Fish recruitment indicators for the Gladstone Harbour Report Card using data derived from castnet sampling

2023

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Gladstone Healthy Harbour Partnership

Fish recruitment indicators for the Gladstone Harbour Report Card using data derived from castnet sampling 2023

Bill Sawynok and Stefan Sawynok

Infofish Australia Pty Ltd

12 Mingoola Street Murarrie Qld 4172

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SUMMARY

The requirements of this project were to supply fish recruitment grades and scores for Yellowfin and Pikey Bream for the 2023 Gladstone Harbour Report Card, following the same methods used in the past 7 years so that results were comparable from year to year.

This year the sampling period was 3 months with surveys conducted in December, January and February. The number of sites surveyed remained at 26, the same as in previous years. There was a total of 78 surveys with 1,560 casts. A survey involved 20 casts at each site in approximately the same area in each survey.

There was a total of 8,274 individuals recorded across the 78 surveys comprising 5,051 fish and 3,223 prawns with an overall catch rate of 5.3 individuals/casts. The highest catch rate was at Little Enfield Creek at 22.6 individuals/cast followed by Callemondah at 11.8 individuals/cast. Lowest catch rates were recorded at Wappentake Creek at 0.3 individuals/cast and Crematorium Pool at 1.2 individuals/cast. This year the catch rate for Prawn was 2.07 per cast and the second highest rate for any survey year.

This year Banana Prawn was the most recorded species at 3,223 (39.0%) followed by Flattail Mullet at 1,801 (21.8%) and Common Silverbiddy at 636 (7.7%). Yellowfin Bream was the 6th most recorded species at 340 (4.1%) and Pikey Bream was 9th at 193 (2.3%). Flattail Mullet were recorded at all 26 sites while Yellowfin Bream were at 22 sites and Pikey Bream at 15 sites.

There was a total of 533 Bream recorded this year compared to 764 total Bream in 2021-22 (December to February). Bream numbers were highest in January at 208 and lowest in February at 129.

The random effects model used in 2020 was used again, without modification, to determine scores and grades for each site, each zone and for all of harbour. The overall result for Gladstone Harbour was D with most zones recording a C or D. Western Basin scored a B, however this is likely due to moving the site in 2018-19 from Mud Island, which had provided historically poor results, to Wiggins Island.

The following table provides the scores averaged over sites within zones for the last 8 years from 2015-16 to 2022-23, along with the grade colours for the GHHP report card used to convert scores to grades in the 2023 Gladstone Harbour Report Card for each component of harbour health. Historic scores have been adjusted to the current scores to account for the reduction in sampling months since the 2020-21 year. This has marginally altered some of the earlier grades at some sites however has not altered the All of Harbour grades prior to 2020-21.

Zone	2023	2022	2021	2020	2019	2018	2017	2016
1.The Narrows	0.37	0.66	0.52	0.62	0.20	0.58	0.75	0.36
2.Graham Creek	0.53	0.80	0.80	0.86	0.09	0.61	0.27	0.24
3.Western Basin	0.77	0.97	0.85	0.90	0.02	0.42	0.29	0.02
4.Boat Creek	0.57	0.34	0.34	0.36	0.44	0.63	0.32	0.29
5.Inner Harbour	0.56	0.69	0.56	0.54	0.11	0.61	0.45	0.19
6.Calliope Estuary	0.27	0.50	0.69	0.64	0.30	0.67	0.70	0.28
7.Auckland Inlet	0.36	0.62	0.63	0.79	0.56	0.81	0.81	0.40
8.Mid Harbour	0.49	0.59	0.77	0.56	0.06	0.52	0.60	0.14
9.South Trees Inlet	0.31	0.56	0.48	0.37	0.33	0.76	0.69	0.41
10.Boyne Estuary	0.37	0.65	0.52	0.47	0.35	0.47	0.72	0.53
11.Outer Harbour	NS	NS	NS	NS	NS	NS	NS	NS
12.Colosseum Inlet	0.41	0.31	0.59	0.65	0.48	0.56	0.65	0.40
13.Rodds Bay	0.64	0.44	0.49	0.48	0.37	0.54	0.69	0.44
ALL OF HARBOUR	0.47	0.59	0.60	0.60	0.28	0.60	0.58	0.31

NS = not surveyed

A **Very good** (0.85 – 1.00)

B **Good** (0.65 – 0.84)

C **Satisfactory** (0.50 – 0.64)

D **Poor** (0.25 – 0.49)

E **Very poor** (0.00 – 0.24)

1. INTRODUCTION

The Gladstone Healthy Harbour Partnership (GHHP) was established in 2013 to assess the health of Gladstone Harbour. The GHHP produces an annual report on the health of the harbour that includes environmental, social, cultural and economic indicators. Fish recruitment and health were identified as important environmental indicators.

Following trial surveys in 2014-15 Yellowfin and Pikey Bream were selected as appropriate species to be used as fish recruitment indicators. From 2015-16 to 2019-20 standardised surveys were undertaken from December-March at 26 sites in the 13 environmental reporting zones to assess recruitment and provide scores and grades for the report card. From 2020-21 to 2022-23 standardised surveys were undertaken from December-February using the same methodology as in previous years. This resulted in three sampling events rather than the four conducted in prior years.

2. OBJECTIVES

The requirements of this project were to:

1. Conduct a castnet sampling program based on the approved sampling design over the 2022-23 recruitment season.
2. Provide fish recruitment report card scores and grades for the 2023 report card.

3. GLADSTONE HARBOUR MONITORING ZONES

The Gladstone Harbour has been divided into 13 environmental monitoring zones for the GHHP Report Card as shown in Figure 1. The area includes Gladstone Harbour, Calliope River, Boyne River, The Narrows, Outer Harbour and Rodds Bay.

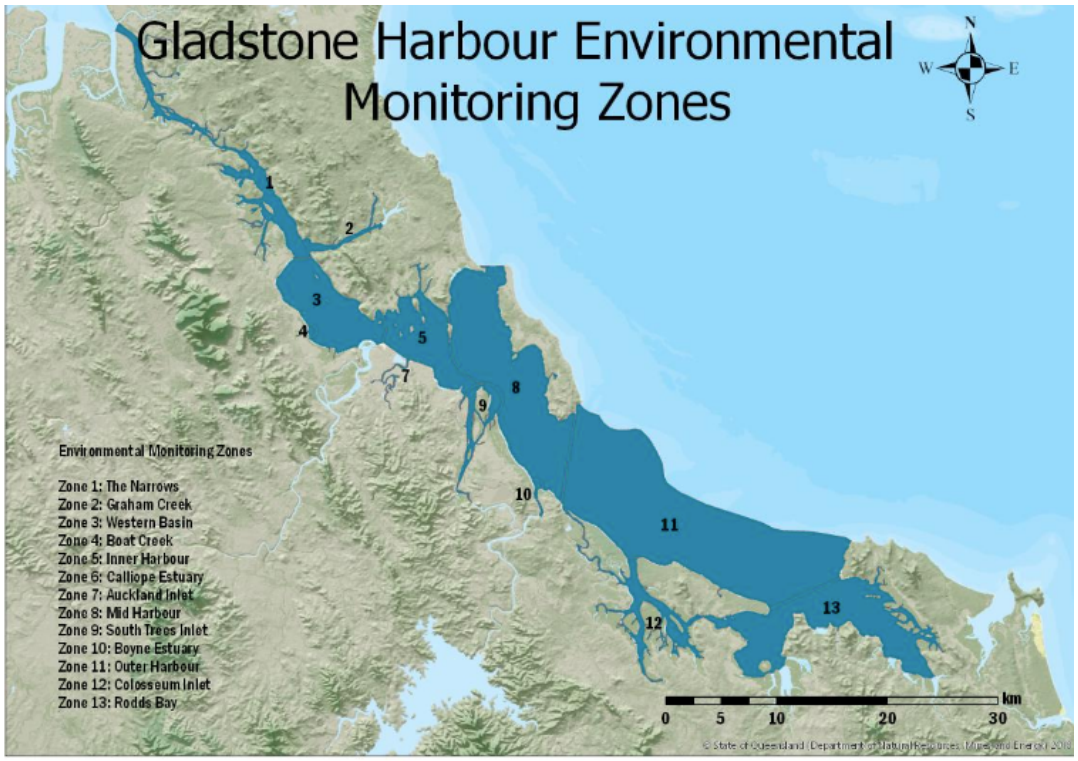

Figure 1: Gladstone reporting zones for the GHHP Report Card (from 2018 Report Card Technical Report.pdf at https://dims.ghhp.org.au/repo/public/79fdb7).

The 13 Gladstone Harbour reporting zones are:

1. The Narrows
2. Graham Creek
3. Western Basin
4. Boat Creek
5. Inner Harbour
6. Calliope Estuary
7. Auckland Creek
8. Mid Harbour
9. South Trees Inlet
10. Boyne Estuary
11. Outer Harbour
12. Colosseum Inlet
13. Rodds Bay

4. SITE LOCATIONS

There were 26 survey sites surveyed in 2022-23. Survey sites were the same as in previous years. Site locations are shown in Figure 2.

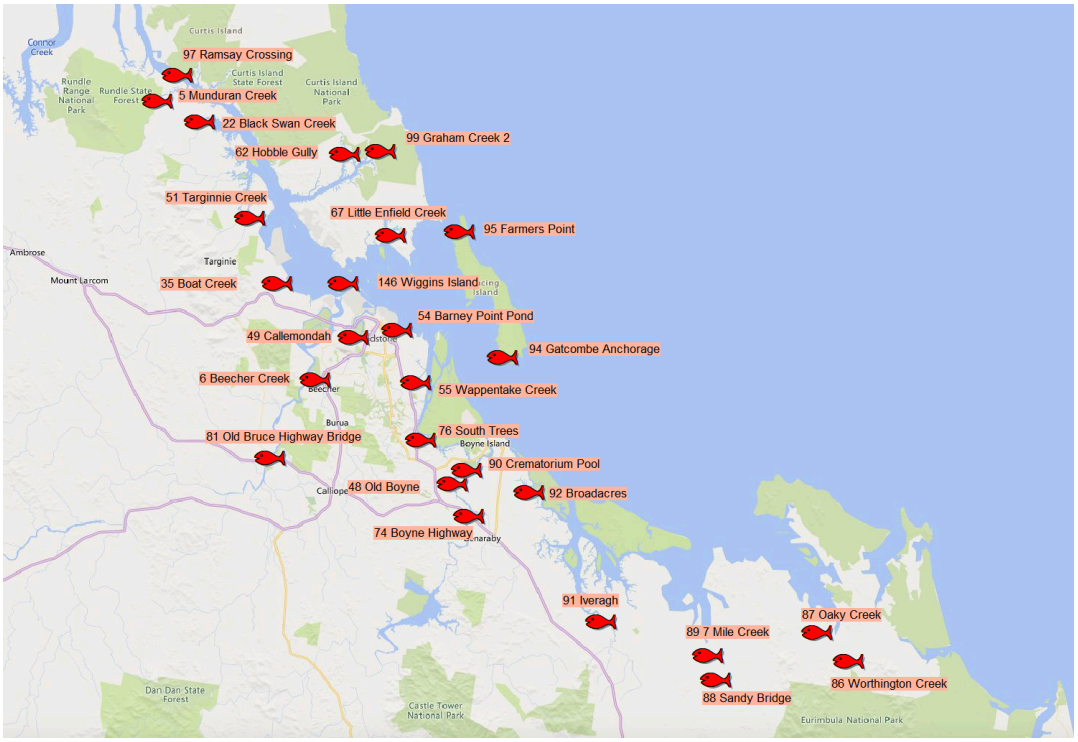

Figure 2: Site locations and site ID in the Gladstone area for Bream recruitment surveys.

5. METHODS

Details of methods used were provided in "Fish recruitment indicators for the Gladstone Harbour Report Card using data derived from castnet sampling 2018" (Sawynok et al. 2018). There were no changes in 2022-23 to the methods used in the previous surveys (Sawynok and Venables 2017). In summary each survey comprised 20 casts with a castnet at each site covering the same areas as previous surveys. Monthly surveys were conducted from December 2022 to February 2023 with a total of three survey rounds. Prior to 2020-21 surveys, sampling was conducted monthly between December and March with a total of four survey rounds. Figure 3 shows the castnet method used and Figure 4 and Figure 5 shows the target species of Bream.

The random effects statistical model used was the same as that described in the 2018 report (Sawynok et al 2018). This year the sample size was 78 surveys, the same as in 2020-21 and 2021-22 and this was compared with 104 surveys in prior years.

In summary the random effects model was used to generate scores on a 0-1 scale for each site. The scores for each site were then averaged to provide a zone score and then zone scores were averaged to give an all-of-harbour score. Scores were then converted to a grade based on the following scale:

E	D	C	B	A
0.00-0.24	0.25-0.49	0.50-0.64	0.65-0.84	0.85-1.00

Figure 3: Castnet method used for the recruitment surveys.

Figure 4: Pikey Bream recruit from Hobble Gully in January 2023.

Figure 5: Yellowfin Bream recruit from Black Swan Creek in January 2023.

6. RESULTS

6.1 SUMMARY OF 2022-23 SURVEYS

Surveys were undertaken around and after full moon tides as these provided the maximum opportunity for Bream recruits to move to all areas subject to tidal influence. Dates for surveys were:

- 4-16 December 2022
- 5-14 January 2023
- 6-17 February 2023

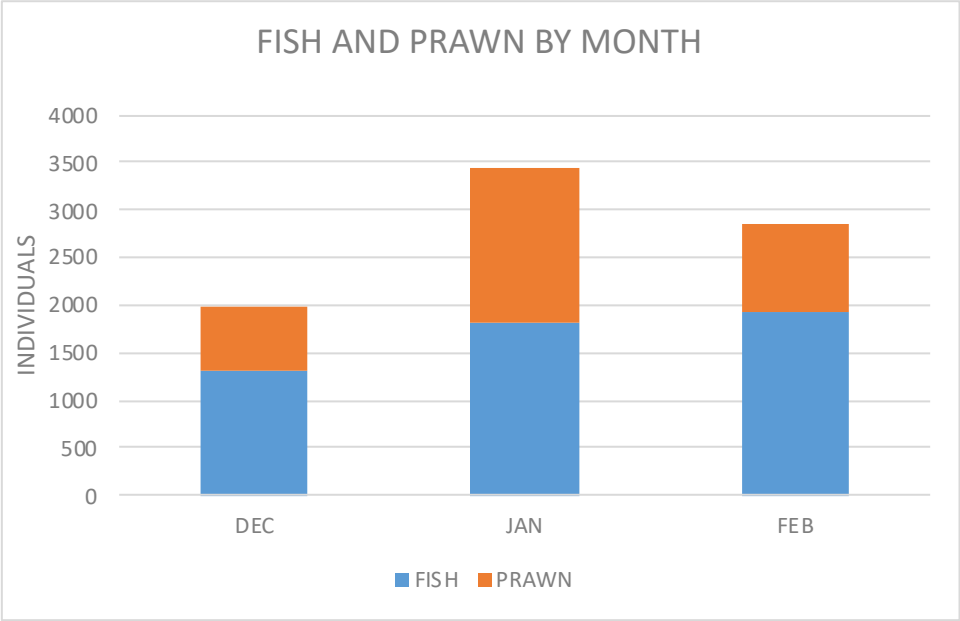

Figure 6: Numbers of fish and prawn recorded from December 2022 - February 2023.

