Western Australian Marine Stewardship Council Report Series

West Coast Estuarine Managed Fishery (Area 2: Peel-Harvey Estuary) & Peel-Harvey Estuary Blue Swimmer Crab Recreational Fishery

Addendum

September 2017

Table of Contents

Background

The West Coast Estuarine Managed Fishery (WCEMF) Area 2 (Peel-Harvey Estuary) uses haul and gillnets to target predominantly sea mullet (*Mugil cephalus*), and crab traps to target blue swimmer crabs (*Portunus armatus*). The recreational crab fishers in the Peel-Harvey Estuary primarily use drop and scoop nets for catching blue swimmer crabs.

The fisheries acheived Marine Stewardship Council (MSC) certification in 2016 and the assessment was based on information presented in Johnston et al. (2015):

http://www.fish.wa.gov.au/Documents/wamsc_reports/wamsc_report_no_3.pdf

This report is an addendum to Johnston et al. (2015) and provides catch and effort information for the 2014 and 2015 fishing seasons in the Peel-Harvey Estuary. It also provides updates on progress made to date to address the MSC conditions placed on the fisheries for the criteria where the standard was not quite achieved.

MSC Principle 1

MSC Principle 1 (P1) focuses on maintaining, indefinitely, fishing activity at a level that is sustainable for the targeted populations (MSC 2013).

1. Current Stock Status

The status of the sea mullet and blue swimmer crab stocks targeted by fishers in the Peel-Harvey Estuary is assessed annually using a weight-of-evidence approach that considers all available information about the stocks (see Wise et al. 2007 for explanation of weight-of-evidence approach). This assessment approach is primarily based on evaluating standardised commercial catch rates (primary performance indicator, considered to represent a proxy for overall stock abundance) and catches (secondary performance indicator) in the WCEMF Area 2 relative to reference points calculated based on a reference period in which these indicators have been stable (see DoF 2015a, b).

1.1 Sea Mullet

In response to the high catch rate observed for sea mullet in the Peel-Harvey Estuary in 2013 (see Figure 1.1), and concerns that the measure of fishing effort used in the original catch rate standardisation undertaken prior to the MSC full assessment in 2014 could be inaccurate, the analyses were re-visited in 2015.

Full details of the original standardisation model, which accounted for factors year, month, fishing vessel and fishing method (gill and haul netting), can be found in the original MSC Report (No. 3, see Johnston et al. 2015). The original standardisation used a measure of fishing effort that was based on the length of net used and the hours fished, which is reported by fishers in their monthly statutory catch and effort returns. Due to the resolution of the reported data (monthly averages), the "100 m netting hours" measure may not accurately reflect the effort in the net fishery. This may be the cause of the apparent phased 'shifts' in the original standardsised catch rate time series (Figure 1.1), corresponding to key events influencing the fishery, namely the introduction of crab traps in 2000 and also the development and implementation of the harvest strategy from around 2013.

To explore the influence on the catch rate time series of the choice of effort measure used in the standardisation, the analyses of data were repeated using fishing day as the effort measure and comparing the outputs with the standardisation that uses the 100 m netting hour effort measure. New values for the catch rate reference points (target, threshold and lower limit) that relate to the seconary catch rate performance indicator for sea mullet were also calculated (see Table 1.1) using the same approach and reference period as described in the finfish harvest stratgey (DoF 2015a).

Table 1.1. Catch rate reference points for sea mullet in the Peel-Harvey Estuary when fishing day is used as a measure of effort in the catch rate standardisation.

Reference point	Value	Justification
Target	103 kg/day	Mid-point between lower and upper threshold reference points (target range = 69-136 kg/day)
Upper Threshold	136 kg/day	Maximum observed standardised catch rate value during reference period of 2000-2011
Lower Threshold	69 kg/day	Minimum observed standardised catch rate value during reference period of 1980-2010
Limit	49 kg/day	70% of lower threshold value

Overall, the two time series of standardised catch rates show similarities, however, the use of the broader effort measure (fishing days) eliminates the sudden shifts that are apparent in the original catch rate (cf. Figure 1.1 and Figure 1.2). It is proposed that the two catch rate series will both be monitored against their respective reference points for the duration of the first harvest strategy for the Peel-Harvey sea mullet resource (until 2020), at which point the performance indicator(s) and reference points for this species will be formally reviewed. Analyses to further review the available fishery-dependent catch and effort data will continue during this time to help inform the next version of a harvest startegy for this resource.

Although the updated time series of standardised commercial catch rates (based on fishing day) remained within the associated threshold reference points of 60-136 kg/day in 2014 (85 kg/day) and 2015 (116 kg/day), the catch rate calculated using the original effort measure breached the upper threshold level of 4.6 kg/100 m netting hour in 2013 (6.7 kg/100 m netting hour) and 2015 (7.2 kg/100 m netting hour) (Figure 1.1 and Figure 1.2). Annual commercial sea mullet catches have been increasing since 2011 and were above the upper threshold value of 70 t in 2014 (75 t) and 2015 (91 t) (Figure 1.3). The increased catch of sea mullet reflects an increased targeting of this species. This is reflected in the increasing trend in haul netting effort over recent years, which is the main method of capture of sea mullet (Figure 1.4).

The trends in sea mullet catch and catch rates are either stable or increasing, indicating that the stock level is currently adequate. However, as required by the harvest strategy control rules, the recent breaches of catch (and the original catch rate) threshold levels have triggered further investigation of the risk to the sustainability of the stock. This will be achieved by obtaining representative samples of the age structure of sea mullet stock in the West Coast Bioregion to enable a Level 3 (catch curve and per-recruit) assessment. This assessment is expected to be completed in 2019 and the outputs will determine whether management action is required, and inform the next version of the harvest strategy.

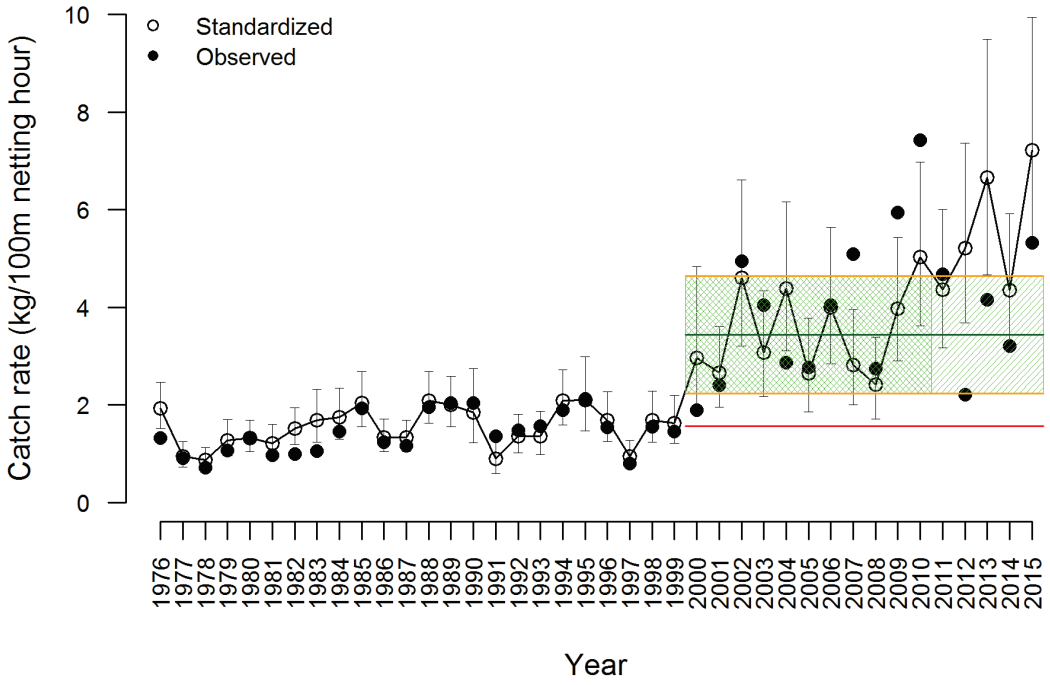

Figure 1.1. Time series of annual standardised commercial catch rate (kg/100 m netting hour) for sea mullet in the Peel-Harvey Estuary net fishery, based on original catch rate standardisation, relative to the associated reference points (target, threshold and limit) outlined in the Finfish Resources of the Peel-Harvey Estuary Harvest Strategy 2015-2020.

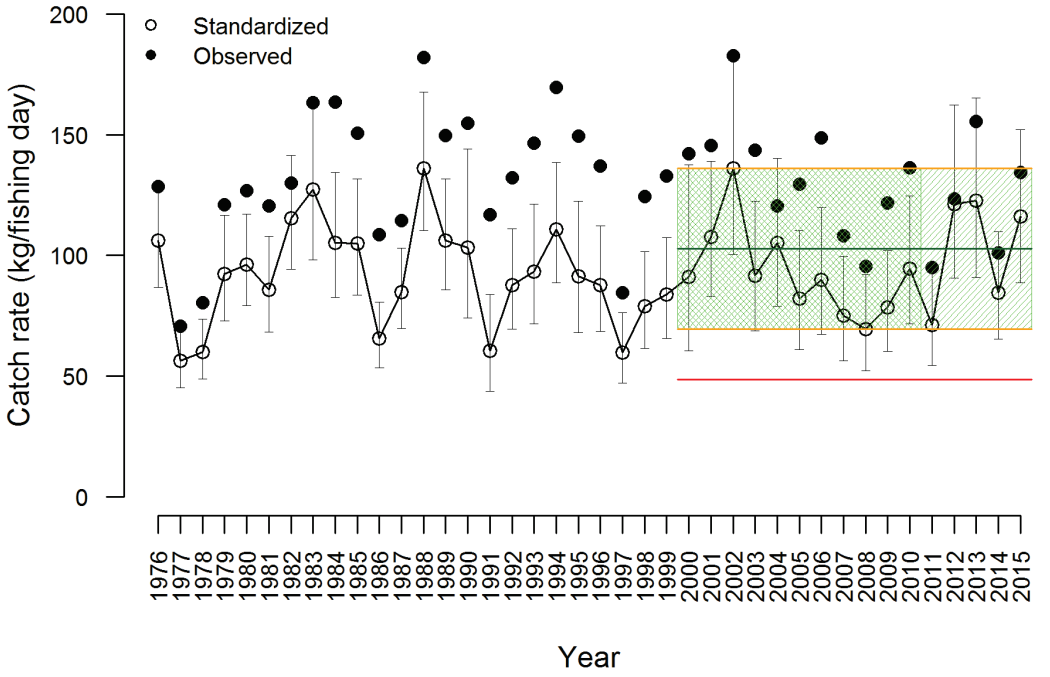

Figure 1.2. Time series of annual standardised commercial catch rate (kg/day) for sea mullet in the Peel-Harvey Estuary net fishery, based on an updated catch rate standardisation, relative to the new reference points (target, threshold and limit, see Table 1.1).

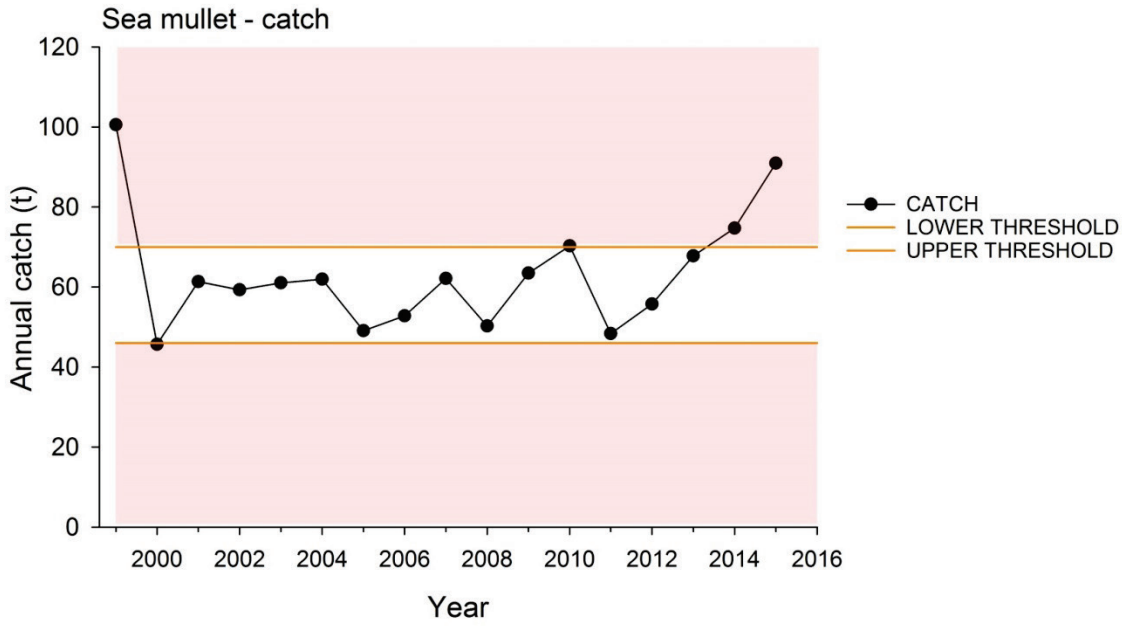

Figure 1.3. Annual commercial catch (tonnes) of sea mullet in the Peel-Harvey Estuary haul and gillnet fishery relative to the associated harvest strategy reference points.

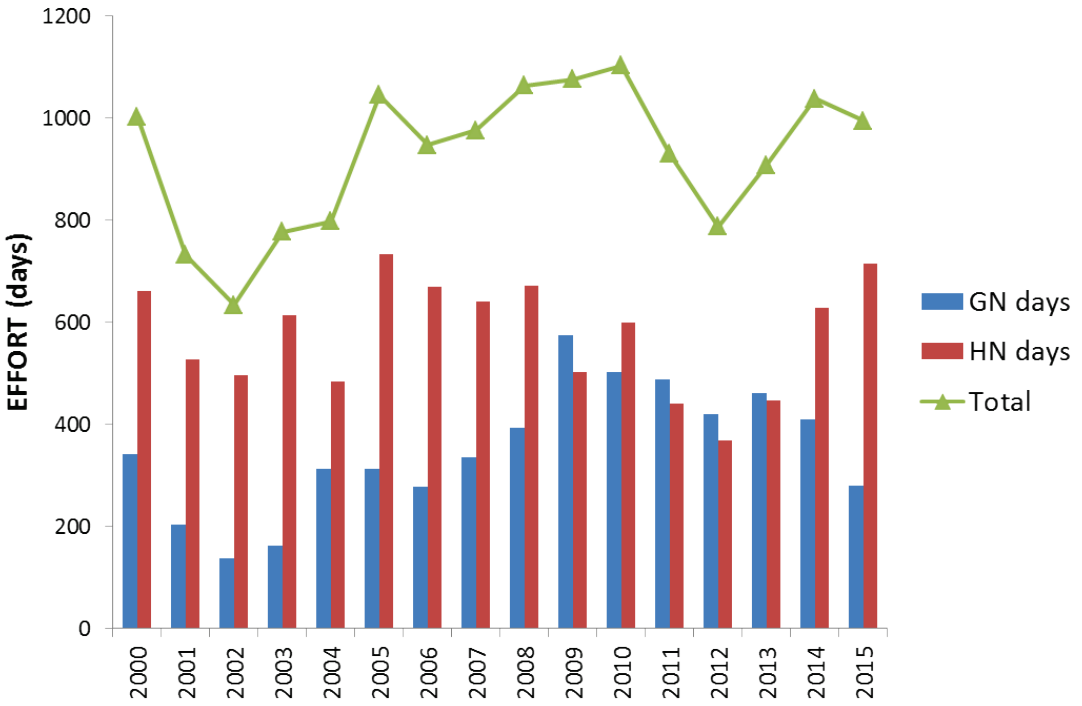

Figure 1.4. Annual nominal commercial netting effort (haul net and gill net days) in the Peel-Harvey Estuary fishery between 2000 and 2015.

1.2 Blue Swimmer Crab

The standardised commercial catch rate for blue swimmer crabs of 1.3 kg/traplift for the 2014/15 fishing season and 1.16 kg/traplift for the 2015/16 fishing season were both above the harvest strategy threshold of 0.7 kg/traplift (Figure 1.5a), indicating the stock is being fished at sustainable levels. Fishing season is defined as 1 November to 31 August. Although annual commercial crab catch declined from 97 t for the 2014/15 fishing season to 58 t in 2015/16, both were within the target range of 45-104 t (Figure 1.5b). As both indicators have remained within the target range, no changes to the management occurred for the 2016/17 season.

