Performance of Queensland's net-free zones

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Queensland Government

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Executive summary

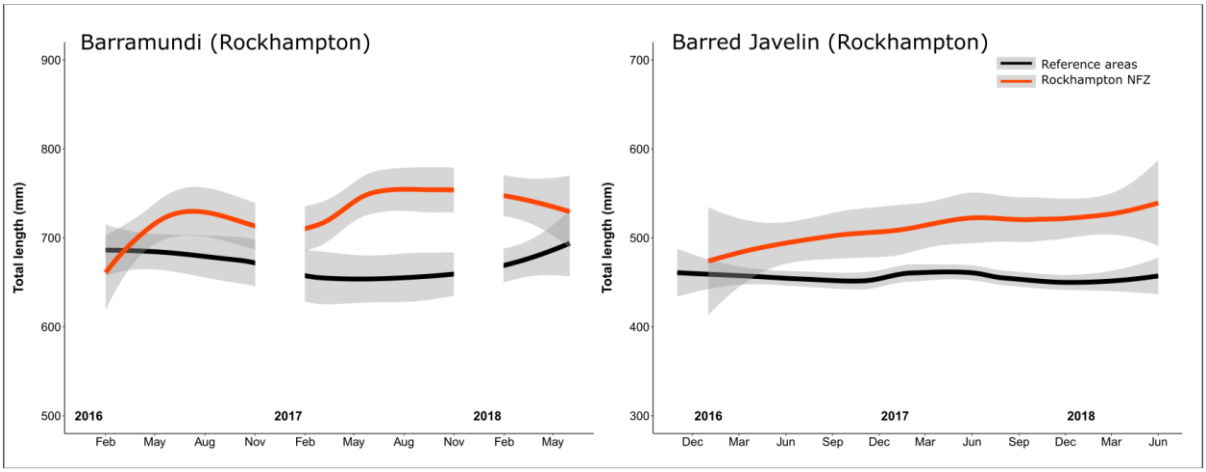
On 1 November 2015, three net-free zones (NFZs) were established in the Cairns, Mackay and Rockhampton regions. The objective of the NFZs is for recreational fishers to catch more and bigger fish, which will increase their enjoyment of recreational fishing in the region. If this occurs, fishers are likely to travel from further afield to fish NFZs, thereby supporting local businesses and tourism.
To examine the impact of the NFZs on recreational fishing, surveys were undertaken at local boat ramps and tackle shops from 2015–18.

These surveys examined:

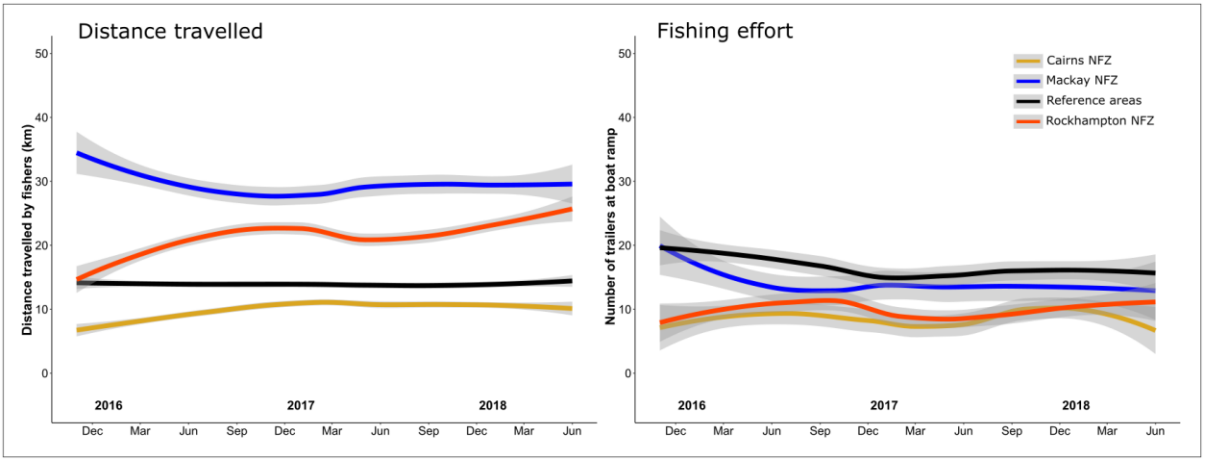
- if fishing effort has increased
- whether important recreational fish species were larger and more commonly caught
- if fishers travelled further to fish the NFZs
- if recreational fishers' satisfaction and expectations of fishing in NFZs have changed through time.

The results of these surveys were compared to a combined set of reference areas (other areas in Queensland where NFZs were not introduced in November 2015) to assess the impacts of the NFZs relative to other trends in recreational fishing through time.

The full benefits of NFZs on the number and size of fish caught by recreational fishers are likely to take time to emerge, however recreational fishers are now harvesting larger barred javelin in the Rockhampton NFZ compared to the reference areas, which have not changed. In 2016 and 2017 Barramundi kept by recreational fishers in the Rockhampton NFZ were also larger than the reference areas. The size or number of fish caught by recreational fishers has not increased in the Mackay or Cairns NFZs.

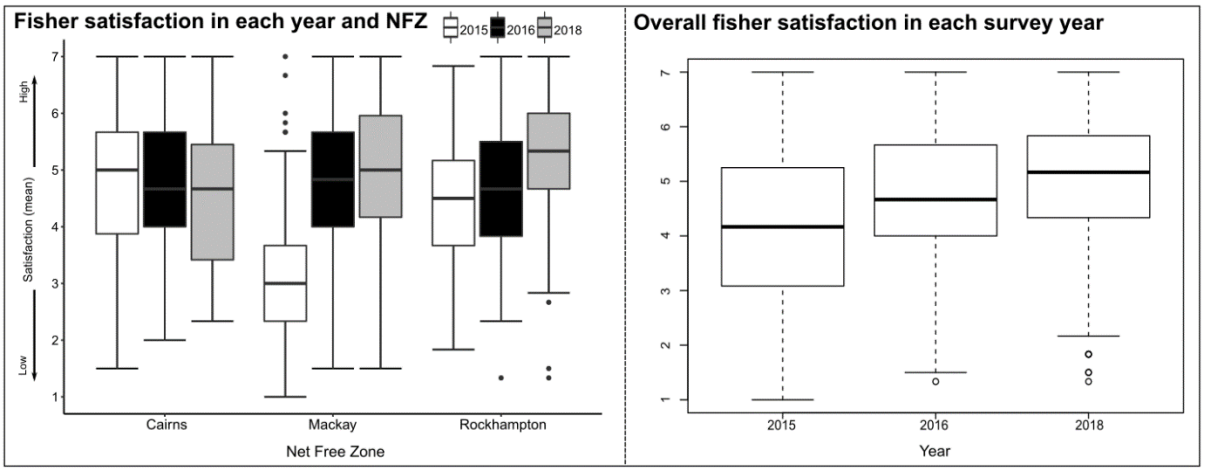


More fishers are travelling further to fish the Rockhampton NFZ since it was created in November 2015. This is likely due to the high levels of community engagement and awareness in Rockhampton, with the council and local groups supporting and promoting the NFZ. The number of trailers counted at the boat ramps has remained steady at all NFZs and reference areas since the NFZs were implemented.



Recreational fishers' satisfaction with fishing in the NFZs is generally positive and appears to be increasing. Overall, fishing satisfaction over the previous 12 months was greater in 2018 than in 2015 or 2016. In Cairns and Rockhampton, satisfaction was similar between years, but in Mackay satisfaction was significantly greater in 2016 and 2018 than 2015.

In 2018, recreational fishers in the NFZs were more satisfied with the following activities compared to 2015 and 2016: more exciting fights with fish; the number and size of fish caught; the quality of fishing in the area. Expectations varied depending on the NFZ and frequency of fishing. Interestingly, while catching a fish is important to recreational fishers, many people stated that it is not necessary for a satisfying fishing trip.



Generally, the effects of NFZs have been positive for recreational fishing. The predicted flow-on benefits of NFZs (e.g. tourism) requires that fishers are satisfied with their fishing trips, which depends largely on them catching more targeted species. As NFZs age, they might produce stronger effects on recreational fishing catches, but these effects will vary between regions due to the area covered by the NFZ, environmental factors such as floods and drought, and the reproductive and migratory capabilities of the targeted fish and their prey. Monitoring the performance of NFZs will continue as part of Fisheries Queensland's Fisheries Monitoring program.

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Introduction

On 1 November 2015, three net-free zones (NFZs) were established in the Cairns, Mackay and Rockhampton regions (Figure 1; Table 1). The objective of the NFZs is for recreational fishers to catch more and bigger fish, which will increase their enjoyment of recreational fishing in the region.

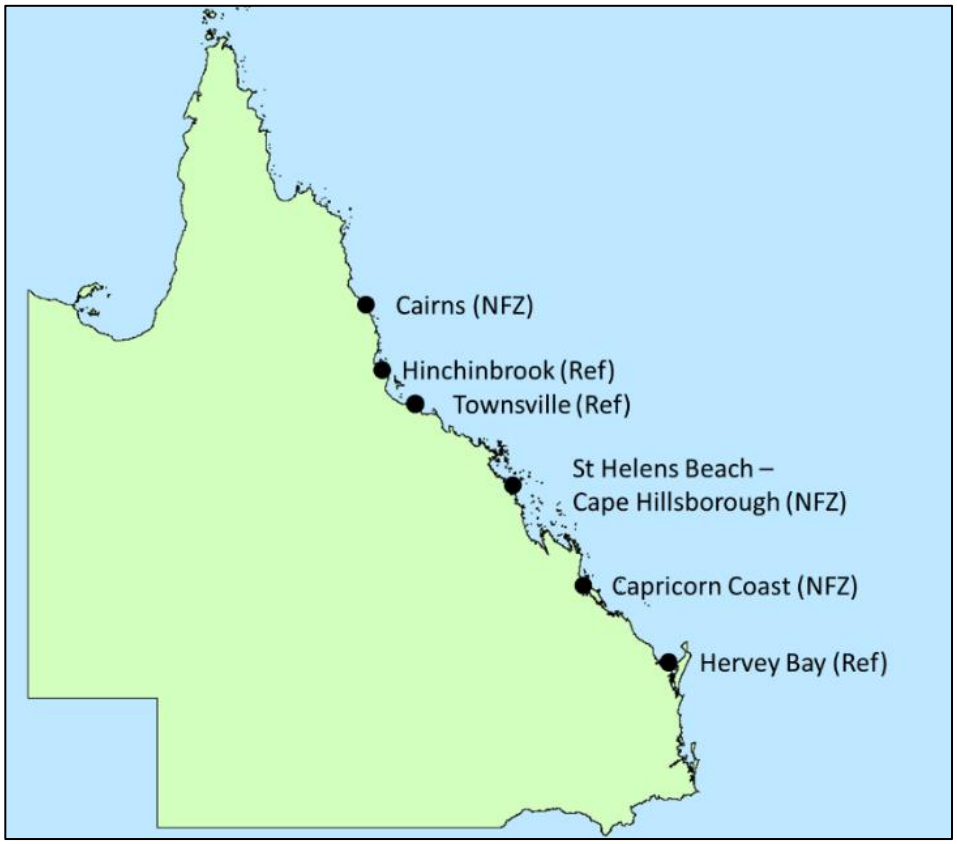

Figure 1: The location of the net-free zones (NFZ) and reference areas (Ref)

Table 1: Area encompassed by the declared net-free zones

Region	**Local area**	**Area (km^2)**
Rockhampton	Capricorn coast	1380
Mackay	St Helens to Cape Hillsborough	163
Cairns	Trinity Bay, Cairns	89

By removing commercial netting pressure in the area, NFZs may result in more and larger fish being caught by recreational fishers compared to areas where netting is still permitted. NFZs might also have psychological benefits to recreational fishers, changing their satisfaction and expectations regarding fishing in these areas. If recreational fishers experience these real (more numerous, larger fish) or perceived (improved fishing satisfaction) benefits of the NFZs, the zones may attract more recreational fishers.

Fisheries Queensland has implemented a statewide boat ramp survey program that collects information on recreational catch, effort and travel information in the NFZs. Fisheries Queensland also conducted recreational fishers' satisfaction and expectation surveys at local tackle stores within the NFZs in 2015, 2016 and 2018. Monitoring occurs in the regions that provide access to the NFZs and also in reference areas which provide a baseline that can be used to compare the performance of the NFZs. Each NFZ's performance is likely to depend on the level of commercial fishing removed, the

size and geography of the coastline (Table 1), as well as the biology and movement capabilities of commercial and recreational target species.

Recreational fishing provides non-monetary social benefits to a community. For example, people gain many health benefits from nature-based recreational experiences (Kaplan & Kaplan, 2011; Young, Foale & Bellwood, 2016). When recreational fishing is sustainably managed, increased participation in recreational fishing is likely to provide these non-monetary social benefits to more members of the community. Participation in a recreational activity is tightly linked to expectations of the activity and the level of satisfaction experienced once that activity is complete. While the number and size of fish caught contributes to satisfaction, there are many other factors at play. What people consider to be a satisfying experience is relative to their personal values and expectations. For example, a fisher who regularly catches ten fish may consider a catch of five fish to be disappointing, whereas someone who catches two fish per trip may consider a catch of five fish to be very satisfying. Therefore, satisfaction with a fishing trip cannot be measured simply by the number or size of fish caught. In fact, many people report that a fishing trip can be successful even when no fish are caught (McInnes, Taylor, & Webley, 2012).

Likewise, expectations of a change in satisfaction or performance are often based on a person's perception of the potential for change. Once change has been observed, a fisher's expectations may lower if they expect little additional change in the future. Expectation can be independent of satisfaction, i.e. a person can be satisfied but not expect much change in the future. It is a widely held view among recreational fishers that the introduction of NFZs will lead to ongoing improvements in recreational fishing within the zones. This would likely be reflected in positive responses to questions about their expectations of recreational fishing in the future.

The NFZs may also draw recreational fishers from further afield. This may happen gradually over time if recreational fishing improves, or fishers are more satisfied with their fishing trips in the NFZs and this information spreads beyond the local region. Effective promotional campaigns, such as those implemented by Rockhampton City Council (www.advancerockhampton.com.au/Visit/Fishing), may also increase visitation rates. The surveys collected information about the fishers' residential suburbs, which can be used to estimate the distance travelled to the interview location. If fishers are travelling further to fish the NFZs they may also boost the local economy by purchasing accommodation, fuel, food and tackle through local businesses.