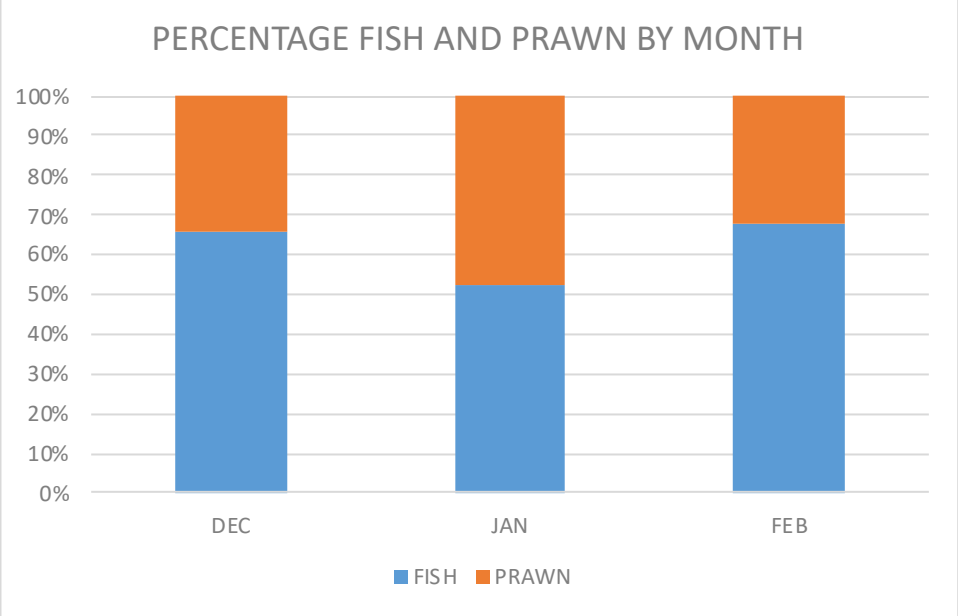

Figure 7: Percentage of fish and prawn in the catch from December 2022 - February 2023.

Figure 6 shows the number of individuals recorded at all sites from December 2022 - February 2023. There were 78 surveys with 1,560 casts resulting in a catch of 5,051 fish and 3,223 prawns for a total of 8,274 individuals.

The numbers of fish increased from 1,313 in December to 1,802 in January then to 1,936 in February. Prawns increased from 677 in December to 1,641 in January and then fell to 905 in February. Figure 7 shows the percentage of fish and prawn in the catch each month. The percentage of prawn in the catch was 34.0% in December rising to 47.7% in January and then falling to 31.9% in February.

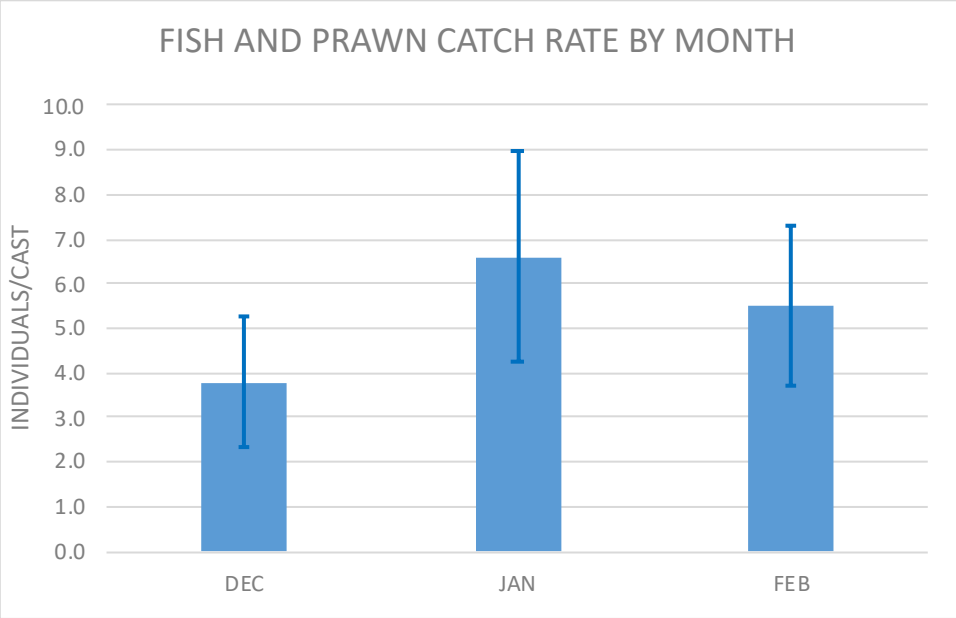

Figure 8: Catch rate of fish and prawn from December 2022 – February 2023 (bars show 95% confidence level).

Figure 8 shows the catch rate of fish and prawn in each of the 3 monthly surveys with a low of 3.8 individuals/cast in December and a high of 6.6 in February. The overall catch rate for 2022-23 was 5.3.

Table 1 provides a summary of the number of fish and prawn and the overall catch rate at each site from December 2022 - February 2023. Figure 9 shows the lowest to the highest catch rate from December 2022 – February 2023 with the February rate highlighted by the red dots.

Catch rates varied considerably between sites as shown in Table 1 and Figure 9. The highest catch rate was at Little Enfield Creek at 22.6 individuals/cast followed by Callemondah at 11.8. The lowest catch rate was recorded at Wappentake Creek at 0.3.

Sites that had daily tidal influence generally had a wider range of catch rates than those with intermittent tidal influence. Targinnie Creek had the largest range in catch rates from 4.8 individuals/cast in December to 15.0 in January. Wappentake Creek had the lowest catch rate as well as the smallest range in catch rates from 0.1 in January to 0.4 in February.

Table 1: Summary of catch and catch rates at each site from December 2022 - February 2023.

Zone	SITE ID	SITE	SURVEYS	CASTS	FISH/ PRAWN	CATCH RATE
1	97	RAMSAY CROSSING	3	60	162	2.7
1	5	MUNDURAN CREEK	3	60	140	2.3
1	22	BLACK SWAN CREEK	3	60	195	3.3
1	51	TARGINNIE CREEK	3	60	476	7.9
2	62	HOBBLE GULLY	3	60	515	8.6
2	99	GRAHAM CREEK 2	3	60	452	7.5
3	146	WIGGINS ISLAND	3	60	400	6.7
4	35	BOAT CREEK	3	60	175	2.9
5	67	LITTLE ENFIELD CREEK	3	60	1355	22.6
5	54	BARNEY POINT POND	3	60	126	2.1
6	6	BEECHER CREEK	3	60	77	1.3
6	81	OLD BRUCE HWY BRIDGE	3	60	272	4.5
7	49	CALLEMONDAH	3	60	710	11.8
8	95	FARMERS POINT	3	60	78	1.3
8	94	GATCOMBE ANCHORAGE	3	60	156	2.6
9	55	WAPPENTAKE CREEK	3	60	16	0.3
9	76	SOUTH TREES	3	60	581	9.7
9	90	CREMATORIUM POOL	3	60	72	1.2
10	48	OLD BOYNE	3	60	140	2.3
10	74	BOYNE HIGHWAY	3	60	117	2.0
11	OUTER HARBOUR NO SITES					
12	92	BROADACRES	3	60	208	3.5
12	91	IVERAGH	3	60	386	6.4
13	89	7 MILE CREEK	3	60	438	7.3
13	88	SANDY BRIDGE	3	60	479	8.0
13	87	OAKY CREEK	3	60	274	4.6
13	86	WORTHINGTON CREEK	3	60	199	3.3
		TOTAL	78	1560	8274	5.3

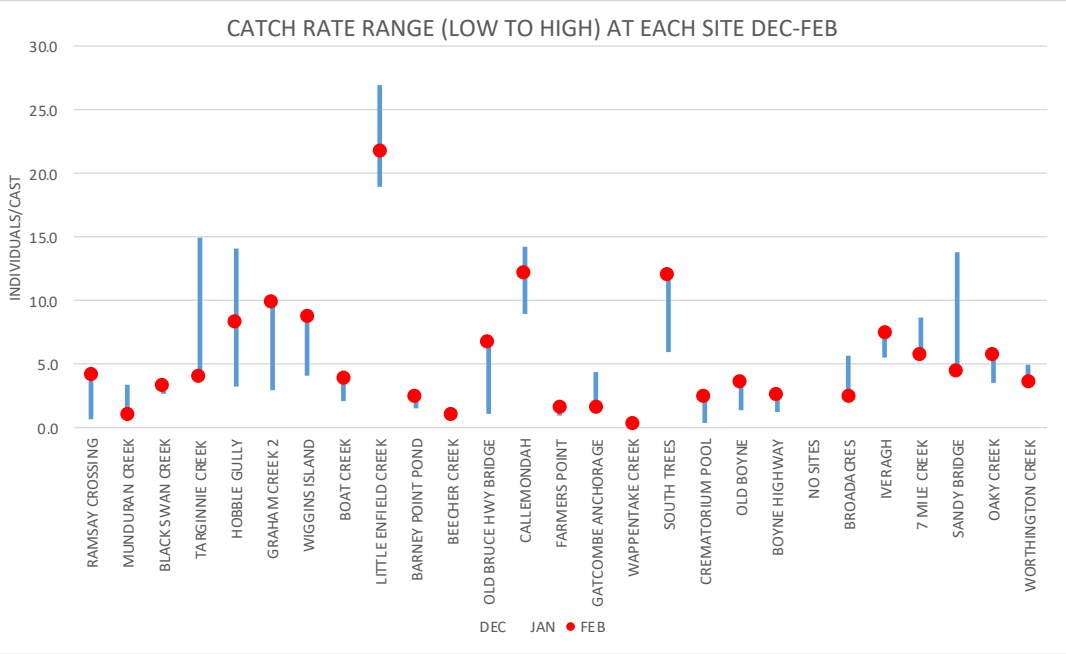

Figure 9: Catch rate at each site from December to February showing lowest to highest rate and red dots showing the February rate.

There was a total of 46 species recorded during the surveys. Figure 10 shows the 20 most recorded species. This year Banana Prawn was the most recorded at 3,223 (39.0%) followed by Flattail Mullet[1] at 1,801 (21.8%) followed by Common Silverbiddy at 636 (7.7%). Yellowfin Bream was the 6th most recorded species at 340 (4.1%) and Pikey Bream the 9th at 193 (2.3%).

There were 10 species (or species groups) of recreational, commercial, indigenous or conservation importance that were recorded during surveys.

Figure 11 shows the number of sites at which these species were recorded. The number of sites where each species was recorded is shown in Appendix 2.

Flattail Mullet was the only species recorded at all 26 sites while Yellowfin Bream were recorded at 22 and Pikey Bream at 15 sites. Banana Prawn was recorded at 18 sites.

[1] Flattail Mullet and Sea Mullet were not identified as separate species so this figure includes both species.

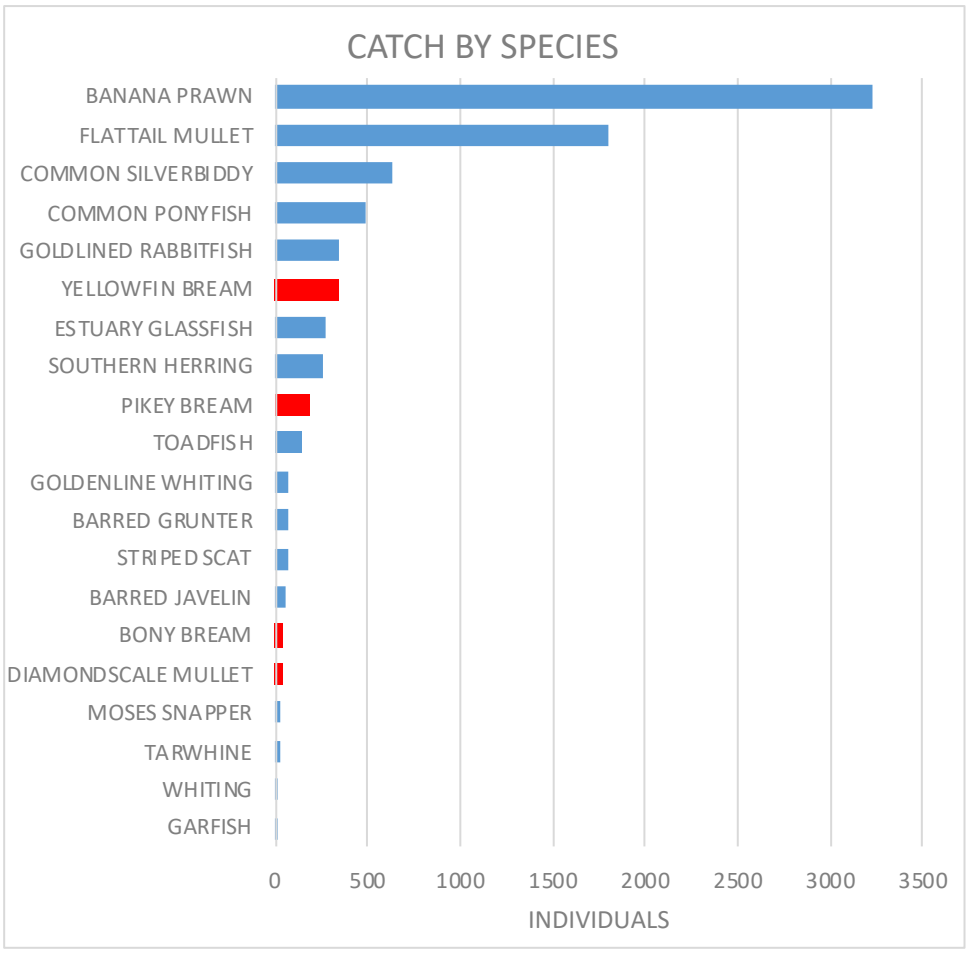

Figure 10: Number of individuals (fish and prawn) of top 20 species (Bream in red) recorded across all sites from December 2022 - February 2023.

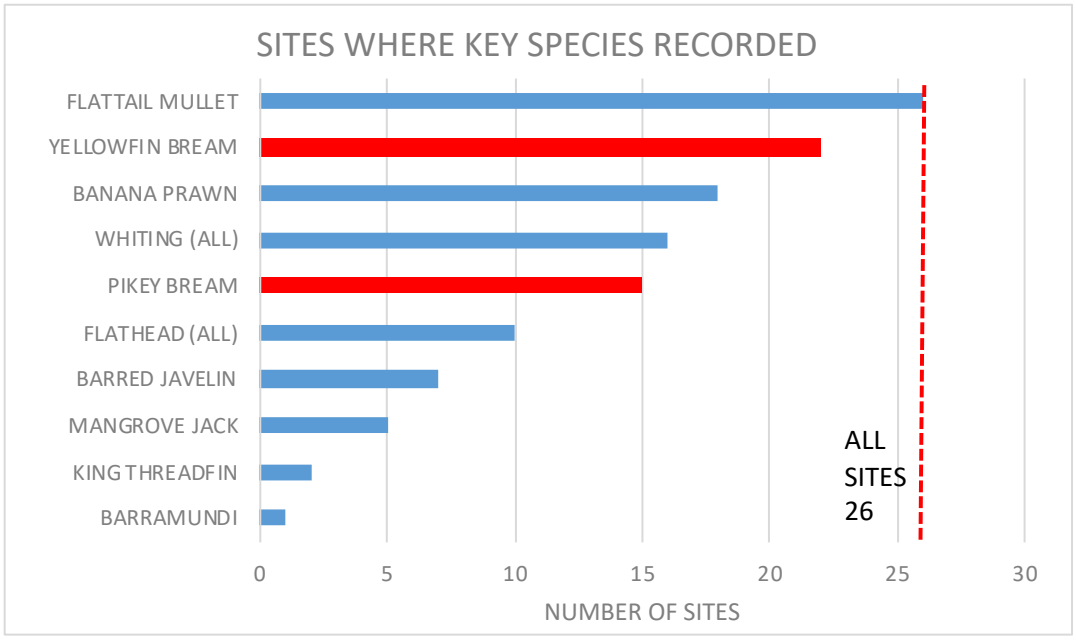

Figure 11: Number of sites where key species (Bream species in red) were recorded (dotted line total number of sites).

