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

2019

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Gladstone Healthy Harbour Partnership

Fish recruitment indicators for the Gladstone Harbour Report Card using data derived from castnet sampling 2019

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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 2019 Gladstone Harbour Report Card, following the same methods used in the past 3 years so that results were comparable from year to year.

Castnet surveys were undertaken monthly at 26 sites from Dec 2018-Mar 2019 covering the same timeframe as in previous years. There was a total of 104 surveys with 2,080 castnet casts in line with the standard survey methodology previously used. A survey involved 20 casts at each site covering the same area in each survey.

There was a total of 6,162 individuals recorded in the 104 surveys comprising 5,272 fish and 880 prawns. The highest catch rate was at South Trees at 9.7 individuals/cast followed by Ramsay Crossing at 5.9 individuals//cast and then Little Enfield Creek at 5.4 individuals/cast. Lowest catch rates were recorded at Mud Island at 0.7 individuals/cast, Farmers Point at 0.9 individuals/cast and Barney Point Pond at 1.0 individuals/cast.

Flattail Mullet 1,425 (23.2%), Banana Prawn 880 (14.3%) and Common Silverbiddy 716 (11.6%) were the most caught species. Yellowfin Bream 248 (4.0%) was the 7th most caught species and Pikey Bream 196 (3.2%) was the 9th most caught species. Flattail Mullet were recorded at all 26 sites while Yellowfin Bream were recorded at 22 sites and Pikey Bream at 19 sites.

In 2019 total fish and prawn were down 21.4% compared with the 2018 total. For 2018 the total fish and prawn were down 11.4% compared with 2017. The percentage of prawn in the 2019 catch was down to 14.3% while from 2016-2018 it was relatively stable ranging from 21.5% to 23.8%. However, the prawn catch for 2019 was down 47.7% compared with 2018.

There was a total of 444 Bream (both species) in 2019 compared with 775 in 2018 and 910 in 2017. Yellowfin Bream were 55.9% of the Bream catch in 2019 while they were 44.6% in 2018, 63.1% in 2017 and 64.5% in 2016. The only year where the proportion of Pikey Bream exceeded Yellowfin Bream was 2018.

The random effects model used in 2018 was used again, without modification, to determine scores and grades for each site, each zone and for all of harbour. This resulted in grades of D and E for all zones except Auckland Creek where the grade was C. The all of harbour grade was D.

The all of harbour D grade (0.26) was down from B (0.6) in 2018. That grade is not a result of a deterioration of the habitat in the Gladstone area but a reflection of the dry climatic conditions impacting on recruitment and was in line with expectations.
The following table provides the scores averaged over sites within zones for each year from 2015-2019 along with the grade colours for the GHHP report card.

Zone	2019	*2018*	*2017*	*2016*	*2015*
1.Narrows	0.17	*0.65*	*0.79*	*0.33*	*0.72*
2.Graham Creek	0.17	*0.84*	*0.58*	*0.39*	*0.66*
3.Western Basin	0.13	*0.86*	*0.77*	*0.17*	*NS*
4.Boat Creek	0.32	*0.65*	*0.47*	*0.27*	*0.80*
5.Inner Harbour	0.15	*0.73*	*0.66*	*0.27*	*0.75*
6.Calliope Estuary	0.27	*0.73*	*0.76*	*0.30*	*0.54*
7.Auckland Inlet	0.52	*0.85*	*0.85*	*0.40*	*0.59*
8.Mid Harbour	0.11	*0.70*	*0.76*	*0.26*	*NS*
9.South Trees Inlet	0.24	*0.73*	*0.71*	*0.34*	*0.54*
10.Boyne Estuary	0.31	*0.55*	*0.75*	*0.49*	*0.61*
11.Outer Harbour	NS	*NS*	*NS*	*NS*	*NS*
12.Colosseum Inlet	0.38	*0.61*	*0.68*	*0.38*	*NS*
13.Rodds Bay	0.32	*0.61*	*0.74*	*0.41*	*NS*
Harbour average	**0.26**	***0.71***	***0.71***	***0.33***	***0.65***

NS = not surveyed

1. INTRODUCTION

The Gladstone Healthy Harbour Partnership (GHHP) was established in 2012 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 2015 Yellowfin and Pikey Bream were selected as appropriate species to be used as fish recruitment indicators. From 2016-2018 standardised surveys were undertaken to assess recruitment and provide scores and grades for the report card. Standardised surveys were again undertaken in 2019.

2. OBJECTIVES

The requirements of this project were to:

1. Conduct a castnet sampling program based on the approved sampling design over the 2018-19 recruitment season.
2. Refine the data collection methods and statistical analytical methods developed in 2018 (if required).
3. Provide fish recruitment report card scores and grades for the 2019 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 no changes to the 26 survey sites surveyed in 2016-17 and 2017-18. Site locations are shown in Figure 2.

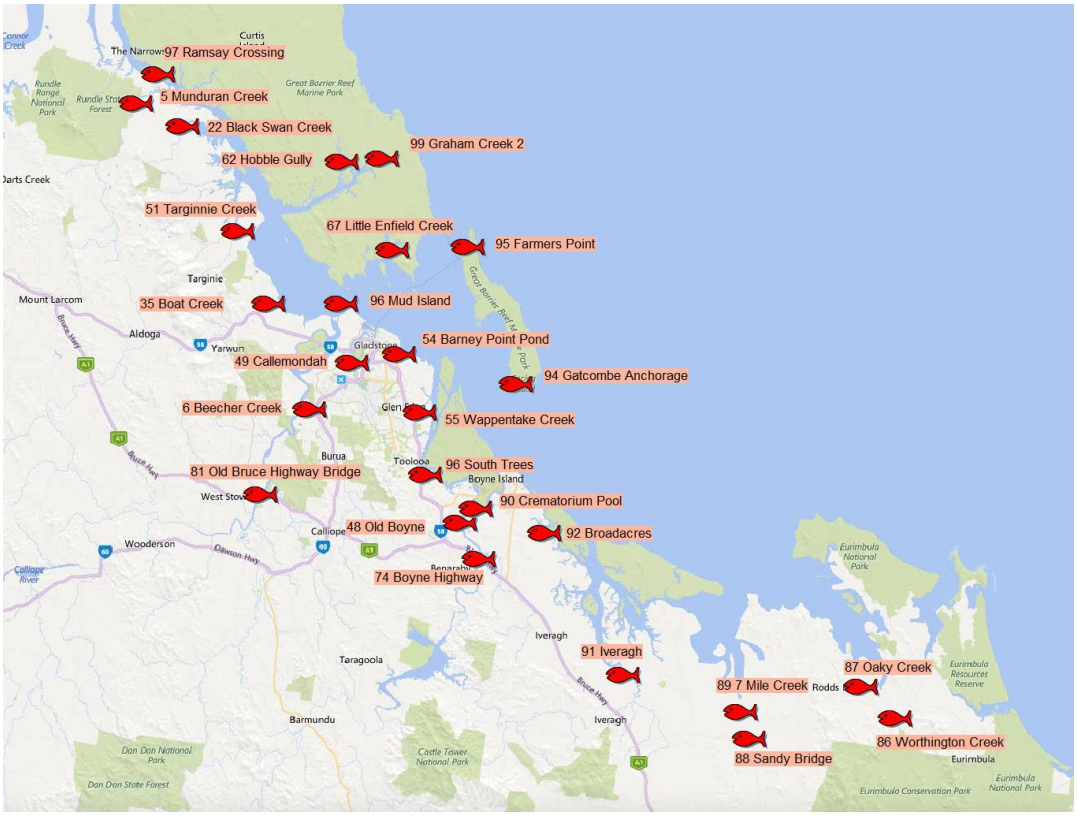

Figure 2**:** Site locations and site ID in the Gladstone area for Bream recruitment surveys

5. METHODS

Details of all methods are 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 to the methods used in 2017-18 and in 2016-17 (Sawynok and Venables 2017). In summary each survey comprised 20 casts with a castnet at each site covering the same areas as previous surveys. Surveys were conducted each month from December 2018-March 2019. Figure 3 shows the castnet method used and Figure 4 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). In summary a 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 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: Bream recruits are the target for the recruitment assessment

6. RESULTS

6.1 SUMMARY OF 2019 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:

- 14-24 December 2018
- 11-22 January 2019
- 9-21 February 2019
- 7 March-2 April 2019

Table 1 provides a summary of surveys at all sites from December 2018-March 2019. There were 104 surveys with 2,080 casts resulting in a catch of 6,152 fish and prawn.

Table 1: Summary of surveys undertaken from December 2018-March 2019

SUB-REGION	SITE ID	SITE	SURVEYS	CASTS	FISH/ PRAWN	CATCH RATE
1	97	RAMSAY CROSSING	4	80	475	5.9
1	5	MUNDURAN CREEK	4	80	150	1.9
1	22	BLACK SWAN	4	80	112	1.4
1	51	TARGINNIE CREEK	4	80	140	1.8
2	62	HOBBLE GULLY	4	80	389	4.9
2	99	GRAHAM CREEK 2	4	80	295	3.7
3	96	MUD ISLAND	4	80	57	0.7
4	35	BOAT CREEK	4	80	312	3.9
5	67	LITTLE ENFIELD CREEK	4	80	429	5.4
5	54	BARNEY POINT POND	4	80	79	1.0
6	6	BEECHER CREEK	4	80	169	2.1
6	81	OLD BRUCE HWY BRIDGE	4	80	274	3.4
7	49	CALLEMONDAH	4	80	312	3.9
8	95	FARMERS POINT	4	80	75	0.9
8	94	GATCOMBE ANCHORAGE	4	80	242	3.0
9	55	WAPPENTAKE CREEK	4	80	163	2.0
9	76	SOUTH TREES	4	80	773	9.7
9	90	CREMATORIUM POOL	4	80	186	2.3
10	48	OLD BOYNE	4	80	156	2.0
10	74	BOYNE HIGHWAY	4	80	112	1.4
11	OUTER HARBOUR NO SITES					
12	92	BROADACRES	4	80	189	2.4
12	91	IVERAGH	4	80	271	3.4
13	89	7 MILE CREEK	4	80	137	1.7
13	88	SANDY BRIDGE	4	80	204	2.6
13	87	OAKY CREEK	4	80	269	3.4
13	86	WORTHINGTON CREEK	4	80	182	2.3
		TOTAL	104	2080	6152	3.0

Catch rates varied considerably between sites as shown in Table 1 and Figure 5. The highest catch rate was at South Trees at 9.7 individuals/cast followed by Ramsay Crossing at 5.9 and then Little Enfield Creek at 5.4 individuals/cast. Lowest catch rates were recorded at Mud Island at 0.7 individuals/cast, Farmers Point at 0.9 individuals/cast and Barney Point Pond at 1.0 individuals/cast.