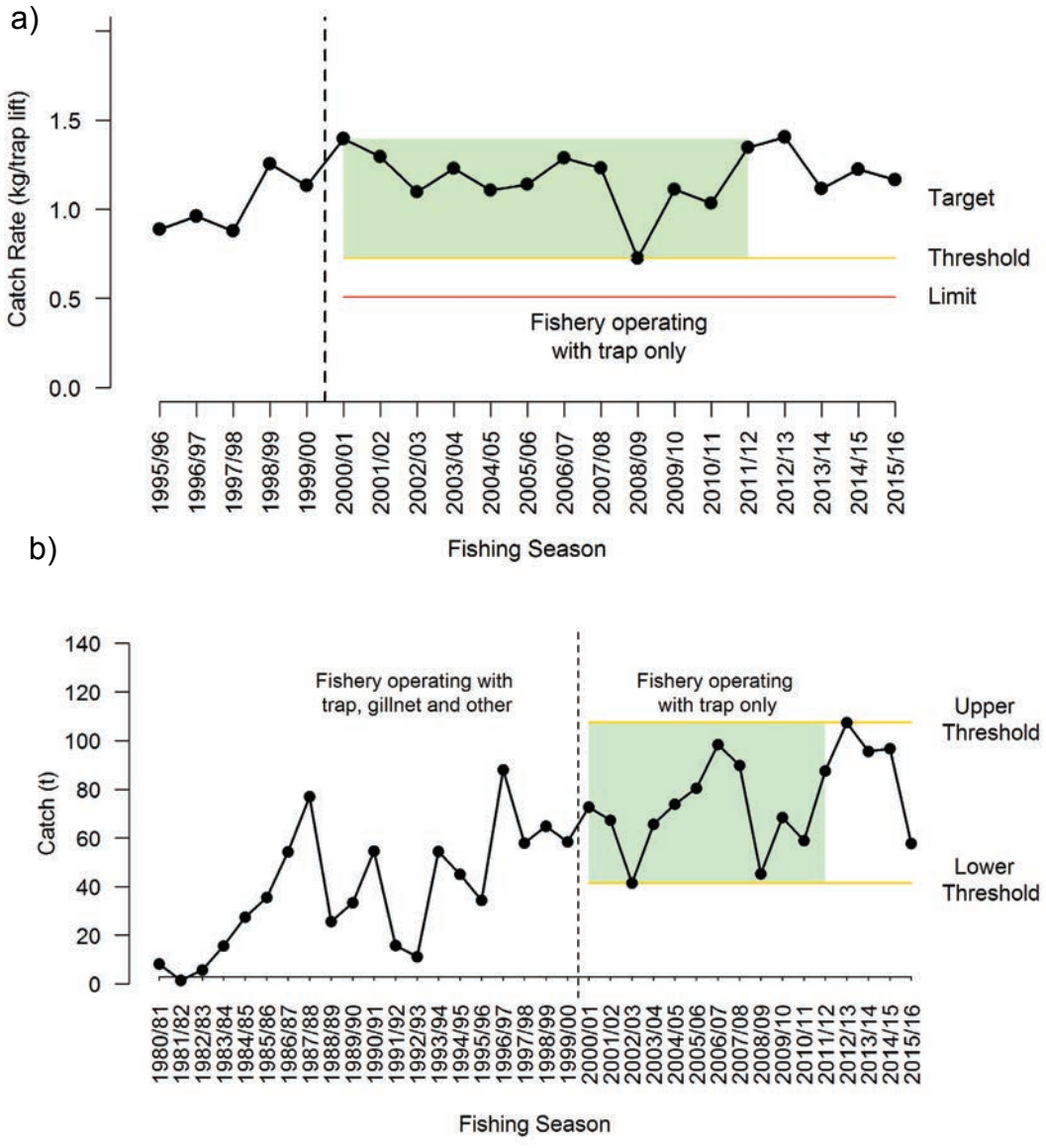

Figure 1.5. Annual (a) standardised commercial catch rate (kg/traplift) and (b) commercial catch of blue swimmer crabs in the Peel-Harvey Estuary fishery relative to the associated reference points (target, threshold and limit) specified in the harvest strategy. The reference period from 2000/01 to 2011/12 is defined as the period where the fishery was operating with traps only and for which the fishery was operating normally following the transition from gillnets in the late 1990s.

An estimate of the 2015/16 boat-based recreational catch of blue swimmer crabs in the Peel-Harvey Estuary will likely be available in late July.

Fishery-dependent and fishery-independent monitoring and examination of environmental data suggest that the recent decline in crab catch (2015/16 season) in the Peel-Harvey Estuary is driven mainly by environmental changes rather than excessive fishing pressure. Below-average water temperatures observed during the 2016 autumn and winter, associated with high rainfall in late January, March and May (Figure 1.6), may have caused crabs to be flushed out of the estuary. The large cohort of sub-legal crabs in the estuary (see fishery-independent monitoring below) suggest growth of crabs may also have been negatively affected, potentially as a result of the cooler and fluctuating water temperatures and/or density-dependence (as experienced in Cockburn Sound).

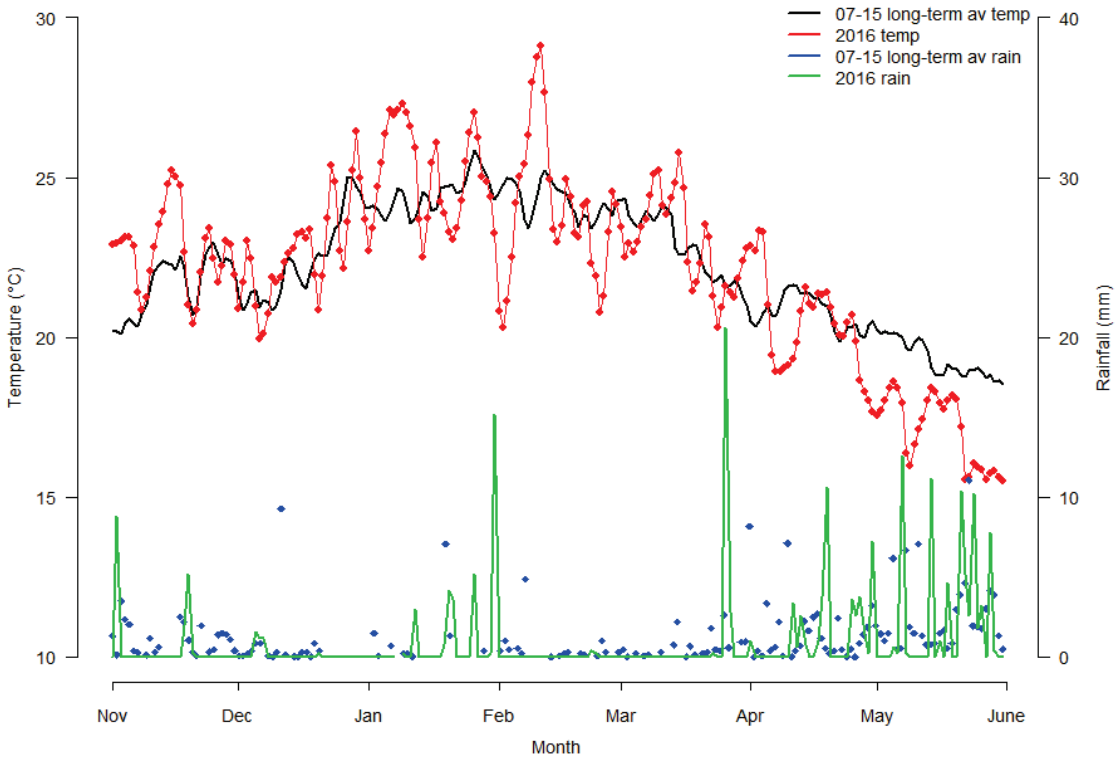

Figure 1.6. Patterns of water temperature and rainfall in the Peel-Harvey Estuary in 2015/16 relative to the long-term (2007-2015) average trends. Rainfall Sourced from Bureau of Meteorology Mandurah Station.

Monthly commercial trap monitoring of blue swimmer crab length frequencies show that males dominate the catch over the summer months between November and March with females becoming more prevalent in traps from April to August, with females often dominating the catch in some months during this period (Figure 1.7). Fishery-independent trap surveys undertaken between June and November using research traps without the escape gaps used in commercial trap to minimise captures of undersize crabs, show an increase in the number of sub-legal crabs since 2014 (Figure 1.8). This may be due to changing environmental conditions (such as cooler and fluctuating water temperatures) that are a key

driver of crab abundance and catch rates in this system. This good undersize crab abundance has also been confirmed by a trawl surveys at 10 sites throughout the estuary that commenced in March 2016 (Figure 1.9).

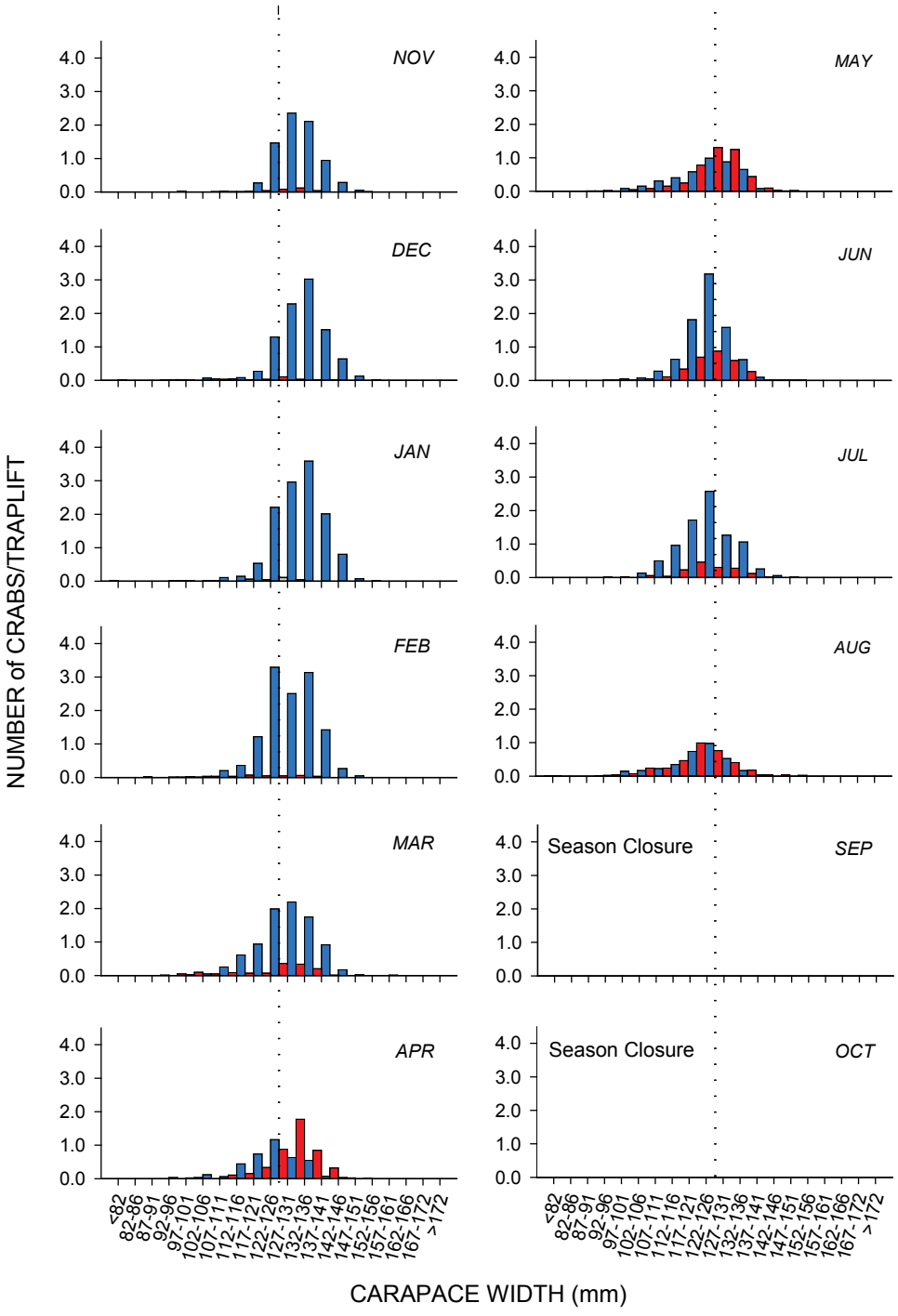

Figure 1.7. Monthly length frequencies of commercial trap catches of male (blue), female (red) and juvenile (yellow) blue swimmer crabs in the Peel-Harvey Estuary during the 2015/16 fishing season (1 November – 31 August). The minimum commercial size limit of 127 mm carapace width is indicated by the vertical dashed lines.

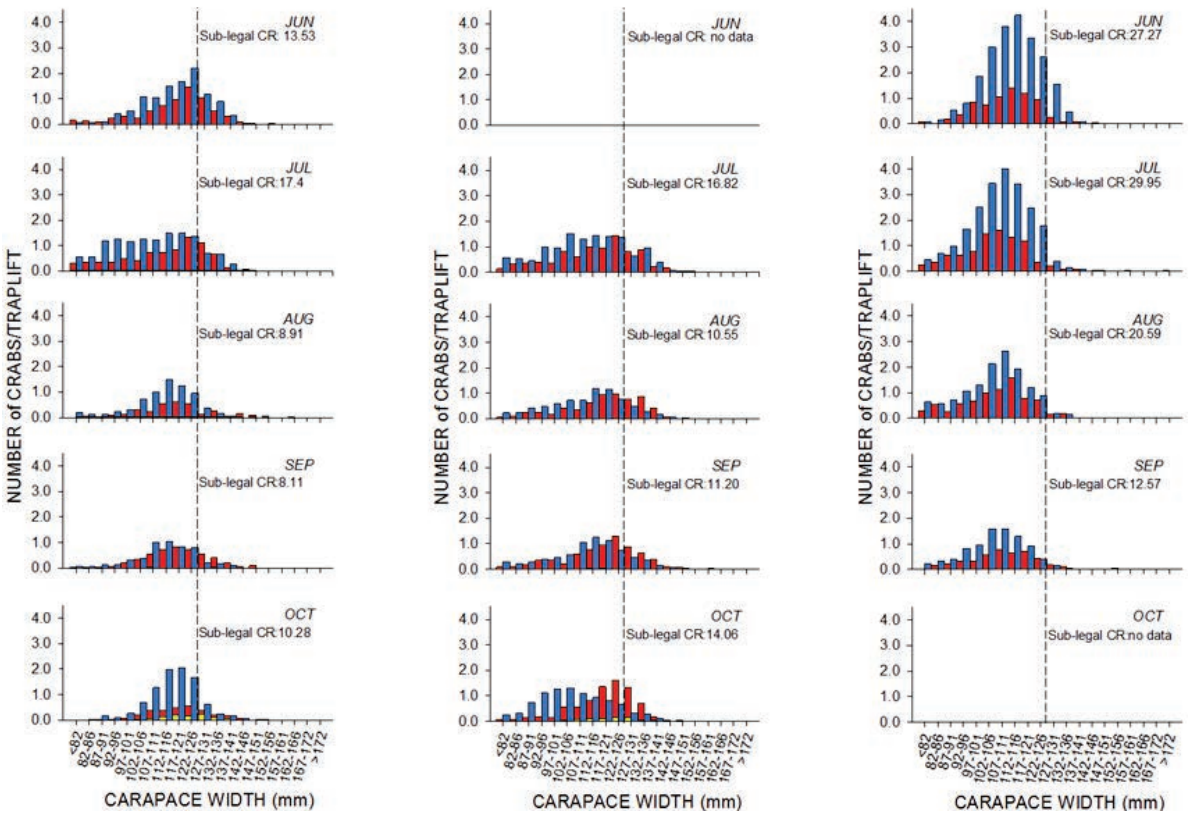

Figure 1.8. Monthly length frequencies of fishery-independent trap catches of male (blue), female (red) and berried (yellow) blue swimmer crabs in the Peel-Harvey Estuary during 2014, 2015 and 2016 fishing seasons (months of respective year shown in figure). The minimum commercial size limit of 127 mm carapace width is indicated by the vertical dashed lines.

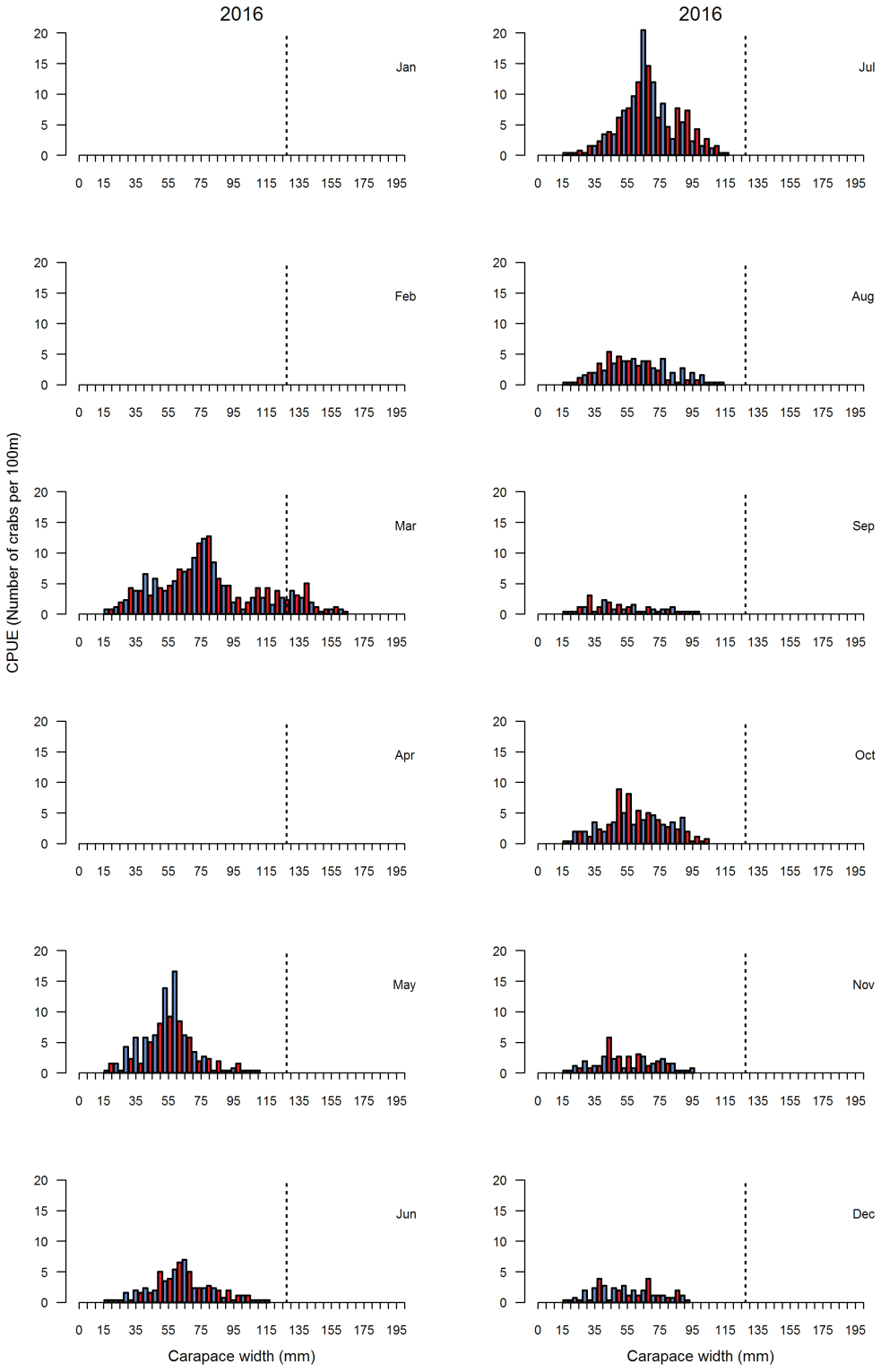

Figure 1.9. Monthly length frequencies of fishery-independent trawl survey catches of male (blue), female (red) and juvenile (yellow) blue swimmer crabs in the Peel-Harvey Estuary during 2016. The minimum commercial size limit of 127 mm carapace width is indicated by the vertical dashed lines.