6.2 BREAM IN 2022-23

Bream recruitment is important for maintaining fish stocks and is being used as a key fish indicator for the Gladstone Harbour Report Card. Figure 12 shows the number of Bream recorded in the surveys from December 2022 - February 2023 with a total of 340 Yellowfin Bream and 193 Pikey Bream.

Yellowfin Bream numbers were similar in December (138) and January (134) and then fell to 68 in February. Pikey Bream numbers were much lower than Yellowfin Bream in December (58) and January (74) and comparable in February (61).

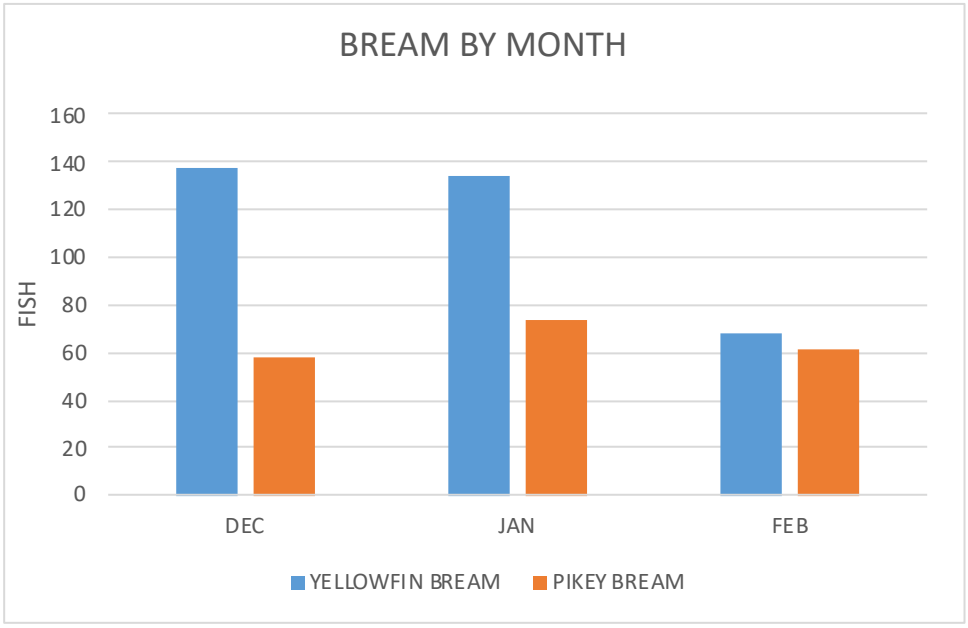

Figure 12: Numbers of Bream recorded during monthly surveys from December 2022 – February 2023.

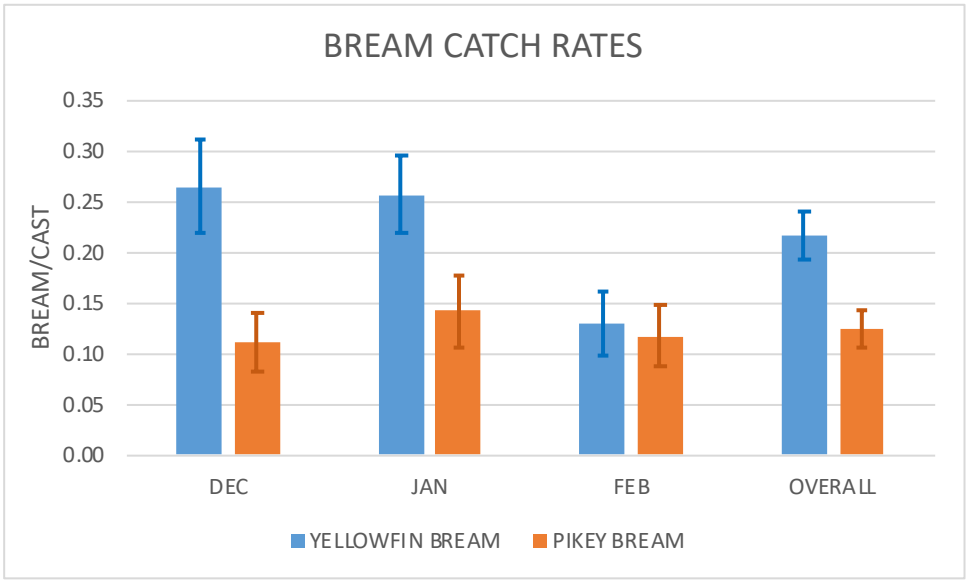

Figure 13: Mean monthly catch rates with 95% confidence bars for each Bream species from December 2022 – February 2023 and overall.

Figure 13 shows the mean catch rates for each of the Bream species in each month's surveys and the overall catch rates for all surveys. The catch rate for Yellowfin Bream was higher than that for Pikey Bream in December and January however was similar in February.

The catch rate for Yellowfin Bream for the 3 survey rounds was 0.22 fish/cast and ranged from a high of 0.27 in December to a low of 0.13 in February. The catch rate for Pikey Bream for the 3 survey rounds was 0.12 fish/cast and ranged from a high of 0.14 in January to a low of 0.11 in December.

Table 2: Bream recorded at each site in surveys from December 2022 – February 2023.

ZONE	SITE ID	SITE	SURVEYS	CASTS	YELLOW FIN BREAM	PIKEY BREAM
1	97	RAMSAY CROSSING	3	60	2	9
1	5	MUNDURAN CREEK	3	60	12	1
1	22	BLACK SWAN CREEK	3	60	12	7
1	51	TARGINNIE CREEK	3	60	8	14
2	62	HOBBLE GULLY	3	60	0	40
2	99	GRAHAM CREEK 2	3	60	0	16
3	146	WIGGINS ISLAND	3	60	20	5
4	35	BOAT CREEK	3	60	4	1
5	67	LITTLE ENFIELD CREEK	3	60	13	40
5	54	BARNEY POINT POND	3	60	0	0
6	6	BEECHER CREEK	3	60	4	1
6	81	OLD BRUCE HWY BRIDGE	3	60	4	12
7	49	CALLEMONDAH	3	60	18	5
8	95	FARMERS POINT	3	60	7	0
8	94	GATCOMBE ANCHORAGE	3	60	4	0
9	55	WAPPENTAKE CREEK	3	60	0	0
9	76	SOUTH TREES	3	60	15	18
9	90	CREMATORIUM POOL	3	60	8	0
10	48	OLD BOYNE	3	60	13	2
10	74	BOYNE HIGHWAY	3	60	26	0
11	OUTER HARBOUR NO SITES					
12	92	BROADACRES	3	60	3	3
12	91	IVERAGH	3	60	21	0
13	89	7 MILE CREEK	3	60	21	13
13	88	SANDY BRIDGE	3	60	74	0
13	87	OAKY CREEK	3	60	45	6
13	86	WORTHINGTON CREEK	3	60	6	0
		TOTAL	78	1560	340	193

Table 2 and Figure 14 show the numbers of Bream recorded at each of the sites from December 2022 – February 2023. The largest number of Yellowfin Bream (74) was recorded at Sandy Bride while the largest number of Pikey Bream (40) was recorded at Little Enfield Creek and Hobble Gully.

Bream were recorded at 24 of the 26 sites. Yellowfin Bream were recorded at 22 sites and Pikey Bream were recorded at 15 sites. There were no sites surveyed in zone 11 (Outer Harbour) as there was no habitat suitable for juvenile Bream in that zone.

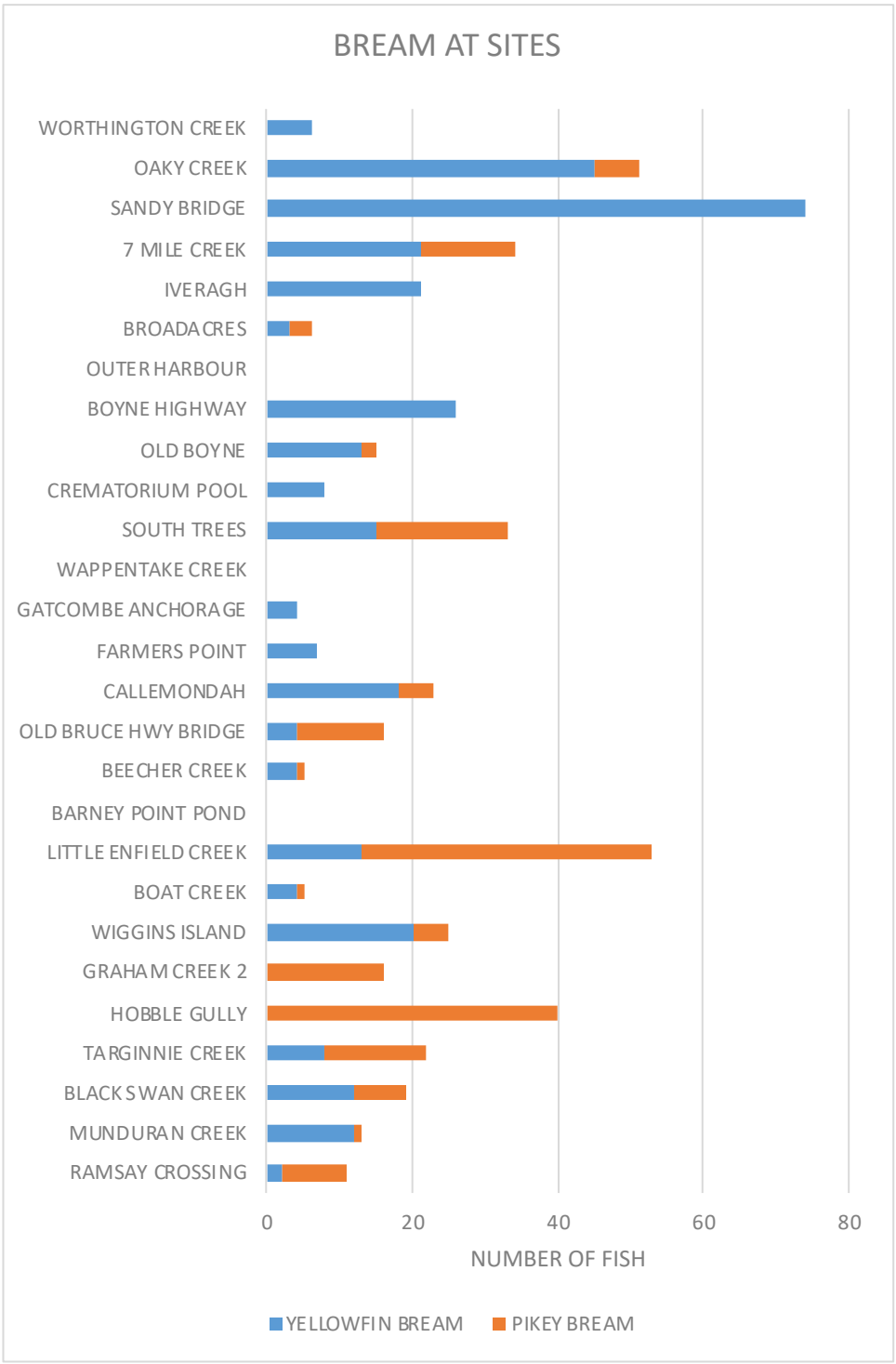

Figure 14: Numbers of Yellowfin and Pikey Bream recorded at each site in surveys from December 2022 - February 2023.

Figure 15 shows the range of lengths recorded in the surveys each month showing fork length (mm) of Bream. Crosses show the average length while the horizontal line shows the median length and dots show observation that fall outside the upper and lower limits of the boxplots.

The median length for Yellowfin Bream was 62mm in December and 65mm in February while for Pikey Bream it was 91mm in December and 70mm in February. The smallest Yellowfin Bream recorded was 43mm in February and the smallest Pikey Bream was 32mm in December.

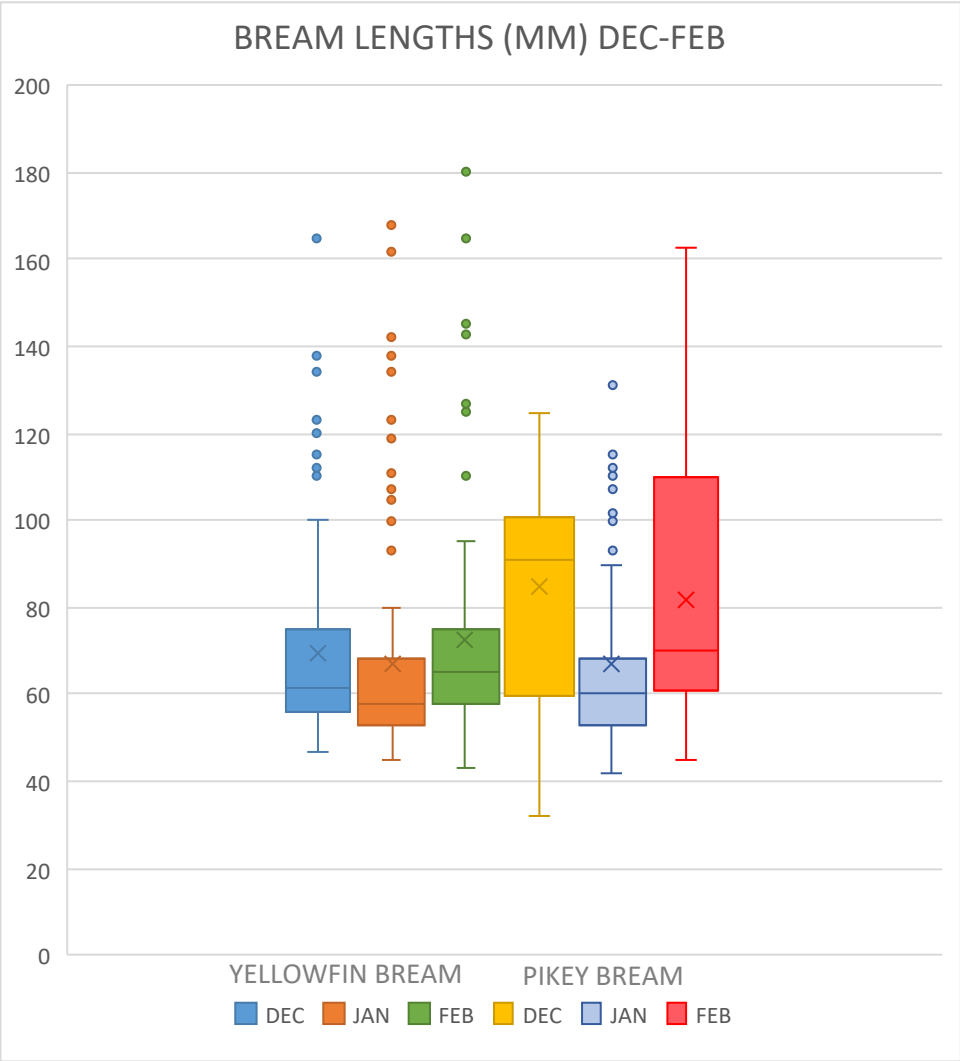

Figure 15: Fork lengths (mm) of Bream recorded during surveys from December 2022 – February 2023.