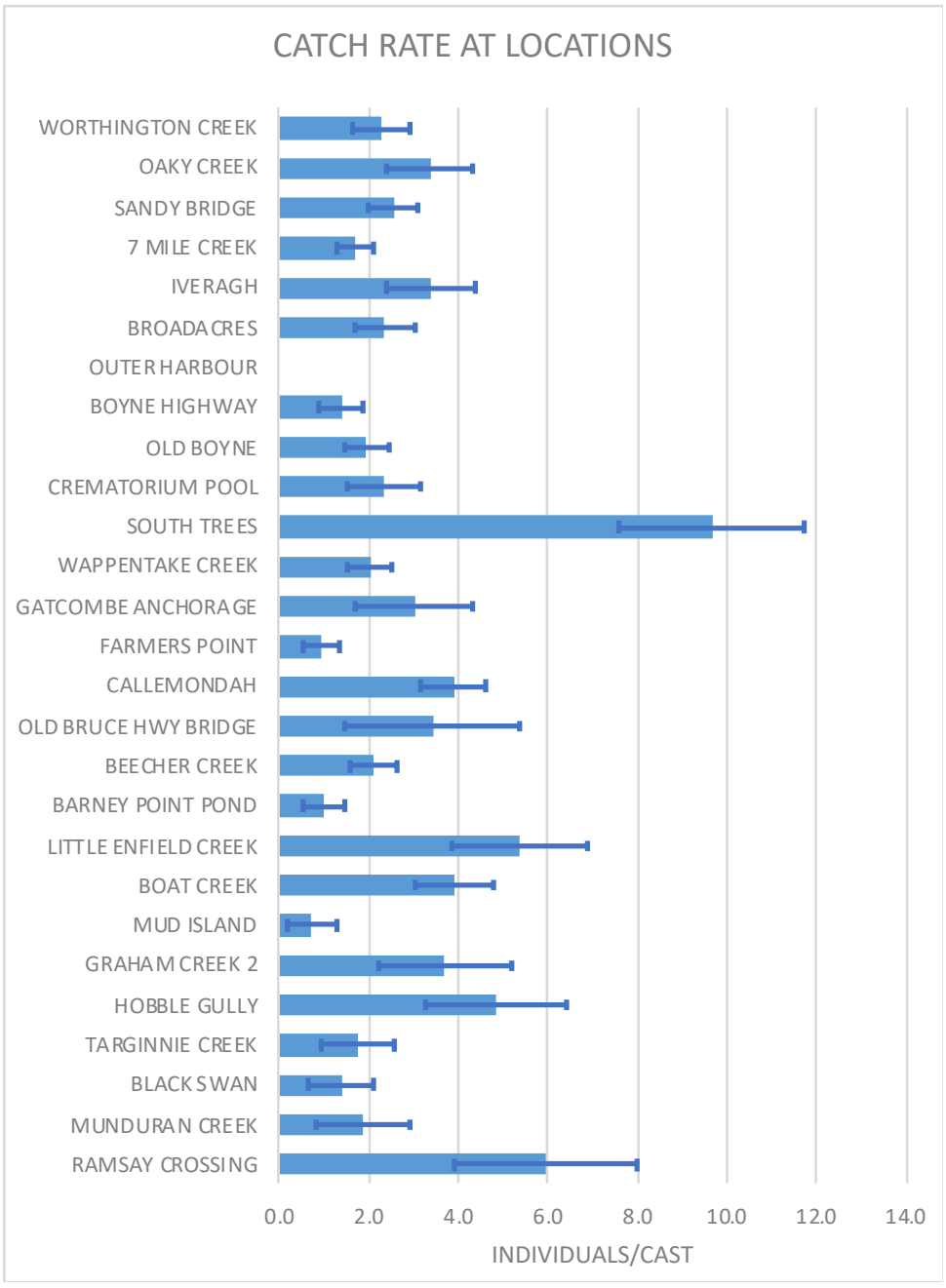

Figure 5: Catch rate at each site (mean with bars showing 95% confidence interval)

Flattail Mullet 1,425 (23.2%), Banana Prawn 880 (14.3%) and Common Silverbiddy 716 (11.6%) were the most caught species. Yellowfin Bream 248 (4.0%) was the 7th most caught species and Pikey Bream 196 (3.2%) was the 9th most caught species as shown in Figure 6. A list of all species including scientific names and the numbers caught is shown in Appendix 2.

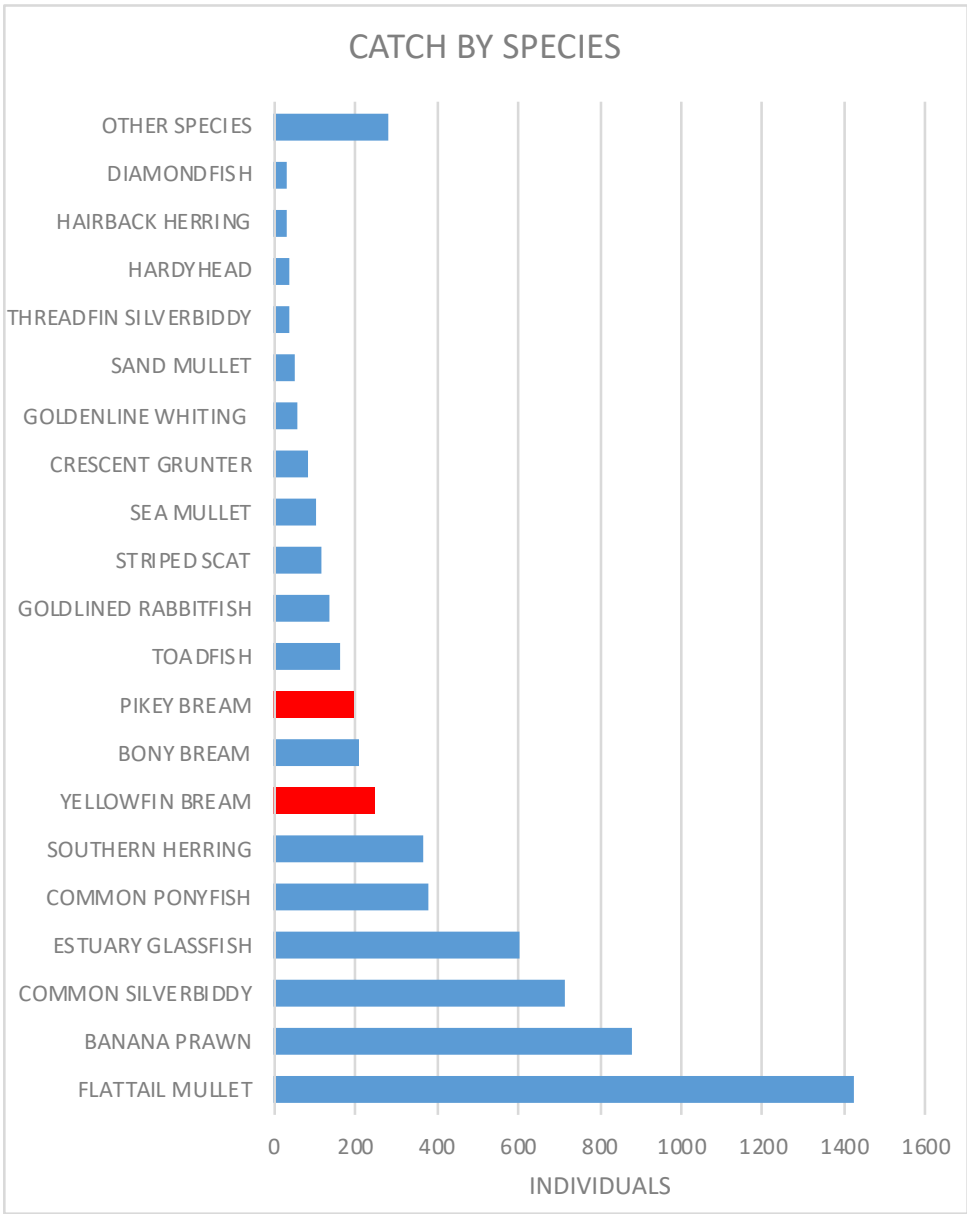

Figure 6: Number of individuals (fish and prawn) recorded across all sites from December 2018-March 2019

There were 12 other species of recreational, commercial, indigenous or conservation importance that were recorded during surveys. Figure 7 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.

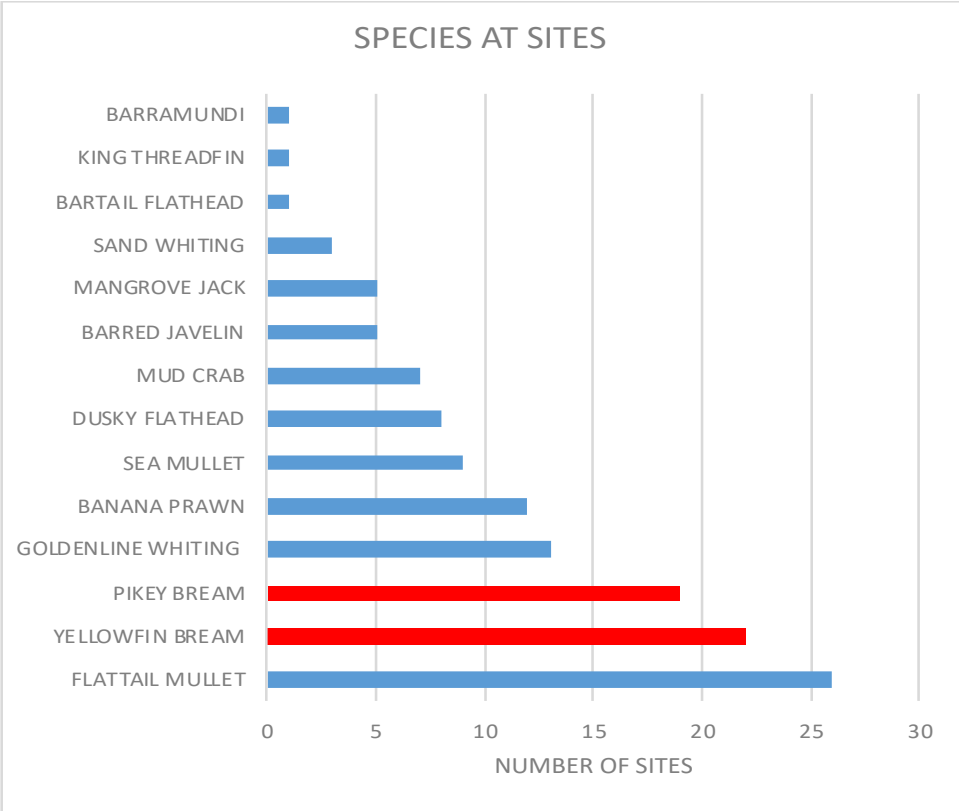

Figure 7: Number of sites where key species were recorded

Surveys were undertaken over a 4-month period from December 2018-March 2019 so that comparisons could be made over time. Figure 8 shows the number of individuals (fish and prawn) recorded at all sites each month. The highest number of individuals was recorded in February with 1,774 (1,554 fish and 220 prawn) while the lowest was recorded in December with 1,148 (1,061 fish and 87 prawn).

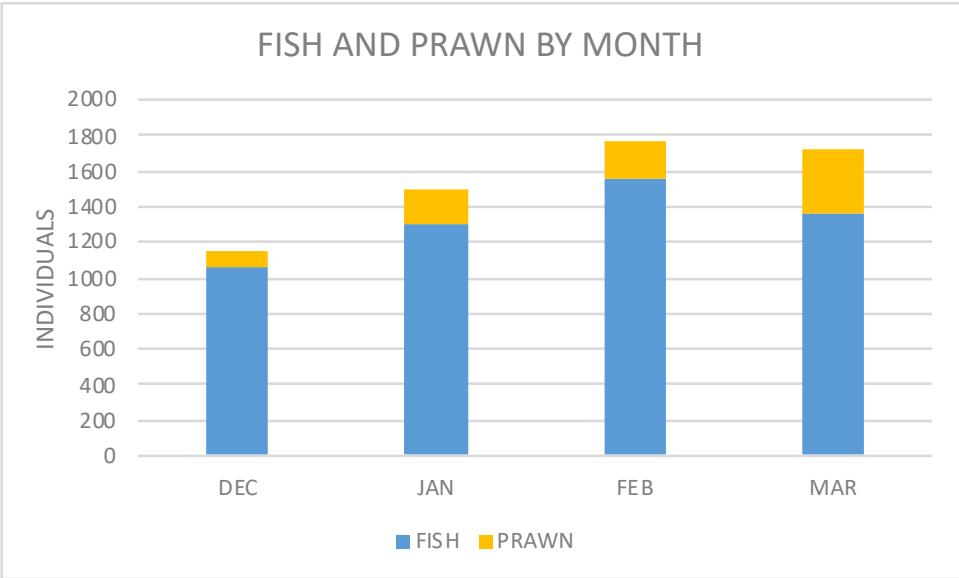

Figure 8: Numbers of individuals recorded at all sites on monthly surveys from December 2018-March 2019

Figure 9 shows the percentage of fish and prawn in the catch each month. The percentage of prawn in the catch was highest in March at 21.2% and was lowest in December at 7.6%.

The mean individuals/cast ranged from a low of 2.2 in December to a high of 3.4 in February. Figure 10 shows the mean catch rate with bars representing the 95% confidence interval for each month's surveys.