This report outlines research methods and presents the performance of the NFZs relating to the following questions:

- Is boat-based fishing effort increasing at a faster rate in NFZs compared to reference areas?
- Is the size or number of fish caught by recreational anglers increasing at a faster rate in NFZs compared to reference areas?
- Are more fishers coming from further away to fish the NFZs compared to reference areas?
- Are recreational fishers satisfied with their fishing experiences in NFZs?

Methods

Data collection and experimental design

Boat ramp surveys

Fisheries Queensland has been performing boat ramp surveys since 2006. When the NFZs were introduced on 1 November 2015, the boat ramp survey (BRS) program was expanded to monitor the NFZs) and corresponding reference sites. The main aim of the BRS program is to monitor trends in recreational fishing catch and effort by collecting information from recreational fishers at boat ramps when they return from a fishing trip. Surveys started at 8 am or 12 pm and ran for four hours. Each month, three shifts were performed on weekends and one shift on a weekday. The program has since been further expanded to cover approximately 45 different ramps across Queensland.

Upon returning from their fishing trip, recreational fishers were asked how many of each species of fish they caught and released, the general fishing location, fishing method, the number of fishers and their residential suburbs. Harvested fish were counted and measured (either to fork length or total length) on a standardised measuring board following the survey's protocol (Department of Agriculture and Fisheries, 2015). Harvested crabs and sharks were counted but not measured and sharks were not identified to species. Additional information relating to the amount of fishing effort at each ramp was gathered by recording the number of trailers at 8 am for a morning shift, and at 12 pm for an afternoon shift (see Appendix 1 for the questionnaire).

The regions analysed in this report include the new net-free zones (Cairns, Mackay and Rockhampton) plus three pooled reference areas (Hervey Bay, Hinchinbrook and Townsville) (Figure 1; Table 2). The reference sites were chosen because they provided access to recreational fishing sites, were relatively well used, and were interspersed among the NFZs. Reference sites were pooled to represent the species mix that that can potentially be caught along the Queensland coast and also to provide a homogeneous baseline to compare the NFZs against. However, this report acknowledges that each place along the Queensland coast is unique in some way and this should be considered when interpreting results.

Table 2: Regions and ramps where interviews are conducted.

Classification	Region	Boat ramps	
Net free zone	Cairns	Tingira Street Dave's Boatyard Yorkeys Knob Boating Club	
	Mackay	Murray Creek, St Helens Victor Creek, Seaforth	
	Rockhampton	Quay Street Nerimbera Street	Keppel Bay Marina Coorooman Creek
Reference site	Townsville	Bohle River Townsville Recreational Boating Park	
	Hinchinbrook Channel*	Port Hinchinbrook, Cardwell Dungeness St, Lucinda	
	Hervey Bay*	Urangan Boat Harbour River Heads	

*: Some forms of commercial netting are not permitted in the Hinchinbrook Channel and part of the Hervey Bay region (Dugong protected area). These locations are included as reference areas as this report aims to measure the effects of establishing a NFZ, and these restrictions have been in place since 1997, so the effects of these netting restrictions are already likely to have occurred and should not affect fish populations.

Satisfaction and expectation surveys

Surveys were completed at local tackle stores and boat ramps during November and December in 2015 and 2016 and then repeated at tackle stores in September and October in 2018 (Table 3). Interviewers attended the stores (and boat ramps in 2015 and 2016) for a series of three-hour shifts and interviewed customers as they left the store. A target sample size of 100 to 150 complete eligible interviews was set for each region (Beardmore et al., 2015). The fishers were asked to answer a short questionnaire that collected their recalled avidity (i.e. how many times they remember going fishing in the last 12 months); their catch orientation (i.e. how important actually catching a fish on each trip is to them); how central fishing was to their lifestyle (i.e. how ingrained fishing is in their daily life); their expectations of fishing in the next 12 months; their satisfaction with fishing over the previous 12 months; their awareness of the NFZs and some demographic information (including their residential suburb).

Table 3: Interview locations 2015, 2016, 2018. Tackle stores were chosen due to their likelihood to be visited by recreational fishers.

Net free zone	Fishing tackle and outdoor recreation stores
Trinity Bay (Cairns)	BCF Cairns Tackle World Cairns Tackle World Erskine's
St Helens Beach to Cape Hillsborough (Mackay)	Nashy's Compleat Angler BCF Mackay Tackle World Mackay
Capricorn Coast (Rockhampton)	Barra Jacks, Rockhampton BCF Rockhampton Tackle World Rockhampton (Closed 2018)

The wording of social survey questions can bias answers (Choi and Pak, 2004). Questions were therefore reviewed by an independent social scientist and interviewers received training on how to ask these questions in a non-biased manner. Customers were asked if they had fished in the local area in the last 12 months by showing them a map of the NFZ that omitted any reference to the NFZ and its boundaries. Only people who said they had fished in the area were eligible for the questionnaire. This allowed interviewers to question people who had fished in the NFZ but were not aware of the NFZ, without informing them of its existence. The generalist outdoor recreation stores (BCF stores) were the busiest, but, as expected, had a larger proportion of ineligible people.

The interviewers recorded the eligible fishers' responses to the questionnaire. The questionnaire consisted of a series of statements to which the fisher indicated their agreement or disagreement based on a 1–7 Likert scale—1 being strongly negative (e.g. disagree or dissatisfied) and 7 being strongly positive (e.g. agree or satisfied). Prior to the interview, the interviewers explained how the Likert scale worked using a simple graphic. Statements were based around four topics:

- catch orientation (i.e. how important actually catching a fish on each trip is to them)
- centrality of fishing to the fisher's lifestyle (i.e. how ingrained fishing is in their daily life)
- expectations of fishing in the next 12 months in the area
- satisfaction with fishing over the last 12 months in the area.

Six statements were negatively worded (e.g. 'When I go fishing, I am just as happy if I don't catch a fish'). This was explained to fishers at the start of the survey. Having statements like this and warning fishers about them improved the quality of the responses by increasing the fishers' attention to what was being asked.

Fishers were asked about their usual residential suburb so the distance by shortest road route between their residence and the survey location could be calculated. For privacy reasons, precise residential information was not collected. They were also asked about their awareness of the NFZs and their age, gender and fishing avidity to refine the analyses if required (see Appendix 2 for the questionnaire).

Data analysis

Boat ramp surveys

Data was analysed using an Analysis of Covariance (ANCOVA) in the R programming language (R Core Team, 2014). The number of trailers (as an index for fishing effort), the total number of fish caught by fishers (including fish that were released), size of fish kept (measured by interviewers at the boat ramp) and distance travelled by fishers were all compared between NFZ ramps and those in reference areas. Data were logged and year was included as a covariate to model any potential interactions between ramp types (NFZ and reference) through time (i.e. were NFZ ramps getting more fishers as time went on). The size and catch rate of barramundi (*Lates calcarifer*), barred javelin (*Pomadasys kaakan*), blue threadfin (*Eleutheronema tetradactylum*), golden snapper (*Lutjanus johnii*), King threadfin (*Polydactylus macrochir*) and mangrove jack (*Lutjanus argentimaculatus*), were compared through time. These species were the primary targets of the commercial net fishery prior to its closure. Data were pooled for reference areas and contrasted with each NFZ (Cairns, Mackay and Rockhampton) individually. Relationships were plotted using a localised regression function (Loess) in the 'ggplot2' package in R (Wickham, 2016). This report aims to provide a broad overview of the performance of the NFZs. For specific comparisons between boat ramps and other species of fish not mentioned in this report, please contact the Fishery Monitoring Team (FisheriesMonitoring@daf.qld.gov.au).

Satisfaction and expectation surveys

Data were analysed using the R programming language (R Core Team, 2014). Six negatively worded statements were reverse-scored prior to analysis. To define the underlying constructs in the interview data, an Exploratory Factor Analysis (EFA) was run with a promax rotation using the 'psych' package in R (Revelle, 2017). Factorability was confirmed using the Kaise-Meyer-Olkin test (KMO index = 0.84) and Bartlett's test ($p < 0.01$) and internal stability was confirmed using Cronbach's α. An EFA reduces the survey's statements into fewer variables, by identifying which statements group together. Most statements in this survey grouped together as expected. The EFA identified four constructs in the data (Appendix 4):

- catch orientation (all statements of question 3)
- centrality to lifestyle (all statements of question 4)
- fishing expectation (all statements of question 5, except 5c and 5e)
- fishing satisfaction (all statements of questions 6 and 7, except 6f and 6g).

Statements 5c, 5e, 6f and 6g did not form part of any analysis. Each fisher was given a score for each construct, which was calculated as the mean (average score) of their responses to the statements of each construct. These scores (i.e. mean of catch orientation, centrality to lifestyle, fishing expectations and fishing satisfaction) were used in subsequent analyses.

Factorial Analysis of Variance (ANOVA) were conducted for each construct of the data (catch orientation, centrality to lifestyle, fishing expectation and fishing satisfaction) against year and NFZ. Where interactions were significant, post-hoc analysis in the form of Tukey's HSD were performed. Relationships were plotted using the Boxplot function in the 'ggplot2' package in R (R Core Team, 2014).

Distance travelled

Boat ramp surveys

The distance between the boat ramp and the fishers' residential suburb was calculated using ArcGIS (for fishers residing in Queensland) and Google Maps (for fishers residing in other states). As fishers may not be travelling to an area with fishing as the main purpose of their visit, a survey question was added in July 2016 that asked whether fishing was the main reason for their travel to the area (yes or no). Fishing was the main reason for their travel to the area for 95% of fishers surveyed. Therefore, all trailer-count and distance data provided by fishers was included from when surveys first began in November 2015 as the vast majority would have travelled to the area with the main purpose of fishing.

Satisfaction and expectation surveys

The distance between the interview location (fishing tackle or outdoor recreation store) and the centroid of the fishers' residential suburb by the shortest road route was calculated using ArcGIS. This question tested the hypothesis that visitors to tackle stores are coming from further afield from year to year. It did not investigate whether or not they had travelled to the area with the main purpose being to fish in the local NFZ. A two-factor ANCOVA using log-transformed data tested for a significant difference between the years for each region.

Results

Boat Ramp Surveys

Boat-based recreational fishing effort appears to have remained steady in the Cairns and Mackay NFZs and reference areas although highly variable due to weather and other factors that affect recreational fishing rates (Figure 2). The Rockhampton NFZ shows a slight increase in the number of trailers at boat ramps since the implementation of the NFZs (Figure 2).

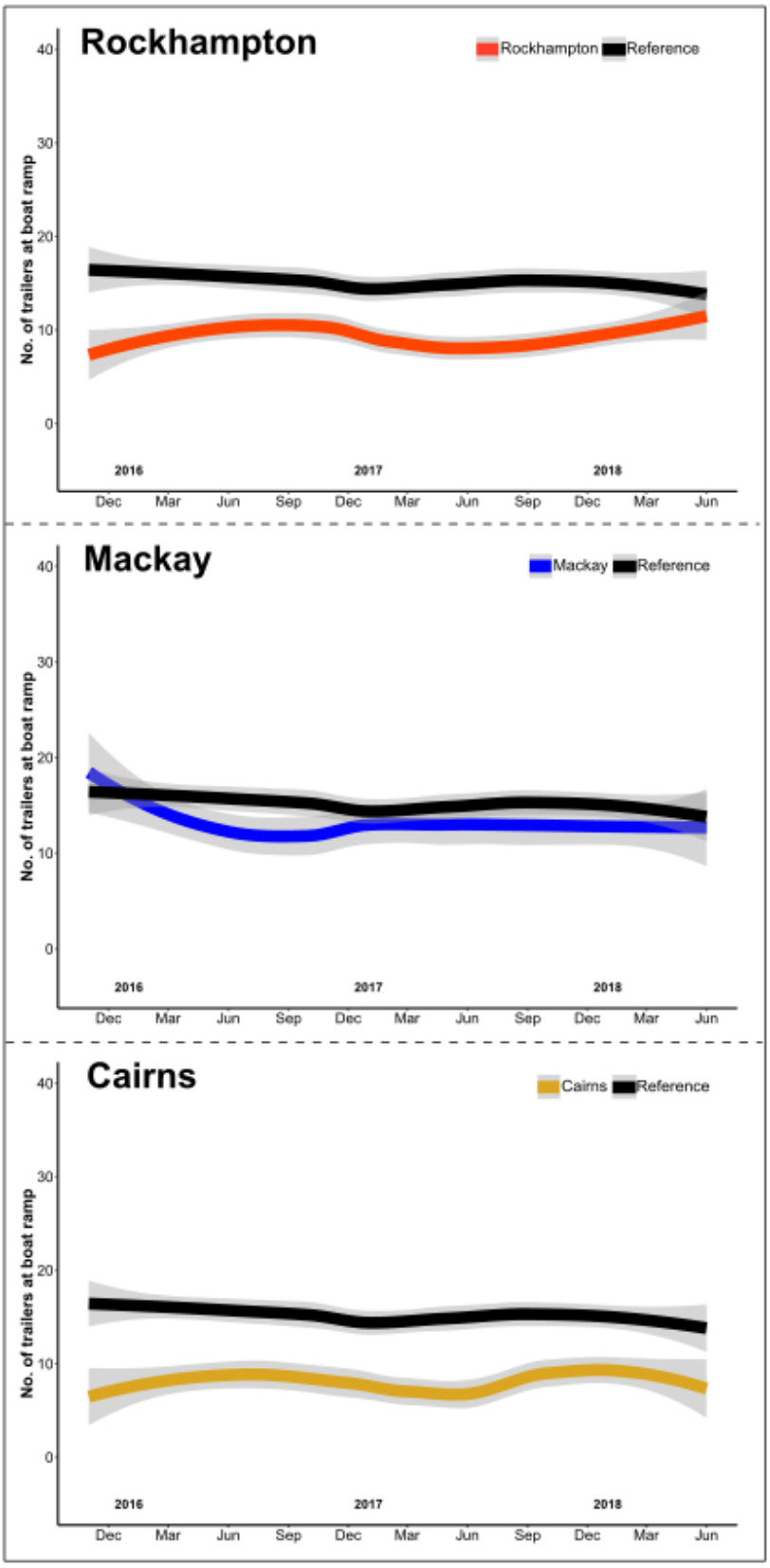

Figure 2: The recreational fishing pressure in NFZs and reference areas. Fishing pressure is indexed by trailer counts at boat ramps. Line and shading represents localised regression trendline and 95% confidence interval.