The fishery-independent trap surveys have been used to develop biological indicators of pre-recruit and legal crab November abundance (with the trawl surveys being used to develop a juvenile index in the future). Catch rates of legal-sized crabs from fishery-independent trap surveys in November (t) showed a good predictive relationship with commercial catches for the following (November – August) fishing season (t, t+1) (Figure 1.10). These indices and catch prediction will be used in future assessments, in addition to the harvest strategy performance indicators, as a weight of evidence approach to stock assessment in this fishery.

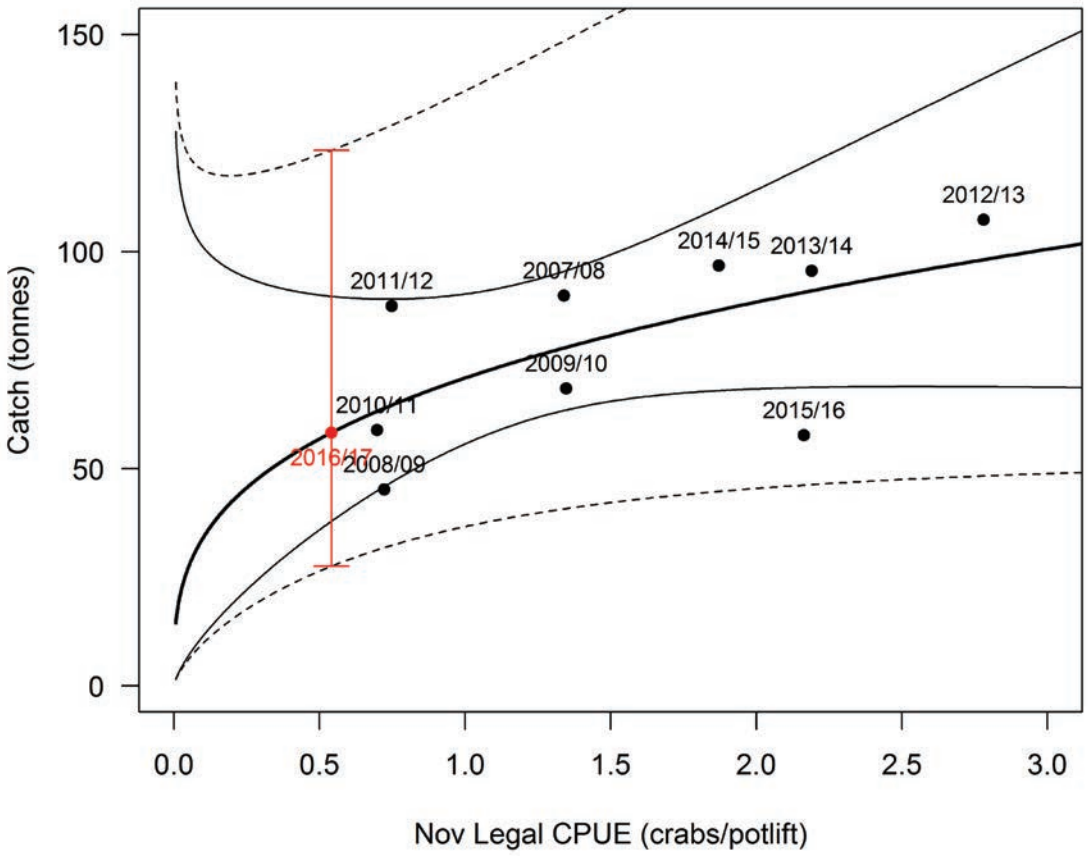

Figure 1.10. Catch prediction model using the November fishery independent catch rates of legal sized blue swimmer crabs (year t) as predictor of commercial catch for the following (November-August) fishing season (year t +1) (power relationship). The solid black line indicates the fitted regression line (bias corrected for estimation in log space), and the 95% confidence limits are indicated by the black line. The dotted line indicates the 95% prediction limits. The predicted catch and its prediction limits for 2016/17 are shown in red.

MSC Principle 2

MSC Principle 2 (P2) focuses on minimising environmental impact, such that fishing operations should be managed to maintain the structure, productivity, function and diversity of the ecosystem on which it depends (MSC 2013). This section has been divided into

- Retained species;
- Bycatch species;
- Endangered, threatened and protected (ETP) species;
- Habitats; and
- Ecosystem.

2. Other Retained Species

This section includes all species other than the 'target' (P1) species that are retained by commercial fishers in the commercial WCEMF (Area 2) and recreational blue swimmer crab fishers in the Peel-Harvey Estuary.

2.1 Commercial Net Fishery

The commercial net fishery is a multi-species fishery and in addition to sea mullet, fishers retain a range of other nearshore and estuarine finfish species. A summary of all retained commercial catches reported by fishers in the Peel-Harvey Estuary haul and gillnet fishery between 2013 and 2016 is provided in Table 2.1. The data show a substantial reduction in gillnet catches, from 37.4 t in 2014 to 16.3 t in 2015, that follows a reduced gillnet effort in recent years (Figure 1.4).

As outlined in the harvest strategy for the finfish resources of the PHE (DoF 2015a), appropriate performance indicators, reference levels and control rules have been developed for all retained species to satisfy the long-term management objective of maintaining spawning stock biomass of each such species at a level where the main factor affecting recruitment is the environment. The target catch / catch rate levels are as follows:

- Yelloweye mullet: annual commercial catch is < 46 tonnes;
- Yellowfin whiting: annual commercial catch is < 12 tonnes;
- Australian herring: annual commercial catch is < 9 tonnes;
- Tailor: annual commercial catch is < 9 tonnes;
- Cobbler: annual catch rate of cobbler is > 6 kg / fishing day and annual commercial catch is < 9 tonnes;
- Perth herring: annual commercial catch of Perth herring is < 2.7 tonnes; and
- All other retained species: annual commercial catch of each other retained species is < 5 % of the total retained catch.

Table 2.1. Retained species catches (kg) for the commercial Peel-Harvey Estuary haul net (HN) and gillnet (GN) sectors between 2013 and 2015. Dark blue shading indicates target (P1) species and light blue shading indicates main retained species (i.e. > 5% total retained catch based on the average catch for 2009 – 2013).

Common Name	Annual Catch (kg)					
	2013		2014		2015	
	GN	HN	GN	HN	GN	HN
Mullet, Sea	11746	56034	17854	56876	11064	79892
Mullet, Yelloweye (Pilch)	3249	13347	6174	10243	883	4928
Whiting, Yellowfin	5992	7962	8489	16105	3178	26432
Herring, Australian	1600	1208	986	2151	113	2580
Tailor	8234	4434	2321	5837	125	6154
Cobbler	1745	9	193		901	356
Whiting, King George	21	5	14	7	7	397
Herring, Perth	1421	104	1298	1225		2529
Trevallies, General	1109	704	89	1176	5	1059
Whiting, General/Sand	594	473		550		112
Trevally, Skipjack/Silver						75
Garfish, Southern Sea						5
Bream, Black	223	43	41	2	7	
Flatheads, General	11	2	28			8
Common Silverbiddy	50	23		30		18
Flounders, General	10			2		
Mulloway	8					
Pilchard						150
Herrings, Giant	3	3		5		
Trumpeters/ Grunters, General				20		
Squids, General						3
Total (kg)	**36016**	**84351**	37487	94229	16283	124698
Annual Total (kg)	**120 367**		**131 716**		**140 981**	

Catch trends for key retained species other than sea mullet, relative to harvest strategy reference points, are presented below.

2.1.1 Yelloweye mullet

The catch of yelloweye mullet shows a decline since the mid-2000s and reached a historical low of 6 t in 2015 (Figure 2.1). The low catches of this species is likely market-driven and follows a greater targeting of sea mullet. The 2014 and 2015 catches were well below the threshold level and thus no harvest strategy response has been necessary.

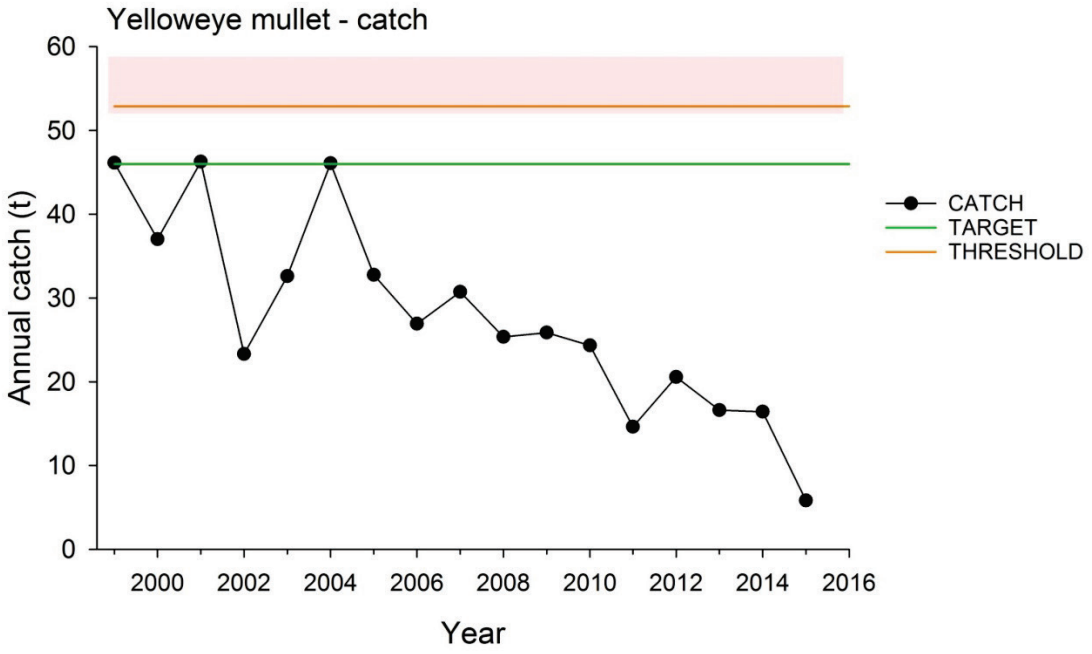

Figure 2.1. Annual commercial catch (tonnes) of yelloweye mullet in the Peel-Harvey Estuary haul and gillnet fishery relative to the associated harvest strategy reference points.

2.1.2 Yellowfin whiting

The large commercial catches of yellowfin whiting observed in the Peel-Harvey Estuary in 2014 and 2015 breached the catch threshold for this species of 13.8 t (Figure 2.2). As outlined in the harvest strategy, the breaches triggered a review to investigate the reasons for this variation and determine if sustainability of the stock was at risk due to the increased catches. The collection of age composition data for yellowfin whiting in the West Coast Bioregion was started in mid-2015 to enable a Level 3 (catch curve and per-recruit) assessment of the stock to be undertaken. Over two consecutive years, commercial and recreational landings were sampled in the Peel-Harvey Estuary and recreational landings were also sampled in ocean waters.

In August 2016 the Department convened a briefing with Recfishwest, WAFIC and commercial fishers to discuss the Department's assessment and harvest strategy in more detail. Data from the first year of age composition sampling were also presented, which showed that a very strong recruitment in 2010/11 had contributed to the greater than average catches in 2014 and 2015. As as outcome from this meeting, in November 2016, the Department finalised a factsheet regarding yellowfin whiting biology and lifecycle. This is available on the Department's website and includes information in relation to the heatwave-driven recruitment pulse and its contribution to catches of yellowfin whiting in the Peel-Harvey. The Department will, in the near future, update its website to include the results of the second and final year of age composition sampling and will inform key stakeholders of the final assessment results.

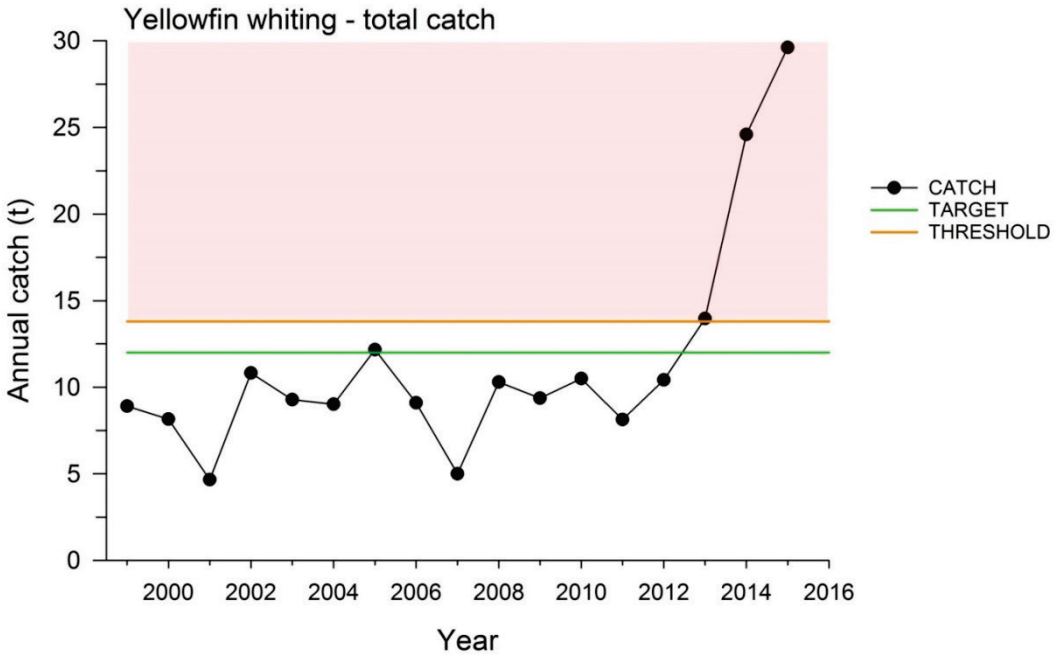

Figure 2.2. Annual commercial catch (tonnes) of yellowfin whiting in the Peel-Harvey Estuary haul and gillnet fishery relative to the associated harvest strategy reference points.

Summary of age-based assessment of yellowfin whiting

Age sampling of yellowfin whiting in 2015 and 2016 showed that, apart from some differences in the ages at which younger fish (ages 1-3) are selected by the different sectors, the age compositions were similar in all samples, i.e. males vs. females (Figure 2.3), estuary vs. ocean, and commercial vs. recreational (Figure 2.4). All samples show an exceptionally strong year class corresponding to fish spawned in summer 2010/11, which is coincident with a marine heatwave event along the west coast of WA. Additionally, in 2016, another relatively strong year class was apparent in samples. These fish were spawned in summer 2012/13 and are assumed to include the progeny of the 2010/11 year class.