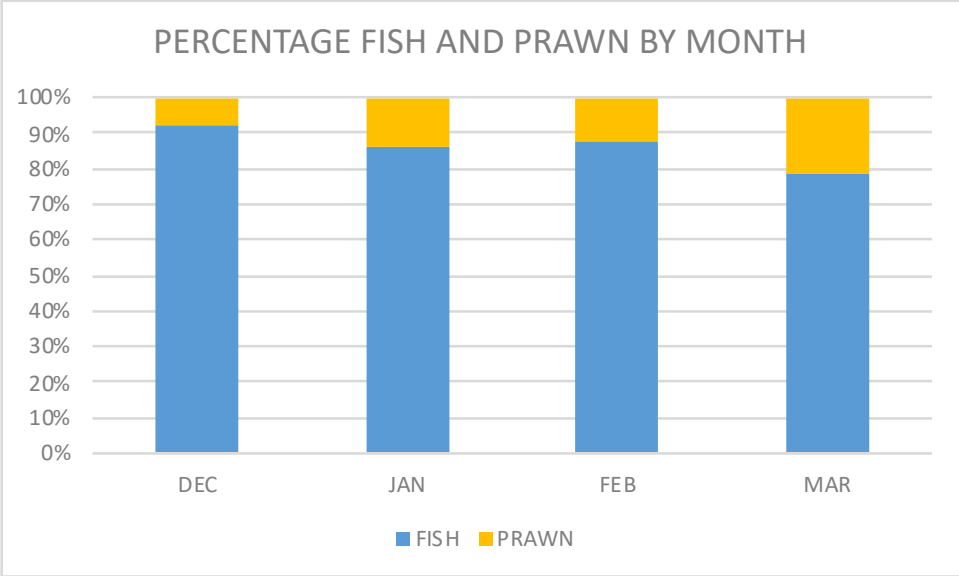

Figure 9: Percentage of fish and prawn in the catch across all sites on monthly surveys from December 2018-March 2019

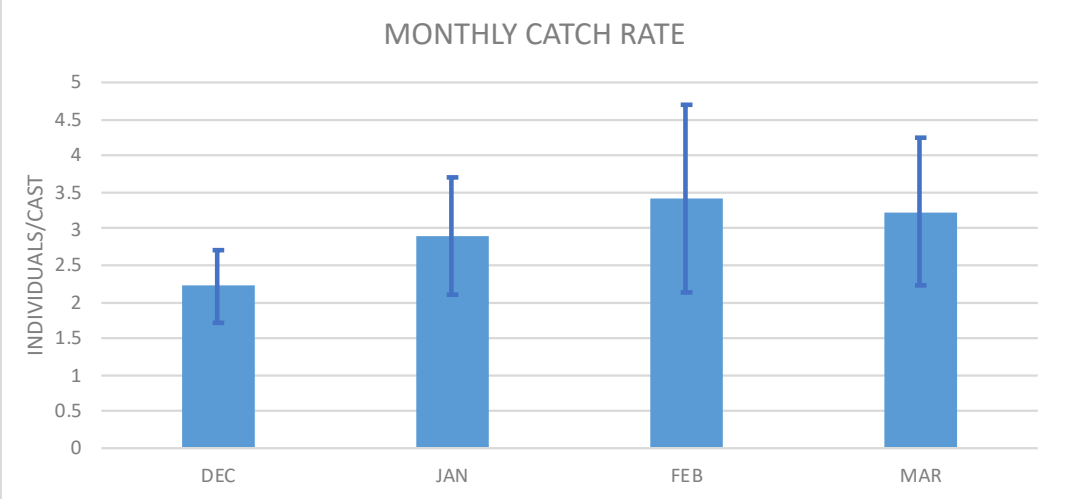

Figure 10: Catch rate for fish and prawn at all sites on monthly surveys from December 2018-March 2019

6.2 BREAM IN 2019

Bream (Yellowfin and Pikey) were the most caught species by recreational fishers in the Gladstone area comprising 20.7% of the catch and 20.3% of the kept catch from 2006-2014 (Sawynok et al 2015). Bream recruitment is important for maintaining fish stocks and is being used as a key fish indicator for the Gladstone Harbour report card. Table 2 shows the number of Bream recorded at each site in surveys from December 2018-March 2019.

Table 2: Bream recorded at each site in surveys from December 2018-March 2019

SUB-REGION	SITE ID	SITE	SURVEYS	CASTS	YELLOW FIN BREAM	PIKEY BREAM
1	97	RAMSAY CROSSING	4	80	4	26
1	5	MUNDURAN CREEK	4	80	8	1
1	22	BLACK SWAN	4	80	2	21
1	51	TARGINNIE CREEK	4	80	2	0
2	62	HOBBLE GULLY	4	80	0	20
2	99	GRAHAM CREEK 2	4	80	0	0
3	96	MUD ISLAND	4	80	0	0
4	35	BOAT CREEK	4	80	3	3
5	67	LITTLE ENFIELD CREEK	4	80	2	6
5	54	BARNEY POINT POND	4	80	0	0
6	6	BEECHER CREEK	4	80	7	10
6	81	OLD BRUCE HWY BRIDGE	4	80	1	12
7	49	CALLEMONDAH	4	80	15	34
8	95	FARMERS POINT	4	80	0	0
8	94	GATCOMBE ANCHORAGE	4	80	0	0
9	55	WAPPENTAKE CREEK	4	80	5	1
9	76	SOUTH TREES	4	80	13	11
9	90	CREMATORIUM POOL	4	80	16	9
10	48	OLD BOYNE	4	80	10	3
10	74	BOYNE HIGHWAY	4	80	51	0
11	OUTER HARBOUR NO SITES					
12	92	BROADACRES	4	80	13	8
12	91	IVERAGH	4	80	18	5
13	89	7 MILE CREEK	4	80	17	9
13	88	SANDY BRIDGE	4	80	27	5
13	87	OAKY CREEK	4	80	27	10
13	86	WORTHINGTON CREEK	4	80	7	2
		TOTAL	104	2080	248	196

Figure 11 shows the sites where Bream were recorded. Yellowfin Bream were recorded at 22 (84.6%) of the 26 sites. Pikey Bream were recorded at 19 (73.1%) sites. There were no sites surveyed in zone 11 (Outer Harbour) as there was no habitat suitable for juvenile Bream in that zone.

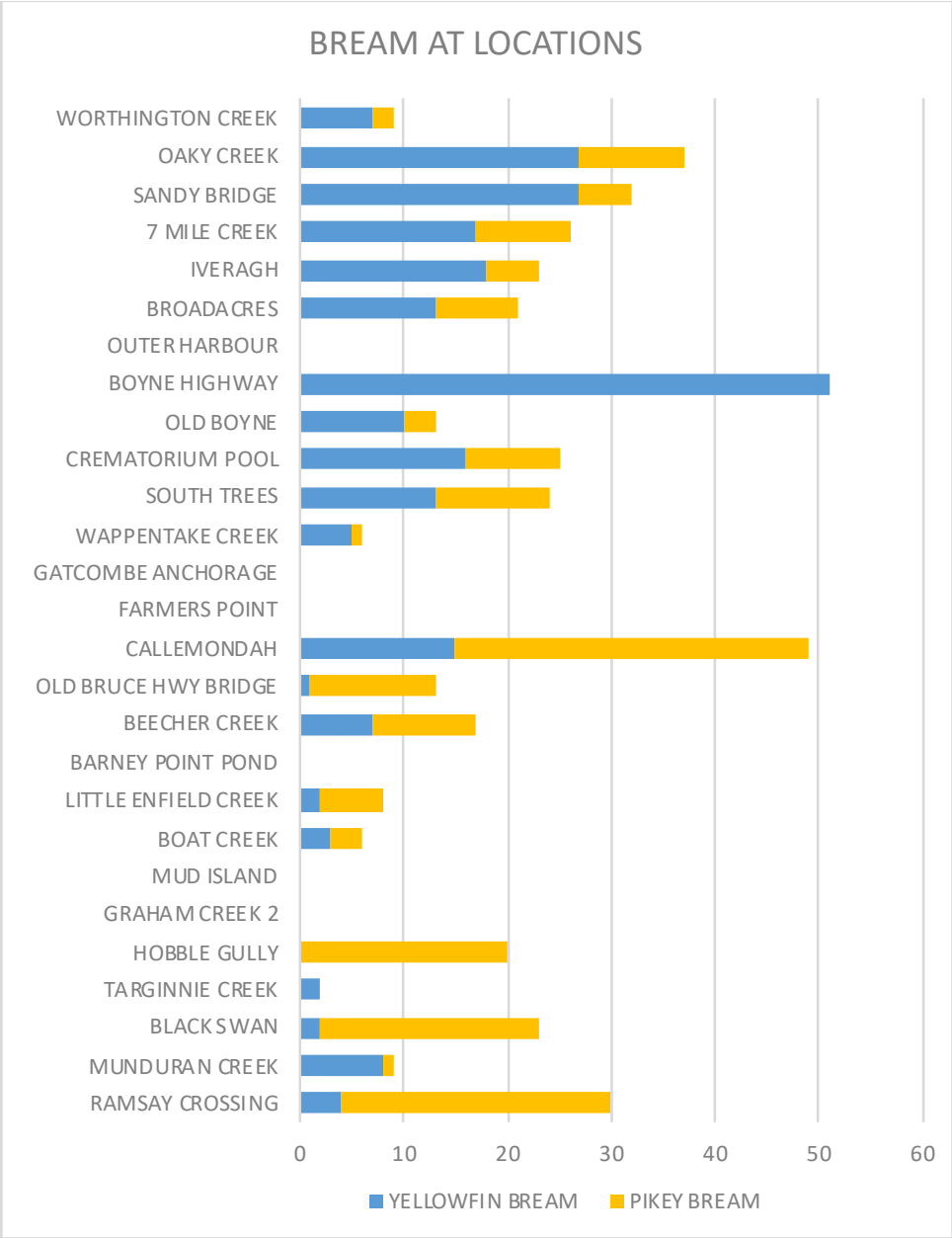

Figure 11: Numbers of Yellowfin and Pikey Bream recorded at each site in surveys from December 2017-March 2018

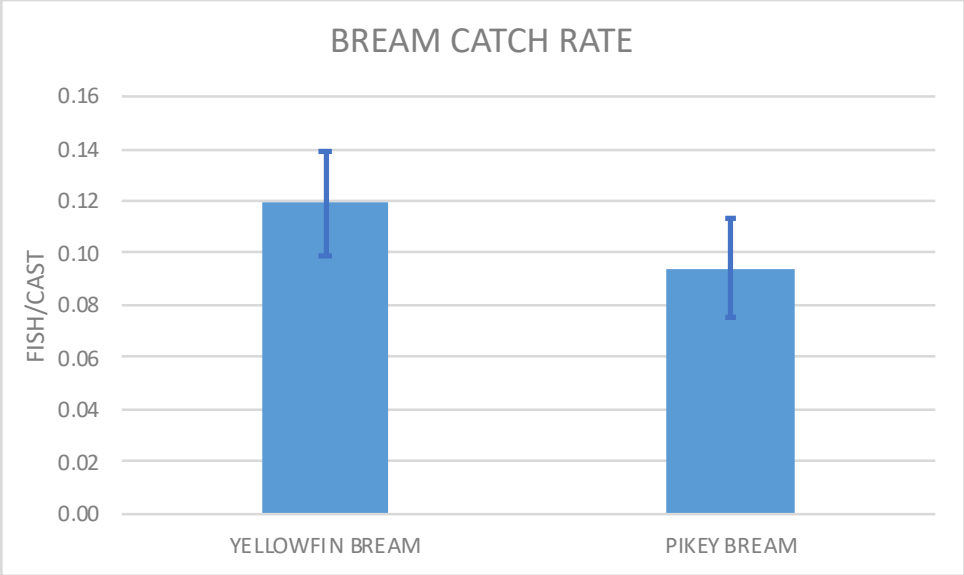

Figure 12: Mean catch rates with 95% confidence intervals for each Bream species

There was a total of 248 Yellowfin Bream and 196 Pikey Bream recorded. Over the whole survey period from December 2018-March 2019 the mean catch rate for Yellowfin Bream was 0.12 fish/cast and for Pikey Bream was 0.09 fish/cast as shown in Figure 12.

Figure 13 shows the numbers of Yellowfin and Pikey Bream recorded during the monthly surveys from December 2018-March 2019. The greatest number of Yellowfin Bream was 83 recorded in December while the least number was 35 in March. The greatest number of Pikey Bream was 65 recorded in February while the least number was 31 recorded in December.

Figure 14 shows the catch rate for each Bream species for each month's surveys. Surveys were undertaken around full moon tides as these provided the maximum opportunity for Bream recruits to move to all areas subject to tidal influence.

