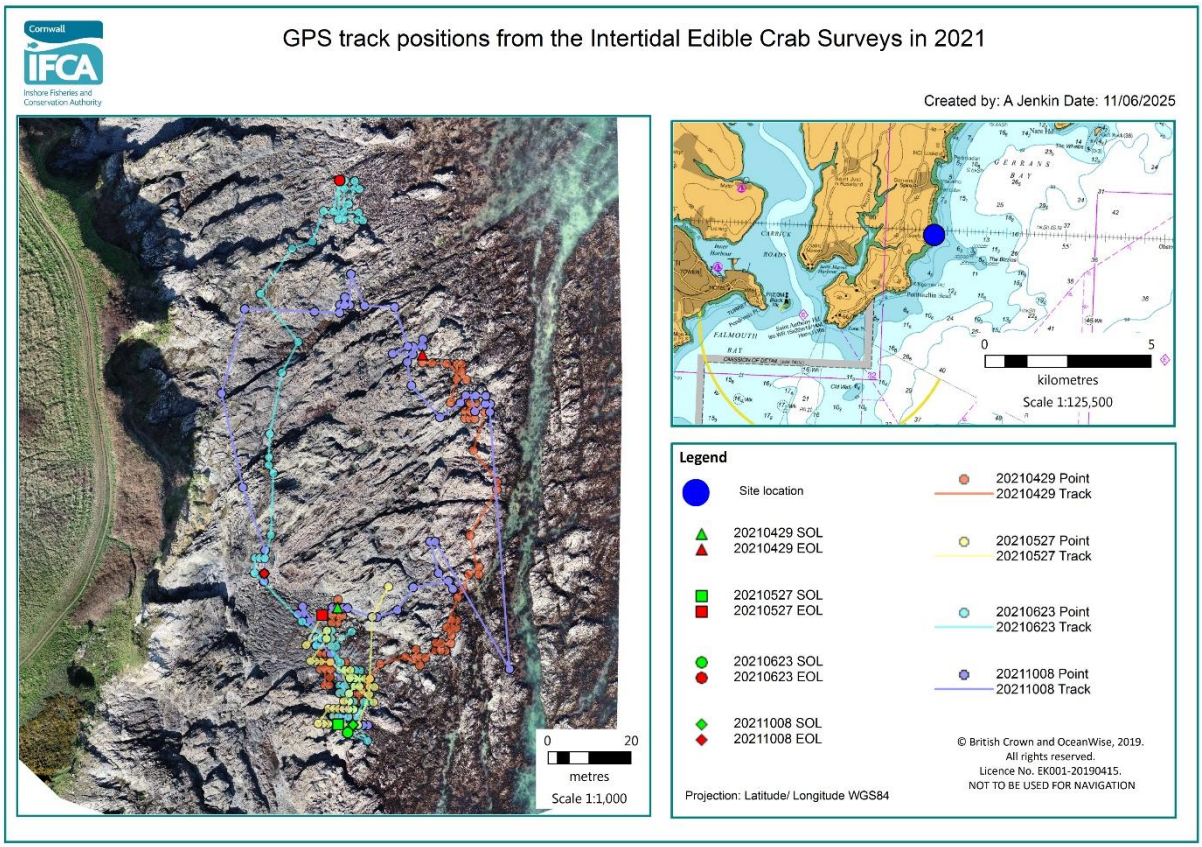
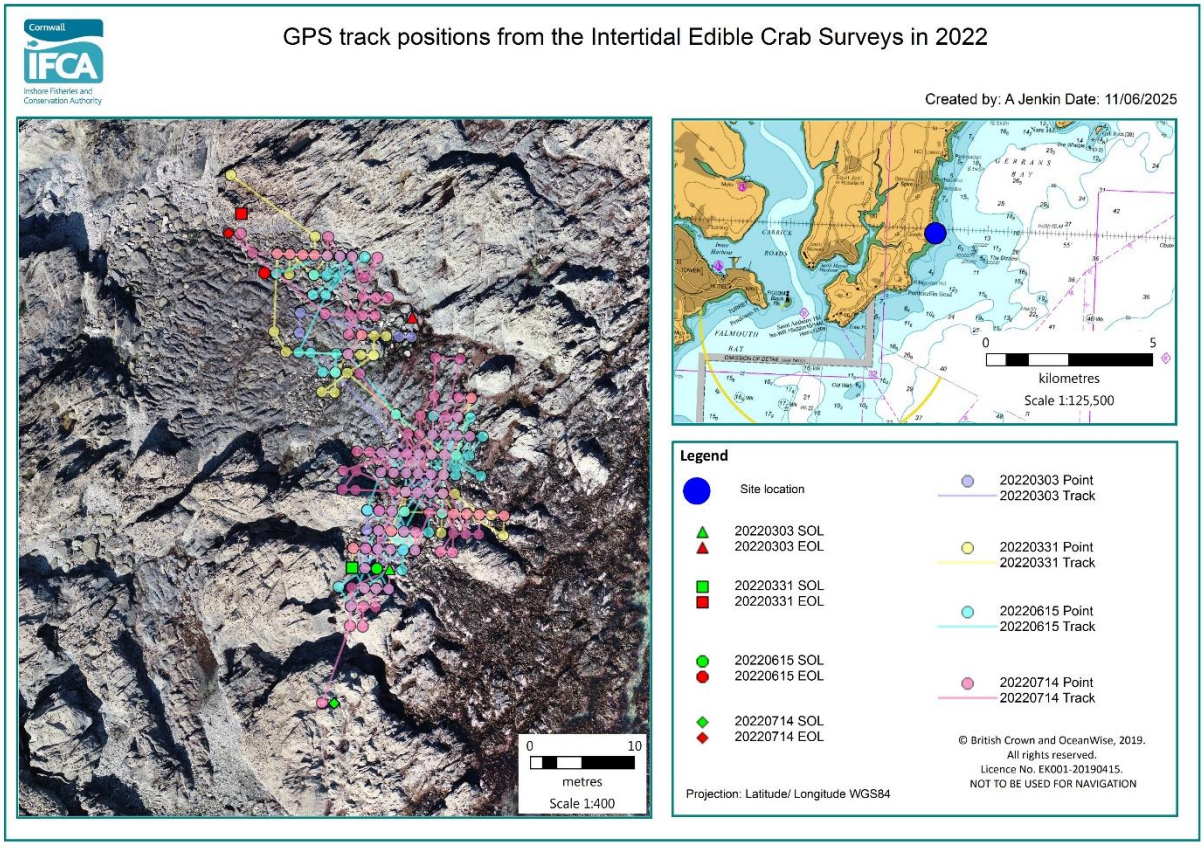
8 Appendices