Figure 16 shows the size range of Bream in 10mm bands. Fish from 30-79mm are likely to be year 0 recruits and those from 90-139mm are likely to be year 1 fish and larger fish likely to be year 2. For Yellowfin Bream most were in the range 50-59mm while for Pikey Bream most were in the range 60-69mm.

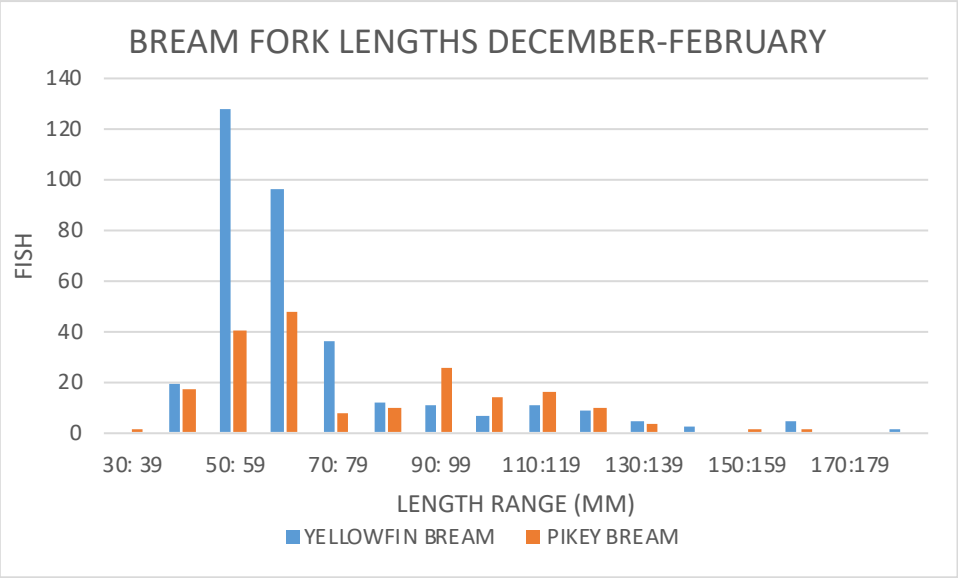

Figure 16: Fork lengths (mm) of Bream recorded during surveys from December 2022 – February 2023.

7. COMPARING RESULTS FROM 2015-16 TO 2022-23

There are now 8 years of surveys where results can be compared.

Table **3** and Figure 17 shows the number of fish and prawn recorded each year. In 2016-17, 2017-18, 2018-19 and 2019-20 there were 104 surveys with 2,080 casts while in 2015-16 there were 103 surveys with 2,020 casts, 60 fewer than in subsequent years. The numbers for 2015-16 have been adjusted by proportional scaling to 104 surveys with 2,080 casts to make the statistics comparable across the 5 survey years. In 2020-21, 2021-22 and 2022-23 there were 78 surveys with 1,560 casts.

Table 3: Summary of surveys of fish and prawn recorded from 2015-16 to 2022-23.

YEAR	SURVEYS	CASTS	FISH	PRAWN	TOTAL	FISH/ CAST	PRAWN /CAST
22-23	78	1560	5051	3223	8274	3.24	2.07
21-22	78	1560	5782	497	6279	3.71	0.32
20-21	78	1560	5169	3366	8535	3.31	2.16
19-20	104	2080	7375	2396	9771	3.55	1.15
18-19	104	2080	5271	880	6151	2.53	0.42
17-18	104	2080	6142	1682	7824	2.95	0.81
16-17	104	2080	6774	2102	8876	3.26	1.01
15-16	104	2080	6988	1922	8910	3.36	0.92

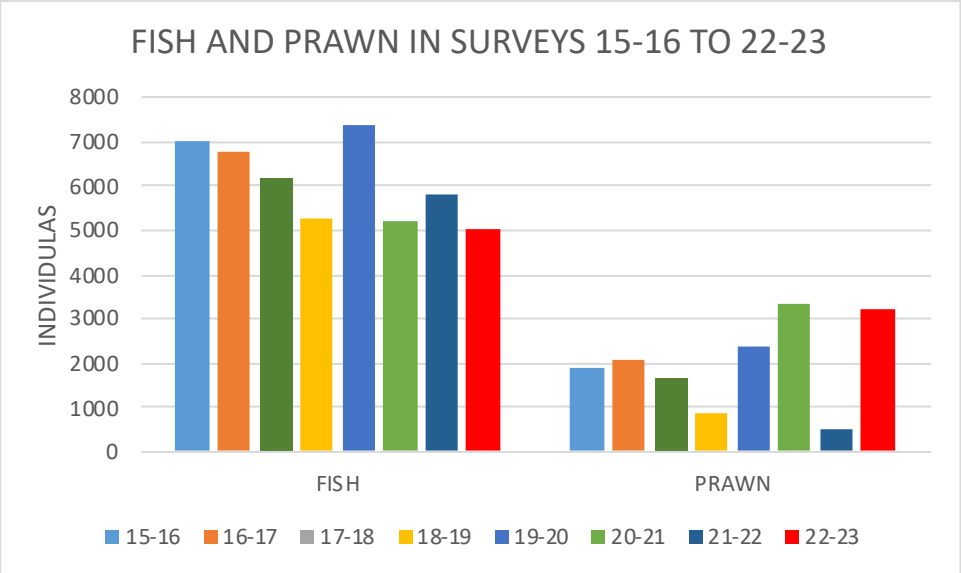

Figure 17: Numbers of fish and prawn recorded during surveys from 2015-16 to 2022-23.

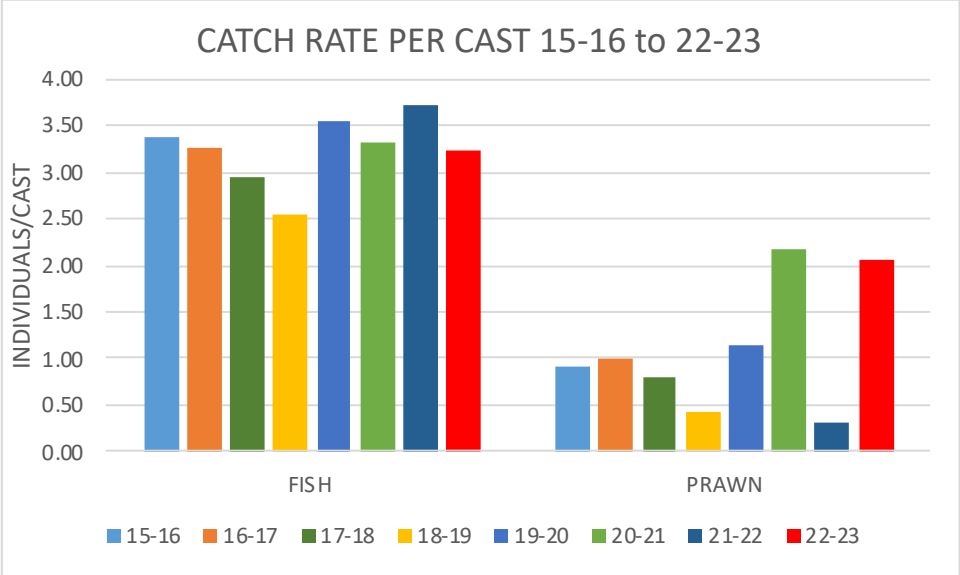

Figure 18: Catch rates of fish and prawn recorded during surveys from 2015-16 to 2022-23.

Figure 18 shows the catch rate of fish and prawn recorded each year. The highest catch rate of fish was 3.71 fish/cast in 2021-22 and the lowest was 2.53 in 2018-19 with 3.24 in 2022-23. The highest catch rate for prawn was 2.16 in 2020-21 and the lowest was 0.32 in 2021-22 with 2.07 in 2022-23.

The percentage of NIL casts in each of the survey years is shown in Figure 19. In 2022-23 the NIL casts were at 24.2%, with the highest at 39.1% occurring in 2018-19. The lowest percentage of NIL casts was 15.7% in 2020-21.

Table 4: Summary of surveys of the Bream catch from 2015-16 to 2022-23.

YEAR	SURVEYS	CASTS	Y'FIN	PIKEY	TOTAL	Y'FIN/ CAST	PIKEY/ CAST
22-23	78	1560	340	193	533	0.22	0.12
21-22	78	1560	316	448	768	0.21	0.29
20-21	78	1560	329	297	626	0.21	0.19
19-20	104	2080	330	475	805	0.16	0.23
18-19	104	2080	248	196	444	0.12	0.09
17-18	104	2080	346	429	775	0.17	0.21
16-17	104	2080	574	336	910	0.28	0.16
15-16	104	2080	335	184	519	0.16	0.09

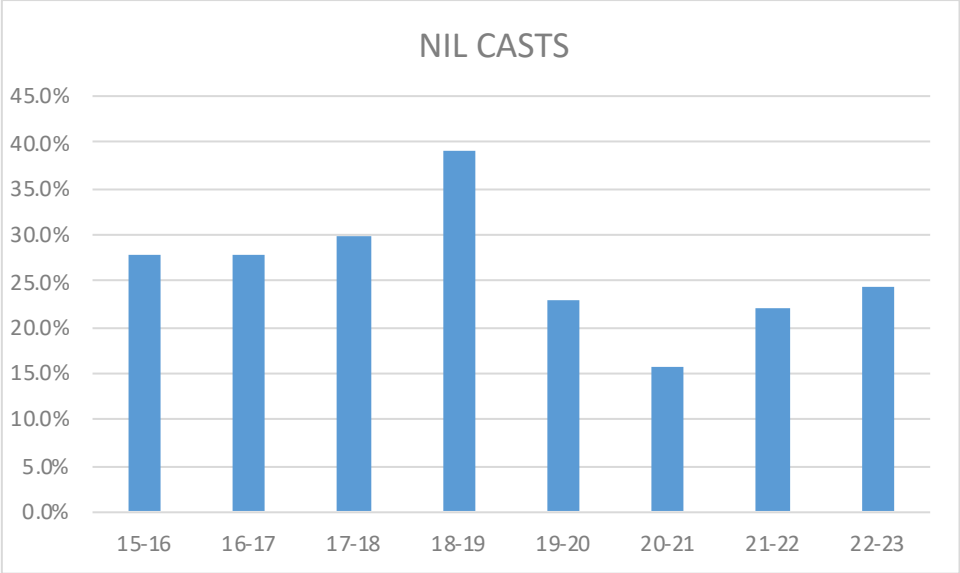

Figure 19: Percentage of NIL casts in each year from 2015-16 to 2021-22.

Table 4 provides a summary of the Bream catch in surveys from 2015-16 to 2022-23 while Figure 20 provides the catch rate as Bream per cast. In 2022-23 the catch rate for Yellowfin Bream was 0.22 while it was highest in 2016-17 at 0.28 and lowest in 2018-19 at 0.12. The catch rate for Pikey Bream in 2022-23 was 0.12 while it was highest in 2021-22 at 0.29 and lowest in 2015-16 and in 2018-19 at 0.09.

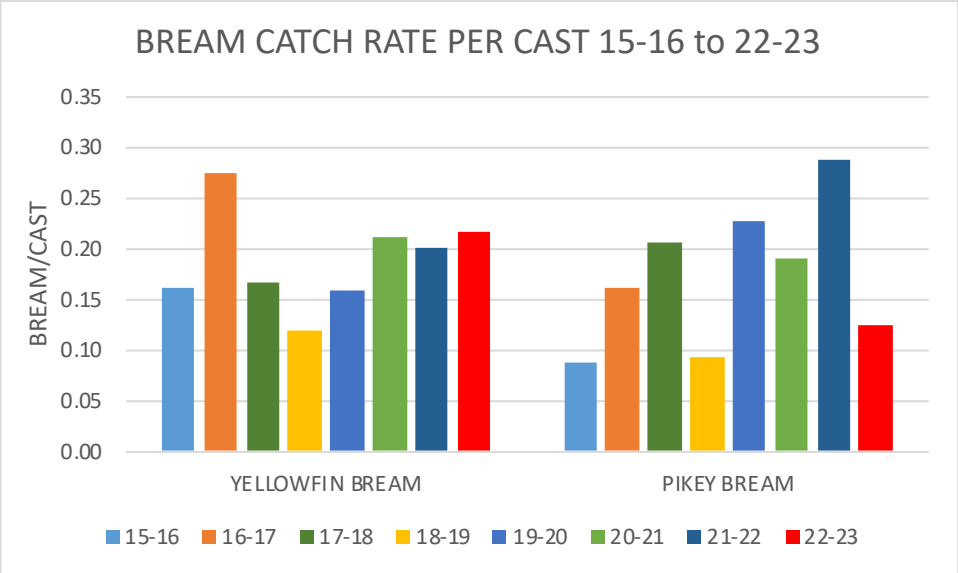

Figure 20: Comparison of Bream catch from 2015-16 to 2021-22.

Table 5 and Figure 21 show the number of sites where Bream were recorded each year. In 2022-23 Yellowfin Bream were recorded at 22 of the 26 sites while Pikey Bream were recorded at 15 sites which is the lowest number of sites they were recorded at since surveys commenced. Over the 8 years of surveys Bream have been recorded at all 26 sites indicating their wide distribution throughout the Gladstone Harbour area.

Table 5: Number of sites where Bream were recorded from 2015-16 to 2022-23.

SPECIES	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23
YELLOWFIN BREAM	22	21	25	22	23	24	23	22
PIKEY BREAM	19	20	23	19	22	20	21	15

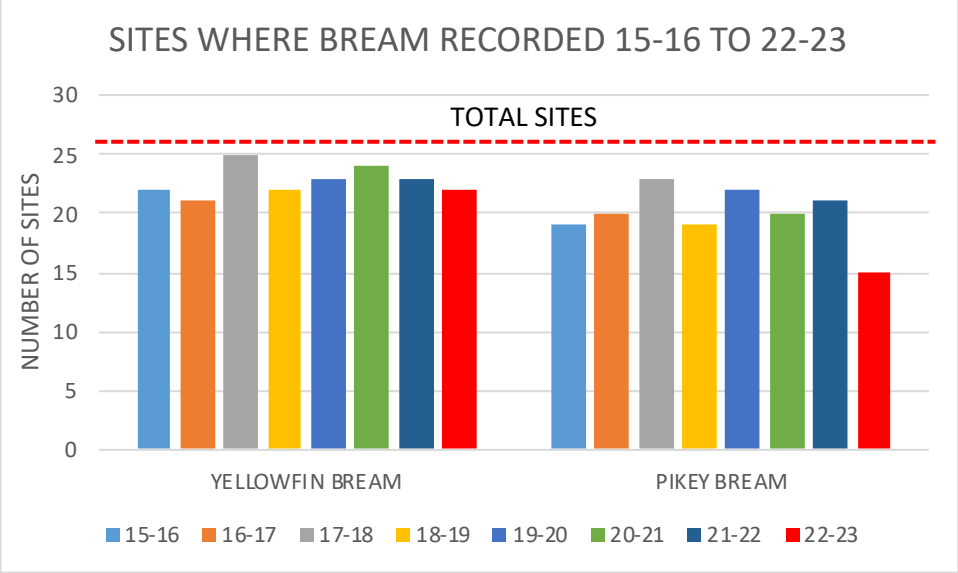

Figure 21: Sites where Bream were recorded 2015-16 to 2022-23 (dotted line is the total number of sites surveyed).