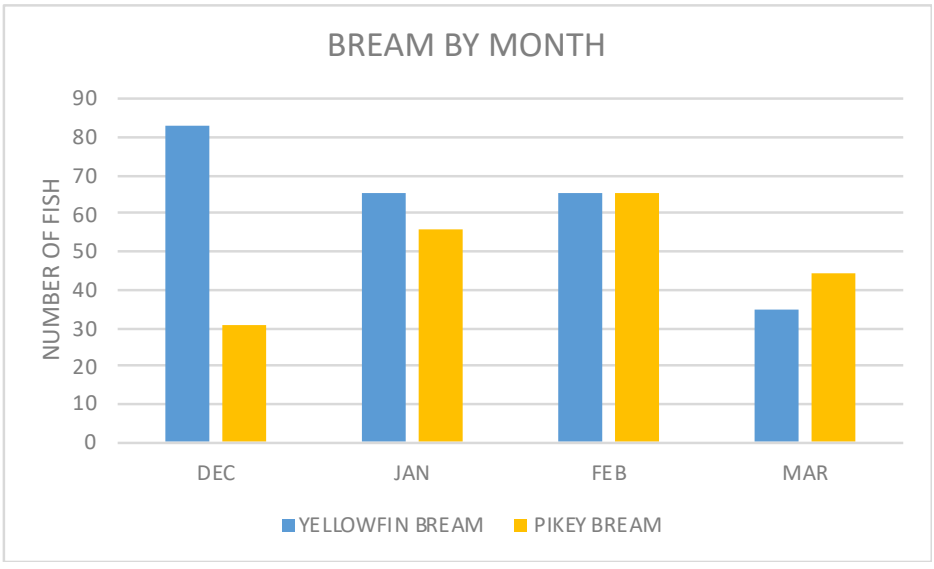

Figure 13: Numbers of Bream recorded during monthly surveys from December 2018-March 2019

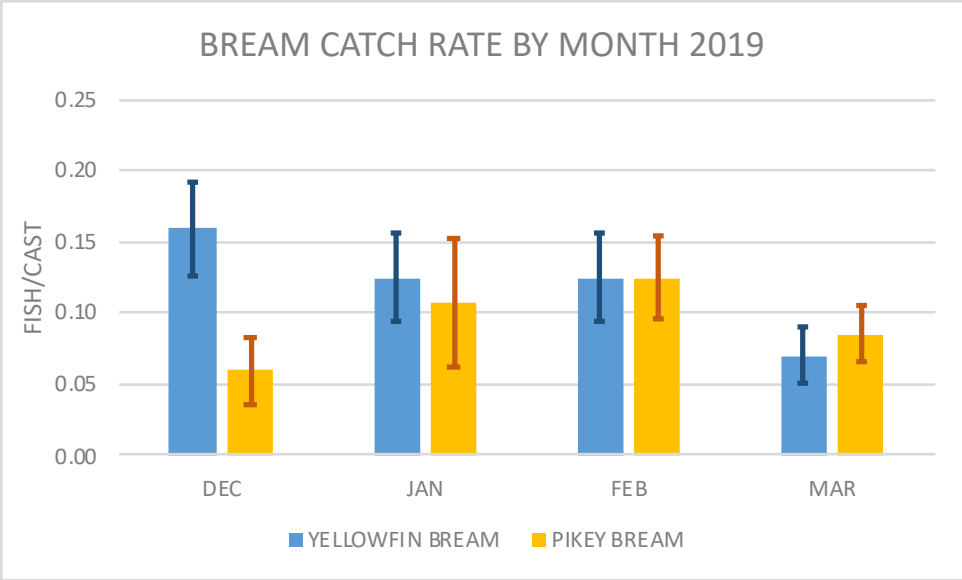

Figure 14: Mean catch rates with 95% confidence intervals for each Bream species for each of the monthly surveys

Figure 15 shows the timeline of the surveys showing fork length (mm) of Bream recorded during the monthly surveys.

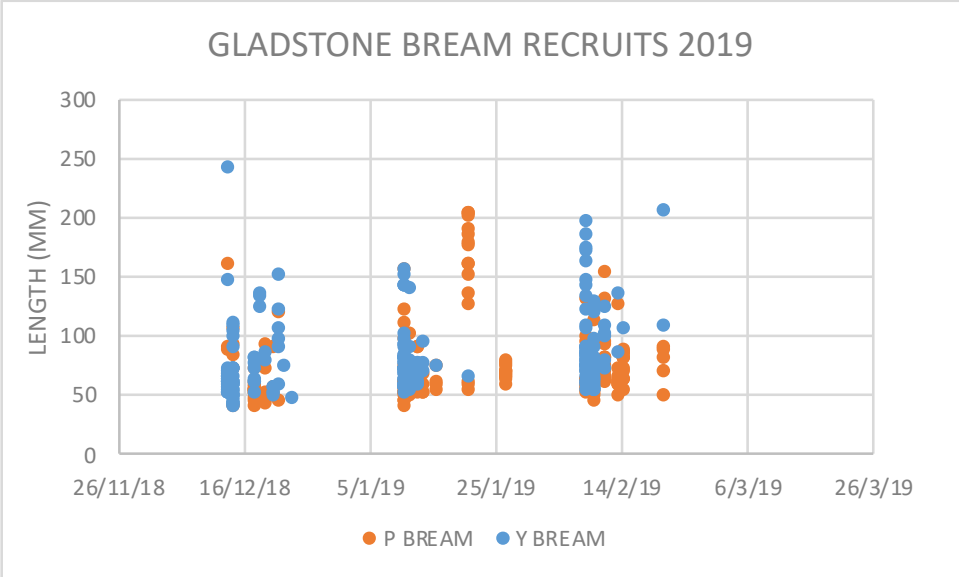

Figure 15: Timelines and fork lengths (mm) of Bream recorded during surveys

Figure 16 shows a typical Pikey Bream being measured. The smallest Yellowfin Bream recorded were 2 fish of 48mm (fork length) at Crematorium Pool and Iveragh in Mar 2019. The smallest Pikey Bream recorded was a fish of 48mm (fork length) at Old Boyne in March 2019. A summary of Bream sizes is presented in Appendix 3.

Figure 16: Typical Pikey Bream being measured

7. COMPARING RESULTS FROM 2016-2019

Table 3 provides a summary of the surveys and catch from 2016-2019. In 2017, 2018 and 2019 there were 104 surveys with 2,080 casts while in 2016 there were 103 surveys with 2,020 casts, 60 less than in the last 3 years. The figures (*) for 2016 were adjusted to 104 surveys with 2,080 casts to make the 4 years comparable.

The previous year shows the percentage of the total fish and prawn recorded each year compared with the previous year. For 2019 the total fish and prawn were down 21.4% compared with the 2018 total. For 2018 the total fish and prawn were down 11.4% compared with 2017. Figure 17 shows the total catch of fish and prawn for the 4 years.

The percentage of prawn in the 2019 catch was down to 14.3% while from 2016-2018 it was relatively stable ranging from 21.5% to 23.8%. However, the prawn catch for 2019 was down 47.7% compared with 2018.

Table 3: Summary of surveys and fish and prawn recorded from 2016-2019

YEAR	SURVEYS	CASTS	FISH	PRAWN	TOTAL	PREVIOUS YEAR	PRAWN PERCENT
2019	104	2080	5271	880	6151	-21.4%	14.3%
2018	104	2080	6142	1682	7824	-11.4%	21.5%
2017	104	2080	6774	2102	8876	*-0.4%*	23.8%
2016	103	2020	6786	1867	8653		21.6%
2016*	*104*	*2080*	*6988*	*1922*	*8910*		

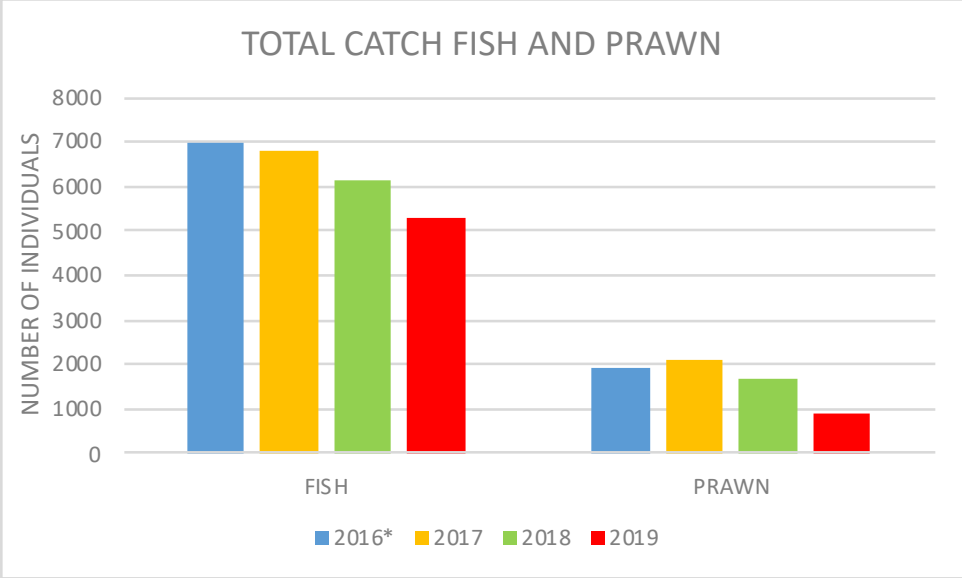

Figure 17: Comparison of total catch from 2016*-2019

The reduction in the catch is reflected in the number of "NIL" casts (no catch) in each of the survey years as shown in Figure 18. In 2016 and 2017 the percentage of nil casts was 27.8% while in 2018 it was slightly higher at 30.0%. In 2019 the percentage of nil casts rose to 39.1%.

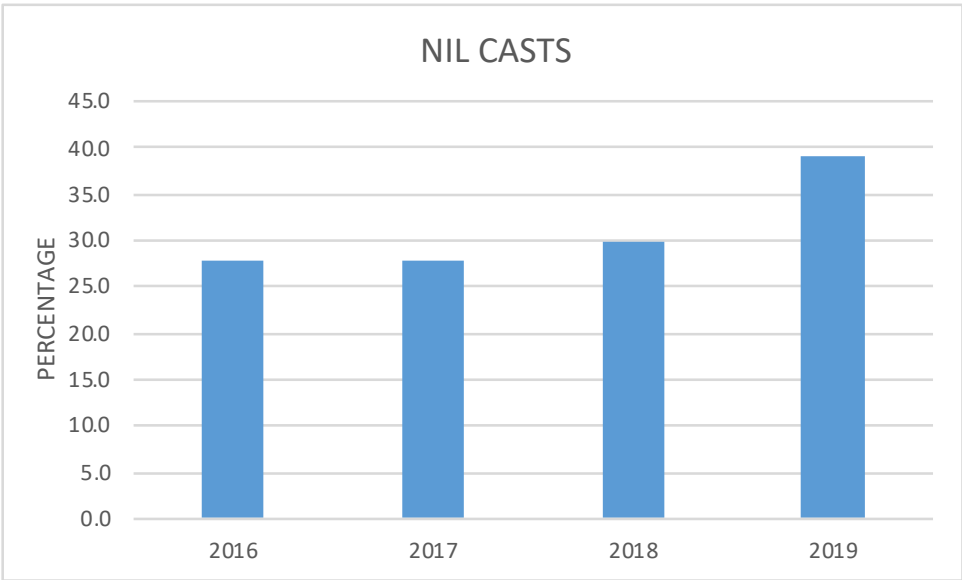

Figure 18: Percentage of NIL casts in each year from 2016-2019

Table 4 provides a summary of the Bream catch in surveys from 2016-2019. There was a total of 444 Bream (both species) in 2019 compared with 775 in 2018 and 910 in 2017. Yellowfin Bream were 55.9% of the Bream catch in 2019 while they were 44.6% in 2018, 63.1% in 2017 and 64.5% in 2016. Figure 19 shows the numbers of Bream in each year's surveys. The only year where the proportion of Pikey Bream exceeded Yellowfin Bream was 2018.