The distance travelled to the boat ramp by fishers has remained constant in the reference areas since the surveys began in November 2015 (Figure 3). The data are skewed due to the small number of fishers that have travelled very large distances (hence increasing the mean distance travelled), so

instead the median distance is presented in Table 4. NFZ boat ramps Rockhampton showed an increase in the median distance travelled by fishers to fish the area over the last three years (Figure 3; Table 4) whereas Mackay and all reference areas remain steady. Cairns showed a slight increase in the distance travelled by fishers to fish the NFZ ramps over the last three years (Figure 3; Table 4).

Table 4: Median distance in kilometres travelled by fishers to fish the NFZ and reference areas from 2015 to 2018.

	Rockhampton	**Mackay**	**Cairns**	**Reference**
2015	12.99	45.76	4.24	22.51
2016	22.18	45.76	7.38	22.51
2017	24.54	45.76	10.89	21.32
2018	31.75	45.76	10.89	20.23

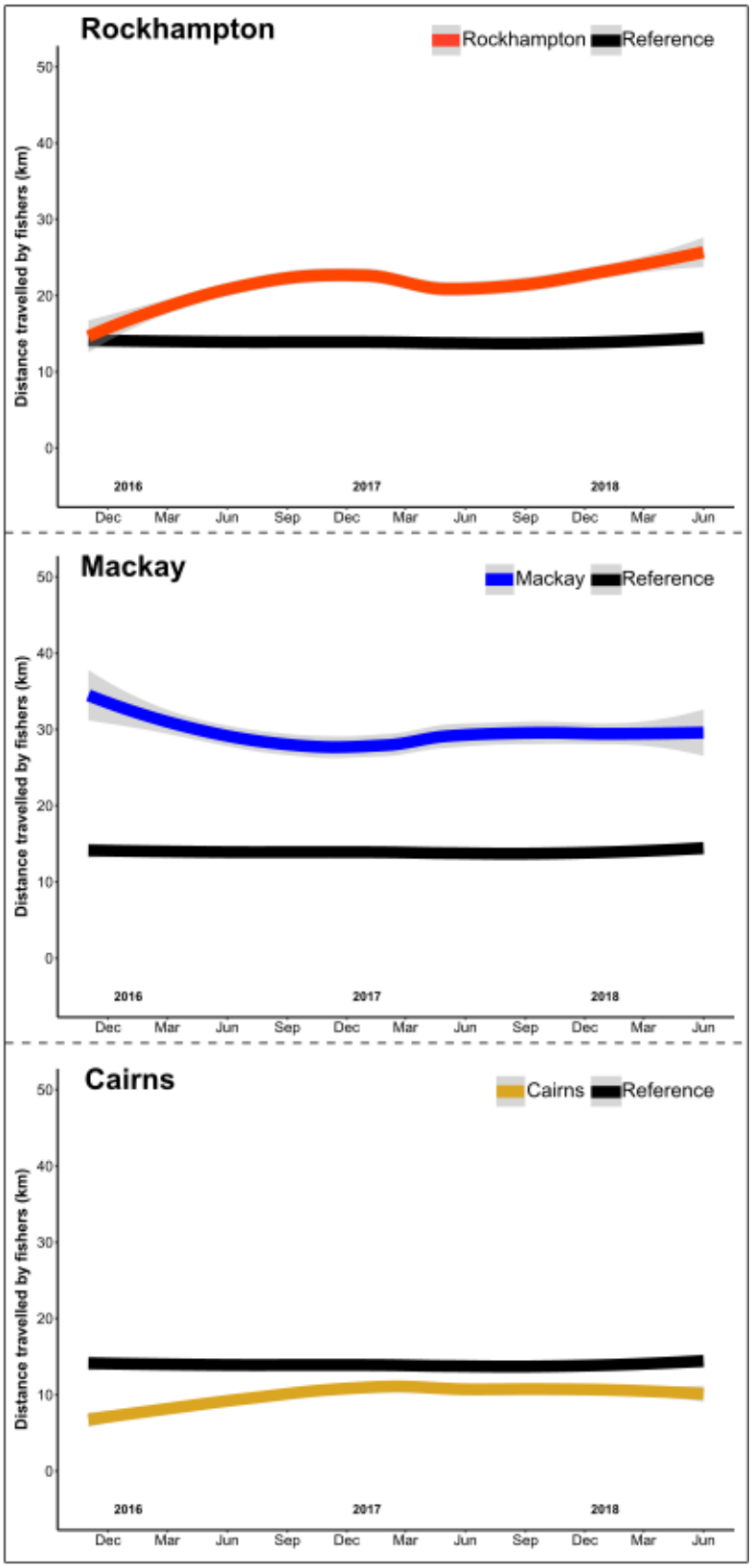

Figure 3: Distance travelled by fishers in NFZs compared with reference areas. Distance travelled is the distance by road between the fishers' residential suburb and the boat ramp. Line and shading represents localised regression trendline and 95% confidence interval.

Effects of NFZs on the size and catch rate of fish varied between species and regions. Barramundi kept by fishers in Rockhampton during 2016 and 2017 were larger than those kept in the reference areas (Figure 4), however there was no increase in the catch rate of barramundi by recreational

fishers. The size of barred javelin significantly increased in the Rockhampton NFZ since its implementation in November 2015, especially compared to the reference areas which remained unchanged (p: <0.01) (Figure 4). The catch rate and size of blue threadfin and king threadfin have not significantly changed in the NFZs or reference areas since the NFZs were established (Figure 4).

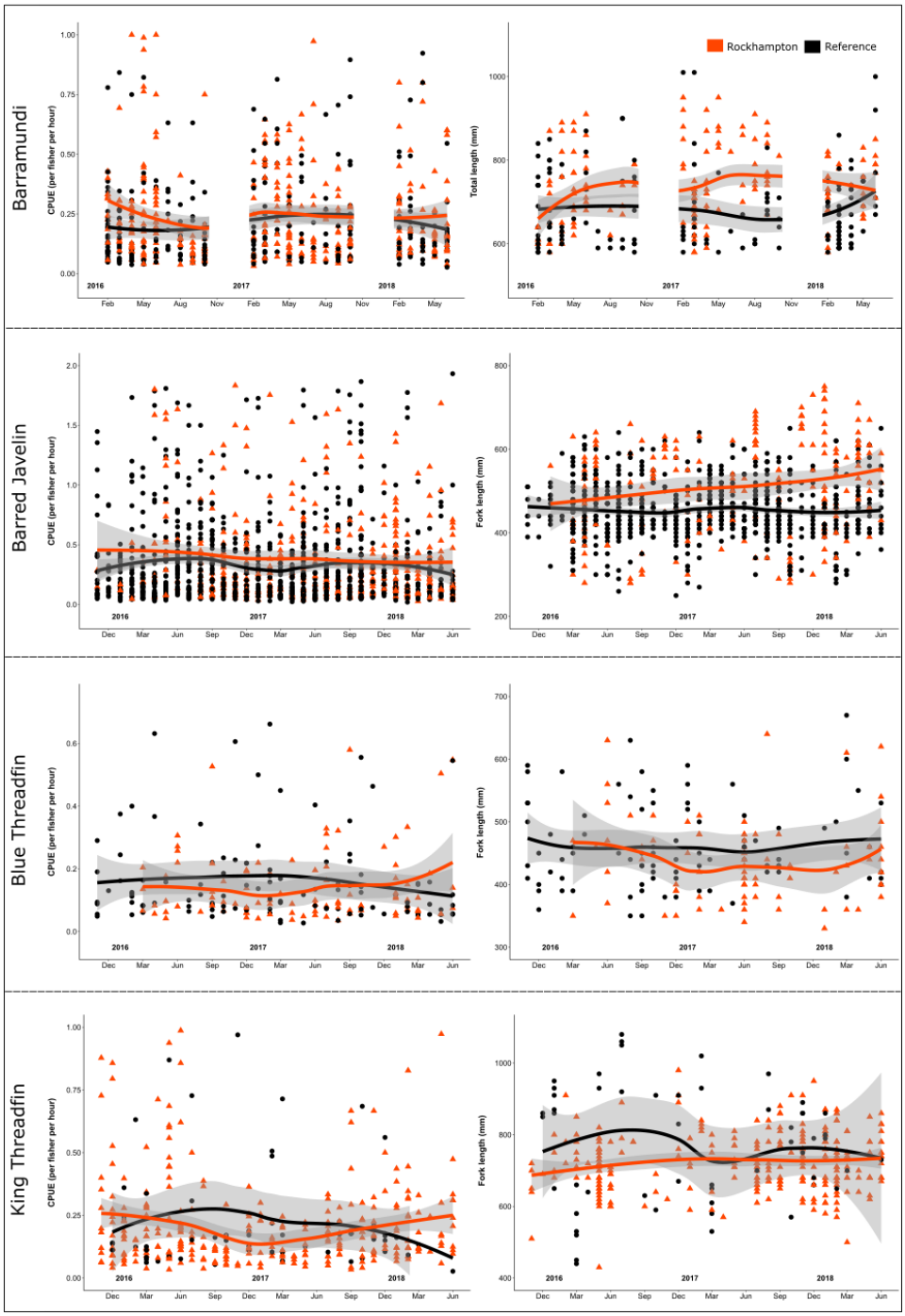

Figure 4: The catch rate and size of barramundi, barred javelin, blue threadfin and king threadfin in the Rockhampton NFZ compared with the reference areas. Line and shading represents localised regression trendline and 95% confidence interval.

The numbers and size of fish caught has not changed in the Mackay or Cairns NFZs relative to the reference areas since the NFZs were established (Figure 5, Figure 6). The size of barred javelin appears to have decreased slightly in the Cairns NFZ, however due to the small numbers of barred javelin kept by recreational fishers in this area and large amount of variation associated with this pattern, there is no significant difference in the size of barred javelin in the Cairns NFZ through time.

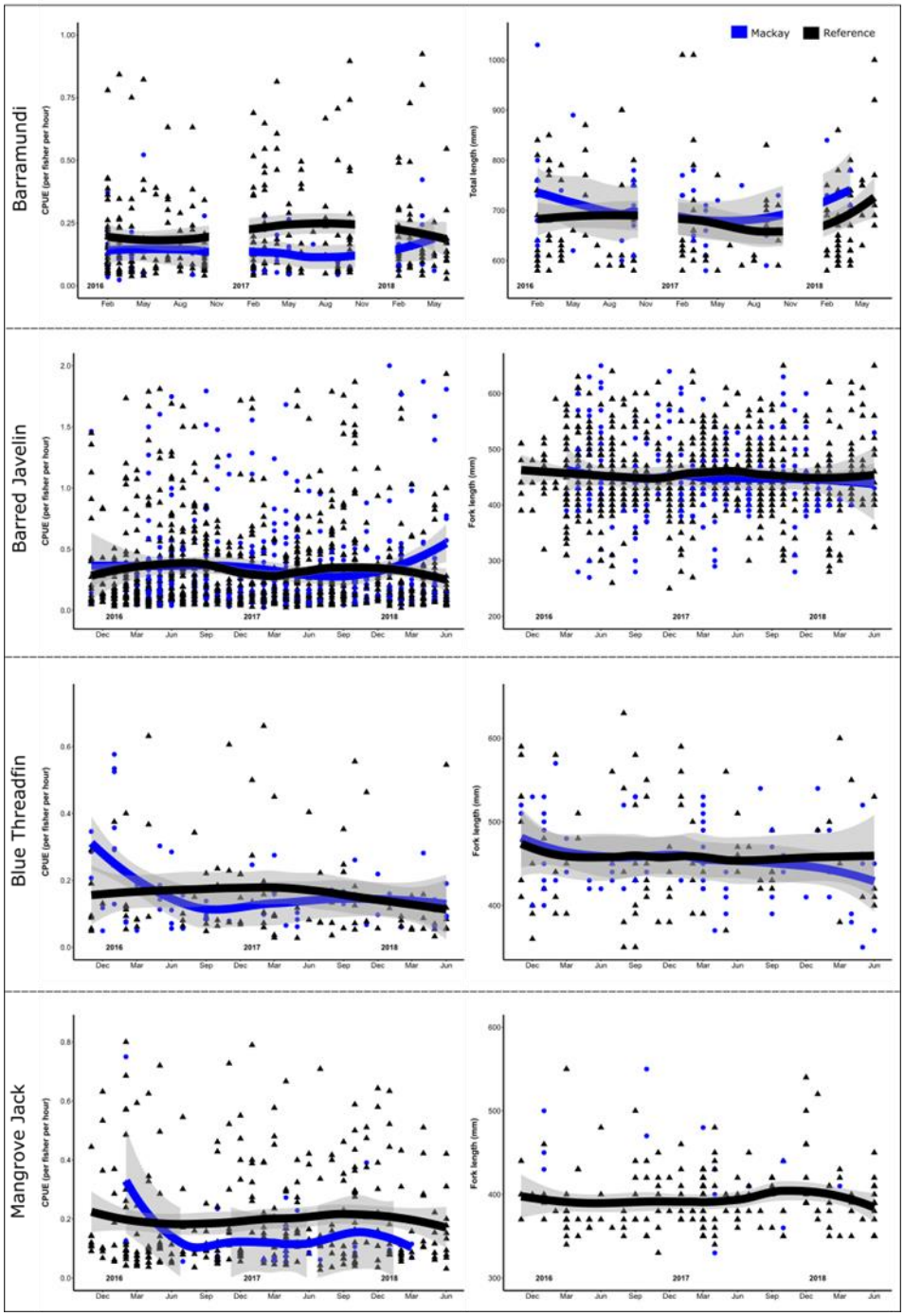

Figure 5: The catch rate and size of barramundi, barred javelin, blue threadfin and mangrove jack in the Mackay NFZ vs the reference areas. Line and shading represents localised regression trendline and 95% confidence interval. Note: due to the low number of mangrove jack retained by fishers (mostly catch and release), a length trendline is not shown.