Figure 22 shows the Bream recruits recorded each year and the total rainfall (mm) recorded at the Gladstone Airport station 039326[2]. Total rainfall from November 2022 - February 2023 was 357.8mm. Prior to the December surveys there was 185.2mm in October and a wet year with a total of 1,146mm. This may have contributed to the increased numbers of prawns recorded during the surveys.

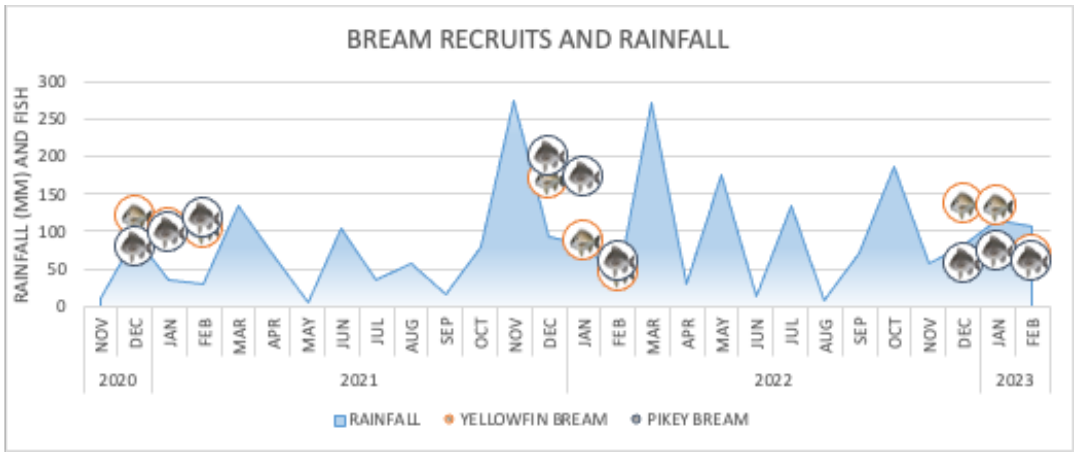

Figure 22: Bream recruits from 2020-21 to 2022-23 and total monthly rainfall (mm) from November 2020.

[2] Rainfall previously was from Gladstone Radar 039123 however rainfall records from that site were incomplete in 2018 and 2021.

8. OTHER SPECIES

Apart from Bream there were 8 species or specie groups of recreational, commercial, indigenous or conservation importance that were recorded during surveys.

Table 6 shows the number of individuals recorded from 2015-16 to 2022-23. Figure 23 shows the number of fish for the top 3 other species recorded. Banana Prawn and Flattail Mullet dominate the other species.

Table 6: Numbers of key species recorded in surveys from 2015-16 to 2021-22.

SPECIES	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23
BANANA PRAWN	1992	2102	1682	880	2396	3366	497	3223
FLATTAIL MULLET[3]	2150	1859	1665	1449	2401	1808	1787	1801
SEA MULLET	401	233	82	104	181	65	24	
BARRED JAVELIN	42	47	25	19	145	35	197	68
WHITING (ALL)	171	141	121	61	75	98	57	99
FLATHEAD (ALL)	11	28	39	15	22	22	18	16
MUD CRAB	6	31	10	18	9	14	0	0
MANGROVE JACK	8	15	20	8	7	6	3	9
BARRAMUNDI	4	0	1	1	2	2	3	2
KING THREADFIN	0	0	4	2	0	0	1	3

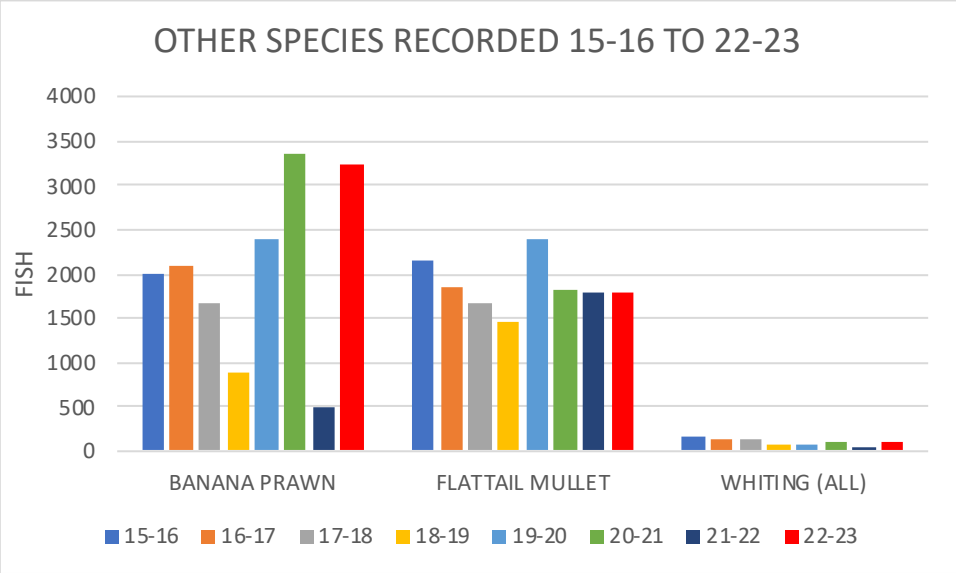

Figure 23: Numbers of other species recorded from 2015-16 to 2022-23.

[3] Flattail Mullet and Sea Mullet were not identified as separate species so this figure includes both species.

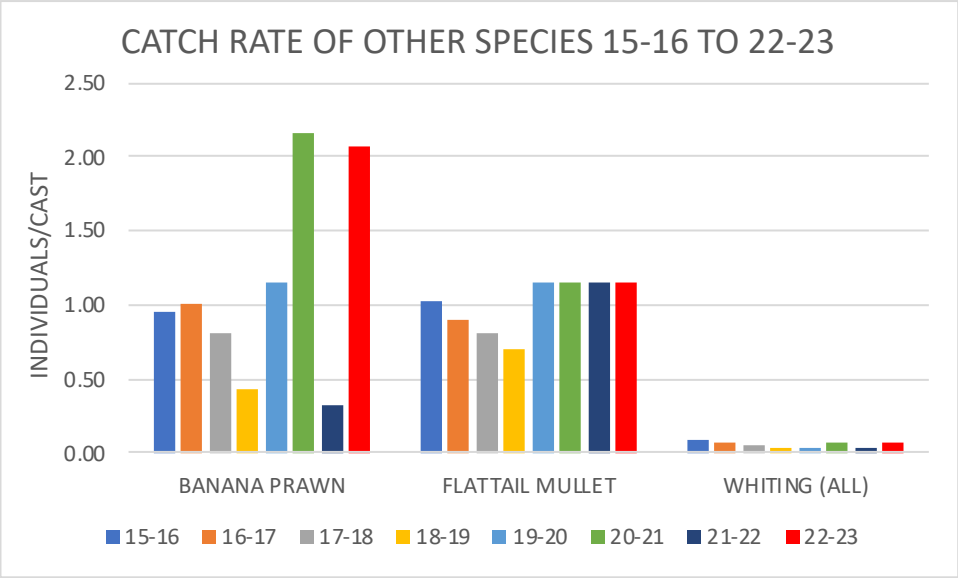

Figure 24: Catch rate of other key species as individuals per cast recorded from 2015-16 to 2022-23.

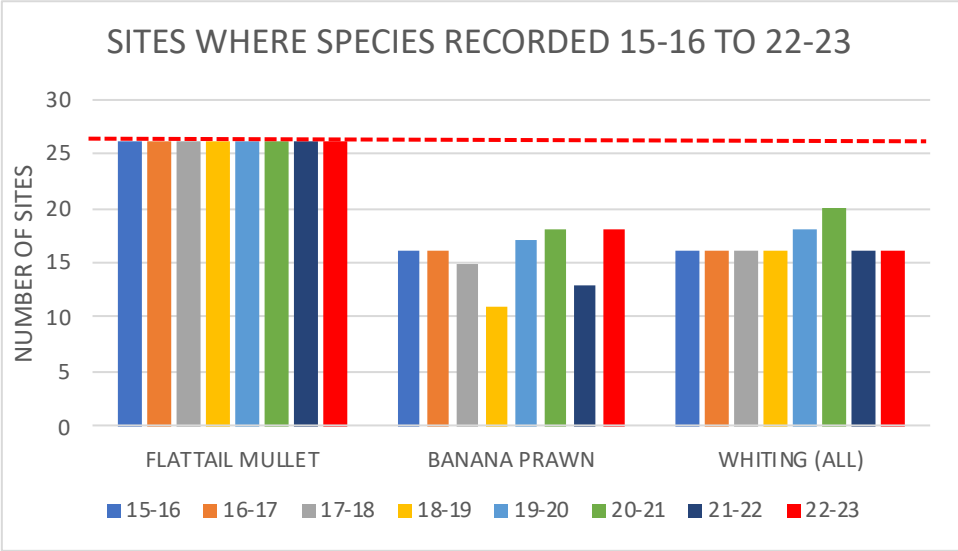

Figure 25: Sites where other species were recorded 2015-16 to 2022-23 (dotted line is the total number of sites).

Figure 24 shows the catch rate for the top 4 other species from 2015-16 - 2022-23. Banana Prawn highest catch rate was 2.07 individuals/cast in 2020-21 and lowest in 2021-22 at 0.32 while in 2022-23 it was 2.07. The catch rate for Flattail Mullet has remained steady for the past 3 years at around 1.15.

Figure 25 shows the number of sites where the top 3 other species were recorded. Flattail Mullet have been consistently recorded at all 26 sites while Banana Prawn have been recorded at 12-18 sites. Whiting have consistently been recorded at 16-20 sites.

9. RECRUITMENT INDEX

A negative binomial random effects statistical model (Sawynok B, Sawynok S and Venables B (2018)) has been applied to the pooled data commencing in 2011-12. While the purpose of fitting this model is to obtain grades for the current survey year 2022-23, it relies on the use of historical data to estimate key model parameters.

One of the important concerns is the stability of the process itself. To examine stability, the results of 2 parameters are presented, namely for the data set up to last year only, that is for 2011-12 to 2022-23 inclusive, and compare that with the results for the entire data record, including 2022-22 as well. This shows the result for last year, as if the method now suggested was used, and the effect on it of adding this year's additional data.

9.1 Negative binomial model parameter

The estimated negative binomial model parameters θ are very stable when approximately equal to 2. Re-estimating them from the final fitted model, for the restricted and full data sets, yields

- $\hat{\theta}$ = 2 for the model fitted with data up to year 2019-20 only, and
- $\hat{\theta}$ = 2 when the further data for year 2020-21 is included and
- $\hat{\theta}$ = 2 when the further data for year 2021-22 is included.

Fixing this parameter at $\theta = 2$ provides a degree of stability in the process, but leaves the crucial estimates, and the scores and grades, relatively unaffected.

9.2 Variance

The additional data gained in the 2022-23 surveys also leaves the variance component estimates for Site and Year x Site relatively unaffected (less than 2.5% change), as shown in Table 7. However, the results for Year show a 7.8% reduction in variability with the extra data included.

Table 7: Variance component estimates (as standard deviations) for the main model using (a) only data up to year 20-21, (b) only data to year 21-22 and (c) all available data.

	(a) data to 20-21	(b) data to 21-22	(c) data to 22-23
Site	0.7731	0.8059	0.8260
Year	0.4167	0.2415	0.2227
Year x Site	0.5118	0.5109	0.5012

9.3 Site Main Effects

The site main effects, $E_S \sim \mathrm{N}(0, \sigma_S^2)$, indicate how variable Bream abundance is at sites. These effects are on a logarithmic scale, so comparisons are proportional rather than differenced. Sites with naturally low average Bream abundance have a low capacity to show small proportional differences, whereas those with higher natural abundance have a greater capacity. It is making justifiable allowance for these natural differences between sampling sites that is a key challenge of this analysis.

In order to show the relative stability of the site main effects with the addition of new data Figure **26** shows the BLUPs using data up to 2021-22 (horizontal scale) and estimates using

the full data set (vertical scale). The diagram is partitioned into zones to show the high degree of heterogeneity between and within zones. Sites with the greatest heterogeneity were Rodds Bay and Inner Harbour. It is this heterogeneity that complicates the production of fully justifiable scores. The diagonal line in each panel indicates where the two estimates would be equal. Points relatively distant from the line had the greatest change. Noted was that very few sites were distant from the equality line.

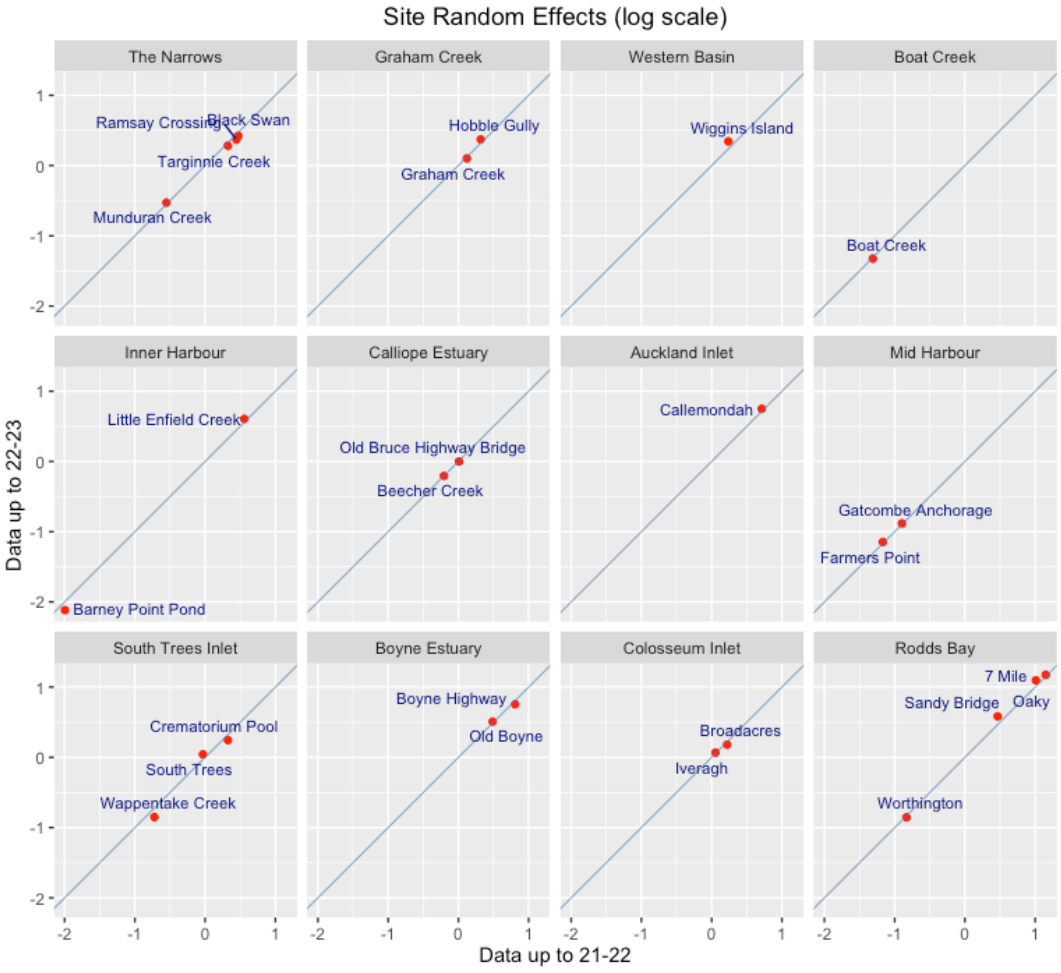

Figure 26: Site random effect estimates. A comparison of BLUPs using the restricted data set with those using the full data set.