Table 4: Summary of surveys and the Bream catch from 2016-2019

YEAR	SURVEYS	CASTS	Y'FIN	PIKEY	TOTAL	PREVIOUS YEAR	Y'FIN PERCENT
2019	104	2080	248	196	444	-42.7%	55.9%
2018	104	2080	346	429	775	-14.8%	44.6%
2017	104	2080	574	336	910	*+75.3%*	63.1%
2016	103	2020	325	179	504		64.5%
2016*	*104*	*2080*	*335*	*184*	*519*		

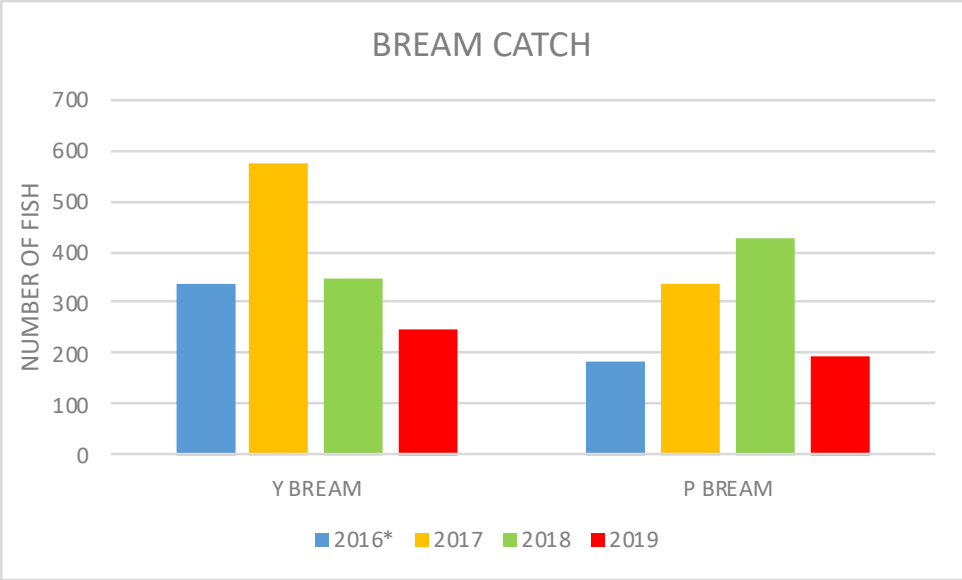

Figure 19: Comparison of Bream catch from 2016*-2019

Table 5 and Figure 20 show the number of sites where Bream were recorded each year. In 2018 Yellowfin Bream were recorded at 25 of the 26 sites while Pikey Bream were recorded at 23 sites. In 2019 Yellowfin Bream were recorded at 22 sites and Pikey Bream at 19 sites.

Table 5: Number of sites where Bream were recorded from 2016*-2019

SPECIES	2016	2017	2018	2019
YELLOWFIN BREAM	22	21	25	22
PIKEY BREAM	19	20	23	19

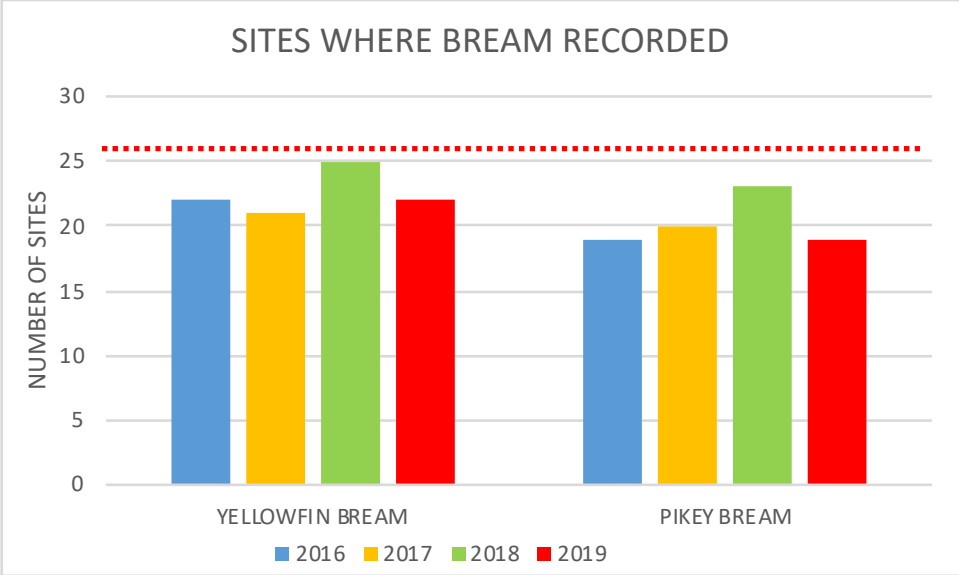

Figure 20: Sites where Bream were recorded 2016-2019 (dotted line total number of sites)

Figure 21 shows the Bream recruits recorded each year and the total rainfall (mm) recorded at the Gladstone Radar station 039123. Total rainfall from December 2018-March 2019 was 350.4mm however for January-February the rainfall was just 69.6mm. At many of the survey sites there was little or no freshwater input for most of the survey period.

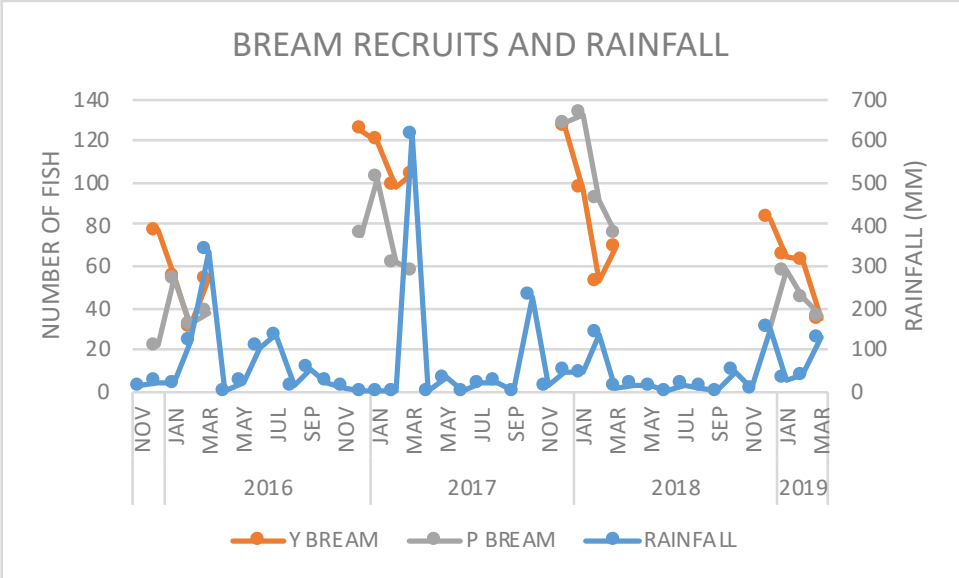

Figure 21: Bream recruits from 2016-2018 and rainfall from November 2015

8. OTHER SPECIES

There were 12 other species of recreational, commercial, indigenous or conservation importance that were recorded during surveys as shown in Table 5. Figure 22 shows the number of sites where the top 3 other species were recorded. Flattail Mullet was the only species recorded at all 26 sites each year. Banana Prawn was recorded at 18 sites in 2016 and 12 sites in 2019. Sea Mullet was recorded at 23 sites in 2016 and only 9 sites in 2019.

Table 6: Number of sites where other species recorded 2016-2018

SPECIES	2016	2017	2018	2019
BANANA PRAWN	18	17	17	12
FLATTAIL MULLET	26	26	26	26
SEA MULLET	23	12	16	9
GOLDENLINE WHITING	13	13	16	11
SAND WHITING	1	4	3	3
DUSKY FLATHEAD	6	10	9	8
BARTAIL FLATHEAD	1	4	7	1
BARRED JAVELIN	10	7	8	5
MANGROVE JACK	5	6	8	5
MUD CRAB	4	7	4	7
KING THREADFIN	0	0	2	1
BARRAMUNDI	2	0	1	1

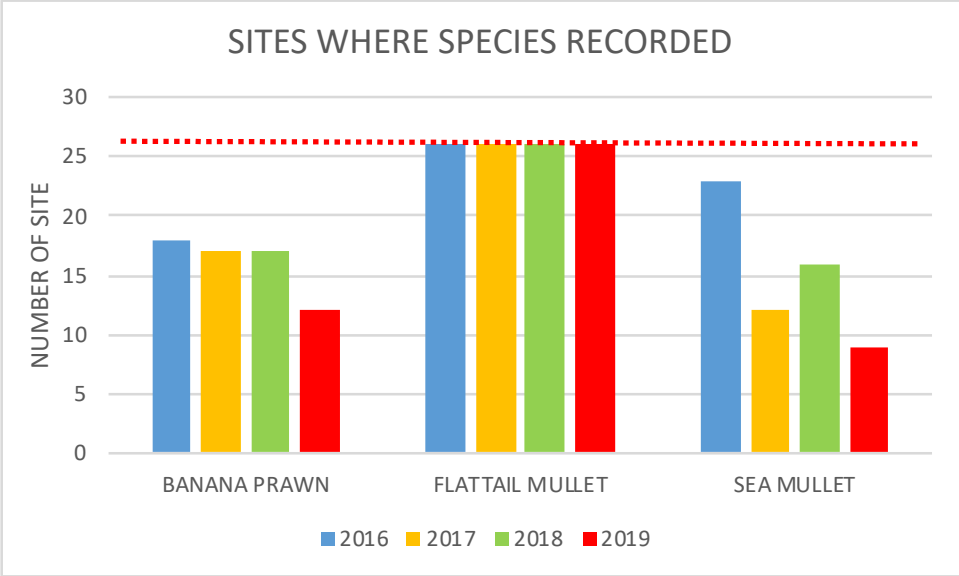

Figure 22: Sites where other species were recorded 2016-2019

For the other key species, the numbers recorded each year are shown in Table 7. Banana Prawn ranged from 2,102 in 2017 to 880 in 2019. Flattail Mullet ranged from 2,150 in 2016 to 1,449 in 2019. Sea Mullet ranged from 401 in 2016 to 82 in 2017. Figure 23 shows the numbers of key species recorded each year.

Table 7: Numbers of key species recorded in surveys from 2016-2019

SPECIES	2016	2017	2018	2019
BANANA PRAWN	1992	2102	1682	880
FLATTAIL MULLET	2150	1859	1665	1449
SEA MULLET	401	233	82	104
GOLDENLINE WHITING	168	130	120	57
SAND WHITING	3	11	8	4
DUSKY FLATHEAD	9	23	13	15
BARTAIL FLATHEAD	2	5	26	7
BARRED JAVELIN	42	47	25	19
MANGROVE JACK	8	15	20	8
MUD CRAB	6	31	10	18
KING THREADFIN	0	0	4	2
BARRAMUNDI	4	0	1	1

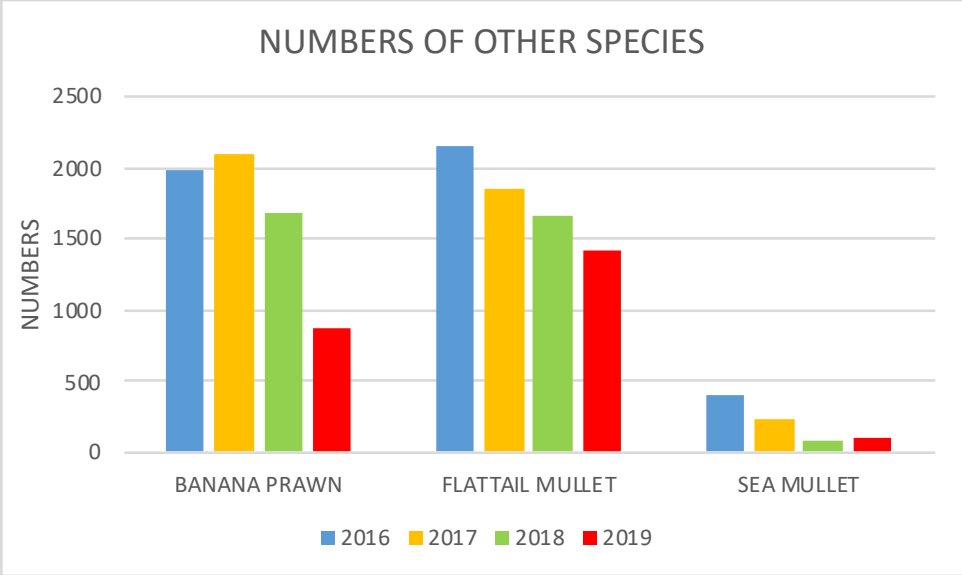

Figure 23: Numbers of other key species recorded from 2016-2019

9. DEVELOPING A RECRUITMENT INDEX

A random effects statistical model (negative binomial model) has been applied to the pooled data set going back to 2011-12. The model predicts the catch rate of Bream species by a number of independent variables, including sites and years. The random coefficients from the model for the sites are termed “BLUPs”, which stand for “Best Linear Unbiased Parameters”, and it is these that provide the basis for the calculation of a recruitment index.

The site main effects indicate how different sites are in Bream abundance. These are on a log scale so comparisons are in a proportional rather than a difference sense. 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 24 shows the BLUPs using data up to 17-18, (horizontal scale) and estimates using the full data set (vertical scale). The diagram is partitioned into zone cells to show the high degree of heterogeneity even within zones. It is this heterogeneity that complicates the production of fully justifiable scores at the zone level. The diagonal line in each panel indicates where the two estimates would be equal where the model predicts the same quantityy as the observed data. Points relatively distant from the line had the greatest change.