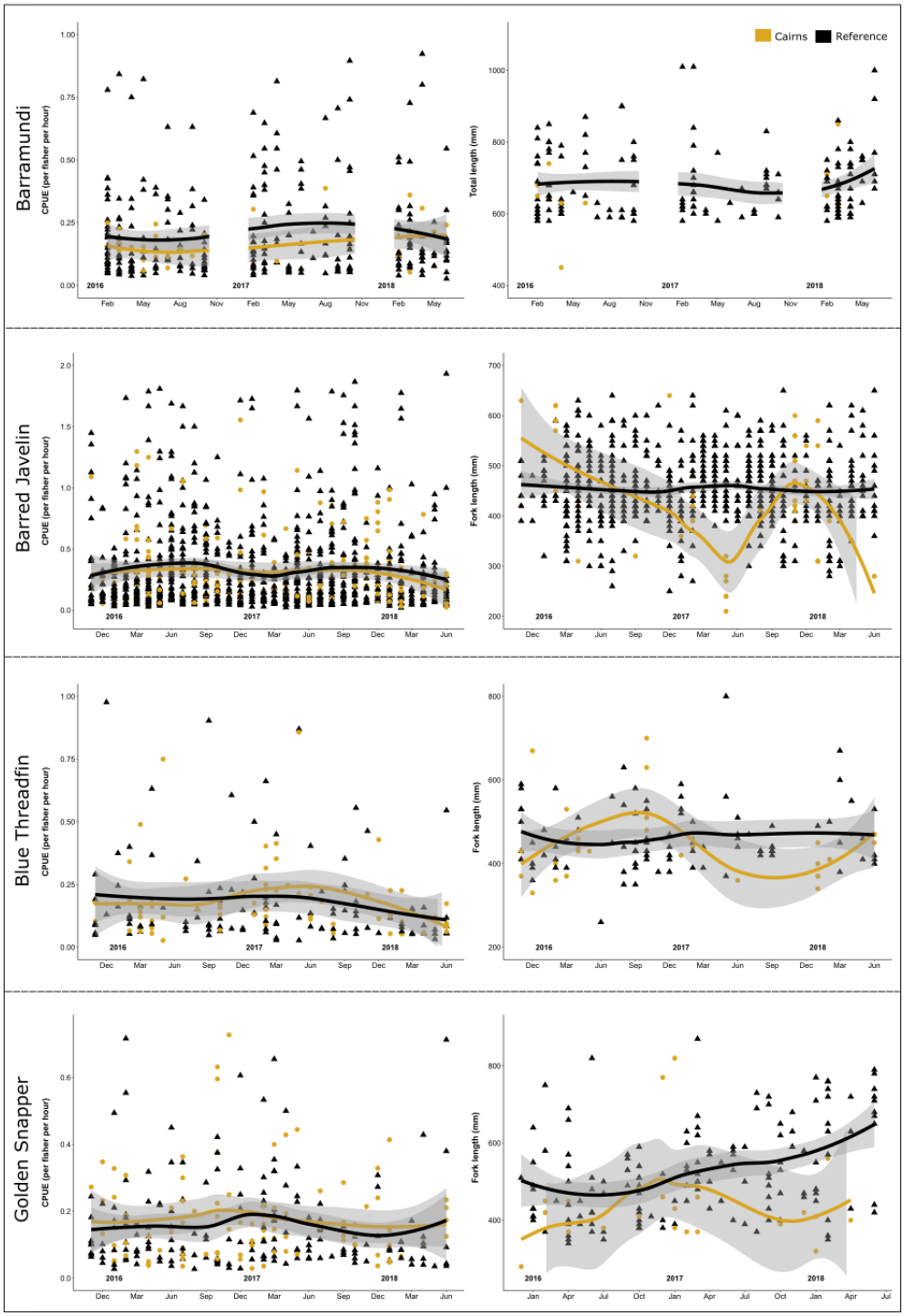

Figure 6: The catch rate and size of barramundi, barred javelin, blue threadfin and golden snapper in the Cairns NFZ compared with the reference areas. Line and shading represents localised regression trendline and 95% confidence interval. Note: due to the low number of barramundi retained by fishers (mostly catch and release), a length trendline is not shown.

Satisfaction and expectation surveys

There were 254 completed interviews in 2015; 265 in 2016 and 350 in 2018 (Table 5). The refusal rate was 17% in 2015 and 29% in 2016 and 2018.

Table 5: Number of recreational fishers interviewed by interview stage and year

	2015		**2016**		**2018**	
Interview stage	**No.**	**%**	**No.**	**%**	**No.**	**%**
Refusals	131	17	237	29	385	29
Ineligible	345	45	262	33	558	42
Incomplete questionnaires	34	5	43	5	33	3
Complete interviews	254	33	265	33	350	26

Overall, more males were interviewed than females—in 2015, 9% of the interviewees were female, in 2016, 11% were female and in 2018, 3.6% were female. The fishers interviewed in 2018 were slightly older than those interviewed in 2015 and 2016 (Appendix 5), but the avidity (number of days fished in a year) of interviewed fishers was similar in all three years (Figure 7). Approximately one-third of fishers said they fished ‘once or twice a month’, with ‘once or twice a year’ being the smallest proportion.

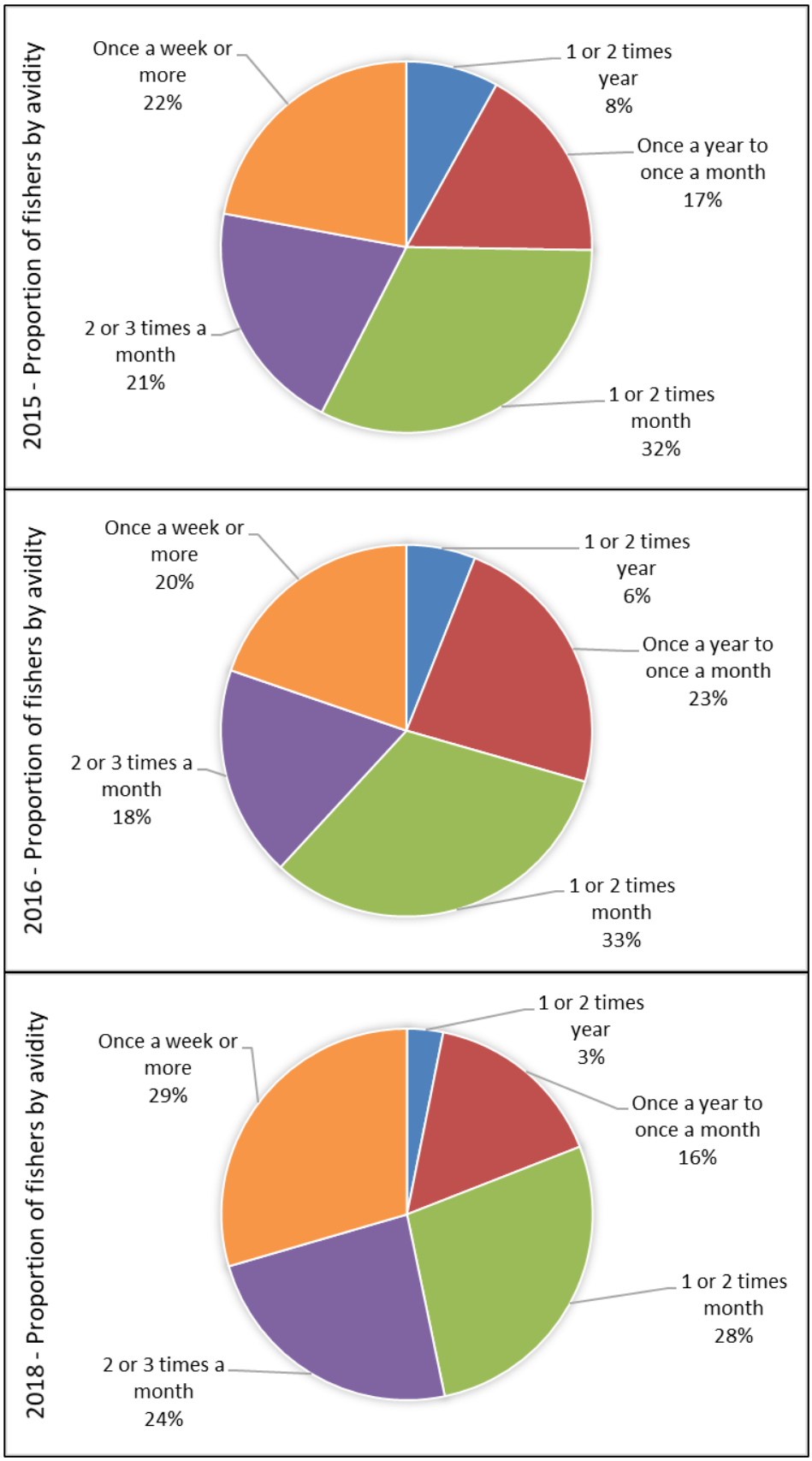

Figure 7: Avidity of recreational fishers interviewed in 2015, 2016 and 2018 (for previous 12 months).

Recreational fishers in Mackay and Rockhampton were slightly more aware of their local NFZ than recreational fishers in Cairns (Mackay and Rockhampton > 90%, Cairns ~ 80%). The level of awareness was high and relatively consistent across the three years (Figure 8). There was a slight movement towards less of the population being aware of the NFZs.

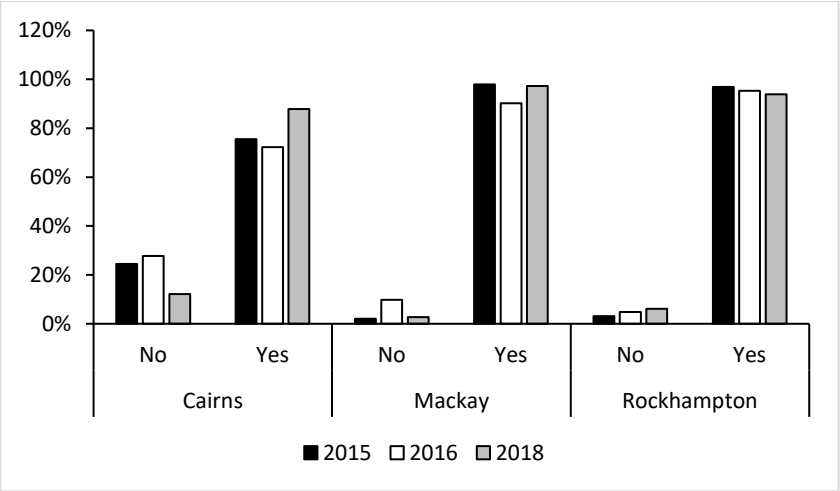

Figure 8: Awareness of the existence of net-free zones in the local area by zone and year.

On average, fishers had a low to medium degree of catch orientation (Figure 9). Generally, their responses suggested that catching fish was not required in order to enjoy their fishing experience (Appendix 6). However, catching fish was a strong reason for going fishing in the first place, which suggests that catching a fish is expected, at least on some trips. There was a significant difference between catch orientation in Rockhampton between 2015 and the other two sampling years (2015-2016: $p < 0.01$, 2015-2018: $p < 0.01$) (Figure 9).

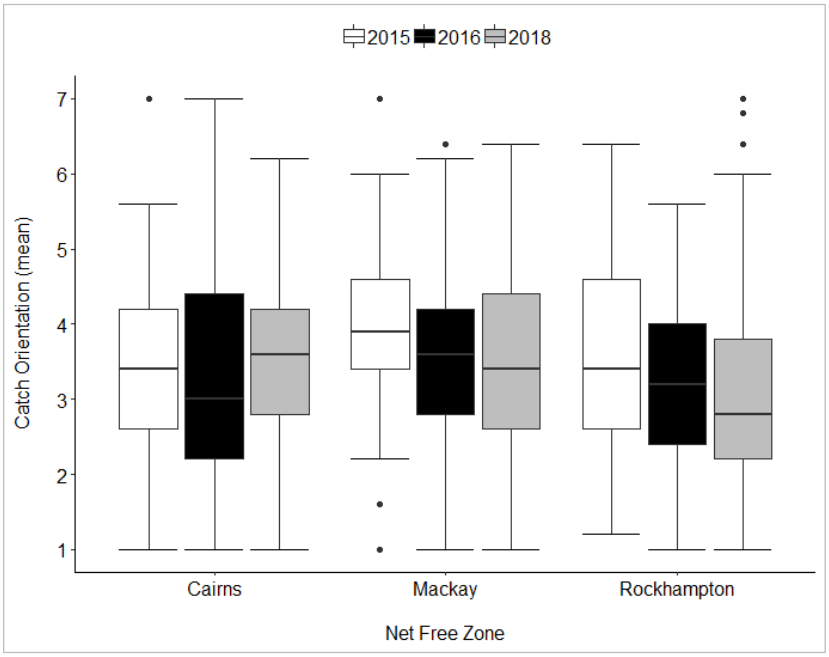

Figure 9: Mean measure of catch orientation by year and net-free zone using the transformed Likert scaled responses to question 3 (scale reflects a low (1) to high (7) catch orientation, bounds of each box represent the 1st and 3rd quartiles, the line within the box is the median).

Interviewed fishers revealed that recreational fishing was moderately central to their lifestyle in both 2015 and 2016, but highly central to their lifestyle in 2018 ($p < 0.01$) (Figure 10). Responses to individual statements reveal that recreational fishers have a strong affection for recreational fishing. In all years, the vast majority of interviewed fishers agreed with the statement 'Going fishing is one of the most enjoyable thing I do'—78% to 88% agreed and only 4% to 8% disagreed (Appendix 7). In 2015 and 2016, the interviewed fishers tended to disagree with statements that would be associated with fishing being very central to their lifestyle—'I would see my friends less often if I stopped fishing' and 'If I couldn't go fishing, I wouldn't know what else to do'. This suggested that they participate in, or are aware of, alternative social and recreational activities—this is corroborated by the more moderate agreement with the statement 'Other leisure activities do not interest me as much as fishing' (Appendix 7). In contrast to 2015 and 2016, interviewed fishers in 2018 had a much stronger agreement with the statements such as 'If I couldn't go fishing, I wouldn't know what else to do' (92% agreement). Fishers interviewed in 2018, in general, had stronger agreement with all lifestyle questions than in previous years.