Table 8 shows the combined year and year by site BLUP estimates, that is $E_Y + E_{YS}$, for all years in the study. The year BLUP, E_Y, is the representation of how much each year differs in aggregate from a conceptual long-term mean in catch rate, and the year by site BLUP, E_{YS}, represents the deviation of each site from its year aggregate. Both of these are *after the allowance* for aggregate site differences, as encapsulated by the site BLUPs, E_S.

The BLUPs are transformed into *scores* by dividing by their standard deviation and finding the cumulative probability in the standard normal distribution. In symbols:

$$qZ_{YS} = \frac{E_Y + E_{YS}}{\sqrt{\sigma_Y^2 + \sigma_{YS}^2}}, \qquad \text{Score}_{YS} = \Phi(Z_{YS})$$

Where $\Phi(z)$ is the standard normal (cumulative) distribution function for a random variable z. The resulting scores are shown in Table **9**.

Table 8: Random effects estimates (BLUPs), $\boldsymbol{E_Y + E_{YS}}$, for the Gladstone Harbour Bream survey sites for all study years.

Zone	Site	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23
The Narrows	Ramsay Crossing					0.56	0.39	0.25	0.34	0.44	0.85	0.25	0.58
	Munduran Creek	0.62	0.10	0.11	0.00	0.03	0.32	0.03	0.49	0.42	0.17	0.03	0.09
	Black Swan				0.17	1.11	0.91	0.08	0.25	0.22	0.12	0.17	0.09
	Targinnie Creek	0.08	0.36		0.47	0.77	0.10	0.14	1.08	0.47	0.50	0.63	0.06
Graham Creek	Graham Creek				0.22	0.50	0.38	0.15	1.19	0.76	0.33	0.66	0.04
	Hobble Gully				0.32	0.30	0.28	0.16	0.51	0.47	0.62	0.31	0.04
Western Basin	Wiggins Island					1.12	0.31	0.12	1.09	0.69	0.57	1.07	0.41
Boat Creek	Boat Creek		0.24	0.05	0.57	0.30	0.26	0.18	0.08	0.20	0.23	0.22	0.10
Inner Harbour	Little Enfield Creek				0.08	0.55	0.06	0.06	0.88	0.26	0.26	0.71	0.41
	Barney Point Pond		0.14	0.12	0.34	0.42	0.07	0.24	0.51	0.13	0.09	0.03	0.23
Calliope Estuary	Beecher Creek	0.57	0.56	0.07	0.19	0.30	0.29	0.07	0.04	0.25	0.06	0.01	0.39
	Old Bruce Highway Bridge				0.36	0.34	0.27	0.68	0.63	0.15	0.54	0.02	0.28
Auckland Inlet	Callemondah	0.09	0.86	0.29	0.01	0.14	0.48	0.49	0.08	0.45	0.18	0.17	0.20
Mid Harbour	Farmers Point					0.78	1.09	0.26	0.82	0.38	0.19	0.17	0.16
	Gatcombe Anchorage					0.47	0.42	0.20	0.89	0.63	0.75	0.44	0.19
South Trees Inlet	Wappentake Creek		0.24	0.10	0.01	0.27	0.10	0.59	0.05	0.06	0.02	0.22	0.45
	South Trees					0.08	0.09	0.35	0.35	0.14	0.25	0.24	0.13
	Crematorium Pool					0.06	0.84	0.24	0.36	0.34	0.13	0.21	0.59
Boyne Estuary	Old Boyne	0.29	0.01		0.25	0.09	0.34	0.01	0.60	0.20	0.11	0.19	0.26
	Boyne Highway				0.11	0.00	0.29	0.09	0.07	0.11	0.06	0.24	0.12
Colosseum Inlet	Broadacres					0.27	0.16	0.47	0.09	0.30	0.02	0.05	0.49
	Iveragh					0.02	0.28	0.26	0.03	0.12	0.22	0.56	0.19
Rodds Bay	Oaky					0.08	0.17	0.08	0.01	0.24	0.26	0.18	0.41
	7 Mile					0.12	0.13	0.28	0.27	0.17	0.40	0.06	0.12
	Worthington					0.23	0.30	0.02	0.39	0.39	0.08	0.25	0.25
	Sandy Bridge					0.08	0.59	0.15	0.10	0.61	0.29	0.05	0.63

Table 9: Score estimates on a $(\mathbf{0}, \mathbf{1})$ –scale, for the Gladstone Harbour Bream survey sites for all years.

Zone	Site	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23
The Narrows	Ramsay Crossing					0.85	0.76	0.67	0.27	0.79	0.06	0.67	0.15
	Munduran Creek	0.87	0.43	0.42	0.50	0.48	0.72	0.48	0.19	0.22	0.62	0.48	0.43
	Black Swan				0.62	0.02	0.95	0.56	0.32	0.65	0.58	0.62	0.44
	Targinnie Creek	0.56	0.25		0.81	0.08	0.57	0.60	0.02	0.81	0.82	0.87	0.46
Graham Creek	Graham Creek				0.66	0.18	0.25	0.61	0.02	0.92	0.72	0.89	0.53
	Hobble Gully				0.28	0.30	0.30	0.62	0.17	0.80	0.87	0.72	0.53
Western Basin	Wiggins Island					0.02	0.29	0.42	0.02	0.90	0.85	0.97	0.77
Boat Creek	Boat Creek		0.33	0.54	0.85	0.29	0.32	0.63	0.44	0.36	0.34	0.34	0.57
Inner Harbour	Little Enfield Creek				0.56	0.16	0.46	0.54	0.05	0.68	0.68	0.90	0.77
	Barney Point Pond		0.40	0.58	0.73	0.22	0.45	0.67	0.17	0.41	0.43	0.48	0.34
Calliope Estuary	Beecher Creek	0.85	0.15	0.45	0.63	0.29	0.70	0.45	0.47	0.68	0.54	0.49	0.24
	Old Bruce Highway Bridge				0.26	0.27	0.69	0.89	0.13	0.61	0.84	0.51	0.31
Auckland Inlet	Callemondah	0.44	0.06	0.30	0.51	0.40	0.81	0.81	0.56	0.79	0.63	0.62	0.36
Mid Harbour	Farmers Point					0.08	0.98	0.68	0.07	0.25	0.63	0.38	0.61
	Gatcombe Anchorage					0.20	0.22	0.36	0.05	0.87	0.91	0.79	0.36
South Trees Inlet	Wappentake Creek		0.33	0.57	0.51	0.31	0.58	0.86	0.47	0.46	0.52	0.34	0.20
	South Trees					0.44	0.57	0.74	0.26	0.40	0.32	0.67	0.59
	Crematorium Pool					0.46	0.94	0.67	0.26	0.27	0.59	0.65	0.14
Boyne Estuary	Old Boyne	0.70	0.50		0.67	0.56	0.73	0.49	0.14	0.36	0.58	0.64	0.32
	Boyne Highway				0.42	0.50	0.70	0.44	0.55	0.58	0.45	0.67	0.42
Colosseum Inlet	Broadacres					0.31	0.61	0.80	0.43	0.71	0.52	0.46	0.19
	Iveragh					0.49	0.70	0.32	0.52	0.59	0.66	0.16	0.63
Rodds Bay	Oaky					0.44	0.62	0.56	0.51	0.67	0.32	0.37	0.77
	7 Mile					0.42	0.59	0.69	0.31	0.38	0.77	0.54	0.59
	Worthington					0.34	0.71	0.52	0.24	0.76	0.56	0.32	0.32
	Sandy Bridge					0.56	0.86	0.39	0.43	0.13	0.30	0.53	0.87

9.4 Aggregation to the Zone Level

Scores are aggregated to the zone level within years by averaging over sites. Zone scores are then averaged to produce an all-of-harbour score.

The results of this averaging process are shown in Table 10, and the resulting grades are shown in Table 11.

Table 10: Score estimates on a $(\mathbf{0}, \mathbf{1})$ —scale, averaged over sites within zones, and over all zones to give all-of harbour scores.

Zone	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23
The Narrows	0.71	0.34	0.42	0.64	0.36	0.75	0.58	0.20	0.62	0.52	0.66	0.37
Graham Creek				0.47	0.24	0.27	0.61	0.09	0.86	0.80	0.80	0.53
Western Basin					0.02	0.29	0.42	0.02	0.90	0.85	0.97	0.77
Boat Creek		0.33	0.54	0.85	0.29	0.32	0.63	0.44	0.36	0.34	0.34	0.57
Inner Harbour		0.40	0.58	0.65	0.19	0.45	0.61	0.11	0.54	0.56	0.69	0.56
Calliope Estuary	0.85	0.15	0.45	0.45	0.28	0.70	0.67	0.30	0.64	0.69	0.50	0.27
Auckland Inlet	0.44	0.06	0.30	0.51	0.40	0.81	0.81	0.56	0.79	0.63	0.62	0.36
Mid Harbour					0.14	0.60	0.52	0.06	0.56	0.77	0.59	0.49
South Trees Inlet		0.33	0.57	0.51	0.41	0.69	0.76	0.33	0.37	0.48	0.56	0.31
Boyne Estuary	0.70	0.50		0.55	0.53	0.72	0.46	0.35	0.47	0.52	0.65	0.37
Colosseum Inlet					0.40	0.65	0.56	0.48	0.65	0.59	0.31	0.41
Rodds Bay					0.44	0.69	0.54	0.37	0.48	0.49	0.44	0.64
All of Gladstone Harbour	0.68	0.30	0.48	0.58	0.31	0.58	0.60	0.28	0.60	0.60	0.59	0.47

Table 11: Grades for (unadjusted) averaged scores over sites within zones, and over zones within the harbour.

Zone	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23
The Narrows	B	D	D	C	D	B	C	E	C	C	B	D
Graham Creek				D	E	D	C	E	A	B	B	C
Western Basin					E	D	D	E	A	B	A	B
Boat Creek		D	C	B	D	D	C	D	D	D	D	C
Inner Harbour		D	C	C	E	D	C	E	C	C	B	C
Calliope Estuary	A	E	D	D	D	B	B	D	C	B	C	D
Auckland Inlet	D	E	D	C	D	B	B	C	B	C	C	D
Mid Harbour					E	C	C	E	C	B	C	D
South Trees Inlet		D	C	C	D	B	B	D	D	D	C	D
Boyne Estuary	B	C		C	C	B	D	D	D	C	B	D
Colosseum Inlet					D	B	C	D	C	C	D	D
Rodds Bay					D	B	C	D	D	D	D	C
All of Gladstone Harbour	B	D	D	C	D	C	C	D	C	C	C	D

To provide uncertainty measures for the scores, standard bootstrapping techniques were used as described in Sawynok et al (2018). Bootstrap simulations were used in the aggregation process to incorporate zone- and harbour-level scores into higher levels of the GHHP report card.

Table 12 and Figure 27 show the original scores for the 12 zones, and all of harbour, together with their lower and upper uncertainty limits as calculated by the bootstrap simulation method. The Western Basin had the highest A grade while Colosseum Inlet had the lowest D grade.

Table 12: Estimates and bootstrap uncertainty intervals.

Zone	Score	2.5%	97.5%
The Narrows	0.3692	0.2359	0.4974
Graham Creek	0.5299	0.2903	0.7286
Western Basin	0.7748	0.6121	0.9060
Boat Creek	0.5745	0.3602	0.8138
Inner Harbour	0.5562	0.4416	0.6498
Calliope Estuary	0.2733	0.1563	0.3988
Auckland Inlet	0.3554	0.0802	0.6518
Mid Harbour	0.4884	0.2970	0.6895
South Trees Inlet	0.3119	0.2244	0.4357
Boyne Estuary	0.3654	0.2894	0.4439
Colosseum Inlet	0.4104	0.2704	0.5577
Rodds Bay	0.6390	0.5689	0.7051
All of Harbour	0.4707	0.4033	0.5338

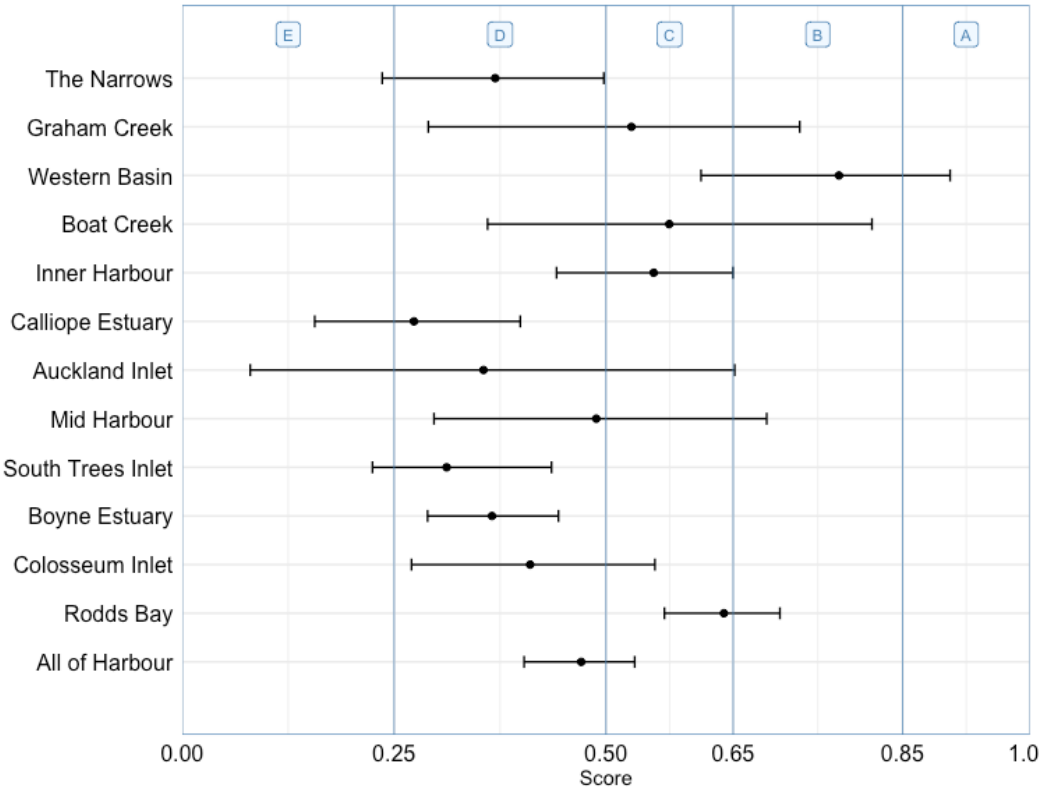

Figure 27: Zone scores and corresponding bootstrap 95% confidence intervals.

10. DISCUSSION

For 2022-23, the number of surveys conducted was 78, the same as in 2020-21 and 2021-22. Surveys were conducted in December, January and February and none in March as in years prior to 2020-21. The reduction in the number of surveys has had little effect on the overall results. In the recalculation of the historical scores using the negative binomial model there were minor changes to some zone scores, however, this had little or no effect on the scores in the previous reports (not shown). There were no changes in the grades when the historic sampling regime was adjusted.

The average catch rates per cast does not have a direct relationship to the scores. The derived final score includes the site level effect and as such is more sensitive to individual site variation than the catch rate. At the individual sites there were variations that showed a number of sites underperformed relative to last year.

The number of prawns this year was the second highest recorded in any year, even considering the reduced number of surveys in the past 3 years, resulting in a catch rate of 2.07 prawn/cast and just below 2020-21 when the catch rate was 2.17 prawn/cast. Prawn numbers were likely boosted by rainfall from October-February.