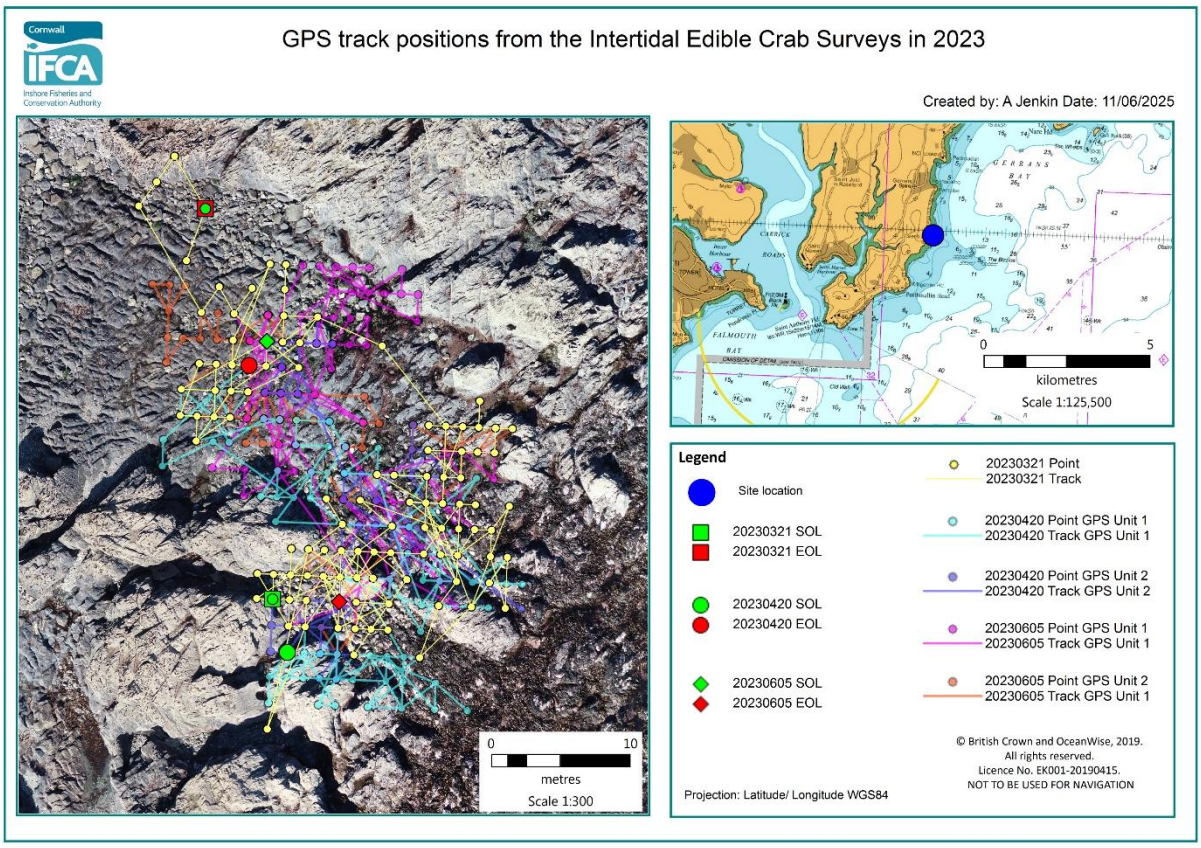
Annex 1 – GPS Track positions



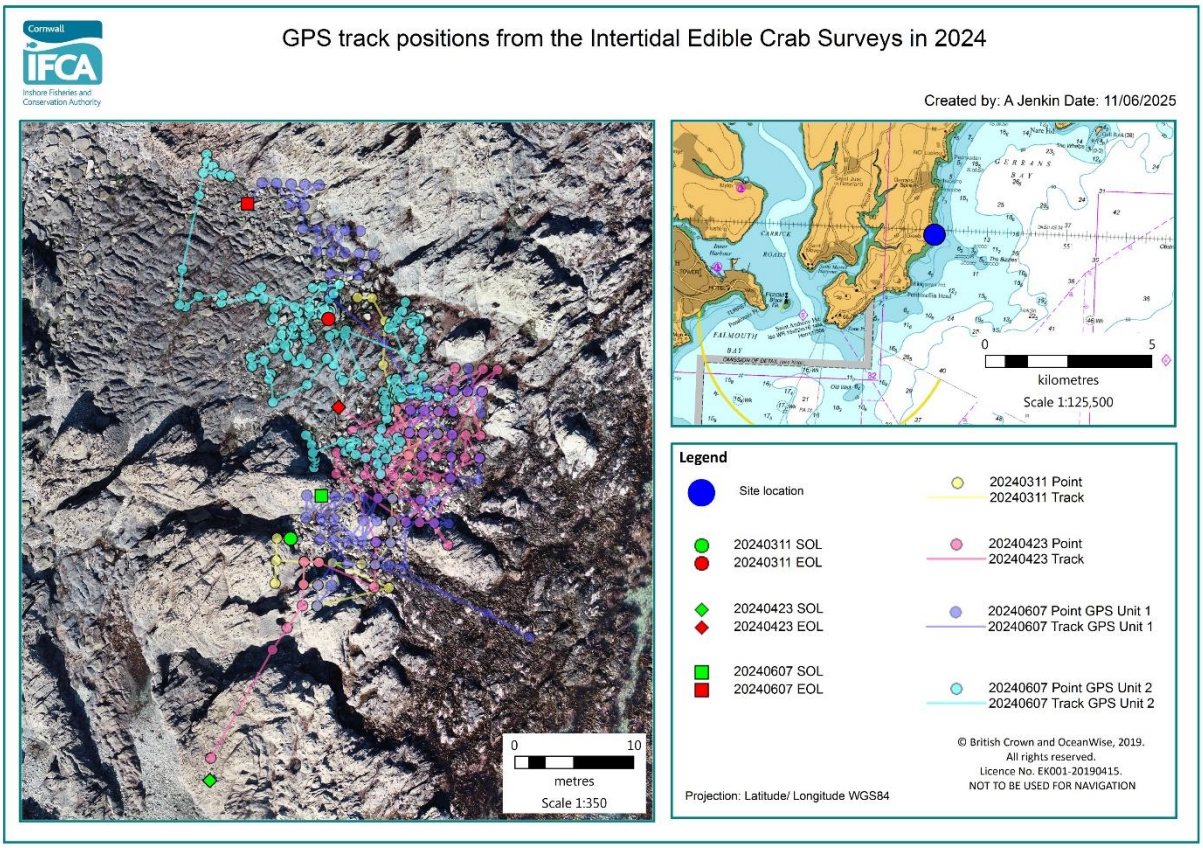
Annex Figure A: GPS track points from the intertidal edible crab surveys in 2021