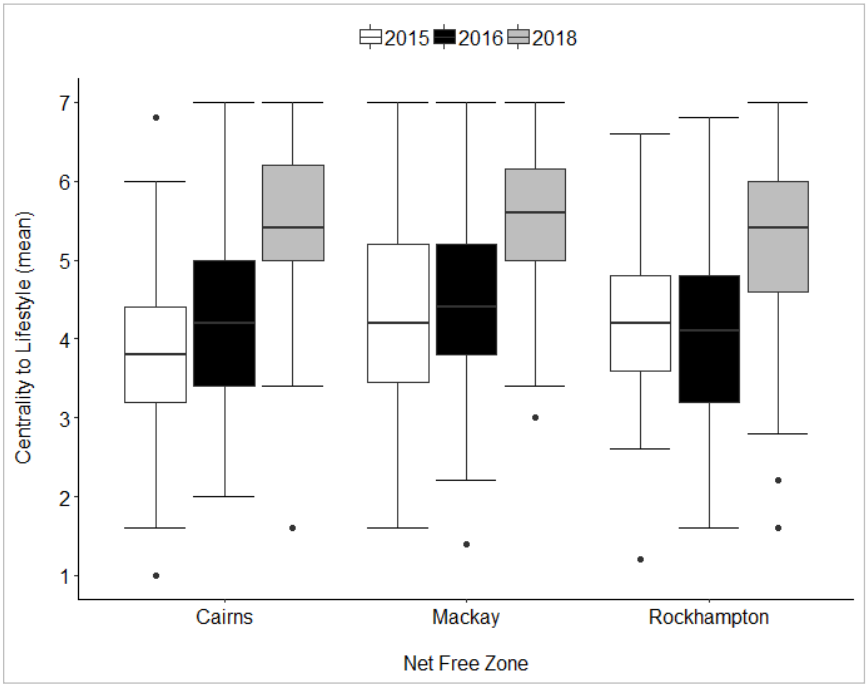

Figure 10: Mean measure of centrality to lifestyle by year and net-free zone using Likert scaled responses to question 4 (scale reflects a low (1) to high (7) centrality to lifestyle, bounds of each box represent the 1st and 3rd quartiles, the line within the box is the median).

Recreational fishers' had neutral to positive expectations for the next 12 months across all NFZs, however these expectations differed slightly between years (Figure 11). Cairns was the only region where expectations increased significantly with each year of the survey ($p < 0.05$) (Figure 11). In Rockhampton and Mackay, fishers' expectations decreased between 2015 and 2016 ($p < 0.05$), but increased between 2016 and 2018 ($p < 0.01$) (Figure 11).

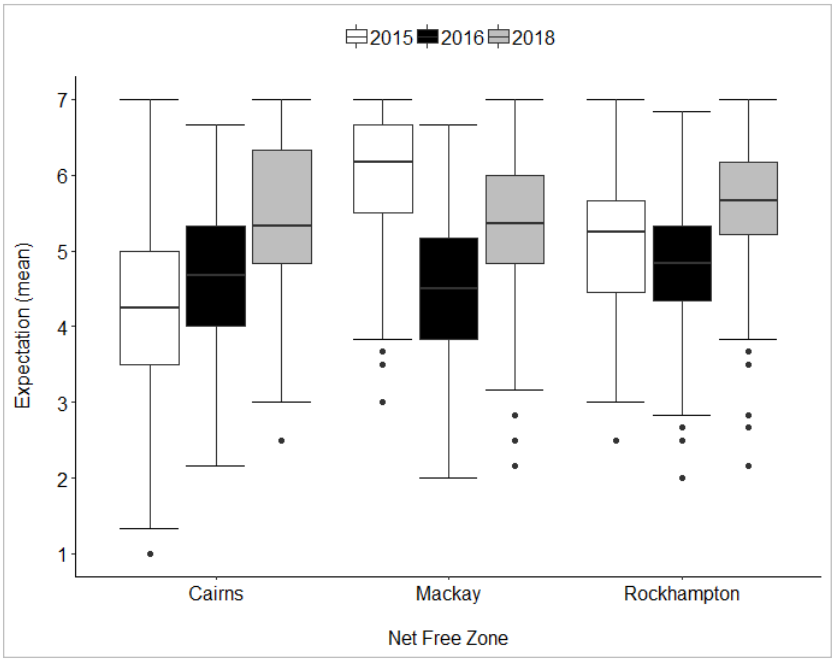

Figure 11: Mean measure of expectation for the next 12 months in 2015 and 2016 by net-free zone using transformed Likert scaled responses to question 5 (scale reflects a low (1) to high (7) expectation, bounds of each box represent the 1st and 3rd quartiles, the line within the box is the median).

In both Mackay and Rockhampton, recreational fishers who were aware of the NFZs had higher expectations of their fishing experiences in the next 12 months than those who were unaware. In Cairns, however, their expectations were similar (Figure 12).

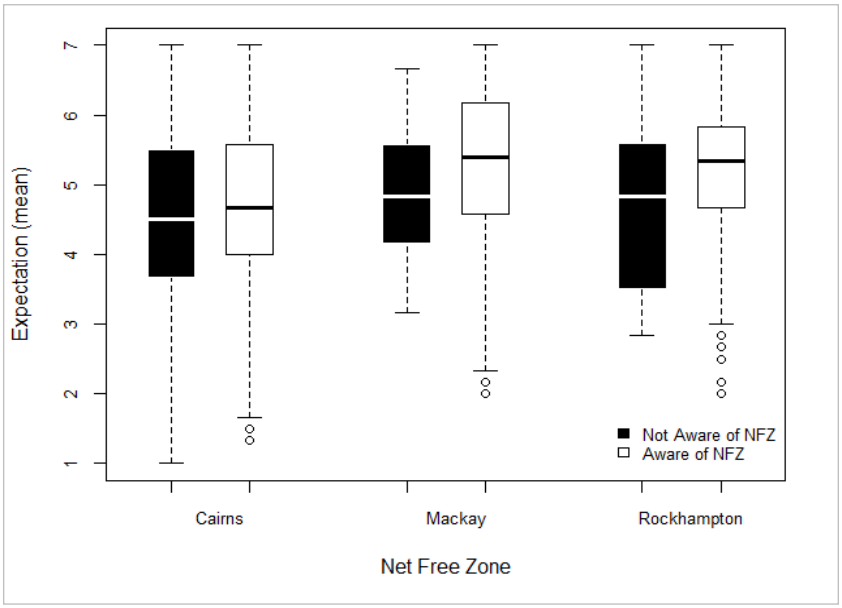

Figure 12: Expectations of recreational fishing in the next 12 months for fishers who were aware or not aware of the introduction of the three net-free zones (bounds of each box represent the 1st and 3rd quartiles, the line within the box is the median).

Fishers were satisfied with their recreational fishing experience over the previous 12 months, and satisfaction levels generally increased during each year of the survey, with 2018 being the highest (Figure 13). In Cairns, satisfaction was similar between years ($p > 0.05$), however, in Mackay and Rockhampton, satisfaction increased through the years ($p < 0.01$) (Figure 14).

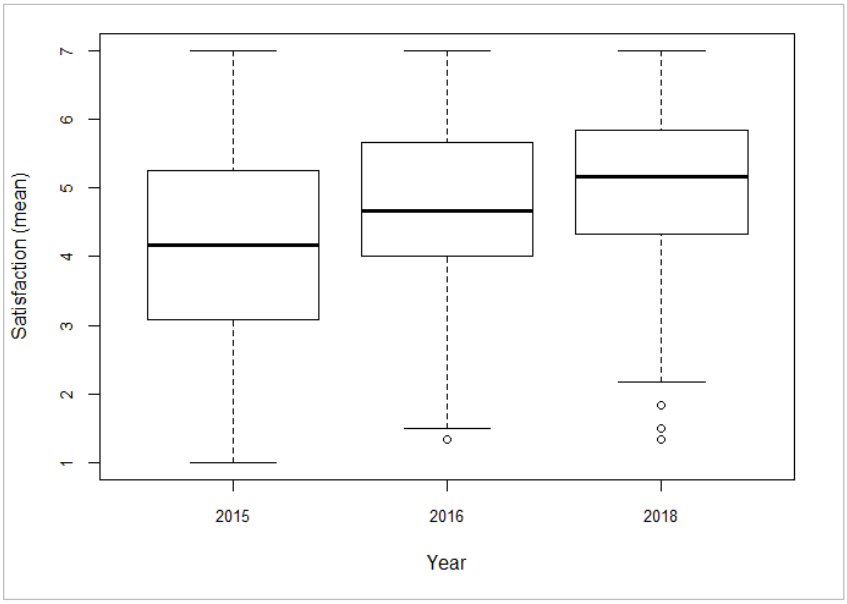

Figure 13: Mean measure of satisfaction by year for all net-free zones combined using Likert scaled responses to questions 6 and 7 (scale reflects a low (1) to high (7) satisfaction, bounds of each box represent the 1st and 3rd quartiles, the line within the box is the median).

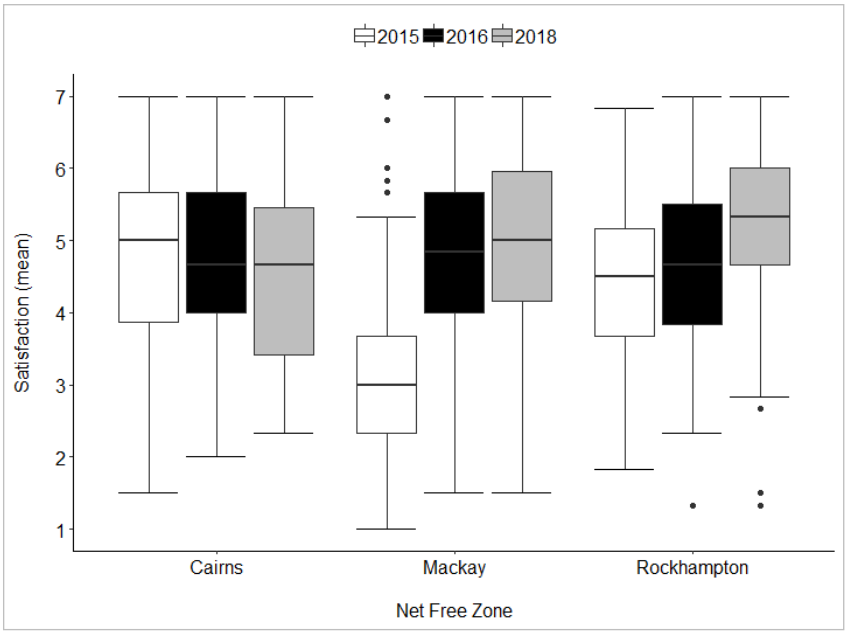

Figure 14: Mean measure of satisfaction by year and NFZ using Likert scaled responses to question 6 and 7 (scale reflects a low (1) to high (7) satisfaction, bounds of each box represent the 1st and 3rd quartiles, the line within the box is the median).

Expectations about recreational fishing differed among the reported avidity groups in 2015, but were similar in 2016 and 2018 (Figure 15). For infrequent fishers, expectations were similar in all years, although generally higher in 2018. More avid fishers generally had higher expectations (Figure 15). Satisfaction with recreational fishing generally improved with each survey year, particularly in the highest avidity group (Figure 16). Satisfaction was similar across lower avidity groups in all years.

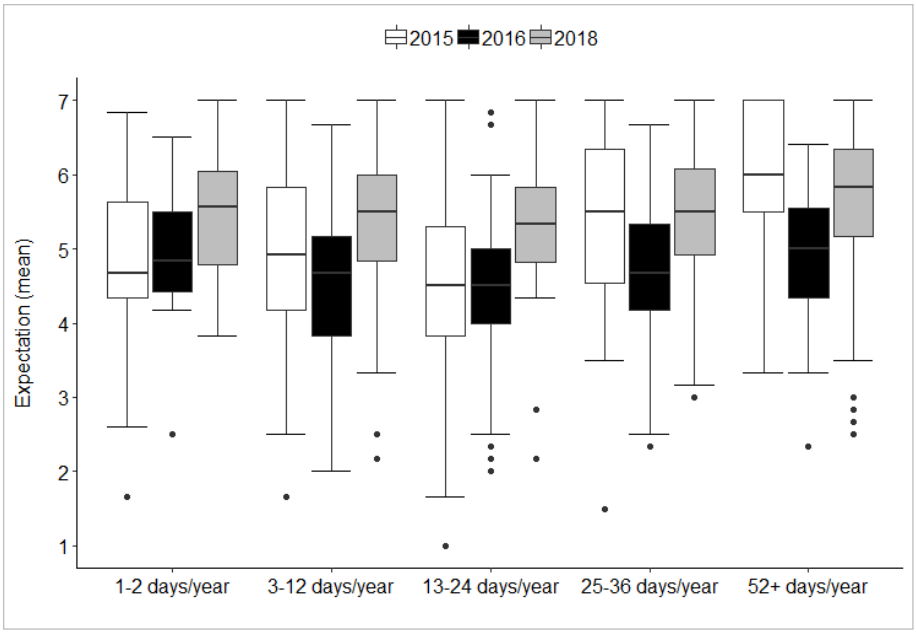

Figure 15: Expectation by reported avidity group in 2015, 2016 and 2017 for all net-free zones combined (bounds of each box represent the 1st and 3rd quartiles, the line within the box is the median).