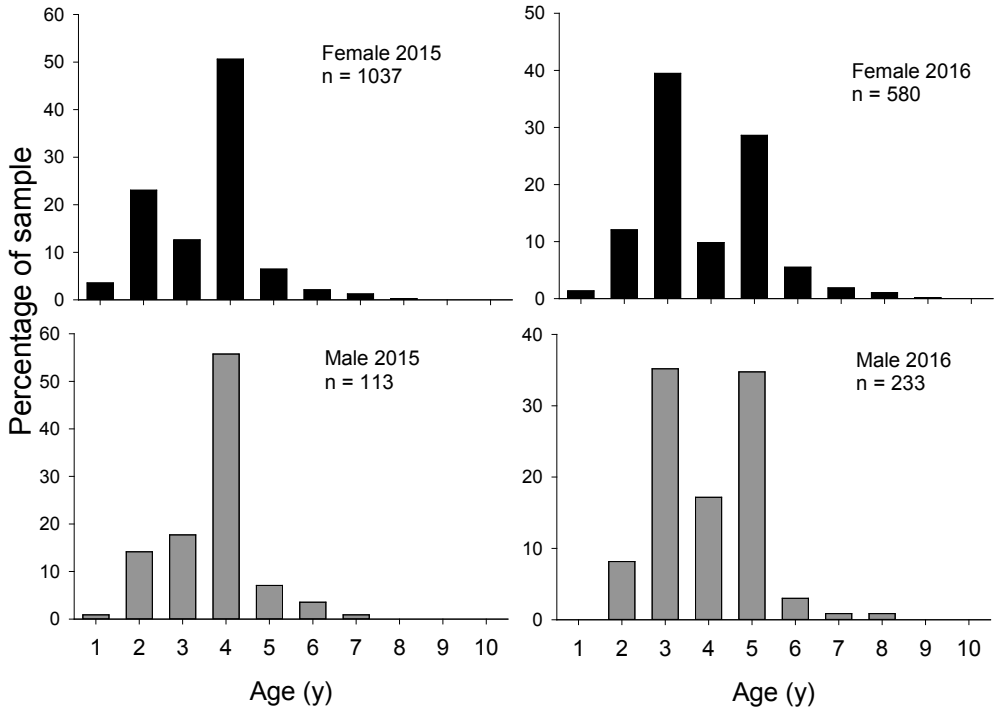

Figure 2.3. Male and female yellowfin whiting age frequency distributions in Peel-Harvey Estuary (WCB Metro Zone) in 2015 and 2016. Sectors/fisheries combined.

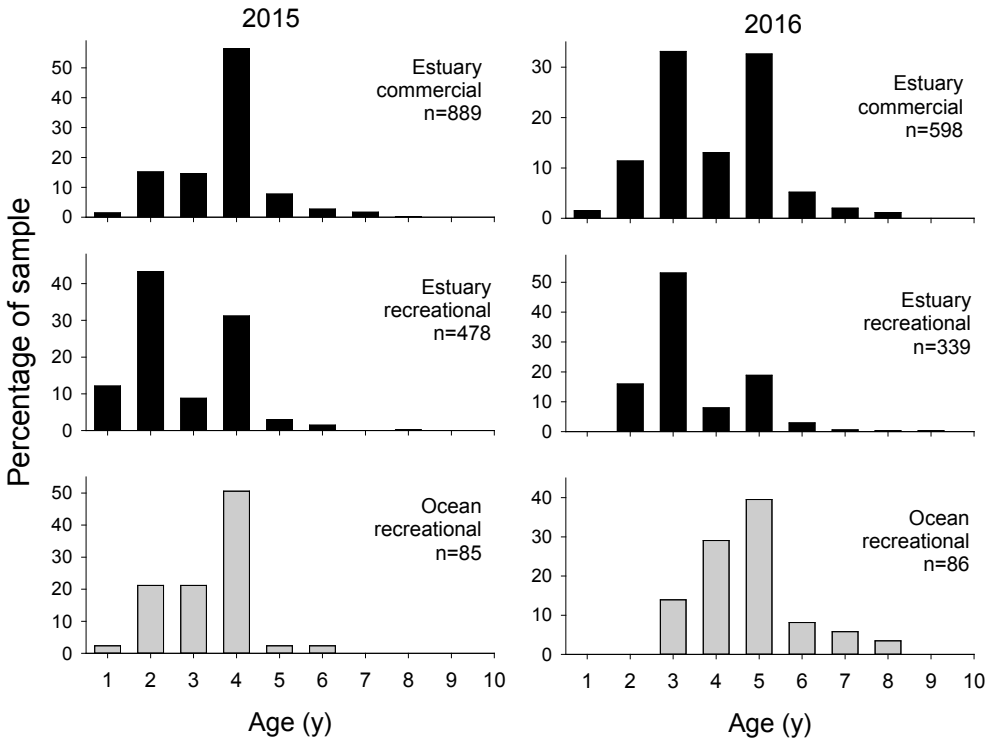

Figure 2.4. Yellowfin whiting age frequency distributions in WCB Metro Zone in 2015 and 2016, comparing commercial versus recreational landings, and estuary (Peel-Harvey) versus ocean landings. Sexes combined.

Estimates of the instantaneous rate of total mortality (Z, year^{-1}) were derived from the age composition data using catch curve analysis. Due to the clear evidence for inter-annual variation in recruitment of this species, a catch curve model that accounts for such recruitment variability by fitting to several years of consecutive age data was chosen as the preferred method. The catch curve model was fitted separately to the commercial and recreational data, with each year class in the sample data identified in terms of the biological year in which the individuals of that year class were spawned. For yellowfin whiting, the biological year is the twelve-month period following the assumed annual birth date for this species (1 January), which corresponds to the peak of spawning.

The catch curve method used in this assessment has been applied to estimate mortality of a range of other finfish species in WA (see Fairclough et al. 2014 and Norriss et al. 2016 for detailed description). In addition to estimating mortality and annual recruitment deviations it also generates estimates of age-based selectivity, as described by a logistic curve where the parameters A_{50} and A_{95} represent the ages by which 50 and 95% of fish are selected by fishers, respectively. Estimates of fishing mortality (F) were calculated by subtracting the estimated value of natural mortality (M) for yellowfin whiting from each catch curve estimate of Z, i.e. $F = Z - M$. The value of natural mortality (M) for yellowfin whiting was estimated as 0.35 year^{-1}, using Hoenig's (1983) empirical equation for fish and based on a maximum observed age of 12 years, noting this method is considered to produce conservative estimates of this parameter (e.g. compared to an alternative formula described by Then et al. 2015).

Catch curve results showed that the point estimate of F from the commercial data was higher (0.60 year^{-1}) than from the recreational data (0.45 year^{-1}) (Table 2.2). The commercial data were considered to be more representative of the stock because of the larger sample size and because it encompassed two fishing seasons/years, to which the model provided a good fit (Figure 2.5). Although the F estimate of 0.60 year^{-1} is greater than the value of M, it is important to note that this represents the mortality of fully-selected fish in the population. As catch curve estimates of selectivity suggest full selectivity into the commercial fishery is at >4.5 years (Table 2.2), which is much later than the age at which this species attains maturity (at 2 years), much of the stock is protected from commercial fishing and thus the level of exploitation experienced by fish on average in the population is likely to be much lower than 0.60 year^{-1}.

Table 2.2. Estimates of fishing mortality and age-based selectivity (±95% confidence intervals) derived from catch curve analysis of age composition data for yellowfin whiting sampled from the commercial and recreational fishery in the West Coast Bioregion in 2015 and 2016.

Parameter	Commercial	Recreational
Fishing mortality (F; year^{-1})	0.60 (0.48-0.72)	0.45 (0.35-0.55)
A_{50} selectivity (years)	3.43 (3.20-3.65)	2.68 (0.48-0.88)
A_{95} selectivity (years)	4.74 (4.36-5.12)	3.90 (3.55-4.26)

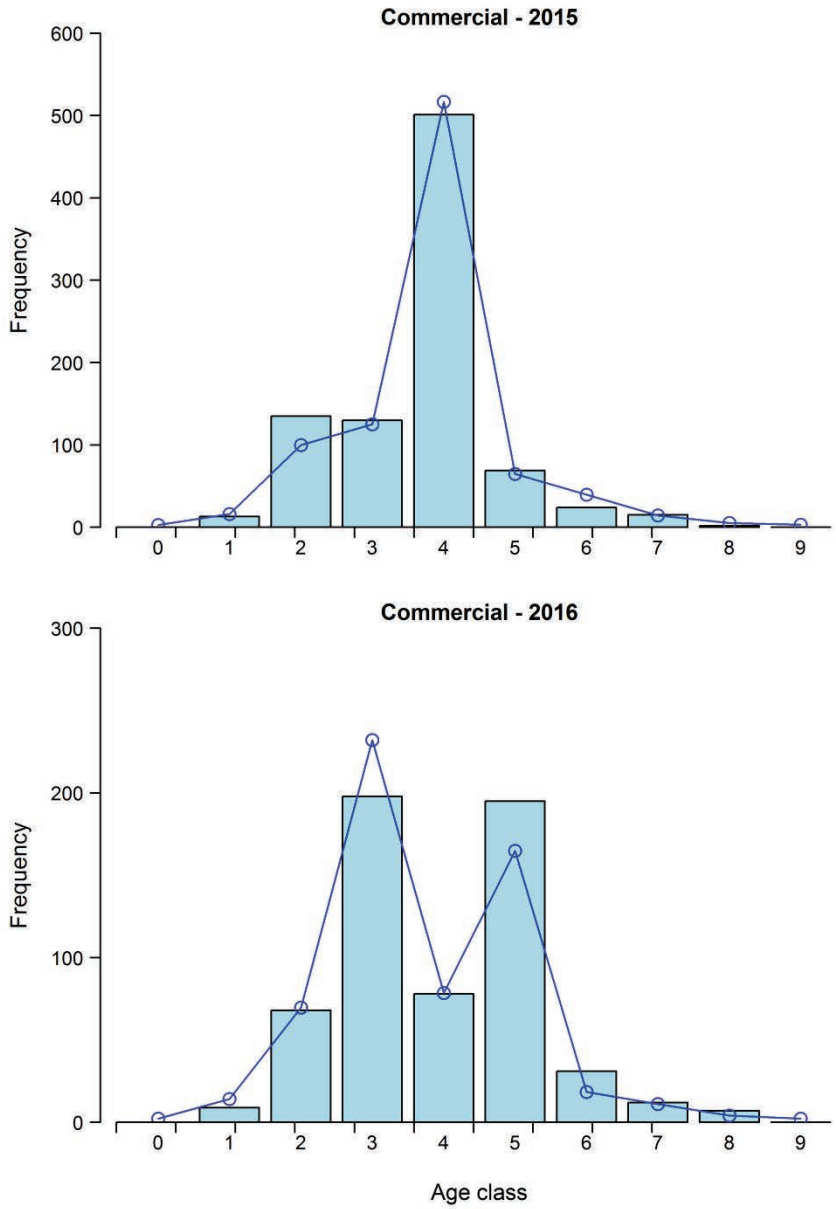

Figure 2.5. Multi-year, variable recruitment catch curve model (blue line) fitted to the age composition data for yellowfin whiting sampled from the recreational and commercial fishery in the West Coast Bioregion in 2015 and 2016.

Two equilibrium age-based population models, including a traditional per-recruit analysis and a similar model that extends the per-recruit analysis to incorporate a Beverton and Holt stock-recruitment relationship (assuming steepness $h = 0.75$) to account for potential impacts of exploitation on recruitment, were applied to produce estimates of female spawning potential ratio (SPR) for yellowfin whiting. Detailed mathematical descriptions of the two models are provided in Norris et al (2016). The SPR analyses were based on catch curve estimates of F and selectivity for the commercial sector (Table 2.2), in addition to available biological information for this species (DoF unpublished data).

Point estimates of female SPR (and 95% confidence intervals) for yellowfin whiting derived from catch curve outputs for the commercial sector using the traditional and extended per-recruit models were 0.48 (0.45-0.52) and 0.43 (0.40-0.48), respectively (Figure 2.6). As these estimates are all above the SPR target of 0.4 and well above the SPR threshold of 0.3, which is considered to correspond to B_{MSY}, the current level of fishing is considered acceptable.

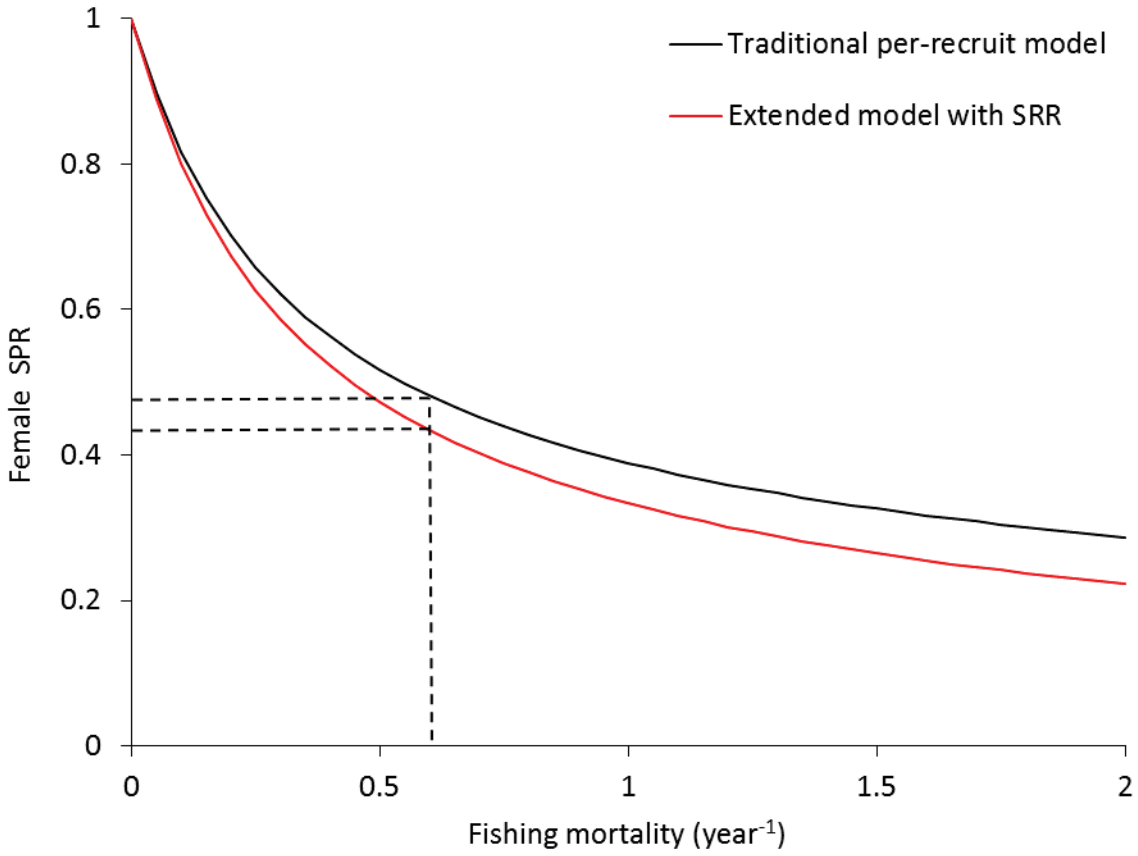

Figure 2.6. Female spawning potential ratio (SPR) for yellowfin whiting at different levels of fishing mortality (*F*, year^{-1}) derived from a traditional per-recruit model (black curve) and an extended model that incorporates a stock-recruitment relationship (red curve). The dashed lines indicates the current SPR estimates based on the commercial *F* estimate of 0.6 year^{-1} for 2015/16.

The recruitment pulse coincident with a marine heatwave event suggests that yellowfin whiting may be one of the species that could benefit from future ocean warming (as predicted under a range of climate change scenarios) through greater recruitment. It is therefore expected that greater than average catches of yellowfin whiting may become more common in the West Coast Bioregion. Although catches are expected to decline in 2016 and 2017 as the 2010/11 recruitment pulse and its progeny is fished down by the commercial and recreational fishers, the recent assessment suggests that the current catch threshold for this species of 13.8 t commercial catch may need to be revised when the harvest strategy is reviewed in 2020.

2.1.3 Australian herring

The catch of Australian herring in the Peel-Harvey Estuary has remained at a low level of ~3 t for the past four years (Figure 2.7). The broader Australian herring stock in south-western WA is currently in a recovery phase after management changes were implemented in March 2015 in response to a Level 3 assessment indicating inadequate stock levels (Smith et al. 2013). Note that the current commercial catch level of ~3 t in the Peel-Harvey Estuary is very low compared to the Statewide catch from the overall stock.

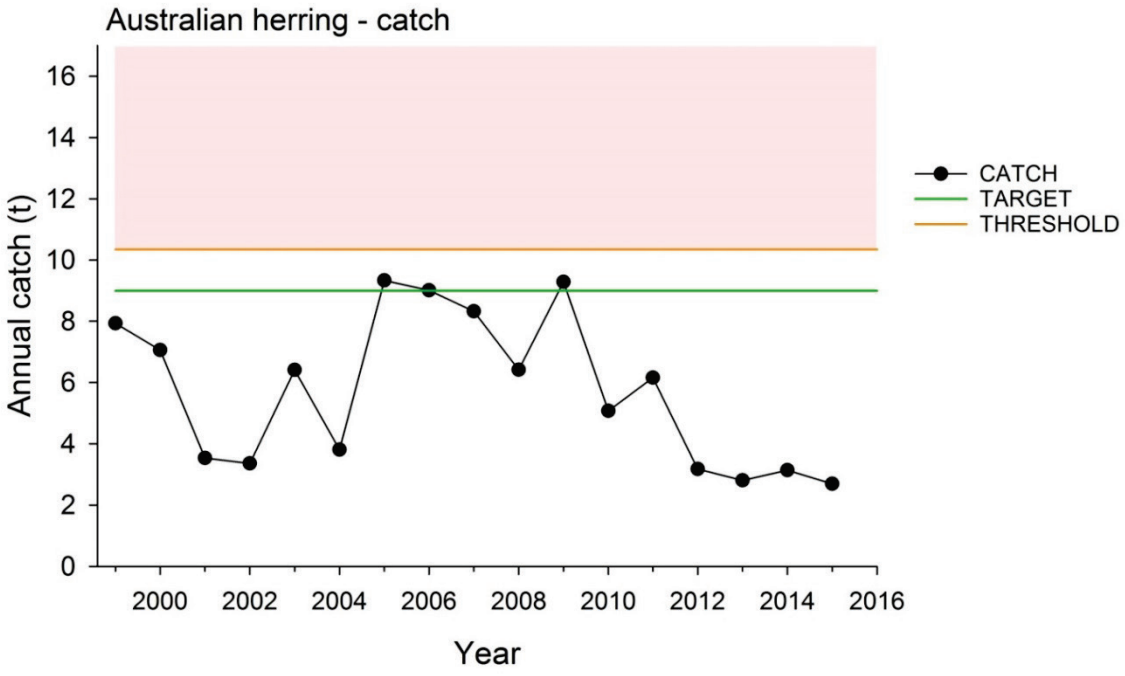

Figure 2.7. Annual commercial catch (tonnes) of Australian herring in the Peel-Harvey Estuary haul and gillnet fishery relative to the associated harvest strategy reference points.