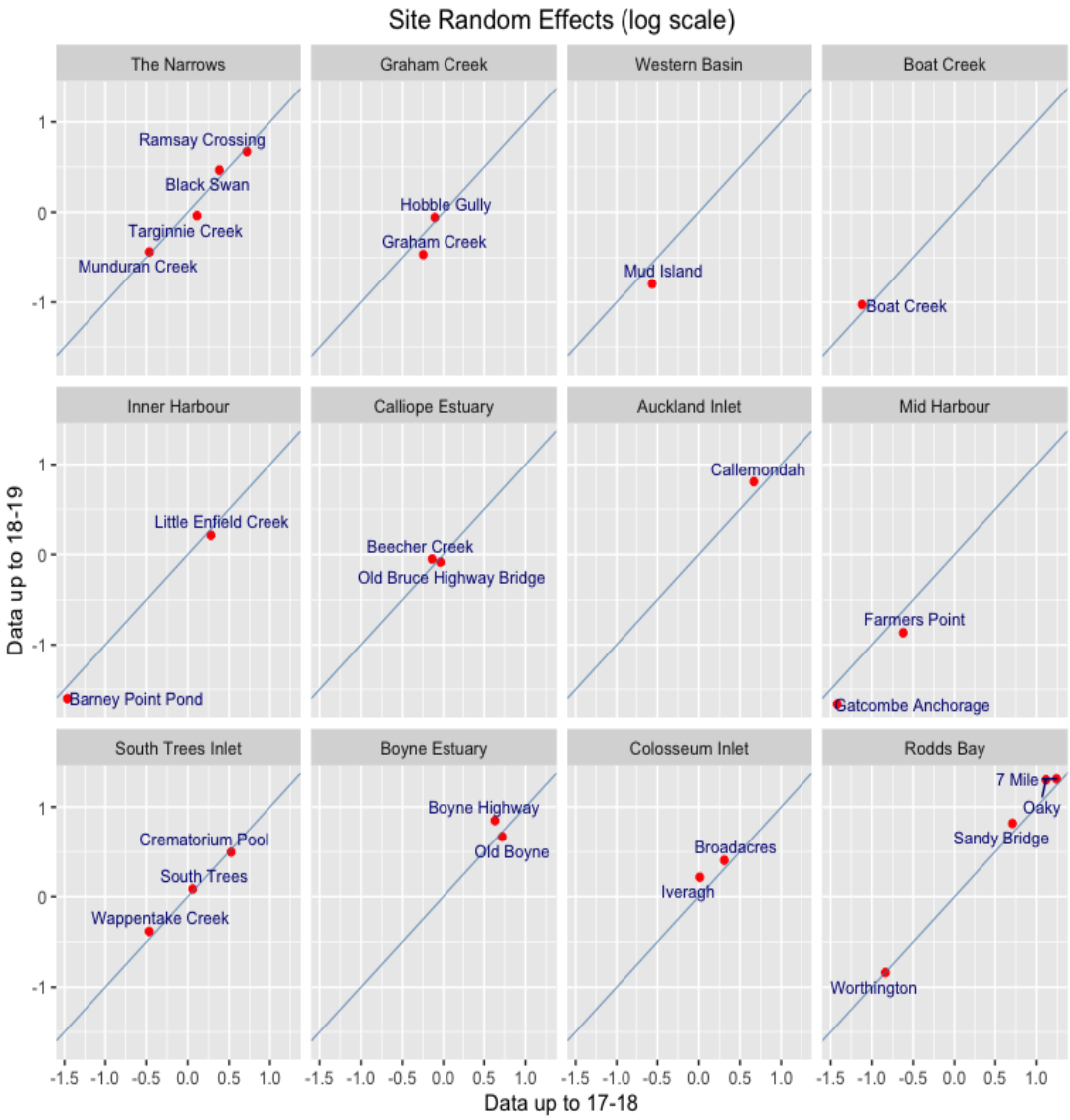

Figure 24: Site random effect estimates. A comparison of BLUPs using the restricted data set with those using the full data set.

Table 8 shows the site main effects for the combined year and year by site BLUP estimates for all years in the study, including the historic years. The year BLUP 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 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.

Table 8: Random effects estimates (BLUPs), 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
The Narrows	Ramsay Crossing					0.23	0.25	0.13	-0.49
	Munduran Creek	0.55	-0.29	-0.17	0.05	-0.11	0.31	0.06	-0.48

	Black Swan				0.25	-0.75	0.85	0.19	-0.26
	Targinnie Creek	0.27	-0.44		0.66	-0.44	0.37	0.39	-0.71
Graham Creek	Graham Creek				0.41	-0.19	0.11	0.52	-0.74
	Hobble Gully				0.03	-0.07	0.09	0.44	-0.31
Western Basin	Mud Island					-0.48	0.36	0.53	-0.56
Boat Creek	Boat Creek		-0.40	-0.09	0.41	-0.29	-0.04	0.19	-0.23
Inner Harbour	Little Enfield Creek				0.39	-0.26	0.29	0.36	-0.55
	Barney Point Pond		-0.36	-0.06	0.28	-0.33	0.11	0.25	-0.47
Calliope Estuary	Beecher Creek	0.50	-0.58	-0.12	0.20	-0.26	0.33	0.06	-0.14
	Old Bruce Highway Bridge				-0.10	-0.25	0.36	0.68	-0.52
Auckland Inlet	Callemondah	0.10	-0.74	-0.24	0.11	-0.12	0.51	0.51	0.02
Mid Harbour	Farmers Point					-0.57	0.83	0.25	-0.66
	Gatcombe Anchorage					-0.12	0.09	0.26	-0.53
South Trees Inlet	Wappentake Creek		-0.41	-0.07	0.05	-0.29	0.15	0.43	-0.22
	South Trees					-0.12	0.15	0.35	-0.36
	Crematorium Pool					-0.20	0.61	0.15	-0.48
Boyne Estuary	Old Boyne	0.33	-0.22		0.23	0.00	0.34	0.08	-0.53
	Boyne Highway				0.04	-0.04	0.32	0.05	-0.02
Colosseum Inlet	Broadacres					-0.29	0.18	0.39	-0.21
	Iveragh					-0.07	0.29	-0.08	-0.09
Rodds Bay	Oaky					-0.10	0.25	0.15	-0.07
	7 Mile					-0.08	0.24	0.33	-0.25
	Worthington					-0.22	0.32	0.12	-0.38

	Sandy Bridge					-0.05	0.48	-0.05	-0.23

The BLUPs are transformed into scores by dividing by their standard deviation and finding the cumulative probability in the standard normal distribution. The results are shown in Table 9.

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
The Narrows	Ramsay Crossing					0.68	0.69	0.61	0.16
	Munduran Creek	0.87	0.28	0.37	0.54	0.41	0.74	0.55	0.16
	Black Swan				0.70	0.06	0.96	0.65	0.30
	Targinnie Creek	0.71	0.19		0.91	0.18	0.77	0.79	0.07
Graham Creek	Graham Creek				0.80	0.35	0.59	0.86	0.07
	Hobble Gully				0.52	0.44	0.58	0.82	0.27
Western Basin	Mud Island					0.17	0.77	0.86	0.13
Boat Creek	Boat Creek		0.21	0.43	0.80	0.27	0.47	0.65	0.32
Inner Harbour	Little Enfield Creek				0.79	0.30	0.72	0.77	0.13
	Barney Point Pond		0.23	0.45	0.72	0.25	0.59	0.69	0.17
Calliope Estuary	Beecher Creek	0.85	0.12	0.40	0.66	0.29	0.75	0.55	0.39
	Old Bruce Highway Bridge				0.42	0.30	0.77	0.92	0.14
Auckland Inlet	Callemondah	0.58	0.06	0.31	0.59	0.40	0.85	0.85	0.52
Mid Harbour	Farmers Point					0.12	0.95	0.70	0.09
	Gatcombe Anchorage					0.40	0.57	0.70	0.14
South Trees Inlet	Wappentake Creek		0.20	0.44	0.54	0.28	0.62	0.81	0.33
	South Trees					0.40	0.62	0.76	0.23
	Crematorium Pool					0.34	0.89	0.62	0.17
Boyne Estuary	Old Boyne	0.75	0.32		0.68	0.50	0.75	0.56	0.14
	Boyne Highway				0.53	0.47	0.74	0.54	0.49

Colosseum Inlet	Broadacres	0.28	0.64	0.79	0.33
	Iveragh	0.44	0.72	0.43	0.42
Rodds Bay	Oaky	0.42	0.70	0.62	0.44
	7 Mile	0.43	0.69	0.75	0.30
	Worthington	0.33	0.74	0.60	0.22
	Sandy Bridge	0.46	0.84	0.46	0.32

Scores were aggregated to the zone level within years by averaging, as required for reporting purposes, and further aggregated by averaging to all of harbour. The results of this averaging process are 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 of harbour

Zone	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19
The Narrows	0.79	0.23	0.37	0.72	0.33	0.79	0.65	0.17
Graham Creek				0.66	0.39	0.58	0.84	0.17
Western Basin					0.17	0.77	0.86	0.13
Boat Creek		0.21	0.43	0.80	0.27	0.47	0.65	0.32
Inner Harbour		0.23	0.45	0.75	0.27	0.66	0.73	0.15
Calliope Estuary	0.85	0.12	0.40	0.54	0.30	0.76	0.73	0.27
Auckland Inlet	0.58	0.06	0.31	0.59	0.40	0.85	0.85	0.52
Mid Harbour					0.26	0.76	0.70	0.11
South Trees Inlet		0.20	0.44	0.54	0.34	0.71	0.73	0.24
Boyne Estuary	0.75	0.32		0.61	0.49	0.75	0.55	0.31
Colosseum Inlet					0.36	0.68	0.61	0.38
Rodds Bay					0.41	0.74	0.61	0.32
All of Gladstone Harbour	0.74	0.20	0.40	0.65	0.33	0.71	0.71	0.26

Table 11: Alphabetic grades for (unadjusted) averaged scores over sites within zones and over all of harbour

Zone	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19
The Narrows	B	E	D	B	D	B	C	E
Graham Creek				B	D	C	B	E
Western Basin					E	B	A	E
Boat Creek		E	D	B	D	D	C	D
Inner Harbour		E	D	B	D	B	B	E
Calliope Estuary	B	E	D	C	D	B	B	D
Auckland Inlet	C	E	D	C	D	A	A	C

Mid Harbour					D	B	B	E
South Trees Inlet		E	D	C	D	B	B	E
Boyne Estuary	B	D		C	D	B	C	D
Colosseum Inlet					D	B	C	D
Rodds Bay					D	B	C	D
All of Gladstone Harbour	B	E	D	B	D	B	B	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 25 show the original scores for the 12 scores zones, and all of harbour, together with their lower and upper uncertainty limits as calculated by the bootstrap simulation method.