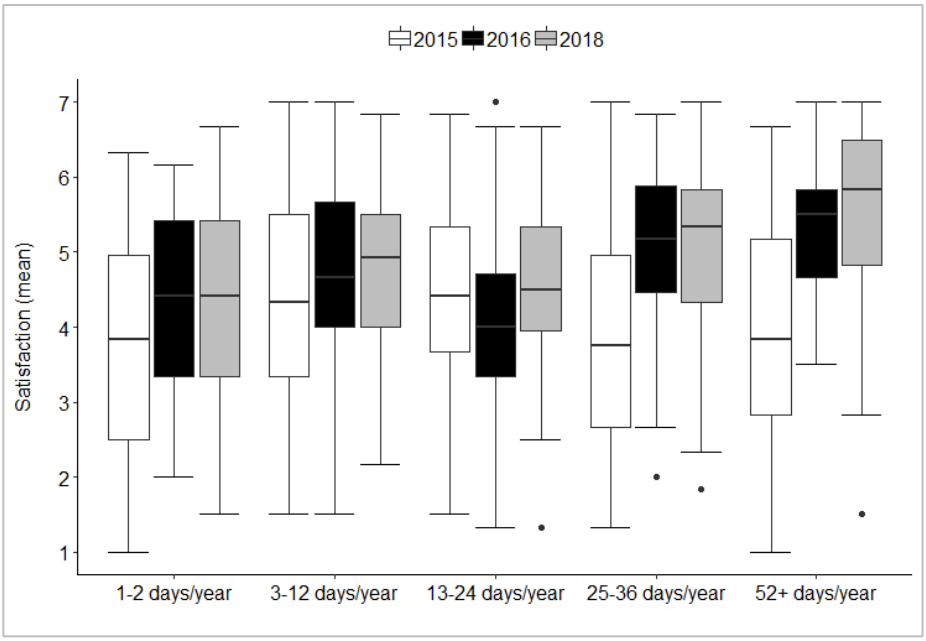

Figure 16: Satisfaction by avidity and year using Likert scaled responses to question 6 and 7 (scale reflects a low (1) to high (7) expectations, bounds of each box represent the 1st and 3rd quartiles, the line within the box is the median).

There was no significant difference in the distance by road between the fishers' usual residential suburb and the tackle stores they were interviewed in by year, region or year interacting with region due to a high degree of variability in the data (Figure 17). The high degree of variance masked any statistically significant differences between distances travelled even with data transformation. This data is not erroneous and cannot be excluded—travellers such as these are genuine and do contribute to the activity within a region. Although not statistically significant, in Rockhampton there is a trend through time for fishers to be from increasingly distant places of residence (Figure 17).

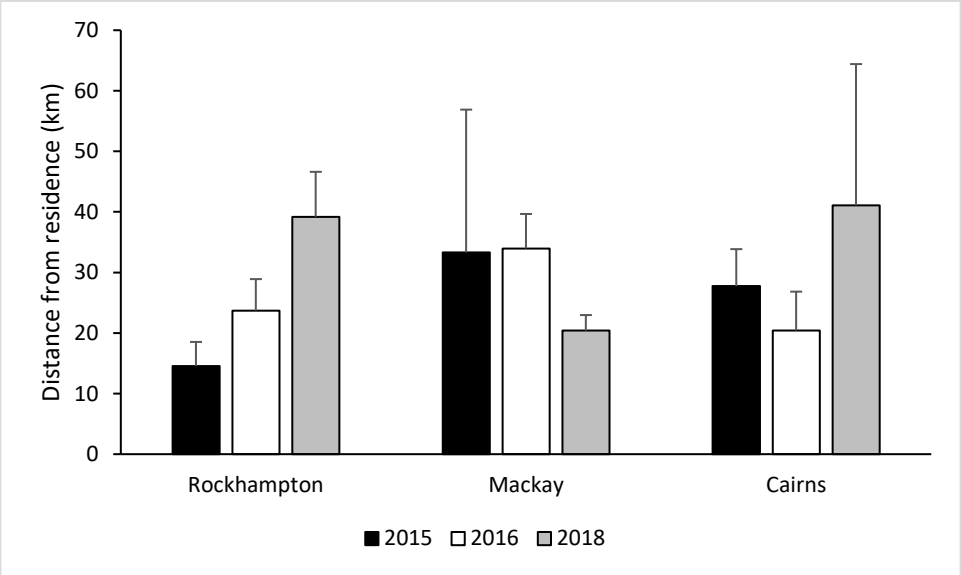

Figure 17: Average distance (± standard error) between the interview site and the fisher's residential suburb or postcode (2015: n = 99 Rockhampton, 98 Mackay, 90 Cairns; 2016: n = 106 Rockhampton, 100 Mackay, 101 Cairns; 2018: n = 162 Rockhampton, 146 Mackay, 74 Cairns).

Discussion

Boat ramp surveys

The boat ramp survey program revealed the effects of NFZs on recreational fishing varied between regions. The greatest changes to recreational fishing have been detected in the Rockhampton NFZ. Larger barramundi and barred javelin are being caught and more fishers are travelling further to fish the NFZ. The monitoring program is not detecting any significant changes in the abundance or size of fish caught by recreational fishers in the Cairns and Mackay NFZs. The distance travelled by fishers to the ramp has increased slightly in the Cairns NFZ, but not in the Mackay NFZ. Across all regions however, recreational fishers are generally satisfied, with fishing experiences matching their expectations.

The length of the two major target species for recreational fishers appears to be increasing in the Rockhampton NFZ. The size of barred javelin kept by fishers in the Rockhampton NFZ has increased significantly since its implementation in November 2015, and barramundi kept by recreational fishers were also larger in Rockhampton than the reference areas during 2016 and 2017. Barramundi and barred javelin were both harvested in Rockhampton prior to the introduction of NFZs, with nets on average removing approximately 96 000 kg and 5400 kg of fish during Jan–Oct 2015 (Department of Agriculture and Fisheries, 2018). In contrast, commercial netting removed approximately 15 000 kg of barramundi and 3100 kg of barred javelin from Mackay and 4500 kg of barramundi and 500 kg of barred javelin from Cairns during Jan–Oct 2015 (Department of Agriculture and Fisheries, 2018), but unlike Rockhampton, the size of these species in Mackay and Cairns remains unchanged. In addition to the level of commercial netting pressure that has been removed, the size of the NFZs may also affect their performance. The Rockhampton NFZ is much larger than the Cairns and Mackay NFZs,

covering 1380 km^2, compared with 89 and 163 km^2 respectively. The Rockhampton NFZ covers a large section of the Fitzroy River, which has the largest catchment of any river draining to the eastern coast of Australia. NFZs may therefore function similarly to no-take marine reserves (albeit allowing recreational fishing and commercial fishing without nets), where larger reserves perform much better than smaller ones due to their ability to protect species with large home ranges (Claudet et al., 2008). As barramundi and barred javelin are both mobile coastal species, sometimes travelling large distances through estuaries and along coastlines (Szczecinski, 2012; Crook et al., 2016), it is possible that they are moving outside of the much smaller NFZs at Cairns and Mackay. The Rockhampton NFZ, however, is potentially large enough that barred javelin and barramundi can move around but not encounter netting activity, thus avoiding capture and increasing their overall size. However, NFZs did not result in more or larger fish being caught by recreational fishers for other species tested (some of which are also mobile coastal species). Subsequently, to infer causality to the relationship between NFZ size and effectiveness would require further testing.

The catch rate of barramundi and barred javelin in the Rockhampton NFZ has not significantly increased since the implementation of the NFZs, despite those species being caught at larger sizes by recreational fishers. Barred javelin take more than three years to get to legal size (Szczecinski, 2012), therefore, it would be unlikely to see an increase in their catch rates until the NFZ has been in place for at least three years (data presented in this report covers November 2015 to June 2018). Barramundi recruitment is strongly affected by freshwater flow in summer and autumn (Robins et al., 2005). Barramundi catch rates are usually high three to four years after these freshwater flow events once the majority of these fish have reached legal size (Staunton-Smith et al., 2004; Robins et al., 2005). There was above-average freshwater flow in the Fitzroy River during autumn 2017 (National Water Account, 2017 and 2018). This increased flow is likely to raise barramundi catch rates in the region, however the data analysed in this report is for surveys conducted before July 2018, and it is therefore unlikely an increase in barramundi numbers will be reported by recreational fishers until at least three to four years following the flow event. Additionally, there was a large cohort of barramundi spawned in 2009–10 (Department of Agriculture and Fisheries, 2017). Following the removal of commercial netting, these fish may be gradually increasing in size, causing larger barramundi to be caught by recreational fishers in 2016 and 2017. Barramundi recruitment was also low in 2015 (Department of Agriculture and Fisheries, 2017), so these fish are unlikely to have a significant effect on the catch rates of barramundi in following years. This may explain why catch rates have not increased in the Rockhampton NFZ. Due to the complex environmental drivers that cause large fluctuations in barramundi recruitment and catch rates, changes in the size or numbers of barramundi cannot be solely attributed to the NFZs. There are also likely to be differences in the baseline populations and catch rates among regions along the Queensland coast.

Despite geographical differences in the layout of boat ramps and residential suburbs across Queensland, overall trends in fishing effort through years should affect regions similarly. During the study period (November 2015–July 2018) an increasing number of fishers travelled large distances to fish the Rockhampton NFZ, but not the other NFZs or the reference areas. This is possibly due to the high level of marketing and promotion that the Rockhampton NFZ experiences compared to the other areas. In Rockhampton, levels of community engagement and awareness are high, with forums and local groups promoting the NFZs. The satisfaction and expectation surveys performed in Rockhampton tackle stores corroborated this, with the average distance travelled by fishers to fish the area increasing during each survey year.

Satisfaction and expectation of fishers

Satisfaction with recreational fishing experiences were largely positive across all NFZs. Expectations for fishing in the next 12 months were also largely positive, peaking in 2018 for Cairns and Rockhampton, and 2015 for Mackay. The underlying demographics of each region may affect the satisfaction and expectation of fishers, so care should be taken while interpreting these results which have not been adjusted. These results should be treated as reflective of fishers that would visit fishing tackle or outdoor recreation stores on any given day in September and October or November

and December. They may not be reflective of the situation at all times throughout the year, nor of fishers who do not frequently visit tackle stores. Overall, however, these results demonstrate that fishers were satisfied with the fishing experience in the NFZs and expect things to improve further over the coming year.

There was a very high level of awareness of the local NFZs among fishers from all three regions. However, a greater proportion of fishers in Mackay and Rockhampton were aware of their respective local NFZs (both > 90%) than fishers in Cairns (~ 80%). Fishers in Mackay and Rockhampton who were aware of the NFZ had greater expectations for fishing in the local area that than those who were not aware of the NFZ. This is predictable if people are thinking that the NFZ will improve recreational fishing. However, a similar pattern was not as apparent in recreational fishers from Cairns, where recreational fishers who were aware of the NFZ and those who were unaware of it had almost identical expectation scores. There are many possible explanations for the anomaly in Cairns, for example, recreational fishers have positive expectations for the Cairns area generally (whether or not they are aware of the NFZs), or fishers who are aware think that it will take further time for the effects of the NFZ to become apparent.

More keen or more avid fishers tended to have different changes in satisfaction and expectations between the years than their less avid peers. Expectations for the most avid fishers were generally slightly higher than those for least avid fishers. This may be because the more avid fishers were more interested in the potential effects of the NFZs and were predicting larger positive changes than their less avid, and perhaps less interested, peers. In 2016 and 2018, these expectations seem to have reduced somewhat but remained positive, perhaps because they considered some of the benefits had already been realised or, alternatively, they had simply reduced their expectations. Interestingly, mean satisfaction levels of fishing in the NFZs were similar among all the avidity groups in 2015, but were greater in 2016 and 2018 among the more avid groups (Figure 16). It appears that the more avid fishers expected large positive changes in 2015, became more satisfied with their fishing in 2016 through to 2018, and now expect smaller positive changes into the future. Meanwhile, the expectations and satisfaction of the less avid fishers has remained consistent (i.e. slightly positive).

Catch orientation is a measure of how much recreational fishers value actually catching fish on a trip. For example, some fishers may be quite happy not to catch a fish on every trip, while others may desire to catch their possession limit. People can have different degrees of catch orientation. Understanding the catch orientation of recreational fishers can help when choosing management strategies that are acceptable to the majority of recreational fishers. The responses to catch orientation over the two years showed that, generally, fishers have a low to moderate catch orientation. This agrees with surveys completed by Fisheries Queensland and other researchers, which show that the benefits derived from recreational fishing are more than simply catching fish (McInnes et al., 2012; Beardmore et al., 2015). Catch orientation is a character of a fisher's psyche that is unlikely to change suddenly. Therefore, little change would be expected in catch orientation of fishers between the survey years. The results show little change across years except for a slight reduction in catch orientation in Mackay and Rockhampton.

How central an activity is to a person's lifestyle provides some insight into how much they value that activity. People who spend much of their recreation time doing a particular activity indicate they place a high value on that activity. Other lines of evidence, such as associating with people who also participate in that activity, also suggests that it is central to their lifestyle and is highly valued. However, it is important to realise recreation time is a resource for which other activities compete. How cognitively difficult a person would find it to spend their recreation time on different activities also indicates how central the activity is to their lifestyle. The results from the lifestyle statements suggest that in 2015 and 2016 recreational fishing was only moderately central to the lifestyle of the recreational fishers interviewed. Looking at the responses to the individual statements, however enjoying recreational fishing and associating with people who go fishing were both rated very highly (Appendix 7). This suggests recreational fishers are enjoying their fishing, as do many of their friends. However, the responses to the statement 'Other leisure activities do not interest me as much as

fishing' were not as positive. This suggests recreational fishers are aware of other recreational activities and many are interested in them, suggesting recreational fishing is susceptible to competition from other recreational activities. Most recreational fishers disagreed with the statements 'I would see my friends less often if I stopped fishing' and 'If I couldn't go fishing I wouldn't know what else to do' (Appendix 7). This suggests if they chose not to participate in recreational fishing they would continue to interact with friends and find other enjoyable recreational activities. In contrast to 2015 and 2016, recreational fishers who were interviewed in 2018 had significantly higher centrality to lifestyle associated with fishing (Figure 10). There could be a number of reasons for this change including targeting a slightly different group of fishers due to survey period changes (the 2018 survey occurred prior to the barramundi closure) or a change in interpretation of the question. From the data collected, the most obvious reasons for this change is recreational fishers interviewed in 2018 had a higher degree of avidity and were more skewed to male fishers than previous.

Summary

This report examines boat ramp survey data collected in the two years and eight months following the establishment of the NFZs, as well as the data collected by the satisfaction and expectation surveys performed at tackle stores in NFZs during 2015, 2016 and 2018. The benefits of NFZs on the number and size of fish caught by recreational fishers are likely to take time to emerge, however recreational fishers are already harvesting larger barred javelin in the Rockhampton NFZ compared to when the NFZs were first implemented. Barramundi were also larger in the Rockhampton NFZ compared to the reference areas during 2016 and 2017. Recreational fishers are not catching more or larger fish in the Mackay or Cairns NFZ. The promotion of NFZs in Rockhampton has likely resulted in fishers travelling further to fish these areas. In addition to the increase in size of some key species in the Rockhampton NFZ, recreational fishers in all NFZs are satisfied with their recreational fishing experiences and have increasing expectations for the future.