2.1.4 Tailor

In the West Coast Bioregion, 80% of tailor caught commercially in the past decade has been reported from the Peel-Harvey Estuary. Catches peaked at around 20 t in a number of years between 1965 and 1975, with reductions in effort leading to reduced tailor catches over the past few decades. The most recent peak observed in 2013 at 13 t (Figure 2.8) corresponds to a period of high recreational catch rates observed between 2011 and 2014 (Figure 2.9). A fishery-independent survey of juvenile (age 6-18 months) tailor in the Swan Estuary undertaken annually since 1996 shows a period of low tailor recruitment in 1998-2007, followed by a period of higher recruitment in 2008-2013. These data suggest that trends in tailor catch and catch rates follow trends in recruitment of this species and the 2013 breach of the upper catch threshold reflects high abundance due to strong recruitment. Hence there are no concerns about the current status of the stock.

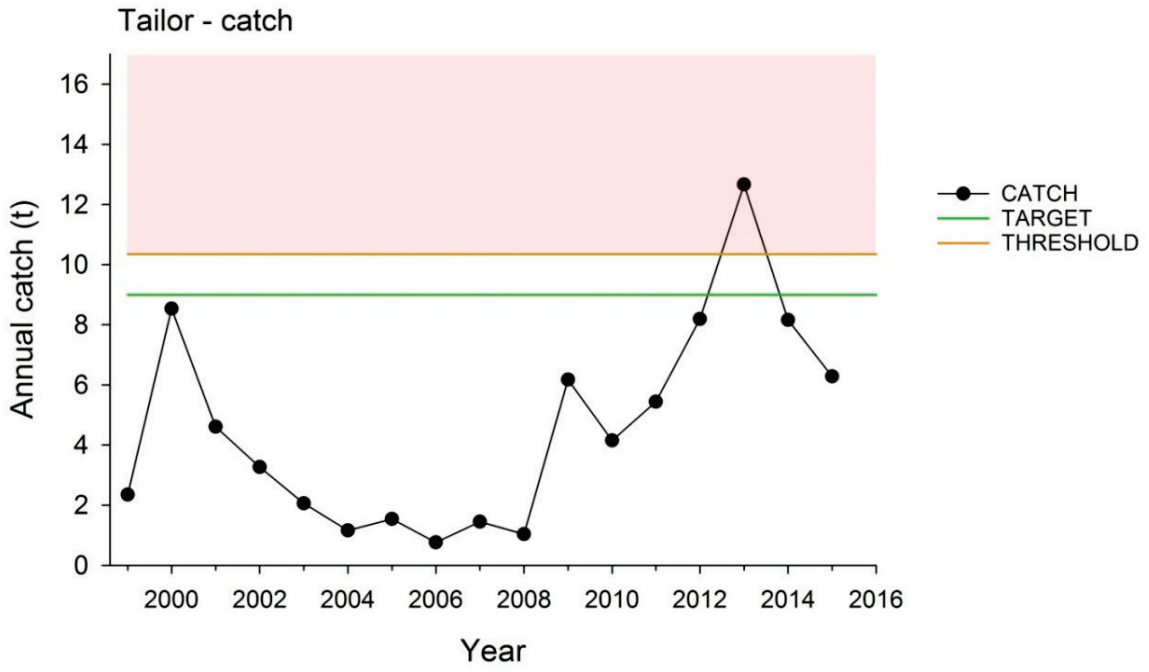

Figure 2.8. Annual commercial catch (tonnes) of tailor in the Peel-Harvey Estuary haul and gillnet fishery relative to the associated harvest strategy reference points.

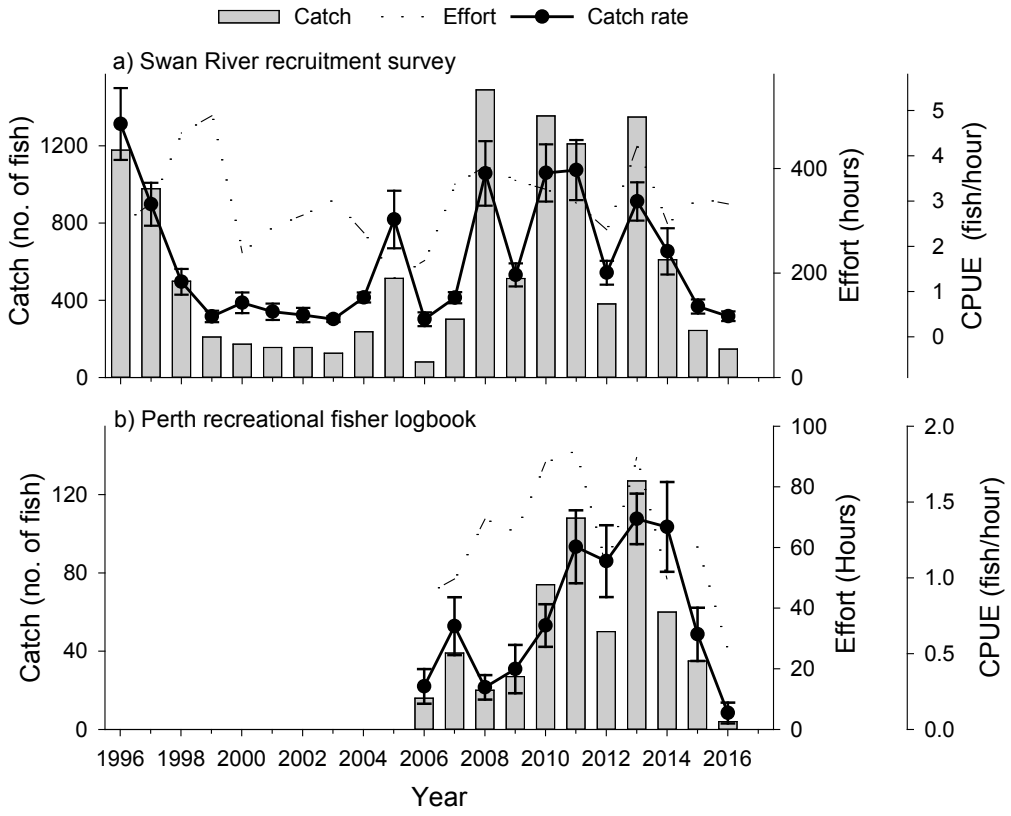

Figure 2.9. Average annual catch rate (fish/hour) of tailor in a fishery-independent recruitment survey in the Swan Estuary (top graph), and reported in a voluntary daily logbook by an avid shore-based recreational fisher in Perth (bottom graph).

2.1.5 Cobbler

Catches of cobbler in the Peel-Harvey Estuary fluctuate between years, with catches over the past three years remaining at low levels (<2 t) below the upper catch threshold of 9 t (Figure 2.10). The very low catch rate observed in 2014 was a result of the close-to-zero catches in that year but increased to above the threshold level of 6 kg/day in 2015 (Figure 2.10).

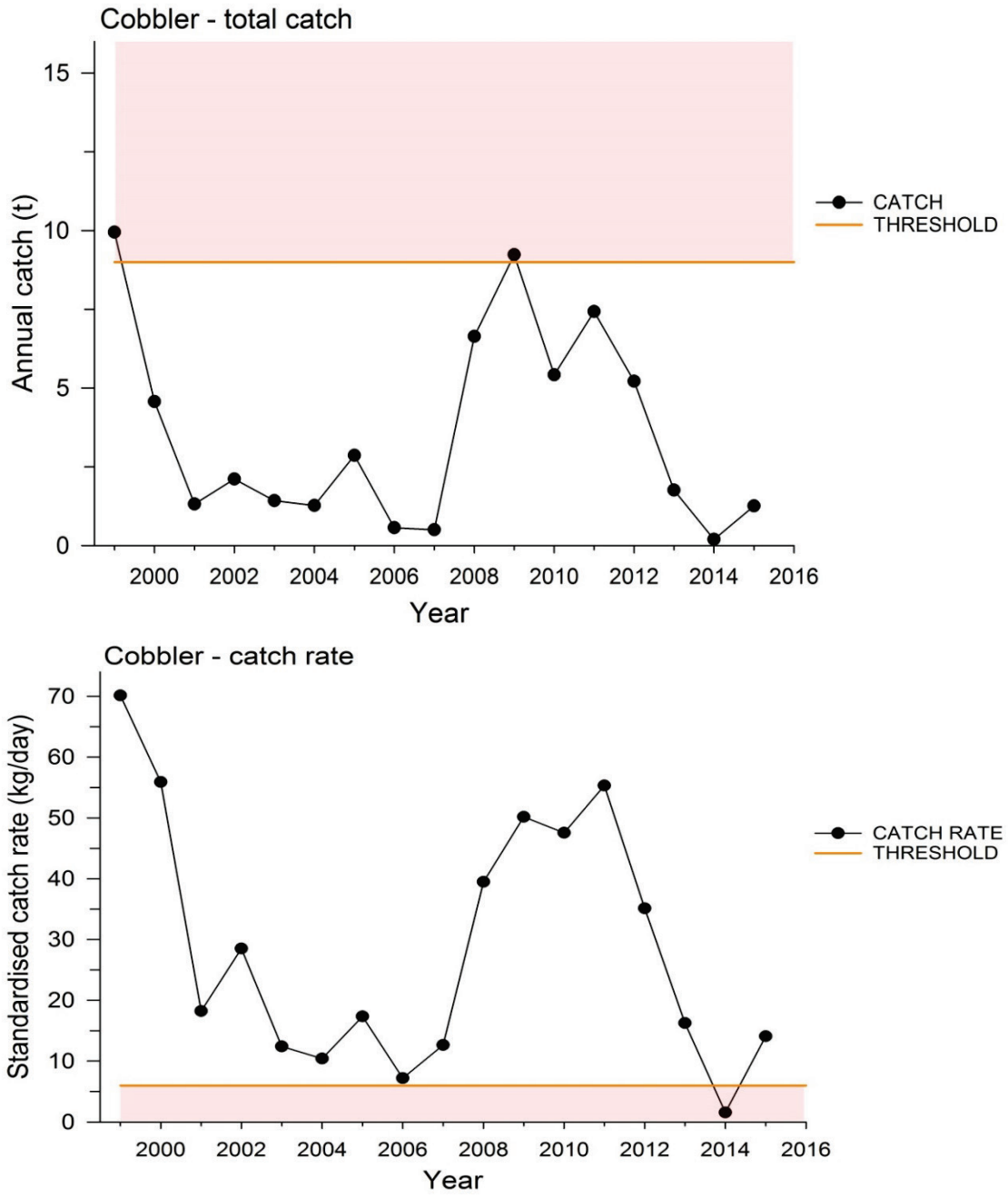

Figure 2.10. Annual commercial catch (tonnes) and catch rate (kg/day) of cobbler in the Peel-Harvey Estuary haul and gillnet fishery relative to the associated harvest strategy reference points.

2.1.6 Perth herring

The catch of Perth herring in the Peel-Harvey Estuary show an increasing trend between 2010 and 2014 to 2.5 t and remained at this level in 2015 (Figure 2.11).

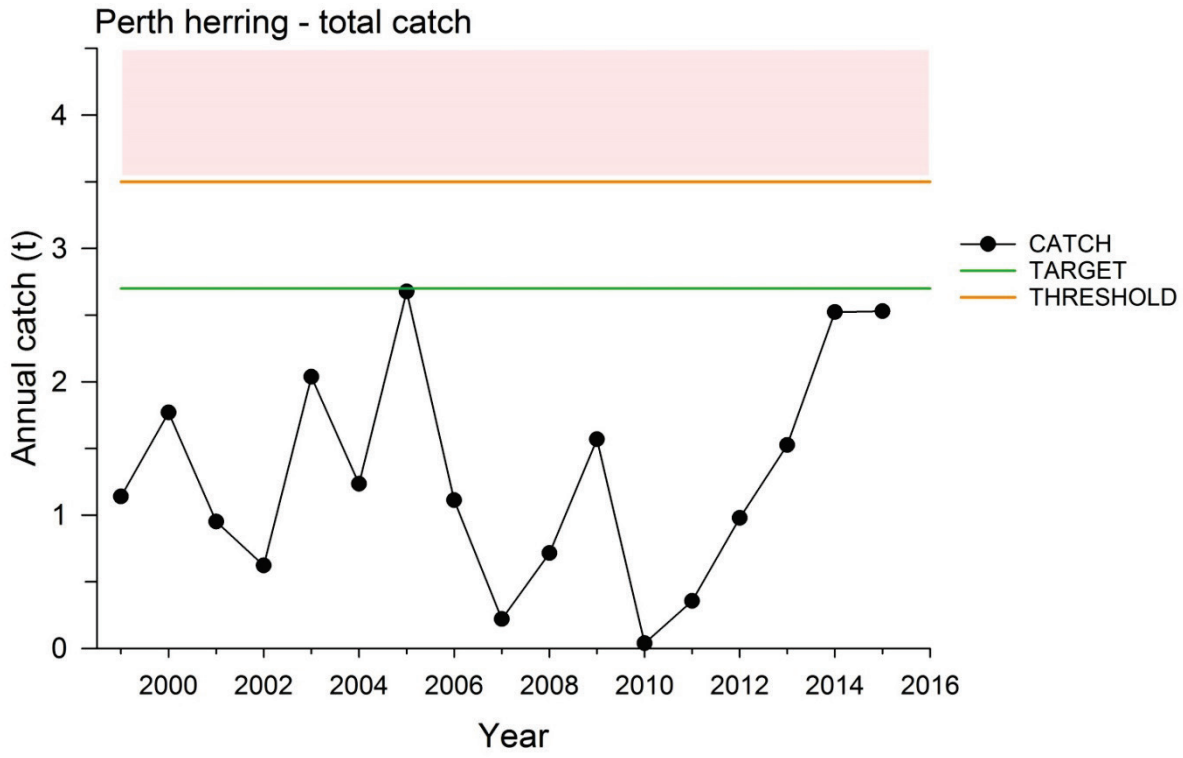

Figure 2.11. Annual commercial catch (tonnes) of Perth herring in the Peel-Harvey Estuary haul and gillnet fishery relative to the associated harvest strategy reference points.

2.1.7 Other finfish species

The combined annual commercial catch of all other species retained in the Peel-Harvey Estuary net fishery has remained low (~2 t) over the past three years. This catch level corresponds to <2% of the total catch in the fishery, which is well below the catch threshold level of 5% (Figure 2.12).

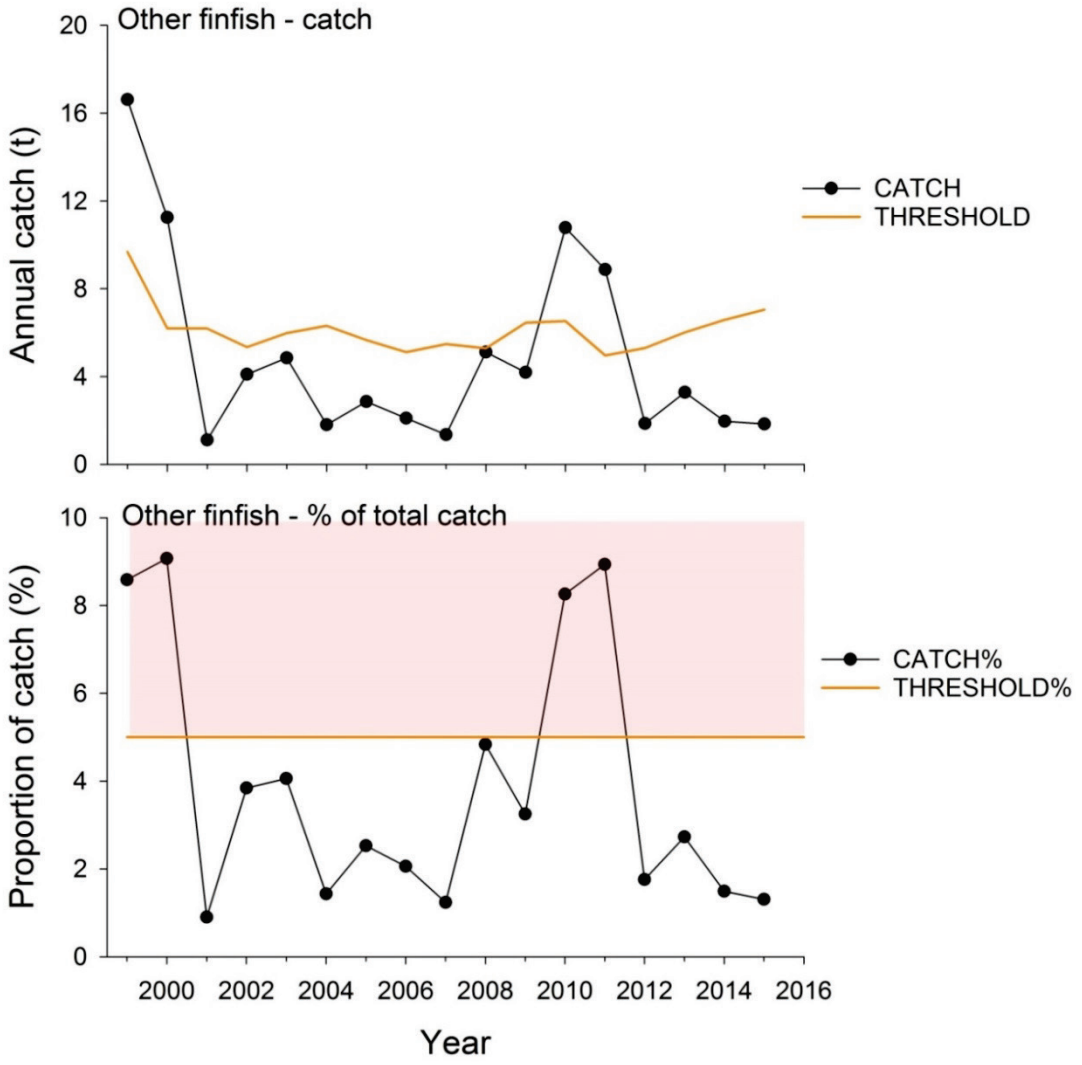

Figure 2.12. Annual commercial catch (tonnes) of all other retained species in the Peel-Harvey Estuary haul and gillnet fishery (top graph), and as a percentage of total commercial catches relative to the associated harvest strategy reference point (bottom graph).