Overall, the reduction in score and grade from the previous year is due to the reduction in Pikey Bream catch rates. Over the years of the surveys the catch rate for Yellowfin Bream ahs varied from 0.12-0.28 fish/cast with 0.22 fish/cast this year being the second highest so far. The catch rate for Pikey Bream has ranged from 0.09-0.29 fish/cast, with the rate this year of 0.12 fish/cast being the third lowest so far. The marked drop in the Pikey Bream catch rate from the previous year is likely to be bigger than the data shows due to the number of possible second year recruits in the count.

11. REFERENCES

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APPENDIX 1 – SURVEY SITES

Table 13 provides a summary of sites and site details, as stored in the Infofish 2022 database, along with a more detailed description of the habitat. Details for each site are available in the report "Fish recruitment indicators for the Gladstone Harbour Report Card using data derived from castnet sampling 2018" (Sawynok et al 2018).

Table 13: Summary of site details.

Sub-Region	Site ID	Site Name	Latitude	Longitude	Map	Grid
1	97	RAMSAY CROSSING	-23.641	151.066	CIS	S31
1	5	MUNDURAN CREEK	-23.658	151.048	CISG	R33
1	22	BLACK SWAN	-23.679	151.089	CISG	V35
1	51	TARGINNIE CREEK	-23.762	151.13	GLD	HZ1
2	62	HOBBLE GULLY	-23.71	151.222	GLD	NZ10
2	99	GRAHAM CREEK 2	-23.712	151.24	GLD	MZ12
3	146	WIGGINS ISLAND	-23.821	151.218	GLD	AZ10
4	35	BOAT CREEK	-23.814	151.162	GLD	BZ4
5	67	LITTLE ENFIELD CREEK	-23.775	151.266	GLD	FZ15
5	54	BARNEY POINT POND	-23.86	151.275	GLD	D16
6	6	BEECHER CREEK	-23.923	151.207	CR02	I9
6	81	OLD BRUCE HIGHWAY BRIDGE	-23.964	151.154	CR02	P4
7	49	CALLEMONDAH	-23.862	151.232	GLD	D12
8	95	FARMERS POINT	-23.774	151.33	GLD	GZ22
8	94	GATCOMBE ANCHORAGE	-23.876	151.365	GLD	F25
9	55	WAPPENTAKE CREEK	-23.89	151.282	BRG	H17
9	76	SOUTH TREES	-23.951	151.291	BRG	N17
9	90	CREMATORIUM POOL	-23.972	151.334	BRG	Q22
10	48	OLD BOYNE	-23.981	151.33	BRG	R21
10	74	BOYNE HIGHWAY	-24.01	151.338	BRG	U22
11		OUTER HARBOUR NO SITES				
12	92	BROADACRES	-23.991	151.392	BRG	S28
12	91	IVERAGH	-24.103	151.46	RBT	H17
13	89	7 MILE CREEK	-24.131	151.561	RBT	R21
13	88	SANDY BRIDGE	-24.15	151.567	RBT	R23
13	87	OAKY CREEK	-24.11	151.663	RBT	AB18
13	86	WORTHINGTON CREEK	-24.135	151.689	RBT	AE21

APPENDIX 2 - SPECIES

Table 14 is a list of species recorded using standard name, scientific name, number of sites, and number of fish recorded in surveys from December 2022 – February 2023.

Table 14: Number of each species recorded and number of sites where recorded.

STANDARD NAME	SCIENTIFIC NAME	SITES	NUMBER
Prawn – Banana	*Fenneropenaeus indicus*	18	3223
Mullet – Flattail	*Liza dussumieri*	26	1801
Silverbiddy – Common	*Gerres subfasciatus*	24	636
Ponyfish – Common	*Leiognathus equulus*	17	487
Rabbitfish – Goldlined	*Siganus lineatus*	17	349
Bream – Yellowfin	*Acanthopagrus australis*	22	340
Glassfish – Estuary	*Ambassis marianus*	15	273
Herring – Southern	*Herklotsichthys castelnaui*	12	258
Bream – Pikey	*Acanthopagrus berda*	15	193
Toadfish – Common	*Tetractenos hamiltoni*	13	143
Whiting – Goldenline	*Sillago analis*	12	78
Grunter – Barred	*Terapon jarbua*	16	68
Scat – Striped	*Selenotoca multifasciata*	6	68
Javelin – Barred	*Pomadasys kaakan*	7	55
Bream – Bony	*Nematalosa erebi*	8	48
Mullet - Diamondscale	*Liza vaigiensis*	6	44
Snapper – Moses	*Lutjanus russellii*	11	28
Tarwhine	*Rhabdosargus sarba*	5	27
Whiting spp	*Sillago spp*	4	21
Garfish spp		4	19
Diamondfish	*Monodactylus argenteus*	3	18
Anchovy spp	*Engraulis spp*	3	17
Sole – Black	*Brachinus nigra*	6	16
Flathead – Dusky	*Platycephalus fuscus*	9	12
Mangrove Jack	*Lutjanus argentimaculatus*	5	9
Silverbiddy – Threadfin	*Gerres filamentosus*	1	5
Scat – Spotted	*Scatophagus argus*	3	5
Flathead – Bartail	*Platycephalus indicus*	1	4
Herring – Hairback	*Nematalosa come*	1	4
Strippy – Australian		2	3
Threadfin – King	*Polydactylus macrochir*	2	3
Barramundi	*Lates calcarifer*	1	2
Herring – Giant	*Elops machnata*	2	2
Garfish – Snubnose	*Arrhamphus sclerolepis*	2	2
Steelback	*Ophiocara porocephala*	2	2
Trevally spp		1	2

Rockcod – Blackspotted	*Epinephelus malabaricus*	1	1
Rockcod – Goldspotted	*Epinephelus coioides*	1	1
Shrimp – Freshwater	*Macrobrchium spp*	1	1
Goatfish		1	1
Gudgeon – Spangled	*Ophiocara ophicephalus*	1	1
Crab – Mud	*Scylla Serrata*	1	1
Crab – Blue Swimmer	*Portunus pelagicus*	1	1
Barracuda spp	*Sphyraena spp*	1	1

APPENDIX 3 – BREAM SIZE PROFILE

Figure 28 and Table 15 show the size distribution of the Bream catch, by species, for each of the 3 months of the surveys and for all of harbour.

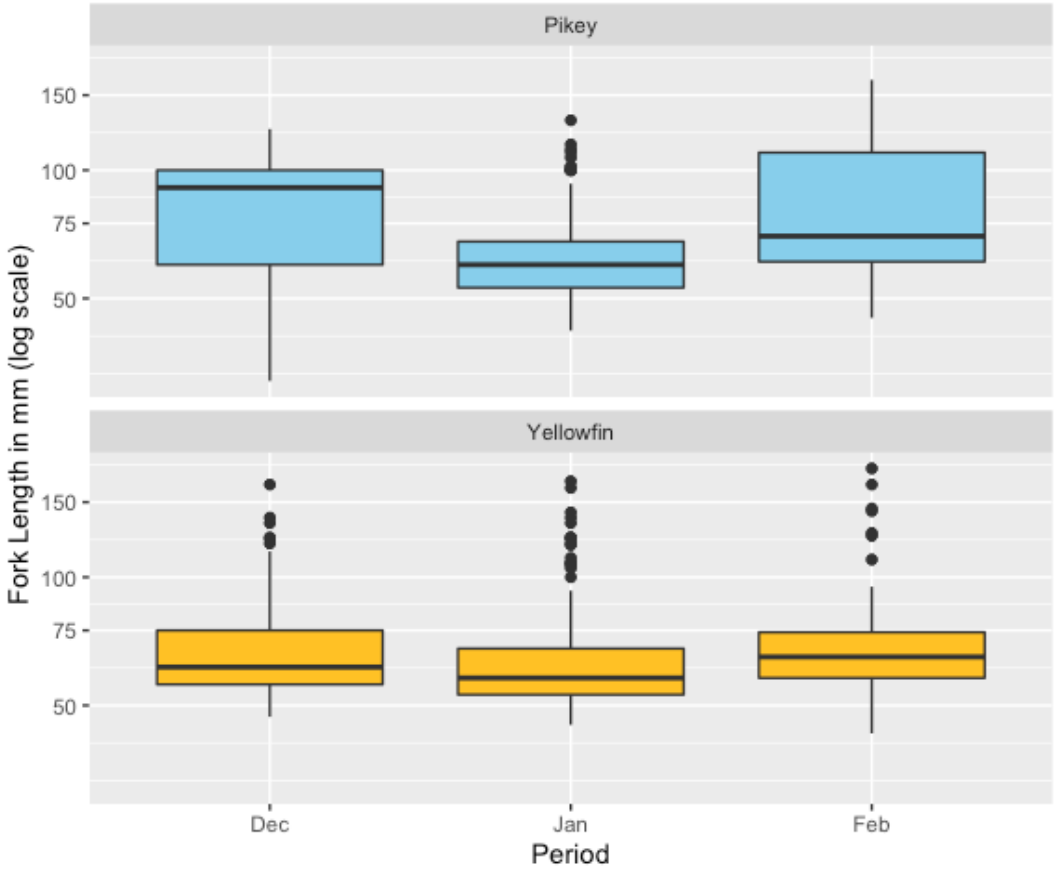

Figure 28: Fork Length change at the harbour level over the data collection period.

Table 15: Bream size distribution summary statistics: Fork Length (mm).

Species	Month	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
Pikey Bream	Dec	38	50	55.0	59.23116	58	210
	Feb	51	58	66.0	71.15068	75	205
	Jan	44	58	63.0	64.51163	68	140
Yellowfin Bream	Dec	48	56	63.0	69.81065	70	241
	Feb	56	70	76.5	85.36207	102	150
	Jan	44	56	64.0	68.39080	73	130

APPENDIX 4 – CATCH AND EFFORT DATA

Table 16: Numbers of casts per site for all survey years.

Zone	Site	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23
The Narrows	Ramsay Crossing					50	80	80	80	80	60	60	60
	Munduran Creek	60	60	80	100	100	80	80	80	80	60	60	60
	Black Swan				80	80	80	80	80	80	60	60	60
	Targinnie Creek	10	10		80	80	80	80	80	80	60	60	60
Graham Creek	Graham Creek				20	60	80	80	80	80	60	40	60
	Hobble Gully				80	80	80	80	80	80	60	60	60
Western Basin	Wiggins Island					100	80	80	80	80	60	80	60
Boat Creek	Boat Creek		10	80	75	80	80	80	80	80	60	60	60
Inner Harbour	Little Enfield Creek				100	80	80	80	80	80	60	80	60
	Barney Point Pond		80	100	100	80	80	80	80	80	60	40	60
Calliope Estuary	Beecher Creek	50	70	80	100	80	80	80	80	80	60	60	60
	Old Bruce Highway Bridge				50	80	80	80	80	80	60	60	61
Auckland Inlet	Callemondah	50	70	100	100	80	80	80	80	80	60	60	60
Mid Harbour	Farmers Point					90	80	80	80	80	60	60	60
	Gatcombe Anchorage					100	80	80	80	80	60	60	60
South Trees Inlet	Wappentake Creek		70	60	100	80	80	80	80	80	60	40	60
	South Trees					90	80	80	80	80	60	80	60
	Crematorium Pool					100	80	80	80	80	60	60	60
Boyne Estuary	Old Boyne	20	20		100	80	80	80	80	80	60	60	60
	Boyne Highway				40	80	80	80	80	80	60	60	60
Colosseum Inlet	Broadacres					100	80	80	80	80	60	80	60
	Iveragh					100	80	80	80	80	60	80	60
Rodds Bay	Oaky					100	80	80	80	80	60	60	60
	7 Mile					100	80	80	80	80	60	40	60
	Worthington					100	80	80	80	80	60	60	60
	Sandy Bridge					100	80	80	80	80	60	40	60

Table 17: Total numbers of Pikey Bream caught per site per survey year.

Zone	Site	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23
The Narrows	Ramsay Crossing					56	48	56	26	74	1	42	9
”	Munduran Creek	0	0	2	0	0	0	0	1	1	1	0	1
	Black Swan				25	1	77	22	21	33	21	25	7
	Targinnie Creek	0	0		0	0	2	6	0	20	8	22	14
Graham Creek	Graham Creek				3	2	8	24	0	60	28	36	16
	Hobble Gully				21	30	24	53	20	84	83	59	40
Western Basin	Wiggins Island					0	3	8	0	15	8	18	5
Boat Creek	Boat Creek		0	0	5	2	1	2	3	2	0	1	1
Inner Harbour	Little Enfield Creek				30	13	24	30	6	39	33	95	40
	Barney Point Pond		0	2	1	0	0	1	0	0	0	0	0
Calliope Estuary	Beecher Creek	0	0	0	1	1	2	0	10	9	5	5	1
	Old Bruce Highway Bridge				0	10	37	12	12	18	11	10	12
Auckland Inlet	Callemondah	2	0	12	17	15	43	57	34	37	28	27	5
Mid Harbour	Farmers Point					0	0	3	0	0	0	0	0
	Gatcombe Anchorage					2	1	0	0	12	18	8	0
South Trees Inlet	Wappentake Creek		0	1	1	1	1	1	1	1	1	0	0
	South Trees					11	16	44	11	13	7	27	18
	Crematorium Pool					1	0	14	9	7	11	16	0
Boyne Estuary	Old Boyne	2	0		4	1	0	6	3	5	4	12	2
	Boyne Highway				0	1	0	1	0	0	0	1	0
Colosseum Inlet	Broadacres					2	12	31	8	14	8	9	3
	Iveragh					2	3	1	5	2	0	0	0
Rodds Bay	Oaky					13	12	13	10	12	3	7	6
	7 Mile					23	16	35	9	15	17	14	13
	Worthington					1	4	5	2	2	1	3	0
	Sandy Bridge					0	2	4	5	0	0	0	0

Table 18: Total numbers of Yellowfin Bream caught per site per survey year.

Zone	Site	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23
The Narrows	Ramsay Crossing					6	22	9	4	7	1	10	2
	Munduran Creek	33	13	10	20	23	29	15	8	6	17	12	12
	Black Swan				4	0	17	4	2	2	4	2	12
	Targinnie Creek	2	0		38	5	21	21	2	25	32	26	5
Graham Creek	Graham Creek				4	5	0	0	0	0	0	1	0
	Hobble Gully				1	2	0	2	0	2	2	3	0
Western Basin	Wiggins Island					0	3	2	0	25	21	49	20
Boat Creek	Boat Creek		0	5	4	1	0	4	3	0	1	0	4
Inner Harbour	Little Enfield Creek				7	1	4	1	2	9	4	4	13
	Barney Point Pond		1	0	2	0	0	1	0	0	0	0	0
Calliope Estuary	Beecher Creek	18	3	11	18	9	20	12	7	13	7	5	4
	Old Bruce Highway Bridge				9	11	8	76	1	23	47	15	4
Auckland Inlet	Callemondah	9	5	13	25	16	35	20	15	30	9	11	18
Mid Harbour	Farmers Point					0	26	6	0	1	6	2	7
	Gatcombe Anchorage					2	0	4	0	6	2	5	4
South Trees Inlet	Wappentake Creek		2	2	3	2	3	10	5	2	2	0	0
	South Trees					17	15	11	13	10	5	19	15
	Crematorium Pool					50	123	35	16	14	23	27	8
Boyne Estuary	Old Boyne	8	6		35	34	42	20	10	15	23	20	13
	Boyne Highway				10	42	49	29	51	40	23	40	26
Colosseum Inlet	Broadacres					17	11	9	13	16	8	11	3
	Iveragh					23	20	8	18	19	21	5	21
Rodds Bay	Oaky					23	25	15	27	30	10	9	45
	7 Mile					15	19	6	17	7	26	2	21
	Worthington					11	14	8	7	20	10	2	6
	Sandy Bridge					47	68	18	27	8	13	17	74

Table 19: Total numbers of Pikey Bream and Yellowfin Bream combined per site, per survey year.