Annex Figure B: GPS track points from the intertidal edible crab surveys in 2022



Annex Figure C: GPS track points from the intertidal edible crab surveys in 2023



Annex Figure D: GPS track points from the intertidal edible crab surveys in 2024

Annex 2 – Survey data

Annex Table A: Summary of raw survey data from 2021 to 2024.
Damage codes are; D = Dead, 1C = 1 Claw, BC = Broken Carapace, NC = No Claws, LM = Legs Missing, LCM = Legs and claw missing, RC = Regrowing claw, DC = Damaged claw, BC1C = Broken Carapace, 1 claw, BCDF = Broken Carapace, deformed flap, 1CDF = 1 Claw, deformed flap, S = Soft, Mo = Moult

Crab No./ Survey date	20210429			20210527			20210623			20211008			20220303			20220331			20220615			20220714			20230321			20230420			20230605			20240311			20240423			20240607		
Carapace size (mm) Sex (M/F) Damage code	Carapace size (mm)	Sex (M/F/U)	Code	Carapace size (mm)	Sex (M/F/U)	Code	Carapace size (mm)	Sex (M/F/U)	Code	Carapace size (mm)	Sex (M/F/U)	Code	Carapace size (mm)	Sex (M/F/U)	Code	Carapace size (mm)	Sex (M/F/U)	Code	Carapace size (mm)	Sex (M/F/U)	Code	Carapace size (mm)	Sex (M/F/U)	Code	Carapace size (mm)	Sex (M/F/U)	Code	Carapace size (mm)	Sex (M/F/U)	Code	Carapace size (mm)	Sex (M/F/U)	Code	Carapace size (mm)	Sex (M/F/U)	Code	Carapace size (mm)	Sex (M/F/U)	Code	Carapace size (mm)	Sex (M/F/U)	Code
1	58	U		40	U		16	U		70	M	S, Mo	14	U	1C	30	U		34	U	1C	44	U		23	U	LM	42	U		93	U		28	U		31	U		11	U	1C
2	37	U		23	U		46	U		59	U		29	U		14	U	BC	75	F		53	U		19	U		38	U		29	U		21	U		19	U		50	U	
3	45	U	BC	18	U		42	U		20	U		20	U		12	U		42	U		67	F		26	U	BC	31	U		30	U		18	U		22	U		37	U	
4	40	U		41	U		59	U		72	F		32	U		50	U		28	U		66	M		53	U		52	U		55	U		15	U		28	U	S	74	M	
5	27	U		26	U		43	U		72	F		37	U		77	F		79	F		58	U		53	U		32	U		24	U		22	U		22	U		48	U	
6	35	U		55	U	S	17	U		51	U		13	U		78	F		39	U		40	U		56	U		33	U		31	U		18	U		14	U		45	U	
7	17	U		20	U		43	U		46	U		40	U		54	U		64	F		80	M		71	F		50	U	1C	25	U		20	U		18	U	BC	23	U	
8	12	U		68	M		33	U		19	U		37	U		68	M		37	U		61	F		50	U		53	U		38	U	BC	25	U	BC1C	30	U	1C	34	U	
9	44	U		49	U		38	U		30	U	S, Mo	28	U		20	U		46	U		82	M		23	U		41	U		24	U		18	U		58	U	1C	22	U	
10	39	U		62	F		42	U		29	U		21	U	BC	32	U		69	F		65	F		18	U	S, Mo	63	F		82	U		16	U		22	U		68	F	1C
11	20	U	NC	47	U		68	M		55	U		28	U		26	U		73	F		62	M		77	F		16	U		40	U		26	U		49	U		15	U	1C
12	21	U		71	M		39	U		32	U		26	U		25	U	S	39	U		55	U		91	F		50	U		67	U		17	U	LCM	27	U		35	U	
13	48	U	S	25	U		39	U		53	U		21	U		63	M	1C	42	U		66	F		16	U		78	U		65	U		14	U	BC1C	39	U		19	U	
14	35	U		39	U		62	F		42	U		61	M		33	U	1C	73	M		61	F		38	U		41	U		86	U		21	U		59	U		21	U	
15	30	U		30	U		48	U		73	M		12	U		40	U	1C	32	U		97	F		16	U		70	M		62	U		21	U		25	U		23	U	
16	19	U		58	U		37	U		55	U		27	U		30	U	RCS	56	U		59	U		24	U		42	U	1C	83	U		23	U	SM	27	U		26	U	
17	22	U		25	U		59	U		51	U		28	U		16	U		42	U		46	U	S, Mo	45	U		76	F		67	U		17	U		12	U	BC	49	U	
18	16	U		60	M		24	U		24	U		156	M	Mo	28	U		36	U		47	U		31	U		88	M		43	U	S	18	U		44	U		52	U	BCDF