2.2 Commercial Trap Fishery

2.2.1 Octopus

As in previous years, the only other retained species in the commercial trap fishery for blue swimmer crabs has been octopus. Reported catches of octopus in the Peel-Harvey Estuary during the 2014/15 and 2015/16 fishing seasons were 5 kg and 23 kg, respectively.

2.2.2 Bait Usage

Commercial monitoring of the commercial trap fishery for blue swimmer crabs has not indicated any change in the use of bait, with the species (mainly locally-caught sea mullet and yelloweye mullet) and amount (~ 300 g per trap) remaining the same as previously reported. Conversion rates (kg bait used per kg of blue swimmer crab caught) for the 2014/15 and 2015/16 fishing seasons have remained the same as those previously reported in the range of 0.2-0.3 (Table 2.3).

Table 2.3. Summary of bait usage in the Peel-Harvey Estuary commercial trap fishery in 2014/15 and 2015/16

Year	Total No. of trap lifts	Total crab Catch (kg)	Bait Type	Amount of Bait used per Trap (g)	Total Bait used (kg)	Conversion Rate
2014/15	69,888	96,753	Sea mullet Yelloweye mullet	300	20,966	0.2
2015/16	56,746	57,702	Sea mullet Yelloweye mullet	300	17,024	0.3

2.3 Recreational Drop and Scoop Net Fishery

No new information on other retained catches (or bait) in the recreational drop and scoop net fishery for blue swimmer crabs has been collected since that reported in Johnston et al. 2015.

3. Bycatch

In 2016, the Department underwent an organisational re-structure of its Science and Resource Assessment Division (previously the "Research Division") that has included the formation of a new Ecosystem Based Fisheries Management (EBFM) Branch. The EBFM Branch has been established to assist the Department and its stakeholders in meeting EBFM objectives, MSC accreditation requirements and modern expectations of ecologically-sustainable fisheries management. As such, EBFM Branch objectives include undertaking activities to improve understanding of Western Australian fisheries' bycatch of protected, listed and discarded species and their potential impacts on habitats. This change of organisational structure represents a more formal and systematic approach to researching and monitoring the broader ecosystem effects of fishing around WA.

3.1 Commercial Net Fishery

As only limited information was previsouly available to describe the type and quantity of bycatch (discards) in the commercial net fishery, an ongoing bycatch reporting and validation program was implemented in the fishery in April 2017. The program includes fishery-dependent reporting using log sheets developed together with the commercial licence holders, and verification of these data from bi-monthly independent observation trips on board the commercial fishing vessels. More information about the program and the methodology is provided in Appendix 1, with a summary of data collected as of 1 August 2017 provided below.

3.1.1 Fishery-Dependent Reporting

With only limited set netting undertaken in the estuary (primarily in winter), the majority of bycatch data reported by commercial fishers to date is from haul netting shots. At the time of writing, the retained and discarded catches from 91 haul net shots had been reported by six commercial fishers operating between April and July 2017. Thirty percent of the reported shots had zero discards. The majority of the shots retained sea mullet as the main target

species but also included a number of trips targeting yellowfin whiting, typically using nets of smaller mesh size. There was no marked difference in the type or quantity of discarded species between shots targeting these two different species.

The most commonly discarded species was blue swimmer crabs (*Portunus armatus*), which occurred in just under half of all reported net shots but are not permitted to be retained in the net fishery (Table 3.1). This was followed by silver bream/tarwhine (*Rhabdosargus sarba*) and weeping toadfish/blowfish (*Torquigener pleurogramma*), which occurred in 37 and 11% of reported net shots, respectively. Silver bream were discarded due to being below the mimum legal size for retention, whilst the toadfish were discarded due to their low economic value.

Table 3.1. Bycatch species reported by commercial net fishers in the Peel-Harvey Estuary from 91 haul net shots completed between April and July 2017.

Name	Main reason for discarding	% occurrence in shots	Average number per shot
Blue swimmer crab (*Portunus armatus*)	Not permitted	48%	1.05
Silver bream (*Rhabdosargus sarba*)	Under legal size	37%	1.33
Weeping toadfish (*Torquigener pleurogramma*)	Not economical	11%	0.51
Black bream (*Acatchopagrus butcheri*)	Not economical	3%	0.16
Leatherjacket (Monacanthidae)	Not economical	3%	0.05
Yellowtail grunter (*Amniataba caudavittata*)	Not economical	2%	0.02
West Australian salmon (*Arripis truttaceus*)	Not permitted	2%	0.08
Western striped trumpeter (*Pelates octolineatus*)	Not economical	1%	0.01
Roach (*Gerres subfasciatus*)	Not economical	1%	0.05
Smooth ray (*Dasyatis* sp.)	Not permitted	1%	0.01

3.1.2 Fishery-Independent Verification

To verify the bycatch data reported by commercial fishers, eight net fishing trips have been observed in the Peel-Harvey Estuary between April and July 2017; seven of which were haul netting trips and one which retrieved gillnets that had been set overnight. Only one trip resulted in no nets being shot due to poor visibility and windy conditions. Although based on a much lower number of net shots observed (13) compared to the fishery-dependent reporting data, the quantity and type of bycatch observed on these trips reflected well that reported by the fishers on the logsheets.

A summary of the bycatch data collected during the observer trips undertaken to date is provided in Table 3.2. Fifteen percent of observed net shots had zero discards. The most commonly discarded species was blue swimmer crab, which was encountered in just over one third of the observed net shots. This was followed by silver bream, weeping toadfish and

yelloweye mullet (*Aldrichetta forsteri*), which were each encountered and discarded from 23% of the observed net shots. The remainder of the species listed in Table 3.2 were only discarded from a single shot observed.

Table 3.2. Bycatch species caught and discarded by commercial net fishers in the Peel-Harvey Estuary from 13 net shots (11 haul net and 2 set net) during observer trips between April and July 2017.

Name	Main reason for discarding	% occurrence in shots	Average number per shot
Blue swimmer crab (*Portunus armatus*)	Not permitted	38%	2.23
Silver bream (*Rhabdosargus sarba*)	Under legal size	23%	0.85
Weeping toadfish (*Torquigener pleurogramma*)	Not economical	23%	0.77
Yelloweye mullet (*Aldrichetta forsteri*)	Not economical	23%	0.62
Leatherjacket (Monacanthidae)	Not economical	8%	0.08
Yellowtail grunter (*Amniataba caudavittata*)	Not economical	8%	0.08
West Australian salmon (*Arripis truttaceus*)	Not permitted	8%	0.08
Western striped trumpeter (*Pelates octolineatus*)	Not economical	8%	0.08
Soldierfish (*Gymnapistes marmoratus*)	Not economical	8%	0.08
Tailor (*Pomatomus saltatrix*)	Under legal size	8%	0.08
King George whiting (*Sillaginodes punctata*)	Under legal size	8%	0.77
Cobbler (*Cnidoglanis macrocephalus*)	Under legal size	8%	0.08
Mulloway (*Argyrosomus hololepitotus*)	Under legal size	8%	0.08

These preliminary data confirm a very low level of discarding in the Peel-Harvey Estuary commercial net fishery, with the majority of catches retained. Observed haul net trips have indicated that once a net is shot around a school of fish sighted, it would typically take the fishers around 0.5-2 hours (depending on the size of the haul) to gradually retrieve the net and pick out the catch into the boat by hand. As the captured fish and crabs remain in the water until they are picked out of the net, the fish are most often released alive and survival is expected to be good due to the very shallow waters fished (typically around 1 m deep).

Although only two set (gill) net shots had been observed at the time of writing, the discards were not markedly different from those observed haul netting and the majority were still released alive. As further bycatch data are collected, these will be further examined for variations between shots targeting different species and using different fishing gears.

The bycatch reporting and verification program for the Peel-Harvey net fishery will continue to be trialled until the end of 2017 before reviewing if any changes to log sheets and observation program are needed.

3.2 Commercial Trap Fishery

Although there has been no further quantitative data collected on bycatch in the commercial trap fishery, other than what has been previously reported, monthly commercial trap monitoring has not indicated any change in the species composition landed in the traps (Table 3.3). The two species most commonly encountered in the crab traps, weeping toadfish and western striped grunter, have also been recorded as bycatch in the net fishery for finfish species in the estuary.

Table 3.3. Bycatch species observed in the Peel-Harvey Estuary (commercial trap) fishery for blue swimmer crabs during on-board catch monitoring conducted between 2007 and 2016.

Common name	Species name
Weeping toadfish (common blowfish)	*Torquigener pleurogramma*
Western striped grunter (trumpeter)	*Pelates octolineatus*
Common Sydney octopus Gloomy octopus	*Octopus cf. tetricus*
Cobbler	*Cnidoglanis macrocephalus*
Four-lobed swimming crab	*Thalamita sima*
Mud crab	*Scylla* sp.

3.3 Recreational Drop and Scoop Net Fishery

No new information on other retained catches (or bait) in the recreational drop and scoop net fishery for blue swimmer crabs has been collected since that reported in Johnston et al. 2015.

4. ETP Species

There have been no reported interactions in the commercial WCEMF (Area 2) with species listed as Endangered, Threatened or Protected under relevant ETP legislation in 2014 or 2015.

5. Habitats

The client organisations have not undertaken any specific works towards habitat outcomes in the Peel-Harvey Estuary since the MSC certification of the fisheries in 2016. However, as the certification of the recreational scoop net fishery has a condition on PI 2.4.1, work on habitats will be included through addressing this condition (see Appendix 2 for more detail).

6. Ecosystem

The client organisations have not undertaken any specific works toward ecosystem outcomes in the Peel-Harvey Estuary. Some additional research in this area is currently being led by scientists at Murdoch University through the ARC Linkage Project (LP150100451) "*Balancing estuarine and societal health in a changing environment"*. That is a 3-year project, started in early 2016, which is due for completion in 2019.

MSC Principle 3

MSC Principle 3 (P3) relates to the effective management of the fishery under assessment. Within this context, the fishery must demonstrate that it meets all local, national and international laws and must have a management system in place to respond to changing circumstances and maintain sustainability (MSC 2013).

P3 updates for this addendum are mainly focused on improvements made to the Department's stakeholder consultation and engagement processes since the MSC certification in 2016. It also provides some updated fishery compliance statistics for the 2014 and 2015 fishing seasons.

7. Governance and Policy

7.1 Consultation, Roles and Responsibilities

Since the MSC certification of the Peel-Harvey Estuary fisheries, the Department has broadened its stakeholder engagement process through a new Stakeholder Engagement Guideline (DoF 2016). This document sets out the overarching processes through which the Department seeks out relevant information from, and involvement by, stakeholders and interested parties on proposals relating to the management of WAs aquatic resources. The guideline was an outcome of the Non-Fisher Stakeholder Engagement Project, which included a key stakeholder consultation phase during which more than 20 key stakeholders were interviewed.

To implement the SEG for the Peel-Harvey Estuary commercial and recreational fisheries, the list of external (i.e. non-fisher and non-peak body) stakeholders has been updated. This list now includes representatives from State and local government, non-government organisations such as Conservation Council of WA, WWF and Mandurah Offshore Fishing and Sailing Club, and key university and research groups. A matrix has been compiled that outlines what level of enagement and consultation that the SEG indicates is reasonable for each of the key stakeholder groups, e.g. relating to review of harvest strategies, fishery management plan ammendments, environmental risk assessment etc. (see Figure 7.1).

The Department has now got a 'consultation corner' on the website where draft documents such as harvest strategies are now posted for public comment prior to being finalised (http://www.fish.wa.gov.au/About-Us/public-comment/Pages/default.aspx). From 20 March 2017, the Department has also extended its external communications with the introduction of corporate Facebook and Twitter accounts. This expansion in social media will provide powerful new tools to communicate and engage with clients and stakeholders. These platforms will complement existing forms of communications through the website, e-newsletters and education activities.

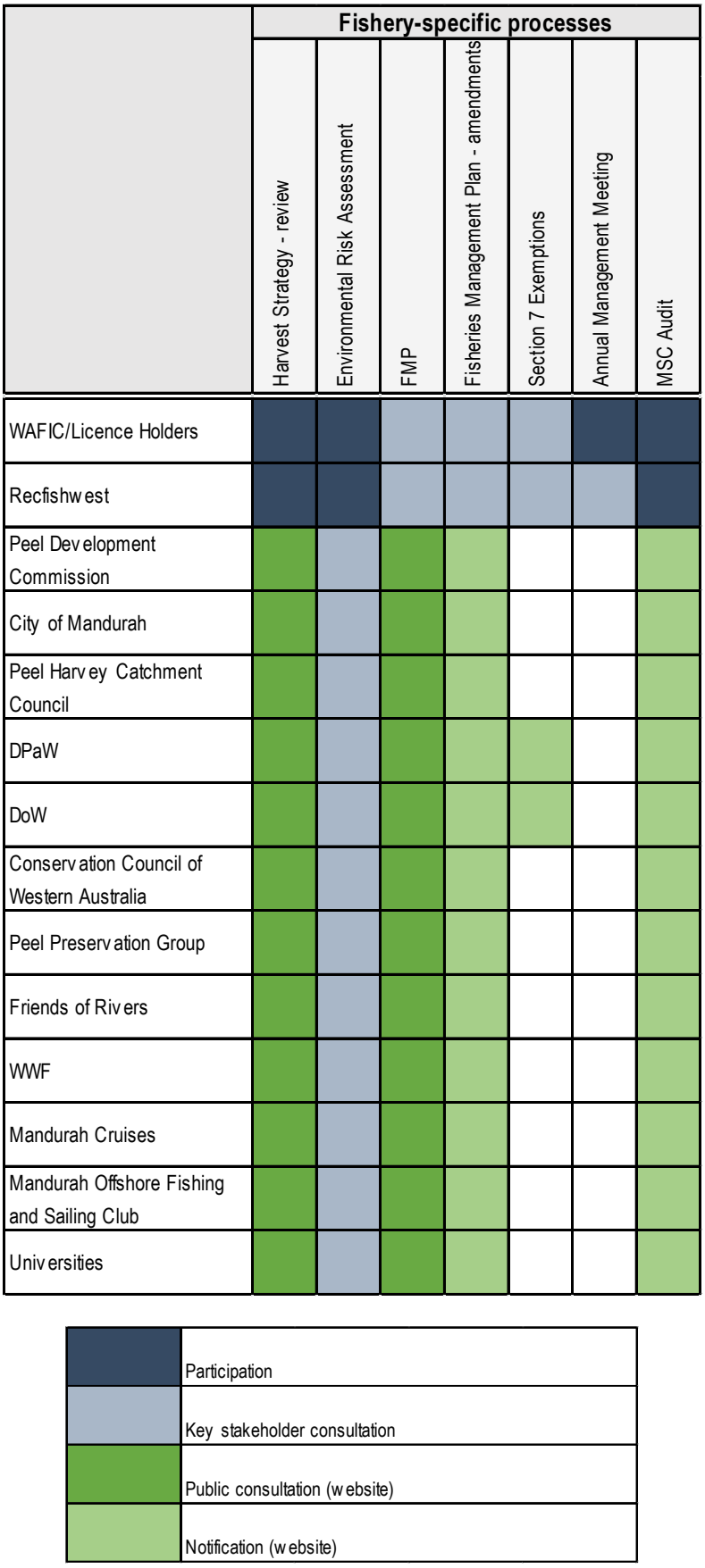

Figure 7.1. Peel-Harvey Estuary fisheries stakeholder engagement and consultation guidelines

8. Fishery-Specific Management System

8.1 Compliance and Enforcement

There have been no offences detected in the commercial WCEMF in the Peel-Harvey Estuary during the 2014/15 and 2015/16 fishing seasons. An updated summary of detected offences in the recreational fishery is provided in Table 8.1.