Zone	Site	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23
The Narrows	Ramsay Crossing					62	70	65	30	81	2	52	11
	Munduran Creek	33	13	12	20	23	29	15	9	7	18	12	13
	Black Swan				29	1	94	26	23	35	25	27	19
	Targinnie Creek	2	0		38	5	23	27	2	45	40	48	19
Graham Creek	Graham Creek				7	7	8	24	0	60	28	37	16
	Hobble Gully				22	32	24	55	20	86	85	62	40
Western Basin	Wiggins Island					0	6	10	0	40	29	67	25
Boat Creek	Boat Creek		0	5	9	3	1	6	6	2	1	1	5
Inner Harbour	Little Enfield Creek				37	14	28	31	8	48	37	99	53
	Barney Point Pond		1	2	3	0	0	2	0	0	0	0	0
Calliope Estuary	Beecher Creek	18	3	11	19	10	22	12	17	22	12	10	5
	Old Bruce Highway Bridge				9	21	45	88	13	41	58	25	16
Auckland Inlet	Callemondah	11	5	25	42	31	78	77	49	67	37	38	23
Mid Harbour	Farmers Point					0	26	9	0	1	6	2	7
	Gatcombe Anchorage					4	1	4	0	18	20	13	4
South Trees Inlet	Wappentake Creek		2	3	4	3	4	11	6	3	3	0	0
	South Trees					28	31	55	24	23	12	46	33
	Crematorium Pool					51	123	49	25	21	34	43	8
Boyne Estuary	Old Boyne	10	6		39	35	42	26	13	20	27	32	15
	Boyne Highway				10	43	49	30	51	40	23	41	26
Colosseum Inlet	Broadacres					19	23	40	21	30	16	20	6
	Iveragh					25	23	9	23	21	21	5	21
Rodds Bay	Oaky					36	37	28	37	42	13	16	51
	7 Mile					38	35	41	26	22	43	16	34
	Worthington					12	18	13	9	22	11	5	6
	Sandy Bridge					47	70	22	32	8	13	17	74

Table 20: Pikey Bream catch per visit of 20 Casts, (CPUE), per site, per survey year.

Zone	Site	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23
The Narrows	Ramsay Crossing					22.40	12.00	14.00	6.50	18.50	0.33	14.00	3.00
	Munduran Creek	0.0	0	0.50	0.00	0.00	0.00	0.00	0.25	0.25	0.33	0.00	0.33
	Black Swan				6.25	0.25	19.25	5.50	5.25	8.25	7.00	8.33	2.33
	Targinnie Creek	0.0	0		0.00	0.00	0.50	1.50	0.00	5.00	2.67	7.33	4.67
Graham Creek	Graham Creek				3.00	0.67	2.00	6.00	0.00	15.00	9.33	18.00	5.33
	Hobble Gully				5.25	7.50	6.00	13.25	5.00	21.00	27.67	19.67	13.33
Western Basin	Wiggins Island					0.00	0.75	2.00	0.00	3.75	2.67	4.50	1.67
Boat Creek	Boat Creek		0	0.00	1.33	0.50	0.25	0.50	0.75	0.50	0.00	0.33	0.33
Inner Harbour	Little Enfield Creek				6.00	3.25	6.00	7.50	1.50	9.75	11.00	23.75	13.33
	Barney Point Pond		0	0.40	0.20	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00
Calliope Estuary	Beecher Creek	0.0	0	0.00	0.20	0.25	0.50	0.00	2.50	2.25	1.67	1.67	0.33
	Old Bruce Highway Bridge				0.00	2.50	9.25	3.00	3.00	4.50	3.67	3.33	3.93
Auckland Inlet	Callemondah	0.8	0	2.40	3.40	3.75	10.75	14.25	8.50	9.25	9.33	9.00	1.67
Mid Harbour	Farmers Point					0.00	0.00	0.75	0.00	0.00	0.00	0.00	0.00
	Gatcombe Anchorage					0.40	0.25	0.00	0.00	3.00	6.00	2.67	0.00
South Trees Inlet	Wappentake Creek		0	0.33	0.20	0.25	0.25	0.25	0.25	0.25	0.33	0.00	0.00
	South Trees					2.44	4.00	11.00	2.75	3.25	2.33	6.75	6.00
	Crematorium Pool					0.20	0.00	3.50	2.25	1.75	3.67	5.33	0.00
Boyne Estuary	Old Boyne	2.0	0		0.80	0.25	0.00	1.50	0.75	1.25	1.33	4.00	0.67
	Boyne Highway				0.00	0.25	0.00	0.25	0.00	0.00	0.00	0.33	0.00
Colosseum Inlet	Broadacres					0.40	3.00	7.75	2.00	3.50	2.67	2.25	1.00
	Iveragh					0.40	0.75	0.25	1.25	0.50	0.00	0.00	0.00
Rodds Bay	Oaky					2.60	3.00	3.25	2.50	3.00	1.00	2.33	2.00
	7 Mile					4.60	4.00	8.75	2.25	3.75	5.67	7.00	4.33
	Worthington					0.20	1.00	1.25	0.50	0.50	0.33	1.00	0.00
	Sandy Bridge					0.00	0.50	1.00	1.25	0.00	0.00	0.00	0.00

Table 21: Yellowfin Bream catch per visit of 20 Casts, (CPUE), per site, per survey year.

Zone	Site	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23
The Narrows	Ramsay Crossing					2.40	5.50	2.25	1.00	1.75	0.33	3.33	0.67
	Munduran Creek	11.0	4.33	2.50	4.00	4.60	7.25	3.75	2.00	1.50	5.67	4.00	4.00
	Black Swan				1.00	0.00	4.25	1.00	0.50	0.50	1.33	0.67	4.00
	Targinnie Creek	4.0	0.00		9.50	1.25	5.25	5.25	0.50	6.25	10.67	8.67	1.67
Graham Creek	Graham Creek				4.00	1.67	0.00	0.00	0.00	0.00	0.00	0.50	0.00
	Hobble Gully				0.25	0.50	0.00	0.50	0.00	0.50	0.67	1.00	0.00
Western Basin	Wiggins Island					0.00	0.75	0.50	0.00	6.25	7.00	12.25	6.67
Boat Creek	Boat Creek		0.00	1.25	1.07	0.25	0.00	1.00	0.75	0.00	0.33	0.00	1.33
Inner Harbour	Little Enfield Creek				1.40	0.25	1.00	0.25	0.50	2.25	1.33	1.00	4.33
	Barney Point Pond		0.25	0.00	0.40	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00
Calliope Estuary	Beecher Creek	7.2	0.86	2.75	3.60	2.25	5.00	3.00	1.75	3.25	2.33	1.67	1.33
	Old Bruce Highway Bridge				3.60	2.75	2.00	19.00	0.25	5.75	15.67	5.00	1.31
Auckland Inlet	Callemondah	3.6	1.43	2.60	5.00	4.00	8.75	5.00	3.75	7.50	3.00	3.67	6.00
Mid Harbour	Farmers Point					0.00	6.50	1.50	0.00	0.25	2.00	0.67	2.33
	Gatcombe Anchorage					0.40	0.00	1.00	0.00	1.50	0.67	1.67	1.33
South Trees Inlet	Wappentake Creek		0.57	0.67	0.60	0.50	0.75	2.50	1.25	0.50	0.67	0.00	0.00
	South Trees					3.78	3.75	2.75	3.25	2.50	1.67	4.75	5.00
	Crematorium Pool					10.00	30.75	8.75	4.00	3.50	7.67	9.00	2.67
Boyne Estuary	Old Boyne	8.0	6.00		7.00	8.50	10.50	5.00	2.50	3.75	7.67	6.67	4.33
	Boyne Highway				5.00	10.50	12.25	7.25	12.75	10.00	7.67	13.33	8.67
Colosseum Inlet	Broadacres					3.40	2.75	2.25	3.25	4.00	2.67	2.75	1.00
	Iveragh					4.60	5.00	2.00	4.50	4.75	7.00	1.25	7.00
Rodds Bay	Oaky					4.60	6.25	3.75	6.75	7.50	3.33	3.00	15.00
	7 Mile					3.00	4.75	1.50	4.25	1.75	8.67	1.00	7.00
	Worthington					2.20	3.50	2.00	1.75	5.00	3.33	0.67	2.00
	Sandy Bridge					9.40	17.00	4.50	6.75	2.00	4.33	8.50	24.67

Table 22: Pikey Bream plus Yellowfin Bream catch per visit of 20 Casts, (CPUE), per site, per survey year.

Zone	Site	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23
The Narrows	Ramsay Crossing					24.80	17.50	16.25	7.50	20.25	0.67	17.33	3.67
	Munduran Creek	11.0	4.33	3.00	4.00	4.60	7.25	3.75	2.25	1.75	6.00	4.00	4.33
	Black Swan				7.25	0.25	23.50	6.50	5.75	8.75	8.33	9.00	6.33
	Targinnie Creek	4.0	0.00		9.50	1.25	5.75	6.75	0.50	11.25	13.33	16.00	6.33
Graham Creek	Graham Creek				7.00	2.33	2.00	6.00	0.00	15.00	9.33	18.50	5.33
	Hobble Gully				5.50	8.00	6.00	13.75	5.00	21.50	28.33	20.67	13.33
Western Basin	Wiggins Island					0.00	1.50	2.50	0.00	10.00	9.67	16.75	8.33
Boat Creek	Boat Creek		0.00	1.25	2.40	0.75	0.25	1.50	1.50	0.50	0.33	0.33	1.67
Inner Harbour	Little Enfield Creek				7.40	3.50	7.00	7.75	2.00	12.00	12.33	24.75	17.67
	Barney Point Pond		0.25	0.40	0.60	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00
Calliope Estuary	Beecher Creek	7.2	0.86	2.75	3.80	2.50	5.50	3.00	4.25	5.50	4.00	3.33	1.67
	Old Bruce Highway Bridge				3.60	5.25	11.25	22.00	3.25	10.25	19.33	8.33	5.25
Auckland Inlet	Callemondah	4.4	1.43	5.00	8.40	7.75	19.50	19.25	12.25	16.75	12.33	12.67	7.67
Mid Harbour	Farmers Point					0.00	6.50	2.25	0.00	0.25	2.00	0.67	2.33
	Gatcombe Anchorage					0.80	0.25	1.00	0.00	4.50	6.67	4.33	1.33
South Trees Inlet	Wappentake Creek		0.57	1.00	0.80	0.75	1.00	2.75	1.50	0.75	1.00	0.00	0.00
	South Trees					6.22	7.75	13.75	6.00	5.75	4.00	11.50	11.00
	Crematorium Pool					10.20	30.75	12.25	6.25	5.25	11.33	14.33	2.67
Boyne Estuary	Old Boyne	10.0	6.00		7.80	8.75	10.50	6.50	3.25	5.00	9.00	10.67	5.00
	Boyne Highway				5.00	10.75	12.25	7.50	12.75	10.00	7.67	13.67	8.67
Colosseum Inlet	Broadacres					3.80	5.75	10.00	5.25	7.50	5.33	5.00	2.00
	Iveragh					5.00	5.75	2.25	5.75	5.25	7.00	1.25	7.00
Rodds Bay	Oaky					7.20	9.25	7.00	9.25	10.50	4.33	5.33	17.00
	7 Mile					7.60	8.75	10.25	6.50	5.50	14.33	8.00	11.33
	Worthington					2.40	4.50	3.25	2.25	5.50	3.67	1.67	2.00
	Sandy Bridge					9.40	17.50	5.50	8.00	2.00	4.33	8.50	24.67

Figure 29 shows the total Bream CPUE per site for survey year 2022-23 plotted against the same total Bream CPUE per site for survey year 2022-23, partitioned into recording zones. Points above the diagonal line correspond to sites whose CPUE increased in 2022-23 from what it was in 2021-22, and points below the line to those for which CPUE decreased.

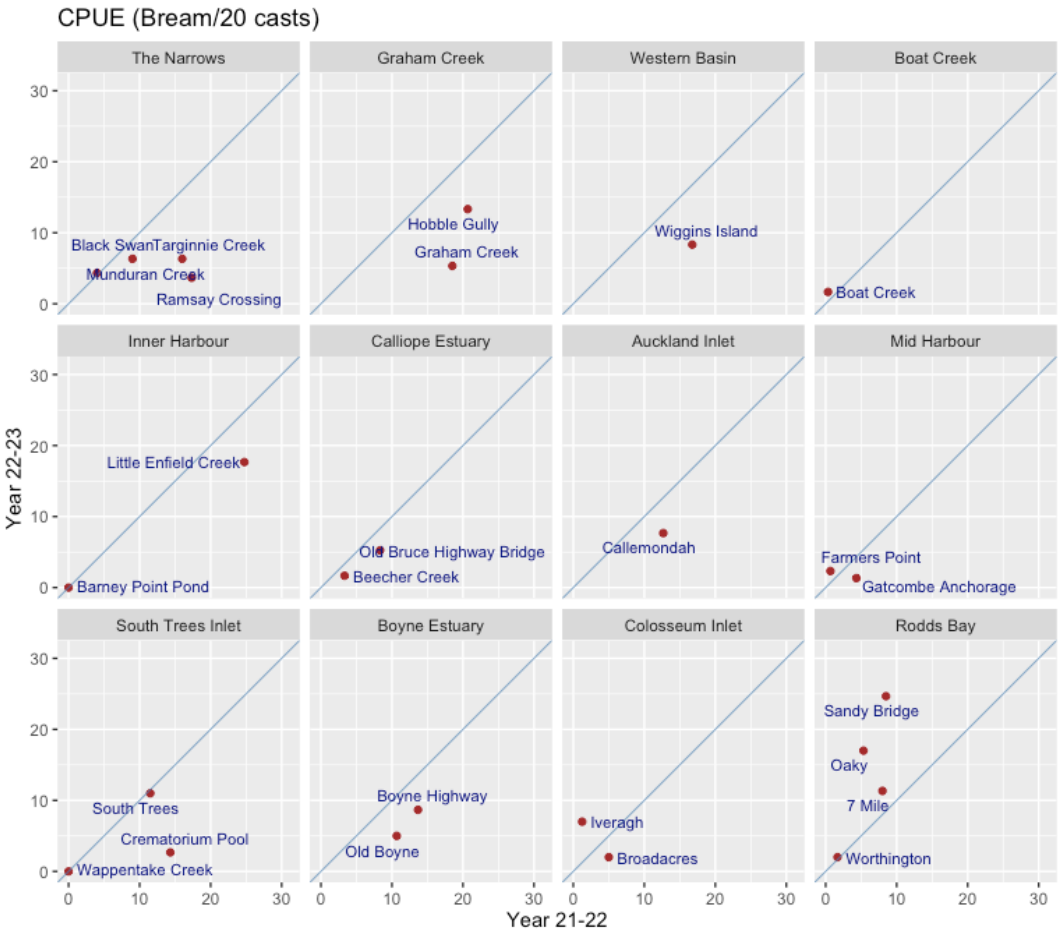

Figure 29: Bream CPUE for 2022-23 against CPUE for 2021-22 per site partitioned into recording zones.