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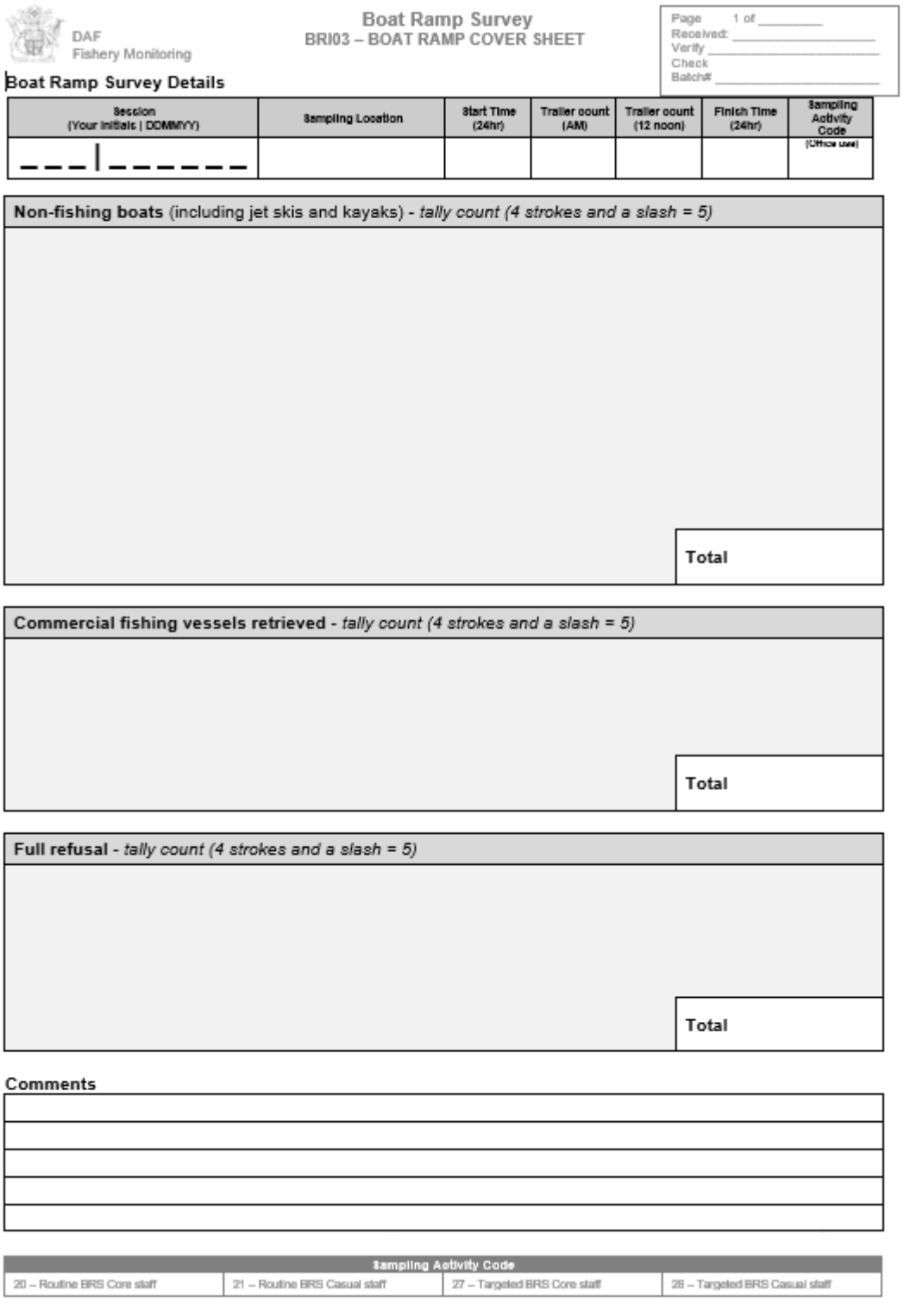
Appendix

Appendix 1: Boat ramp survey cover sheet



DAF
Fishery Monitoring

Boat Ramp Survey
BRI03 – BOAT RAMP COVER SHEET

Page 1 of _____
Received: _____
Verify _____
Check
Batch# _____

Boat Ramp Survey Details

Session (Your initials | DDMMYY)	Sampling Location	Start Time (24hr)	Trailer count (AM)	Trailer count (12 noon)	Finish Time (24hr)	Sampling Activity Code (Office use)
_ _ _ | _ _ _ _ _ _						

Non-fishing boats (including jet skis and kayaks) - *tally count (4 strokes and a slash = 5)*

Total

Commercial fishing vessels retrieved - *tally count (4 strokes and a slash = 5)*

Total

Full refusal - *tally count (4 strokes and a slash = 5)*

Total

Comments

Sampling Activity Code			
20 – Routine BRS Core staff	21 – Routine BRS Casual staff	27 – Targeted BRS Core staff	28 – Targeted BRS Casual staff

Appendix 2: Boat ramp survey interview sheet

DAF
Fishery Monitoring

Boat Ramp Survey
BRI03 - INTERVIEW SHEET

Page _____ of _____
Verify
Check

Boat Ramp Survey Details

Session (Your Initials | DDMMYY)	Sampling Location
_ _ _ | _ _ _ _ _ _	

Interview Details

Interview #	Retrieve Time (24hr)	Launch Date (If not today)	Launch Time (24hr)	No of Fishers	Primary Target Species (Abbreviation)	Secondary Target species (Abbreviation)

Town / Suburb											
If >100km away then	Post code		Fishing main purpose?		Post code		Fishing main purpose?		Post code		Fishing main purpose?	
Town / Suburb											
If >100km away then	Post code		Fishing main purpose trip?		Post code		Fishing main purpose?		Post code		Fishing main purpose?	

Fishing Activity Location & Method Details

Activity #	Location (Abbreviation)	Fishing Method Code	Days Fished	Activity #	Location (Abbreviation)	Fishing Method Code	Days Fished

Total Kept plus Released

Activity #	Species (Abbreviation)	Total Kept	Counted ? Y/N	Total Released	Comments	Activity #	Species (Abbreviation)	Total Kept	Counted ? Y/N	Total Released	Comments

Kept Details

Activity #	Species (Abbreviation)	Length (mm)	Length type	Comments	Activity #	Species (Abbreviation)	Length (mm)	Length type	Comments

Fishing Method Code					Length Type Code	
01 - Line	6C - Pot Checking	6S - Pot Setting	08 - Spearfishing	94 - Cast Netting	1 - Fork Length	2 - Total Length

Appendix 3: Net-free zone satisfaction and expectation survey

NFS01 (NET FREE ZONES TACKLE STORE SURVEY)
INTERVIEW SHEET 2016
DAF FISHERY MONITORING

SurveyID: _____ Verify _____
SessionID: _____ Check _____

Session: _ _ _:_ _ _ _ _	Store:

Q1 Hi, My name is (*your name here*) and I am doing some research on recreational fishing for Fisheries Queensland. In the past 12 months, have you been recreational fishing in this area? **** Show map if necessary: NFZ area and surrounds If No, record as ineligible on the cover sheet ****	**YES.** If **NO**, do not interview.	**Interview #**

Q2 How many times have you been recreational fishing **in Queensland** in the last 12 months?	1. 1-2 times a year (1-2 days/yr)	3. 1-2 times a month (13-24 days/yr)
	2. more than 1-2 times a year, but less than once a month (<12 days/yr)	4. 2-3 times a month (25-36 days/yr)
		5. once a week or more (52+ days/yr)

Q3 ***Catch orientation*** – These next statements are about catching fish and what it means to you. Looking at this scale; 1 being strongly disagree, 7 being strongly agree and 4 being neutral… On a scale or 1 to 7, rate how strongly you agree with the following statements: **** Important: Read these statements exactly as they are written ****

a. "When I go fishing, I'm **not** happy unless I catch something"	1 : 2 : 3 : 4 : 5 : 6 : 7
b. "When I go fishing, I am just as happy if I **don't** catch a fish"	1 : 2 : 3 : 4 : 5 : 6 : 7
c. "I usually have a good time fishing even if no fish are caught"	1 : 2 : 3 : 4 : 5 : 6 : 7
d. "When I'm fishing, I enjoy other parts of the experience **more** than actually catching a fish"	1 : 2 : 3 : 4 : 5 : 6 : 7
e. "The main reason I go fishing is to catch a fish"	1 : 2 : 3 : 4 : 5 : 6 : 7

Q4 ***Lifestyle*** – These questions are about your **fishing generally over the last 12 months**. Looking at this scale again … On a scale or 1 to 7, rate how strongly you agree with the following statements: **** Important: Read these statements exactly as written ****

a. "Most of my friends go fishing"	1 : 2 : 3 : 4 : 5 : 6 : 7
b. "Going fishing is one of the most enjoyable things I do"	1 : 2 : 3 : 4 : 5 : 6 : 7
c. "Other leisure activities **do not** interest me as much as fishing"	1 : 2 : 3 : 4 : 5 : 6 : 7
d. "I would see my friends less often if I stopped fishing"	1 : 2 : 3 : 4 : 5 : 6 : 7
e. "If I couldn't go fishing, I wouldn't know what else to do"	1 : 2 : 3 : 4 : 5 : 6 : 7

Q5 These questions are about your **expectations of fishing in this area in the next 12 months**. Looking at this scale again and thinking about your expectations, on a scale of 1 to 7, rate the following statements: **** Important: Read these statements exactly as written ****

a. "My satisfaction with fishing in this area will **increase** over the next 12 months"	1 : 2 : 3 : 4 : 5 : 6 : 7
b. "I expect the **variety** of species I catch to **increase** over the next 12 months"	1 : 2 : 3 : 4 : 5 : 6 : 7
c. "Over the next 12 months, I expect that fishing spots in this area **won't** become overcrowded"	1 : 2 : 3 : 4 : 5 : 6 : 7
d. "I expect the **number** of fish I catch to **increase** over the next 12 months"	1 : 2 : 3 : 4 : 5 : 6 : 7
e. "Over the next 12 months, I expect that boat ramps in this area **will** become overcrowded"	1 : 2 : 3 : 4 : 5 : 6 : 7
f. "My enjoyment of fishing in this area **will not** improve over the next 12 months"	1 : 2 : 3 : 4 : 5 : 6 : 7
g. "I expect the **size** of the fish I catch to **decrease** over the next 12 months"	1 : 2 : 3 : 4 : 5 : 6 : 7
h. "Over the next 12 months I expect to be able to target new species that I haven't targeted before"	1 : 2 : 3 : 4 : 5 : 6 : 7

Q6 These questions are about your **satisfaction with fishing over the last 12 months in this area**. Looking at this scale: 1 being very dissatisfied, 7 being very satisfied…and thinking about your satisfaction with fishing over the past 12 months in this area, how satisfied have you been with the following: **** Important: Read these statements exactly as written ****

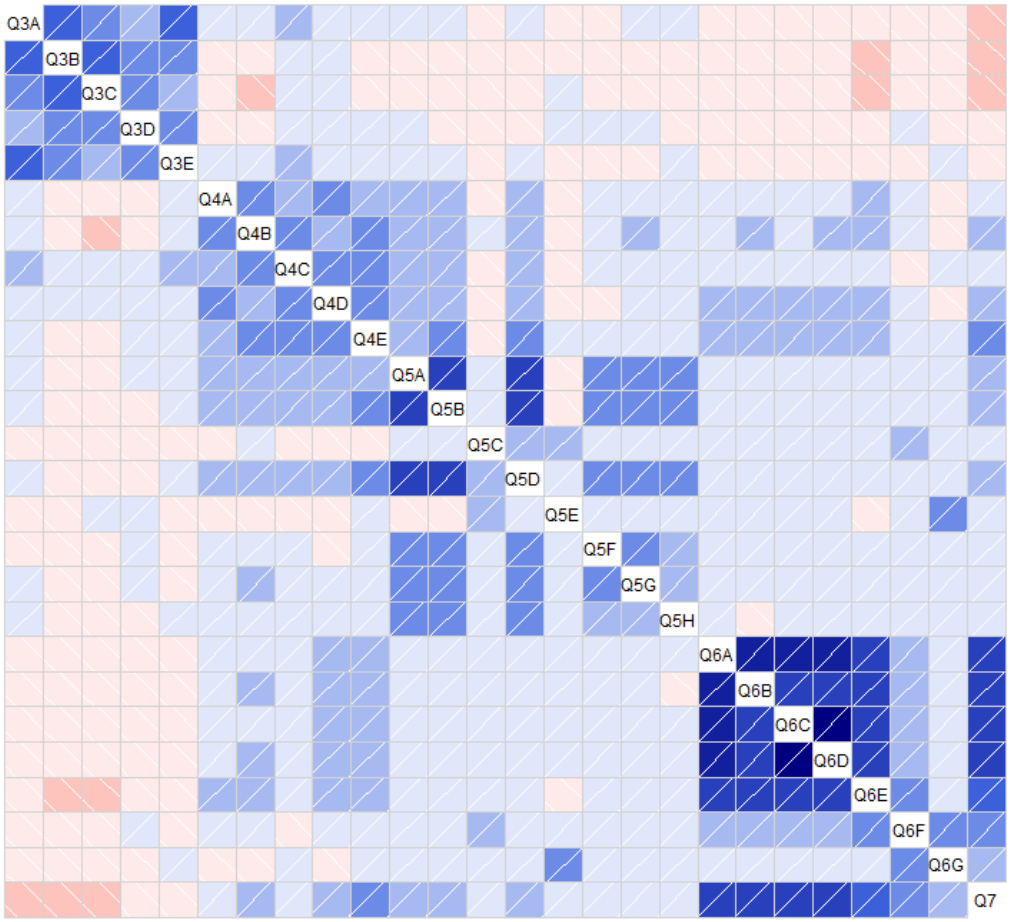
a. "Number of fish you've caught"	1 : 2 : 3 : 4 : 5 : 6 : 7
b. "Variety of fish you've caught"	1 : 2 : 3 : 4 : 5 : 6 : 7
c. "Number of big fish you've caught"	1 : 2 : 3 : 4 : 5 : 6 : 7
d. "Size of the fish you've caught"	1 : 2 : 3 : 4 : 5 : 6 : 7
e. "Experiencing exciting fights with fish"	1 : 2 : 3 : 4 : 5 : 6 : 7
f. "Number of uncrowded fishing spots"	1 : 2 : 3 : 4 : 5 : 6 : 7
g. "Parking space and boat ramp access"	1 : 2 : 3 : 4 : 5 : 6 : 7