Table 8.1. Summary of detected offences by recreational fishers in the Peel-Harvey Estuary between 2012/13 and 2015/16.

Offence Type	Prosecution Briefs				Infringement Notices				Infringement Warnings			
	12/13	13/14	14/15	15/16	12/13	13/14	14/15	15/16	12/13	13/14	14/15	15/16
Crabbing												
Closed Season	1	0	0	0	24	10	18	5	6	5	2	3
Closed Waters	0	0	0	0	0	0	2	0	0	0	0	0
Excess Bag	13	17	27	28	22	28	27	8	48	49	108	61
Excess Gear	1	0	0	0	1	0	1	0	0	0	1	0
Illegal Gear	0	2	2	3	1	12	14	11	10	5	12	16
Licensing	0	0	0	0	0	0	0	0	0	1	0	0
No Licence	0	0	0	0	13	19	18	8	2	1	4	0
Obstruction	5	1	8	14	0	0	0	0	0	0	0	0
Species	0	0	0	0	1	38	5	0	0	1	0	0
Undersize	12	17	27	44	81	310	296	271	273	538	459	320
Processing	0	0	3	0	0	0	0	2	0	0	0	0
Other	0	2	7	0	0	0	0	0	0	0	0	0
TOTAL	32	39	74	90	143	417	381	305	339	600	586	400
Netting												
Closed Season	2	2	0	1	2	2	0	2	3	1	1	0
Closed Waters	4	0	3	5	1	1	0	3	0	0	4	0
Excess Bag	1	0	0	3	1	0	0	1	3	2	7	0
Illegal Gear	4	2	2	7	4	1	5	3	1	0	7	0
No Licence	2	1	0	1	2	2	4	1	1	0	0	0
Obstruction	0	0	0	0	0	0	0	0	0	0	0	0
Species	0	0	0	0	0	0	0	0	0	0	0	0
Undersize	1	1	0	2	0	0	5	0	3	0	1	0
Other	2	2	0	0	0	3	7	3	4	0	4	4
TOTAL	16	8	5	19	10	9	21	13	15	3	24	4

As reported previously for these fisheries, the majority of offences in the Peel-Harvey Estuary recreational fishery relate to the retention of undersize crabs. Changes in the seasonal abundance and size of crabs, changes in recreational fishing effort and changes in compliance resources all affect the observed compliance trends. The iconic nature of the recreational crab fishery and its continuing popularity has meant compliance activities in the estuary have been maintained, while increasing officer availability has allowed a greater amount of compliance effort to be expended in the wider reporting area that the fishery operates within (also includes oceanic waters outside of the estuary). The high numbers of undersize crabs and lack of availability of legal-sized crabs at certain times of the year has prompted attempts to reduce the non-compliance in the recreational crab fishery. Measures have included greater efforts in educating people about the rules prior to them going fishing (using multilingual guides and issuing of free plastic crab gauges) and increased signage on roads by which the estuary can be accessed during the peak summer fishing season.

The number of crabbing offences in the Peel-Harvey Estuary in 2015/16 was lower than the two previous years (Table 8.1; Table 8.2), however, this will also be influenced by factors such as the weather and availability of legal-sized crabs. Additionally, officer resources dedicated to a more educational role speaking with crabbers prior to commencing fishing will results in fewer catches being inspected, and officers also focus on other fisheries such as rock lobster in the area.

Recent compliance trends in the Peel-Harvey Estuary are being considered as part of a broader review of the management of the blue swimmer crab fisheries in south-western WA, which is currently in draft form.

Table 8.2. A summary of offence data relative to the compliance effort in the broader Peel-Harvey Estuary area, noting that this also incorporates oceanic waters outside of the estuary

Financial year	Total Presence (Officer Hours) in area	Compliance contacts in area	Rec Crabbing Offences in area	Rec Netting Offences in area
2012/13	3,562	5,854	514	41
2013/14	3,788	9,283	1,056	20
2014/15	4,497	10,930	1,041	50
2015/16	4,898	7,384	795	36

9. References

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10. Appendix 1

West Coast Estuarine Management Fishery (Area 2: Peel-Harvey Estuary)

Haul and Gillnet Bycatch Reporting & Verification Program

Emily Fisher

Background

Bycatch refers to any organism in a fisher's catch that is not retained, which can include:

- unwanted catches of low value fish and invertebrates (due to damage, disease, size, toxicity or quality);
- legally protected and listed species (e.g. totally and commercially protected fish, specially protected fauna, cetaceans, threatened, migratory and listed marine species);
- species that are otherwise regulated by fisheries management arrangements (e.g. catch limits or restrictions relating to the organisms' sex, size, weight, reproductive condition, area of water or specific period of time from which they are taken); and
- incidental catches of sessile benthic organisms (e.g. sponges, seagrass, corals, etc.).

The WA Department of Primary Industries and Regional Development Fisheries Division (Fisheries) is currently working to improve reporting of bycatch across fisheries, as this has been identified by Marine Stewardship Council (MSC) pre-assessments and full assessments and as a general deficiency in current management arrangements. One strategy for achieving this is the development of new catch and effort reporting protocols, intended to be introduced for all of the State's fisheries in coming years.

To address the MSC certification condition on the West Coast Estuarine Management Fishery (Area 2: Peel-Harvey Estuary) that relates to information on bycatch in the haul and gillnets used to target finfish species, a bycatch reporting and verification program has been developed by Fisheries with input from industry (Mandurah Licenced Fishermen's Association) to be trialled in the fishery and implemented on an ongoing basis until any other bycatch reporting procedures are.

Objective

To develop and implement an ongoing bycatch reporting and verification program to meet contemporary Ecosystem Based Fishery Management (EBFM) expectations and requirements relating to the Marine Stewardship Council (MSC) certification. It is intended that the program would be comprised of two components: (1) fishery-dependent reporting and (2) fishery-independent data collection to validate the fishery-dependent data.

Fishery-Dependent Reporting

Hard-copy paper versions of the proposed Statewide electronic reporting system were drafted in late 2016 and provided to fishers for comment and initial trialling. The log sheets provide a mechanism for fishers to record both retained catch and discarded bycatch (in weight, volume and/or numbers), together with details on dates, fishing location and gear for each fishing trip. While the data collected in these trial log sheets are almost identical to what will be required under the intended new catch and effort reporting system, fishers will still be required to continue filling out CAES fishing returns, as those are currently a statutory requirement under the Fish Resources Management Act (FRMA). However, the log sheets were set up so that monthly retained catches of each species could be easily calculated and copied into monthly CAES returns to minimise the reporting burden for fishers.

Consultation with fishers on the best approach for reporting resulted in the development of a one-page daily log sheet that could be printed on waterproof paper for taking out on fishing trips. A second, monthly log sheet was then provided so that fishers at the end of each trip could easily transfer the information recorded for each net shot from their daily log sheet. At the end of the month, the completed monthly log sheet would then be sent in with their statutory catch and effort returns to Fisheries for data entry. Copies of the daily and monthly log sheets are provided below.

A few modifications were made to the log sheets to make them more relevant to their fishery. For example, as GPS are not commonly used by fishers, a map of the Peel-Harvey Estuary with the common names of general fishing locations was produced during a meeting with the fishers (see Figure A1.1) for easier reporting of which parts of the estuary have been fished. Both log sheets were pre-filled with the names of species most commonly caught to help make the reporting quicker. To maximise the value of bycatch information, fishers are able to include details on their reasons for discarding (e.g. low-value, damaged, undersize) and, for protected and listed species, their release status (e.g. alive or dead).

Netting: Daily Catch Logsheet (Retained and Discarded)

Date:		Master Name:		Boat LFB:	

Shot 1	Gear Name:		Location (Lat/Long):		Start Time (HH:MM):		End Time (HH:MM):	
Shot 2	Gear Name:		Location (Lat/Long):		Start Time (HH:MM):		End Time (HH:MM):	
Shot 3	Gear Name:		Location (Lat/Long):		Start Time (HH:MM):		End Time (HH:MM):	

RETAINED CATCH

Shot	Species	Landed Condition	Weight (kg)	No. of individuals	Comments
	Sea mullet				
	Yelloweye mullet				
	Yellowfin whiting				

DISCARDED CATCH

Shot	Species	Discarding Reason	Weight (kg)	No. of individuals	Comments
	Blue swimmer crab				

PROTECTED/LISTED SPECIES INTERACTION

Shot	Species	Release Status	Weight (kg)	No. of individuals	Comments

Landed Condition: WH – Whole, BT – Used for Bait, GT – Gutted, HT – Headed & Gutted, GL – Gilled & Gutted, FL – Filleted
Discarding Reason: NP – Not Permitted, NS – Not Legal Size, RC – Reproductive Condition, NE – Not Economical, PQ – Poor Quality/Damaged
Release Status: AU – Alive (Uninjured), AI – Alive (Injured), DD – Dead, UN – Unknown

Month, Year	FISHING INFORMATION - Retained and Discarded Catches

Day	Shot	Gear Nickname	Location (Lat/Long)	Start Time (HH:MM)	End Time (HH:MM)	Retained Catch (kg) / Landed Condition								Discarded catch (No. of individuals) / Discarding Reason					Protected/Listed Species Interaction (Y/N*)
						Sea mullet	Yelloweye Mullet	Yellowfin Whiting						Blue Swimmer Crab					
						WH								NP					

* Details of any interactions with Protected and Listed Species must be submitted in the relevant Catch and Effort Monthly Return

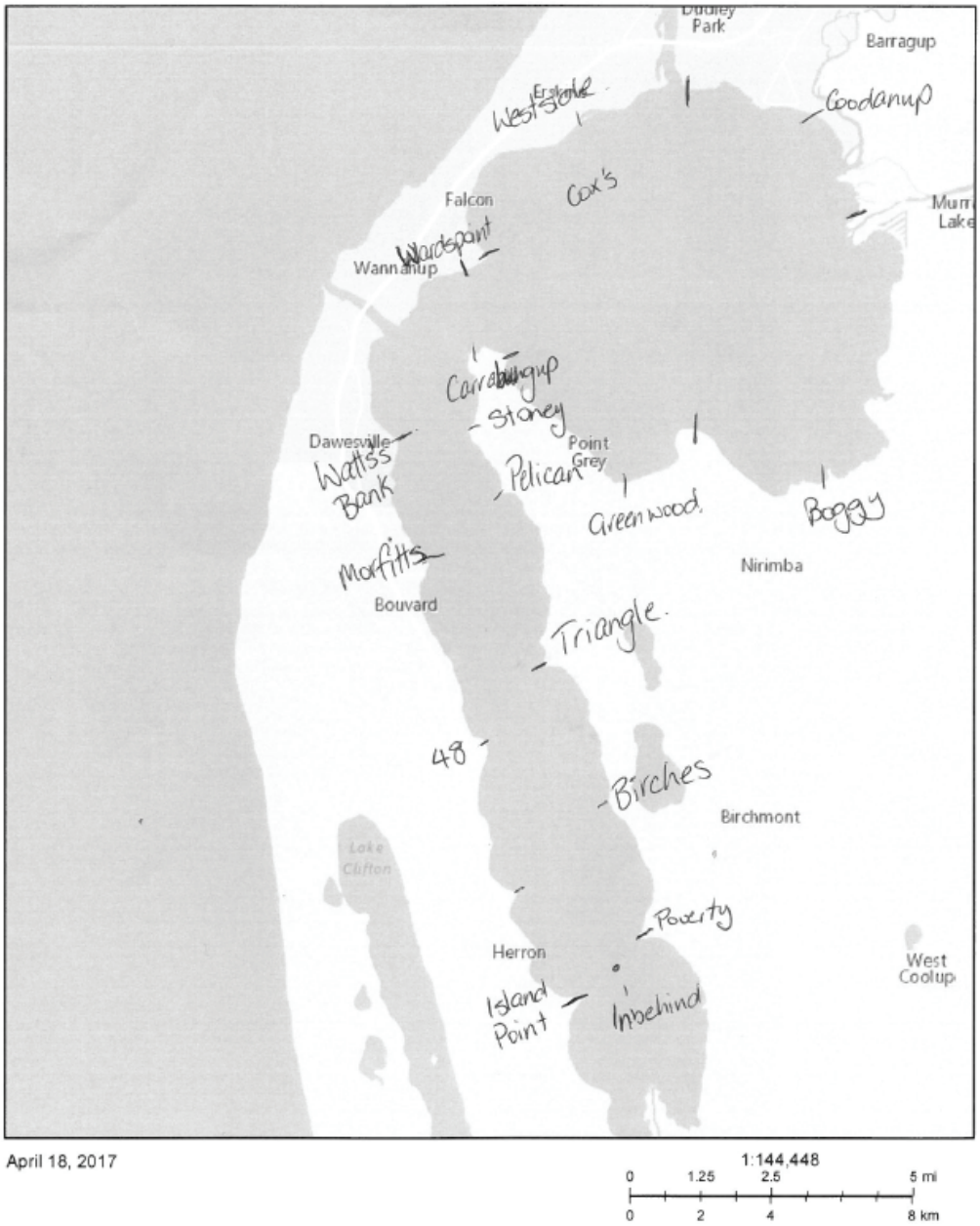

Figure A1.1. Map of the Peel-Harvey Estuary with names of common fishing locations for fishers to use for bycatch reporting.

Fishery-Independent Verification

Several alternative approaches were considered for verification of bycatch data, with the cost of implementation and the usefulness of verified data for addressing the MSC condition being the most important factors for selecting the most appropriate approach for the Peel-Harvey Estuary net fishery.

1. On-board observers: With a statistically-robust sampling design, this option provides the highest-resolution data (in-situ species IDs, quantification, etc.), the most demonstrably-independent validation of fishery-dependent data and the best opportunity to develop an understanding of fishing operations from fishers'

perspectives. However, this option can potentially be logistically-difficult (due to e.g. vessel size, survey requirements, weather constraints, observer-availability, etc.), expensive and invasive. Coverage would likely be defined as some proportion (%) of fishing effort, may require spatial and temporal stratification and needs to consider other characteristics of the fishery (e.g. market supply/demand factors, environmental drivers, etc.). The approach may require funding (and there may also be insurance and Occupational Health and Safety issues to consider) although with appropriate protocols, the use of a local volunteer, as suggested in the wording of the condition, would potentially be a cost-effective option for achieving similar outcomes.

2. On-board cameras: Could be fixed or mounted temporarily, set to record continuously, intermittently or during specific activities (e.g. gear retrieval). Cameras, operating systems and data storage would be self-contained and, depending on requirements, units can be powered by vessel, battery and/or solar panel. Data could be offloaded physically (e.g. external hard drive collection/drop-off) or remotely (WiFi or Bluetooth). Mounting and security could be problematic on smaller boats. May be cost-effective to install and maintain but requires post-processing of footage and validation that the footage can be reliably used to identify bycatch.
3. 2nd vessel observation (planned or impromptu): Bycatch could be transferred to 2nd (Fisheries Research) boat for species ID and quantification before being discarded. This approach would be more resource-intensive but allow observations of multiple boats on the same day.
4. Landing observations: Bycatch could be either entirely retained and returned to shore for fishery-independent verification of species ID and quantity (but does not independently verify that discarding has not occurred), or a subsample (multiple sub-sampling options, depending on objectives) retained for independent ID, measurement, etc. Most sub-sampling options are prone to biases and are unable to independently-verify discarded quantities). Vessel size and storage capacity may be problematic and is a more destructive technique than in-situ options as some bycatch will not be returned to the water alive.

After discussing the feasibility of the bycatch verification approaches with the fishers, the on-board observer option was selected as the optimal approach as this had already been tested in the lead-up to the MSC full assessment. Due to the small-scale nature of the fishery and limited availability of resources, the program would initially incorporate two observer trips per month. This was based on the current commercial crab trap monitoring that has been undertaken bi-monthly in the Peel-Harvey Estuary since 2007.

Where possible fishers have been selected at random for each trip, however, as only around 50% of the licence holders undertake relatively frequent net fishing trips, it is likely that these fishers will be observed more often than others. Due to the very small proportion of the total net fishing effort in the fishery that uses set (gill) nets (mainly during winter when there is sufficient water in the estuary), such trips will be observed opportunistically when fishing is occurring. During each observer trip, the number of discarded fish and crabs are recorded for

each net shot, along with an estimate of retained catches, details of the fishing gear and the location/time of fishing.

The bycatch reporting and verification program for the Peel-Harvey net fishery will continue to be trialled until the end of 2017 before reviewing if any changes to log sheets and observation program will be needed.

11. Appendix 2

Project Plan

Addressing MSC Condition 7 (PI 2.4.1) on the Peel-Harvey Estuary Recreational Scoopnet Fishery

PART 1

Assessing the footprint of the recreational scoop net fishery in the Peel-Harvey Estuary: Progress and intended monitoring

Stephen Taylor

PART 2

Determining the distribution of habitats in the Peel-Harvey Estuary

Scott Evans

PART 3

Determining the habitat use by wading birds in the Peel-Harvey Estuary

Emily Fisher

Assessing the footprint of the recreational scoop net fishery in the Peel Harvey Estuary: Progress and intended monitoring

Executive summary

This document provides a plan to determine the footprint of recreational scoop-net fishing in high-use areas within Peel Harvey Estuary. In addition, progress since the Peel Harvey Estuary Fishery was certified by MSC in June 2016 is reported on. The research plan will address the scoop-net condition in two parts: 1. Identification of high use scoop-net fishing areas in the estuary (spatially and temporally), 2. Ongoing monitoring at the high-use areas.