Table 12: Estimates and bootstrap uncertainty intervals

Zone	Score	2.5%	97.5%
The Narrows	0.1724	0.0692	0.3044
Graham Creek	0.1660	0.0277	0.3122
Western Basin	0.1252	0.0491	0.2424
Boat Creek	0.3159	0.0690	0.6125
Inner Harbour	0.1506	0.0783	0.2524
Calliope Estuary	0.2672	0.1662	0.3800
Auckland Inlet	0.5150	0.2284	0.7571
Mid Harbour	0.1130	0.0527	0.1991
South Trees Inlet	0.2408	0.1149	0.3720
Boyne Estuary	0.3123	0.1856	0.4451
Colosseum Inlet	0.3790	0.1945	0.5390
Rodds Bay	0.3202	0.2038	0.4317
All of Harbour	0.2565	0.1729	0.3259

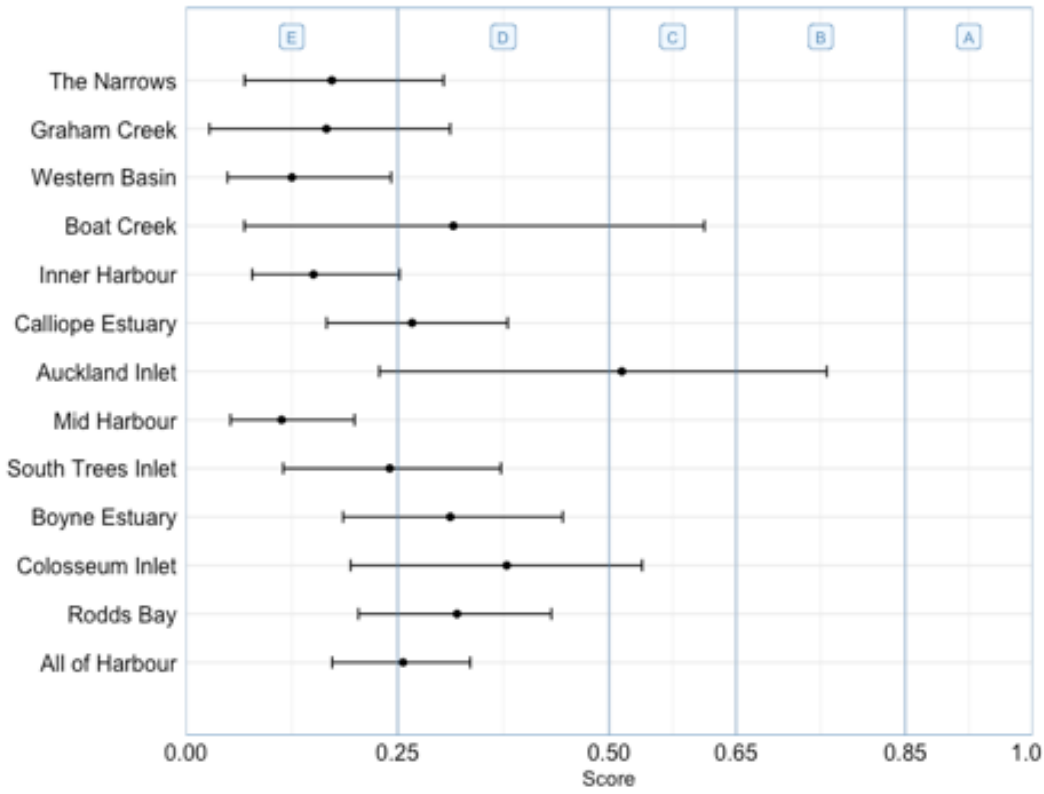

Figure 25: Estimates and bootstrap uncertainty intervals

10. DISCUSSION

The overall result for Gladstone Harbour was D with most sites recording D or E. This was in line with expectations based on the climatic conditions. During the survey months there was little or no freshwater flow at most sites with low rainfall at Gladstone Aero of 69.6mm for the whole of January and February.

This resulted in an increase in nil casts to 39.1%, a fall in the total number of individuals recorded and a fall in Banana Prawn in particular by 47.7% compared with 2018. This also resulted in a fall in Bream recorded by 42.7% compared with 2018. The overall grade for the harbour should not be viewed as a deterioration in the habitat of Gladstone Harbour as it may be a response to the prevailing climatic conditions. Further investigations would be required to determine the extent of this relationship.

In 2018 there were more Pikey Bream recorded than Yellowfin Bream. This was different to 2016 and 2017 when Yellowfin exceed the number of Pikey Bream. In 2019 more Yellowfin Bream were recorded again. This year Pikey Bream dominated at sites north of Gladstone while Yellowfin Bream dominated at sites to the south. This may be influenced by Rockhampton[1] being the southern limit of the range of Pikey Bream.

11. REFERENCES

Sawynok B and Venables B (2016): Developing a fish recruitment indicator for the Gladstone Harbour Report Card using data derived from castnet sampling: http://infofishaustralia.com.au/gladstone/

Sawynok B and Venables B (2017): Fish recruitment indicators for the Gladstone Harbour Report Card using data derived from castnet sampling 2017 http://infofishaustralia.com.au/gladstone

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Sawynok, W., W. N. Venables, and U. Pinto. 2017. "Incorporating a Fish Recruitment Indicator into the Gladstone Harbour Report Card." *PLOS 1*, (Submitted)

[1] From https://www.daf.qld.gov.au/fish-identification-information/fish-species-guide/fish-species-id-info/profile?fish-id=pikey-bream

APPENDIX 1 – SURVEY SITES

A summary of sites and site details, as stored in the Infofish 2018 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).

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	Q33
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	96	MUD ISLAND	-23.815	151.22	GLD	BZ10
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	I8
6	81	OLD BRUCE HIGHWAY BRIDGE	-23.964	151.154	CR02	P4
7	49	CALLEMONDAH	-23.862	151.232	GLD	D11
8	95	FARMERS POINT	-23.774	151.33	GLD	FZ21
8	94	GATCOMBE ANCHORAGE	-23.876	151.365	GLD	F25
9	55	WAPPENTAKE CREEK	-23.89	151.282	BRG	H16
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	H18
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	AD21

APPENDIX 2 - SPECIES

List of species recorded using standard name, scientific name, number of sites, and number of fish recorded in surveys from Dec-Mar. Species with a question mark are those where the identification was uncertain.

STANDARD NAME	SCIENTIFIC NAME	SITES	NUMBER
Mullet – Flattail	*Liza dussumieri*	26	1449
Prawn – Banana	*Fenneropenaeus indicus*	12	880
Silverbiddy – Common	*Gerres subfasciatus*	26	718
Glassfish – Estuary	*Ambassis marianus*	19	611
Ponyfish – Common	*Leiognathus equulus*	19	384
Herring – Southern	*Herklotsichthys castelnaui*	14	375
Bream – Yellowfin	*Acanthopagrus australis*	22	248
Bream – Bony	*Nematalosa erebi*	14	211
Bream – Pikey	*Acanthopagrus berda*	19	196
Toadfish – Common	*Tetractenos hamiltoni*	11	164
Rabbitfish – Goldlined	*Siganus lineatus*	16	139
Scat – Striped	*Selenotoca multifasciata*	7	117
Mullet – Sea	*Mugil cephalus*	9	104
Grunter – Barred	*Terapon jarbua*	17	85
Whiting – Goldenline	*Sillago analis*	13	57
Mullet – Sand	*Valamugil seheli*	1	49
Silverbiddy – Threadfin	*Gerres filamentosus*	10	41
Hardyhead – Common	*Atherinomorus vaigiensis*	1	36
Herring - Hairtail	*Nematalosa*	2	34
Diamondfish	*Monodactylus argenteus*	7	28
Tarwhine	*Rhabdosargus sarba*	6	24
Sole – Black?	*Brachinus nigra*	6	22
Anchovy spp		4	22
Javelin – Barred	*Pomadasys kaakan*	5	20
Mullet - Diamondscale	*Liza vaigiensis*	3	19
Crab – Mud	*Scylla serrata*	7	18
Snapper – Moses	*Lutjanus russellii*	6	17
Flathead – Dusky	*Platycephalus fuscus*	8	15
Mangrove Jack	*Lutjanus argentimaculatus*	5	8
Flathead – Bartail	*Platycephalus indicus*	1	7
Shrimp – Freshwater	*Macrobrachium spp*	2	5
Whiting – Sand	*Sillago ciliata*	3	4
Whiting – Winter	*Sillago maculata*	1	4
Ponyfish spp	*Leiognathus spp*	2	3
Steelback	*Leptobrama muelleri*	3	3
Mullet – Goldspot	*Liza argentea*	1	2
Herring – Giant	*Elops machnata*	1	2

Stingray spp		1	2
Herring – Mud		1	2
Threadfin – King	*Polydactylus macrochir*	1	2
Gudgeon spp		3	2
Garfish spp		2	2
Queenfish – Giant	*Scomeroides commersonnianus*	1	1
Garfish – River	*Hypohamphus regularis*	1	1
Yabby – Saltwater spp		1	1
Stonefish – Estuarine	*Synanceia horrida*	1	1
Garfish – Snubnose	*Arrhamphus scleolepis*	1	1
Trevally spp		1	1
Goby – Greenspotted	*Acentrogobius viridipunctatus*	1	1
Javelin – Speckled	*Pomadasys argenteus*	1	1
Barramundi	*Lates calcarifer*	1	1
Blubberlips – Brown	*Plectorhinchus gibbosus*	1	1
Wrasse spp		1	1
Crab spp		1	1
Unknown		1	1

APPENDIX 3 – BREAM SIZE PROFILE

Figure 26 and Table 13 show the size distribution of the Bream catch, by species, for each of the four months of the survey and for all of harbour.

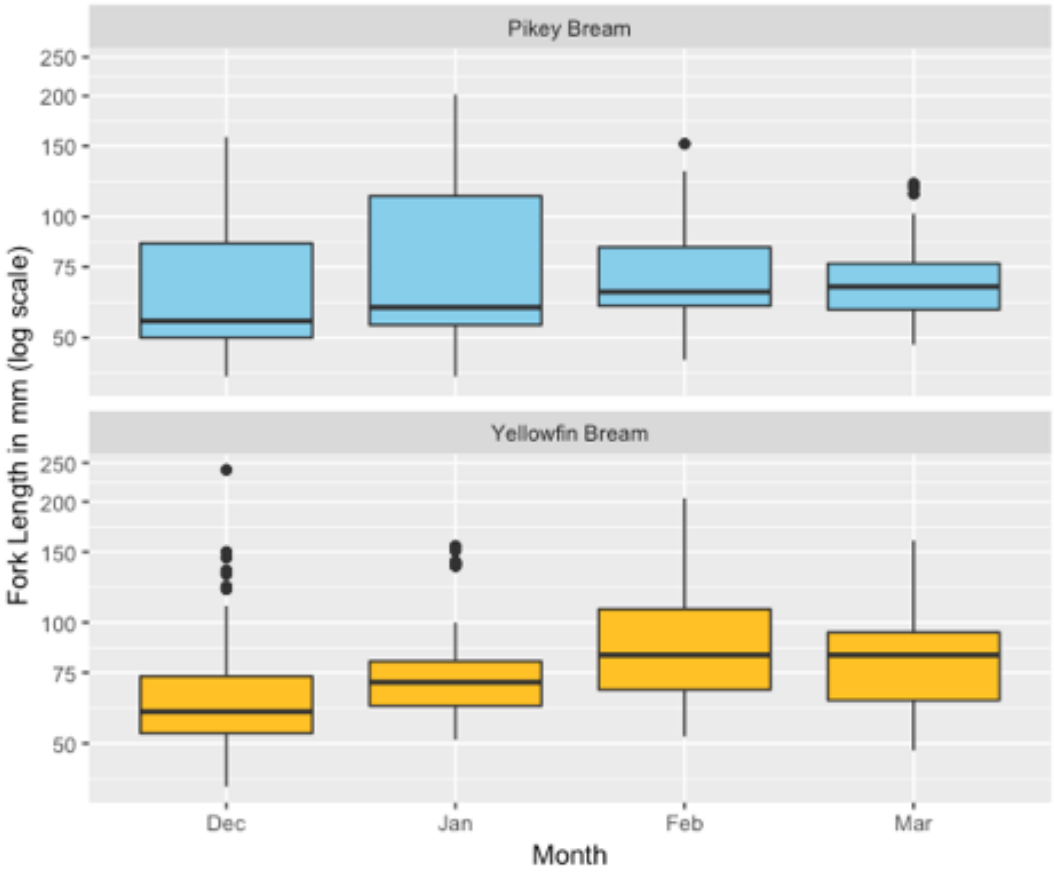

Figure 26: Fork Length change at the harbour level over the data collection period

Table 13: Bream size distribution summary statistics: Fork Length (mm)

Species	Month	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
Pikey Bream	Dec	40	50.00	55.0	66.74	86.00	158
	Jan	40	53.75	59.5	87.36	112.75	202
	Feb	44	60.00	65.0	73.15	84.00	152
	Mar	48	58.75	67.0	70.39	76.50	121
Yellowfin Bream	Dec	39	53.00	60.0	70.16	73.50	240
	Jan	51	62.00	71.0	77.46	80.00	155
	Feb	52	68.00	83.0	93.37	108.00	204
	Mar	48	64.00	83.0	86.94	94.50	160