Q7 Overall, how satisfied are you with fishing in this area in the past 12 months?	1 : 2 : 3 : 4 : 5 : 6 : 7

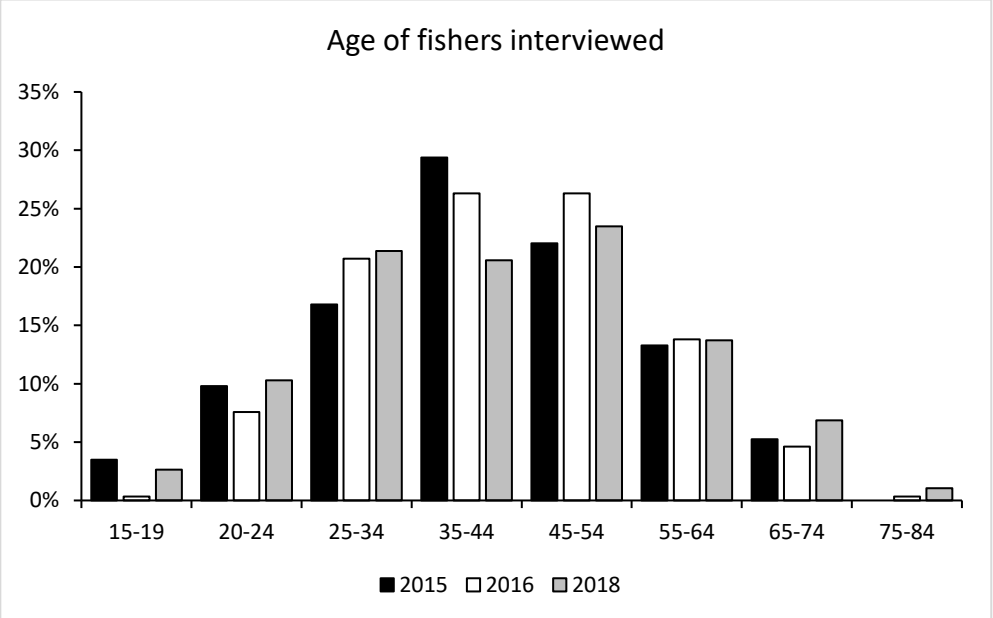
Q8 Have you heard that a Net Free Zone is now in place in this area, since 1st of November 2015? **** If unsure, No****	Yes : No
Q9 What age group do you belong to? Are you…?	15 – 19 : 20 – 24 : 25 – 34 : 35 – 44 : 45 – 54 : 55 – 64 : 65 – 74 : 75 – 84 : 85+
Q10 Gender - don't ask, just record	Male : Female

Q11 What is the suburb or town in which you live? *OR* Postcode?	Suburb or Town:		Postcode:	

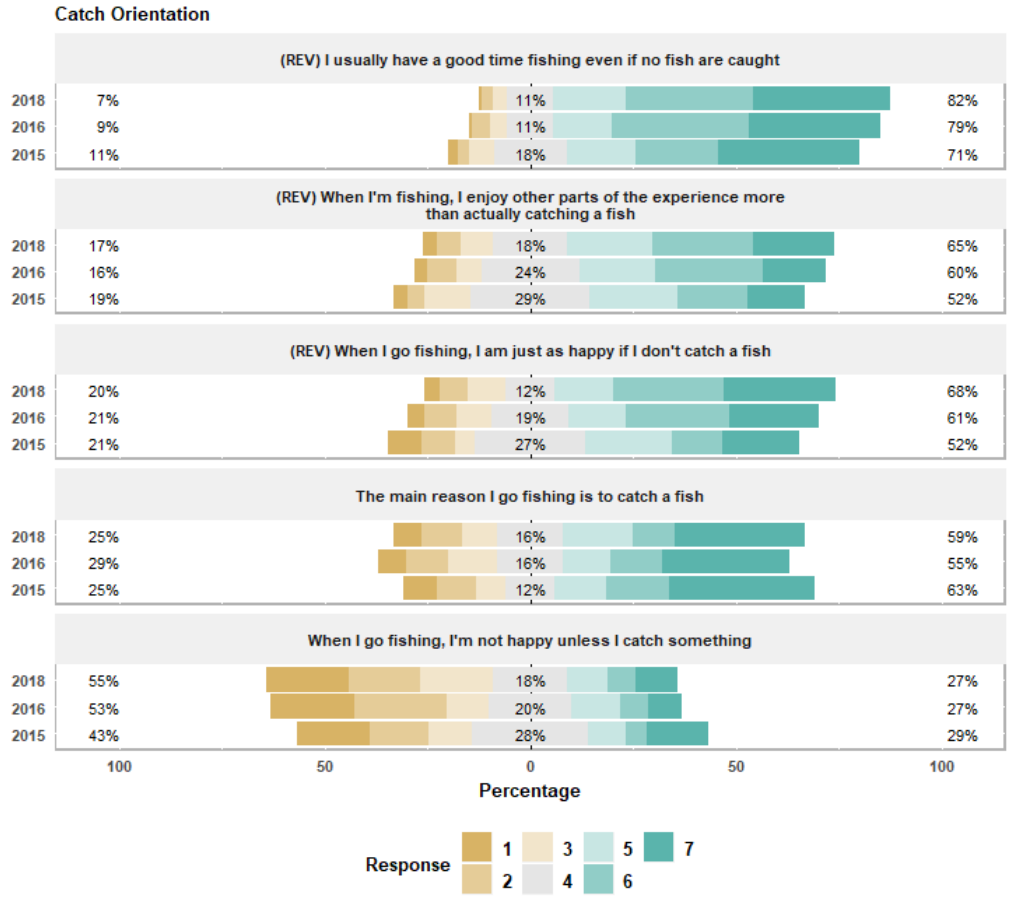
Appendix 4: Correlation matrix of the recreational fishers' responses to the questionnaire statements (Q3-Q7)—blue indicates a positive correlation, red indicates a negative correlation and darker shades indicate stronger relationships



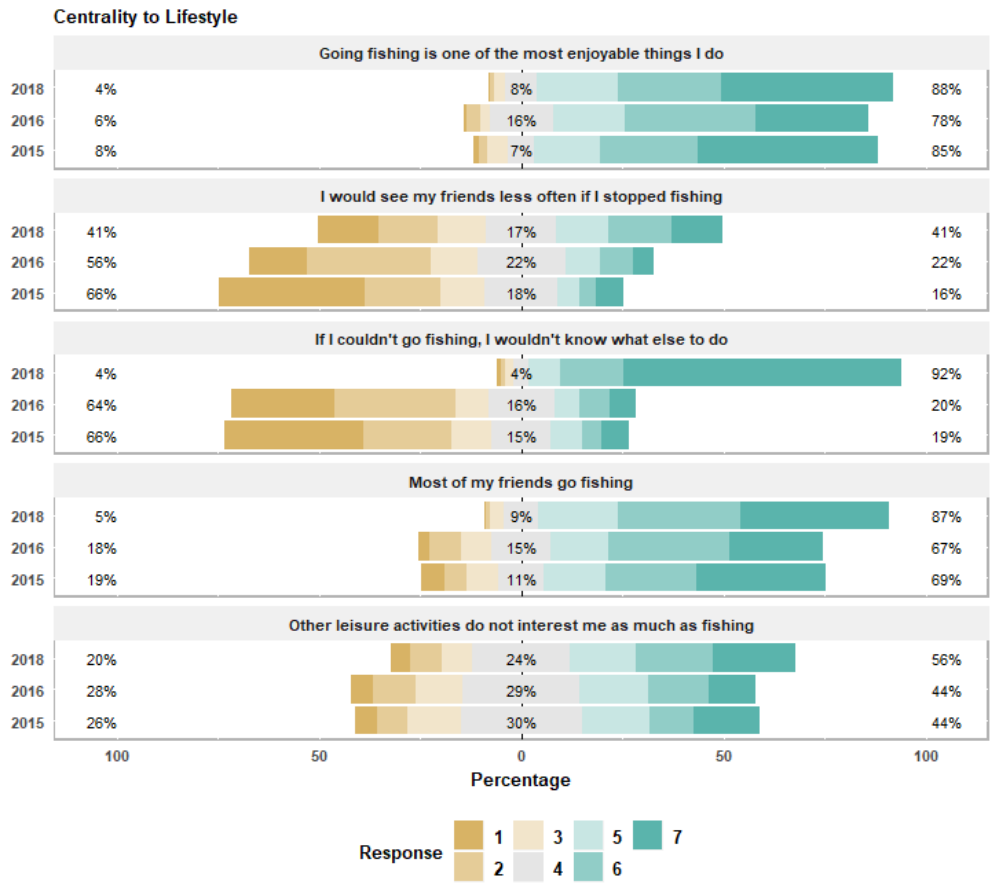
Appendix 5: Age distribution of recreational fishers interviewed in 2015, 2016 and 2018



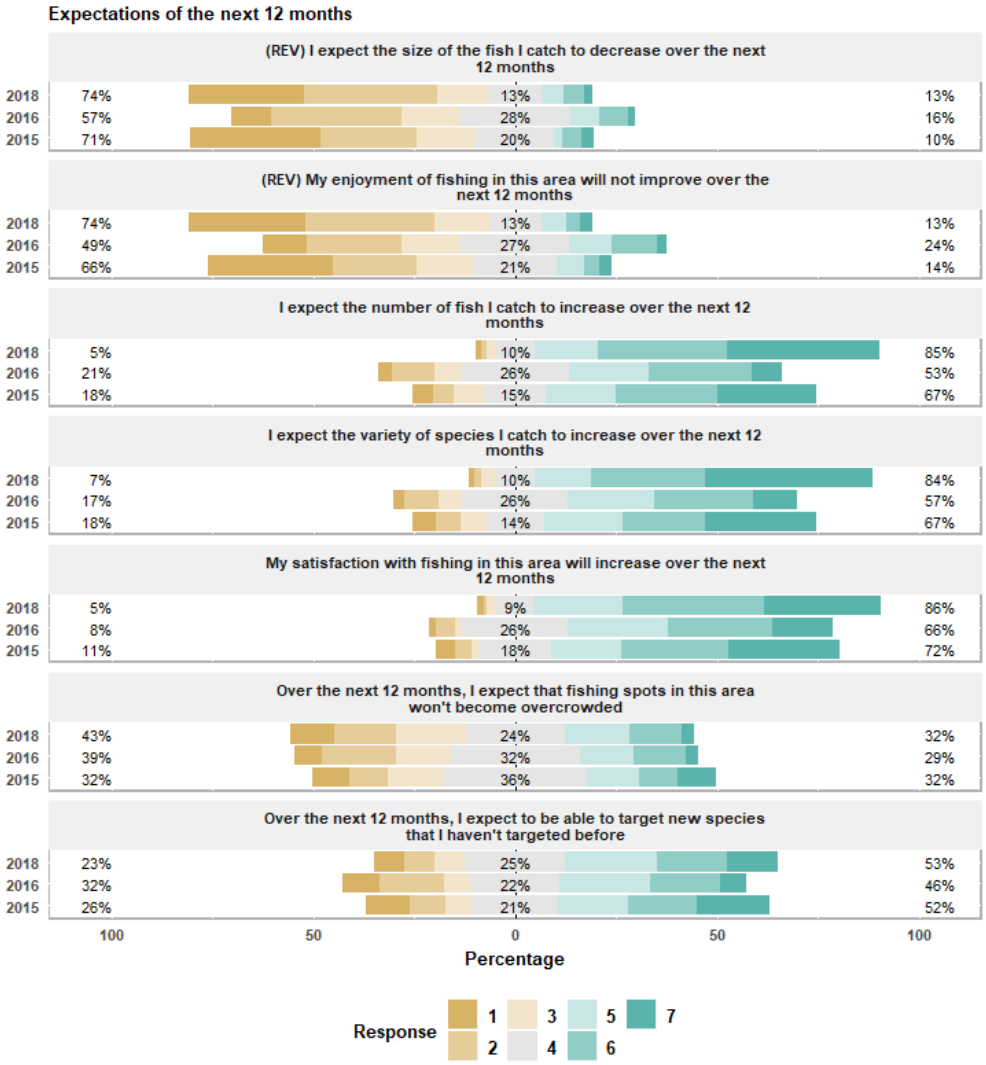
Appendix 6: Raw Likert scale responses to five catch orientation questions for 2015, 2016 and 2018 for all net-free zones combined (response of 1 is strongly disagree and 7 is strongly agree, positive response for statements marked 'REV' indicates a lower degree of catch orientation, these data were transformed prior to further analysis)



Appendix 7: Likert scale responses to five centrality to lifestyle questions for 2015 and 2016 for all net-free zones combined (1 indicates strongly disagree and 7 indicates strongly agree)


Centrality to Lifestyle
Going fishing is one of the most enjoyable things I do
2018 4% 8% 88%
2016 6% 16% 78%
2015 8% 7% 85%
I would see my friends less often if I stopped fishing
2018 41% 17% 41%
2016 56% 22% 22%
2015 66% 18% 16%
If I couldn't go fishing, I wouldn't know what else to do
2018 4% 4% 92%
2016 64% 16% 20%
2015 66% 15% 19%
Most of my friends go fishing
2018 5% 9% 87%
2016 18% 15% 67%
2015 19% 11% 69%
Other leisure activities do not interest me as much as fishing
2018 20% 24% 56%
2016 28% 29% 44%
2015 26% 30% 44%
100
50
0
50
100
Percentage
Response
1
2
3
4
5
6
7

Appendix 8: Raw Likert scale responses to five expectation statements for 2015 and 2016 for all net-free zones combined (REV highlights responses that were transformed prior to analysis, 1 indicates strongly disagree and 7 indicates strongly agree).



Appendix 9: Likert scale responses to five satisfaction statements for 2015 and 2016 for all net-free zones combined (1 indicates strongly disagree and 7 indicates strongly agree).