19	22	U		19	U		102	M		33	U		77	M		75	M		30	U		23	U		63	F		62	U		15	U	LC M	76	U	1CD F	51	U	
20	22	U		23	U		26	U		39	U		78	F	RC	29	U		24	U		16	U		21	U		37	U		25	U		40	U		108	F	
21	15	U		38	U		25	U		71	F		48	U		21	U		54	U		36	U		35	U		45	U		20	U		30	U		79	F	BC
22	26	U		65	F		19	U	BC	66	F		40	U	LM	36	U		89	F	S, Mo	12	U		26	U		19	U	1C	19	U	LC M	27	U		32	U	
23	16	U		30	U		49	U		82	M		38	U		66	M		70	F		82	F		16	U		48	U		20	U		22	U		46	U	1C
24	17	U		21	U		18	U		30	U		71	F		38	U		67	F		23	U		46	U		11	U		27	U		14	U		92	F	
25	12	U		22	U		64	F		47	U		70	F		57	U		46	U		49	U		23	U	LM	32	U	S	28	U		79	M		10	U	
26	25	U	1C	16	U		54	U		66	F		63	F		57	U		55	U		34	U		16	U		31	U	1C	24	U	1C	40	U	LM	60	M	
27	68	M		38	U		38	U		27	U		94	F	S	60	M		58	U		81	F		20	U	LC M	28	U		22	U	S	34	U		37	U	
28	40	U		18	U		36	U		12	U		42	U		45	U		29	U		57	U	S	15	U		60	M		54	U		37	U		22	U	
29	49	U		22	U	S, Mo	19	U	BC	52	U		43	U		50	U		41	U		82	M		74	M		87	F	LM	27	U		30	U				
30	16	U		36	U		46	U		19	U		27	U		43	U					42	U		86	F	1C S	87	F		65	M		23	U				
31	20	U		33	U		48	U	S	33	U		18	U		25	U					35	U		60	F		81	M		46	U		41	U				
32	57	U		23	U		65	F		39	U		28	U		59	U					68	F		75	F		38	U		54	U		61	M				
33	27	U		69	M		57	U		60	F		37	U		54	U					25	U		78	F		56	U		42	U		22	U				
34	31	U		25	U		56	U		39	U		35	U		77	F					43	U		52	U		84	F	1C				28	U				
35	16	U		28	U		41	U		76	M		21	U		40	U					46	U		74	F	LM							10	U				
36	31	U	BC	22	U					33	U		43	U		76	M					44	U	D	41	U								16	U				
37	21	U		77	U	D				31	U		35	U		86	F					40	U	D	14	U								44	U	LM			
38	41	U								29	U	BC	32	U		55	U								48	U								36	U				
39	30	U								39	U		11	U		58	U								12	U								22	U				
40	20	U								32	U		30	U		25	U								22	U								29	U	LM			
41	19	U								52	U		19	U		40	U								10	U								12	U	1C			
42	35	U								30	U		18	U											14	U	1C							18	U				
43	28	U								39	U		61	F											64	M								10	U				
44	58	U								77	F	D	52	U											42	U	LM							26	U				
45	28	U											12	U											22	U								43	U				
46	19	U											16	U											21	U								61	M				
47	30	U											17	U																				14	U	NC			
48	17	U											16	U																				22	U				
49	40	U											27	U																				59	U				
50	41	U											18	U																				23	U				
51	31	U											18	U																				44	U				
52	59	U											19	U																				56	U				
53	37	U											19	U																				27	U				
54	36	U											38	U																				85	F				

55	68	F	
56	43	U	
57	28	U	
58	26	U	
59	50	U	
60	27	U	
61	30	U	1C
62	92	F	S
63	25	U	D, S
64	25	U	D, DC, S
65	34	U	D, S
66			

31	U	
27	U	

19	U	
28	U	LM
42	U	
100	F	S, Mo
47	U	
53	U	
25	U	
74	F	LC M
70	M	LC M
78	F	
27	U	D, S
27	U	D