APPENDIX 4 – CATCH AND EFFORT DATA

Table 14: 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
The Narrows	Ramsay Crossing					50	80	80	80
	Munduran Creek	60	60	80	100	100	80	80	80
	Black Swan				80	80	80	80	80
	Targinnie Creek	10	10		80	80	80	80	80
Graham Creek	Graham Creek				20	60	80	80	80
	Hobble Gully				80	80	80	80	80
Western Basin	Mud Island					100	80	80	80
Boat Creek	Boat Creek		10	80	75	80	80	80	80
Inner Harbour	Little Enfield Creek				100	80	80	80	80
	Barney Point Pond		80	100	100	80	80	80	80
Calliope Estuary	Beecher Creek	50	70	80	100	80	80	80	80
	Old Bruce Highway Bridge				50	80	80	80	80
Auckland Inlet	Callemondah	50	70	100	100	80	80	80	80
Mid Harbour	Farmers Point					90	80	80	80
	Gatcombe Anchorage					100	80	80	80
South Trees Inlet	Wappentake Creek		70	60	100	80	80	80	80
	South Trees					90	80	80	80
	Crematorium Pool					100	80	80	80
Boyne Estuary	Old Boyne	20	20		100	80	80	80	80
	Boyne Highway				40	80	80	80	80
Colosseum Inlet	Broadacres					100	80	80	80
	Iveragh					100	80	80	80
Rodds Bay	Oaky					100	80	80	80
	7 Mile					100	80	80	80
	Worthington					100	80	80	80
	Sandy Bridge					100	80	80	80

Table 15: 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
The Narrows	Ramsay Crossing					56	48	56	26
	Munduran Creek	0	0	2	0	0	0	0	1
	Black Swan				25	1	77	22	21
	Targinnie Creek	0	0		0	0	2	6	0
Graham Creek	Graham Creek				3	2	8	24	0
	Hobble Gully				21	30	24	53	20
Western Basin	Mud Island					0	3	8	0
Boat Creek	Boat Creek		0	0	5	2	1	2	3
Inner Harbour	Little Enfield Creek				30	13	24	30	6
	Barney Point Pond		0	2	1	0	0	1	0
Calliope Estuary	Beecher Creek	0	0	0	1	1	2	0	10
	Old Bruce Highway Bridge				0	10	37	12	12
Auckland Inlet	Callemondah	2	0	12	17	15	43	57	34
Mid Harbour	Farmers Point					0	0	3	0
	Gatcombe Anchorage					2	1	0	0
South Trees Inlet	Wappentake Creek		0	1	1	1	1	1	1
	South Trees					11	16	44	11
	Crematorium Pool					1	0	14	9
Boyne Estuary	Old Boyne	2	0		4	1	0	6	3
	Boyne Highway				0	1	0	1	0
Colosseum Inlet	Broadacres					2	12	31	8
	Iveragh					2	3	1	5
Rodds Bay	Oaky					13	12	13	10
	7 Mile					23	16	35	9
	Worthington					1	4	5	2
	Sandy Bridge					0	2	4	5

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

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

Table 18: 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
The Narrows	Ramsay Crossing					22.40	12.00	14.00	6.50
	Munduran Creek	0.0	0	0.50	0.00	0.00	0.00	0.00	0.25
	Black Swan				6.25	0.25	19.25	5.50	5.25
	Targinnie Creek	0.0	0		0.00	0.00	0.50	1.50	0.00
Graham Creek	Graham Creek				3.00	0.67	2.00	6.00	0.00
	Hobble Gully				5.25	7.50	6.00	13.25	5.00
Western Basin	Mud Island					0.00	0.75	2.00	0.00
Boat Creek	Boat Creek		0	0.00	1.33	0.50	0.25	0.50	0.75
Inner Harbour	Little Enfield Creek				6.00	3.25	6.00	7.50	1.50
	Barney Point Pond		0	0.40	0.20	0.00	0.00	0.25	0.00
Calliope Estuary	Beecher Creek	0.0	0	0.00	0.20	0.25	0.50	0.00	2.50
	Old Bruce Highway Bridge				0.00	2.50	9.25	3.00	3.00
Auckland Inlet	Callemondah	0.8	0	2.40	3.40	3.75	10.75	14.25	8.50
Mid Harbour	Farmers Point					0.00	0.00	0.75	0.00
	Gatcombe Anchorage					0.40	0.25	0.00	0.00
South Trees Inlet	Wappentake Creek		0	0.33	0.20	0.25	0.25	0.25	0.25
	South Trees					2.44	4.00	11.00	2.75
	Crematorium Pool					0.20	0.00	3.50	2.25
Boyne Estuary	Old Boyne	2.0	0		0.80	0.25	0.00	1.50	0.75
	Boyne Highway				0.00	0.25	0.00	0.25	0.00
Colosseum Inlet	Broadacres					0.40	3.00	7.75	2.00
	Iveragh					0.40	0.75	0.25	1.25
Rodds Bay	Oaky					2.60	3.00	3.25	2.50
	7 Mile					4.60	4.00	8.75	2.25
	Worthington					0.20	1.00	1.25	0.50
	Sandy Bridge					0.00	0.50	1.00	1.25

Table 19: 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
The Narrows	Ramsay Crossing					2.40	5.50	2.25	1.00
	Munduran Creek	11.0	4.33	2.50	4.00	4.60	7.25	3.75	2.00
	Black Swan				1.00	0.00	4.25	1.00	0.50
	Targinnie Creek	4.0	0.00		9.50	1.25	5.25	5.25	0.50
Graham Creek	Graham Creek				4.00	1.67	0.00	0.00	0.00
	Hobble Gully				0.25	0.50	0.00	0.50	0.00
Western Basin	Mud Island					0.00	0.75	0.50	0.00
Boat Creek	Boat Creek		0.00	1.25	1.07	0.25	0.00	1.00	0.75
Inner Harbour	Little Enfield Creek				1.40	0.25	1.00	0.25	0.50
	Barney Point Pond		0.25	0.00	0.40	0.00	0.00	0.25	0.00
Calliope Estuary	Beecher Creek	7.2	0.86	2.75	3.60	2.25	5.00	3.00	1.75
	Old Bruce Highway Bridge				3.60	2.75	2.00	19.0	0.25
Auckland Inlet	Callemondah	3.6	1.43	2.60	5.00	4.00	8.75	5.00	3.75
Mid Harbour	Farmers Point					0.00	6.50	1.50	0.00
	Gatcombe Anchorage					0.40	0.00	1.00	0.00
South Trees Inlet	Wappentake Creek		0.57	0.67	0.60	0.50	0.75	2.50	1.25
	South Trees					3.78	3.75	2.75	3.25
	Crematorium Pool					10.0	30.8	8.75	4.00
Boyne Estuary	Old Boyne	8.0	6.00		7.00	8.50	10.5	5.00	2.50
	Boyne Highway				5.00	10.5	12.3	7.25	12.8
Colosseum Inlet	Broadacres					3.40	2.75	2.25	3.25
	Iveragh					4.60	5.00	2.00	4.50
Rodds Bay	Oaky					4.60	6.25	3.75	6.75
	7 Mile					3.00	4.75	1.50	4.25
	Worthington					2.20	3.50	2.00	1.75
	Sandy Bridge					9.40	17.0	4.50	6.75

Table 20: 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
The Narrows	Ramsay Crossing					24.8	17.5	16.3	7.50
	Munduran Creek	11.0	4.33	3.0	4.00	4.60	7.25	3.75	2.25
	Black Swan				7.25	0.25	23.5	6.50	5.75
	Targinnie Creek	4.0	0.00		9.50	1.25	5.75	6.75	0.50
Graham Creek	Graham Creek				7.00	2.33	2.00	6.00	0.00
	Hobble Gully				5.50	8.00	6.00	13.8	5.00
Western Basin	Mud Island					0.00	1.50	2.50	0.00
Boat Creek	Boat Creek		0.00	1.3	2.40	0.75	0.25	1.50	1.50
Inner Harbour	Little Enfield Creek				7.40	3.50	7.00	7.75	2.00
	Barney Point Pond		0.25	0.4	0.60	0.00	0.00	0.50	0.00
Calliope Estuary	Beecher Creek	7.2	0.86	2.8	3.80	2.50	5.50	3.00	4.25
	Old Bruce Highway Bridge				3.60	5.25	11.3	22.0	3.25
Auckland Inlet	Callemondah	4.4	1.43	5.0	8.40	7.75	19.5	19.3	12.3
Mid Harbour	Farmers Point					0.00	6.50	2.25	0.00
	Gatcombe Anchorage					0.80	0.25	1.00	0.00
South Trees Inlet	Wappentake Creek		0.57	1.0	0.80	0.75	1.00	2.75	1.50
	South Trees					6.22	7.75	13.8	6.00
	Crematorium Pool					10.2	30.8	12.3	6.25
Boyne Estuary	Old Boyne	10.0	6.00		7.80	8.75	10.5	6.50	3.25
	Boyne Highway				5.00	10.8	12.3	7.50	12.8
Colosseum Inlet	Broadacres					3.80	5.75	10.0	5.25
	Iveragh					5.00	5.75	2.25	5.75
Rodds Bay	Oaky					7.20	9.25	7.00	9.25
	7 Mile					7.60	8.75	10.3	6.50
	Worthington					2.40	4.50	3.25	2.25
	Sandy Bridge					9.40	17.5	5.50	8.00

Figure 27 shows the total Bream CPUE per site for survey year 2018-19 plotted against the same total Bream CPUE per site for survey year 2018-19, partitioned into recording zones. Points above the diagonal line correspond to sites whose CPUE increased in 2018-19 from what it was in 2017-18, and points below the line to those for which CPUE decreased.

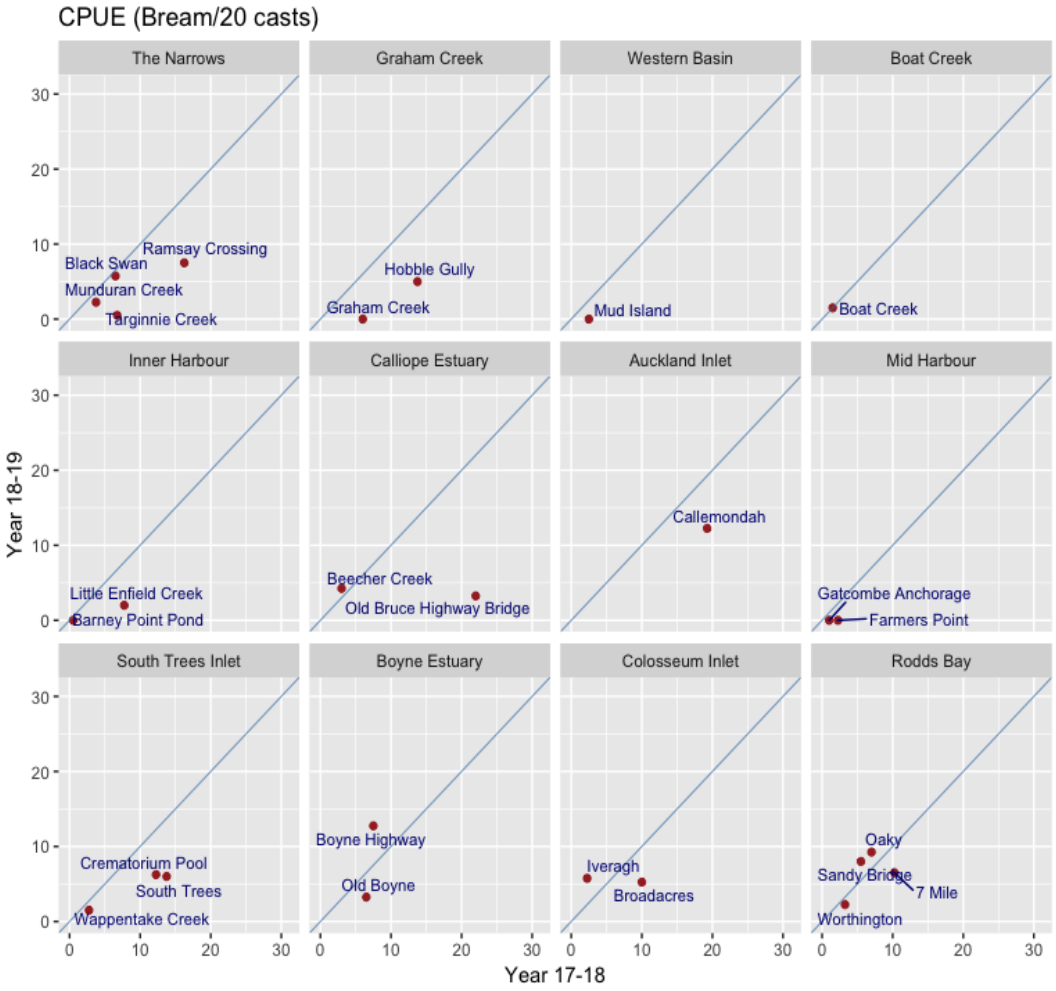

Figure 27: Bream CPUE for 2018-19 against CPUE for 2017-18 per site partitioned into recording zones