Background

Peel Harvey Estuary is a popular location for recreational fishing for blue swimmer crabs *Portunas armatus* (Johnston et al. 2014; Ryan et al. 2015). In June 2016 the Peel Harvey Estuarine Fishery was certified by MSC. The fishery is unique because the certification relates to both commercial and recreational methods. The lack of a licence frame for shore-based recreational fishers, the large number of recreational shore-based fishers and their diffuse access to the resources, and the highly variable temporal levels of scoop-netting activity have been factored into the proposed methods outlined below.

Defining the scooping footprint

Various studies have measured the ecological footprint of commercial fishing activities (e.g. Swartz et al., 2010) and the degree of overlap between commercial fishing activities and habitat utilization by birds (e.g. Bodely et al., 2014; Sugishita et al., 2015). However, the footprint of recreational fishing activities in relation to habitat utilization by birds has not yet been studied. Because there is no standard definition for the recreational footprint, within Peel Harvey Estuary the footprint of recreational scoop-netters is defined as the area in which fishers wade as part of their fishing operations. Various units of measurements (i.e. fisher hrs, number of fishers per km^2) will be used to distinguish between comparably higher and lower areas of scooping activity within the estuary, extending from the astronomical high water mark to the shallow intertidal flats.

Update on progress since accreditation

Remote cameras were installed at three locations in Peel Inlet and one in Harvey Estuary (Figure A2.1) in December 2014 and January 2015. These locations were identified as popular sites for shore-based recreational fishing based on previous daytime onsite survey data and anecdotal reports of nocturnal fishing from Department of Fisheries' (DoF) compliance staff. Subsequent analysis of data collected from the shore-based cameras at Coodanup, Herron Point and Novara (Figure A2.1) between February 2015 and January 2016 revealed high levels of activity between November and March and very low activity levels in other months. These results suggest that the scooping footprint varies considerably between months and locations. Nearly a third (30.1%) of total activity occurred between

20:00 and 05:59 demonstrating the high levels of night-time activity during summer months in the shore-based recreational fishery.

Current research efforts are focused on how the method and technology successfully tested in the above study can be applied to broader areas of Peel Harvey Estuary, in addition to considering alternative approaches that could be applied to the condition (Table A2.1).

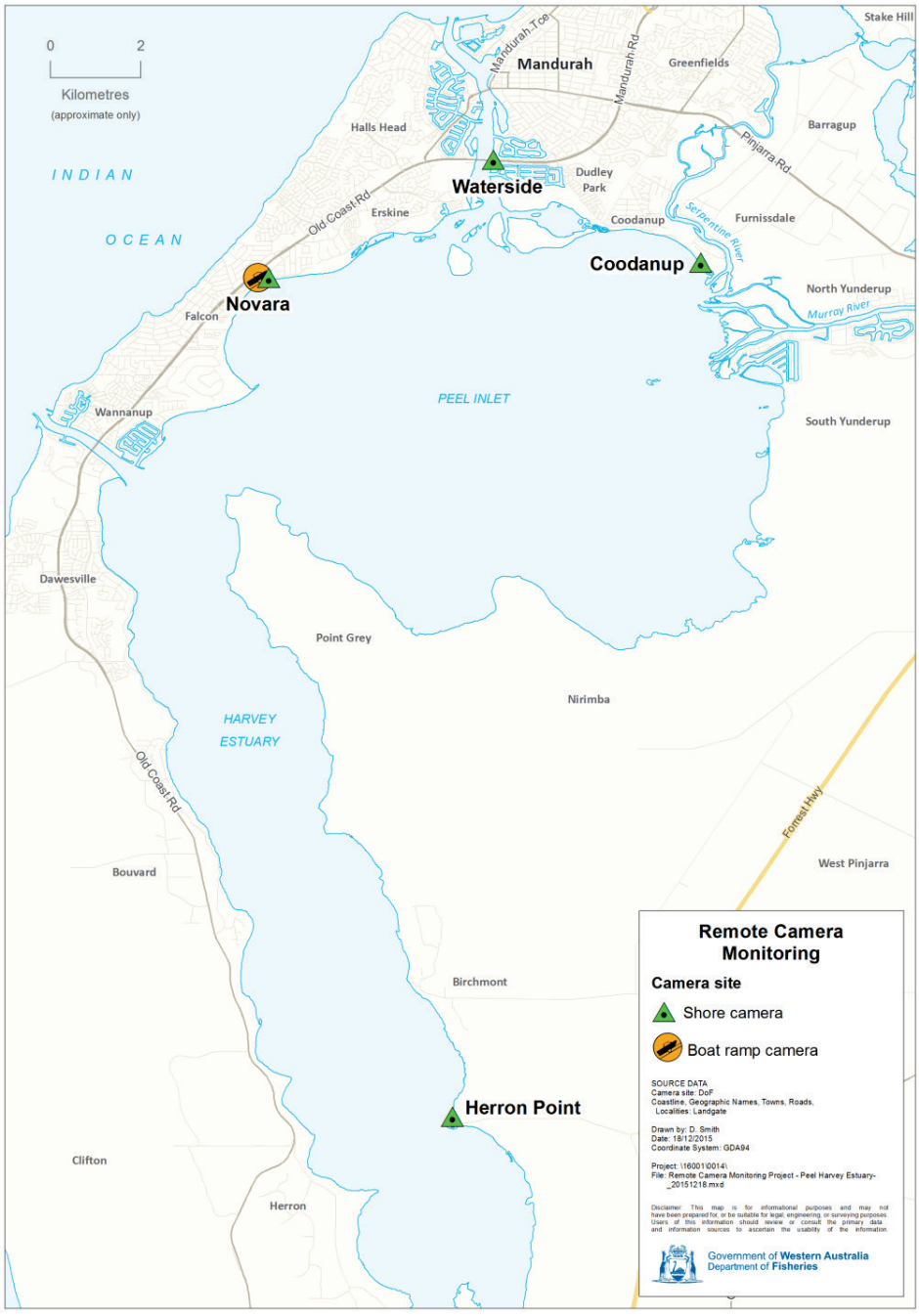

Figure A2-1. Map of Peel Harvey Estuary, Western Australia; Green triangles indicate the locations where remote cameras provide 24-hour footage along the foreshore, noting that the camera at Waterside also provides footage of fishers drop netting off the bridge, orange circle indicates the camera that provides 24-hour footage of boating activity at the public boat ramp.

Objectives and expected outputs before the 2nd audit

The research plan will address the condition in two parts:

1. Identification of high use scoop-net fishing areas in the estuary (spatially and temporally)

An initial trial of the different survey techniques will commence at the start of the 2017/18 recreational crabbing season (1 November 2017). Once the optimal technique has been confirmed, the survey will run for 12-months and will estimate:

- levels of recreational shore-based scoop-netting activity (i.e. in fisher hrs and/or number of fishers per km^2) for broad-areas of the estuary'
- levels of recreational scoop-netting for finer-scale regions of the estuary.

2. Ongoing monitoring at high-use areas

Ongoing low-level monitoring (focused at the high use locations and times of year identified in 1) will be conducted to assist in determining whether the footprint is consistent between years.

Preliminary results obtained from 1 will be presented at the 2nd audit. This staged approach will assist in ensuring the cost-effective use of resources and will allow feedback from the Peel-Harvey Estuary MSC Steering Group and the CAB to be incorporated into the design and the appropriate levels of resourcing.

Design considerations

The requirement to assess the footprint of the recreational scoop-net fishery in high-use areas is challenging for several reasons:

(i) A probability-based survey is required to determine spatial and temporal levels of scooping activity across the entire estuary (Pollock et al. 1994).

(ii) Survey techniques are not typically designed to provide fine-scale information of recreational fishing activity. The delineation of areas of higher scooping activity needs careful consideration; particularly with respect to the correct weighting of the survey data (refer to Fisheries Research report 177).

(iii) High levels of nocturnal recreational fishing activity occur in the estuary. Because not all fishers are identifiable at night and most cameras cannot detect people fishing in low-light conditions, if there is a requirement to estimate the scooping footprint at night, a thermographic camera will likely be required. This would require the technology and analytical technique adopted for the fixed-site cameras to be adapted.

Note that trials conducted between January and April 2017 suggested that a thermographic camera could be incorporated into a probability-based roving creel survey to estimate the

nocturnal scooping footprint; however, this would require the purchase of specialized camera equipment.

Potential methods to measure the scooping footprint

A number of survey techniques are summarized in Table A2.1, each of which has its inherent advantages, limitations, in-scope and out-of-scope activities. The relative cost and assumptions required for each technique are also highlighted.

A framework has been developed that covers the following broad areas (1) project description; (2) survey design and sampling strategy; (3) feasibility and logic checks for proposed analyses (Figures A2.2-5). This framework will be applied to the methods outlined in Table A2.1 to determine which are best suited to the identification of high-use areas and the ongoing monitoring at high-use areas. It is acknowledged that multiple techniques could be used to address different parts of the condition and that other techniques could also be considered. The feasibility of any alternative methods would also need to be assessed against the framework.

Irrespective of whether a roving creel survey (conducted from shore, boat or using an Unmanned Aerial Vehicle (UAV)) or strip transect survey is conducted, counts will be made of all shore-based persons identified to be recreational fishing and their fishing method (e.g. scoop netting, rod and line fishing, netting, other) in addition to the total number of people in the water. As part of a roving creel survey, shore-based recreational fishing effort (in fisher hrs) will be estimated using the Progressive Count Method (refer to Pollock et al. 1994). These replicate sampling days will be expanded to estimate day-type stratum totals (weekdays, weekends/public holidays) within each season. The location of fishers will be georeferenced to assist in interpreting the scooping footprint in different regions of the estuary (measured in fisher hrs or the number of fishers per km^2).

Strip transect sampling is a technique widely used to estimate the abundance and biodiversity of wildlife but this method has rarely been applied to recreational fisheries (Klieven et al., 2011). By counting the number of people in the water within each transect, it is possible to estimate the density of fishers per km^2. A systematic random sample of transects would be allocated on each survey day, the number and feasibility of which would be determined during the pilot study. Using this approach, the unit of measurement would not be directly comparable to previous creel surveys and the current Departmental State-wide survey of boat-based fishing (i.e. not fisher hrs).

Links to other Departmental surveys

Catch and effort from boat-based fishers in Peel-Harvey Estuary are obtained from biennial state-wide surveys. The 2015/16 survey collected shore-based data from Recreational Boat Fishing Licence (RBFL) holders and the 2017/18 survey will be based on a dual-frame design (RBFL and White Pages). As these surveys are designed to produce state-wide and bioregional estimates, restrictions on the public release of small areas estimate depend upon the sample size (where $n > 30$) and precision (rse < 40%)

which are used to qualify if estimates are robust, or not. While these surveys are unlikely to provide accurate estimates for specific areas within the estuary, they are expected to provide a robust estimate for the entire estuary that will provide a useful means to corroborate estimates from the on-site surveys outlined in Table A2.1.

Timeline

A timeline for addressing the scoop-netting condition is outlined in Table A2.2. It is proposed that data collected from the fixed-location thermographic cameras will be read for the 2017/18 crabbing season to coincide with the onsite survey outlined above. Subsequent survey activities will depend upon whether a score of SG80 is achieved at the 2nd Audit.

Table A2.1. Potential methods that could be used to assist in estimating the footprint of recreational scoop netting

Survey method	Options	Unit of measurement	In-scope (I)	Out-of-scope (O)	Assumptions required	Relative operating costs
Fixed-location thermographic cameras at Coodanup, Novara and Herron Point.	Sub-sampling of video footage collected during 2017-2018 and 2018-2019 crabbing season.	Fisher hours Fishers per km^2	24-hour activity patterns across all months and seasons. Recreational scoop netters can be identified from the daytime footage.	Camera viewpoints <1% of all parts of the estuary. Therefore most areas available to scoopers are out-of-scope.	That people identified in the footage at night are recreational scoop netting (multiple lines of evidence support this assumption).	Low
Roving creel survey – Day only	Conducted from the shore or boat	Fisher hours Fishers per km^2	Daytime recreational fishing activity for entire estuary that would enable high-use areas to be identified.	Nocturnal recreational fishing activity.	That areas of higher activity in the day are representative of those at night.	Medium
Roving creel survey – Day only using Unmanned Aerial Vehicle (UAV)	UAV could be operated from the shore or from a boat	Fisher hours (only if part of probability-based survey) Fishers per km^2	Daytime recreational fishing activity	Scooping activity at night	UAV would need to fly a pre-determined route. Requirements to operate UAV within line of sight may complicate this. Restrictions on flying at night as well.	High

Roving creel survey – Day and Night	Conducted from the shore using a mobile thermographic camera	Fisher hours Fishers per km^2	Daytime and nighttime recreational fishing activity that would enable high-use areas to be identified. .	NA	NA	High
Strip Transect Sampling – Day only	Conducted from the shore or boat	Fishers per km^2	Density measure for daytime scooping activity	Approach commonly used in wildlife surveys. Fixed transects often used for looking at long term trends while random transects often used for looking at differences between habitats and locations.	Unlike the roving creel survey, this approach would not estimate fisher hrs so the results would not be directly comparable to other recreational fishing surveys conducted in the estuary.	Medium
Strip Transect Sampling – Day and Night	Conducted from the shore using a mobile thermographic camera	Fishers per km^2	Density measure for daytime and nocturnal scooping activity	NA	As above	High

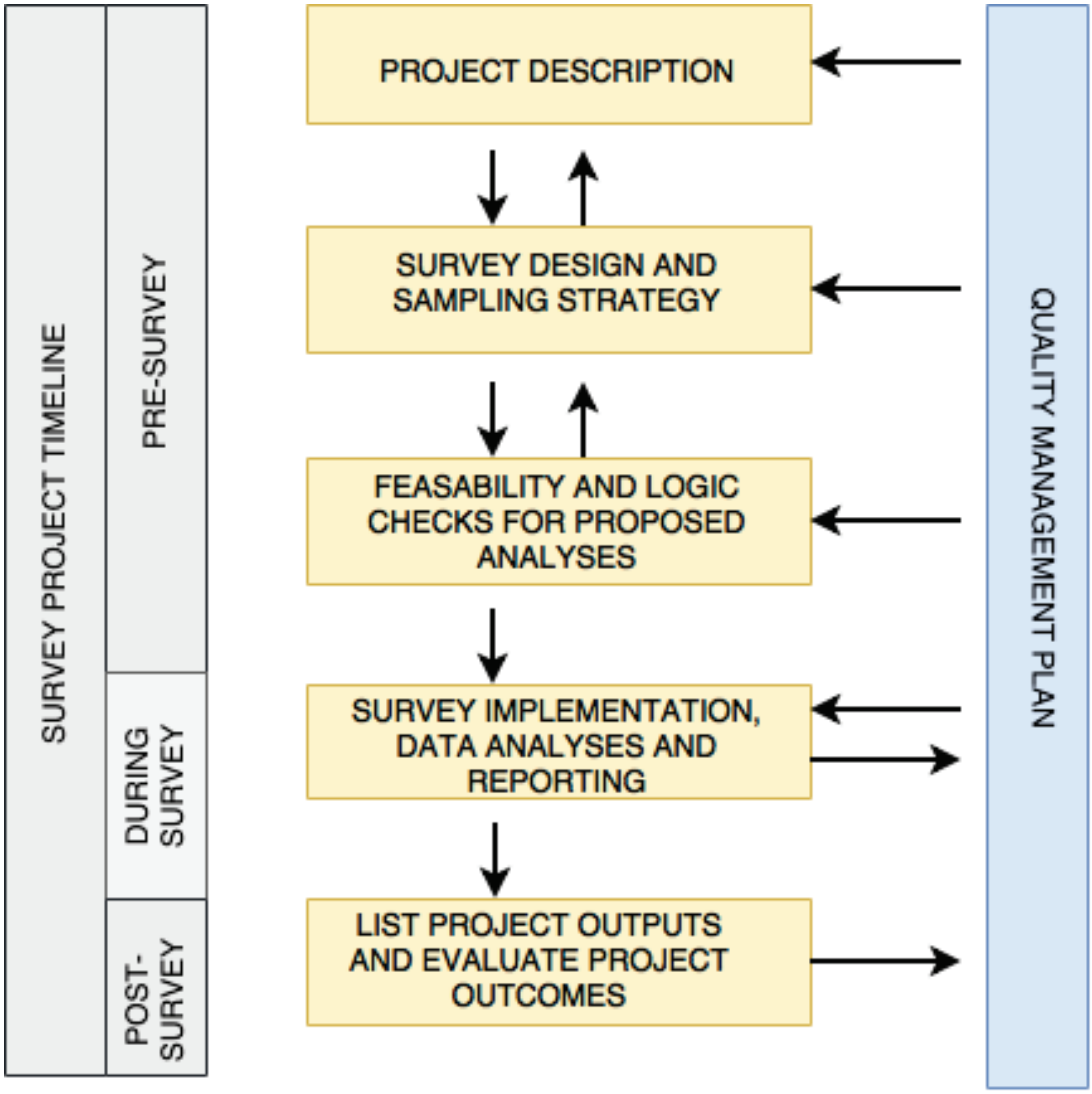

Figure A2.2. Schematic representation of a framework that will be used to guide the development of methods to estimate the recreational scoopnetting footprint

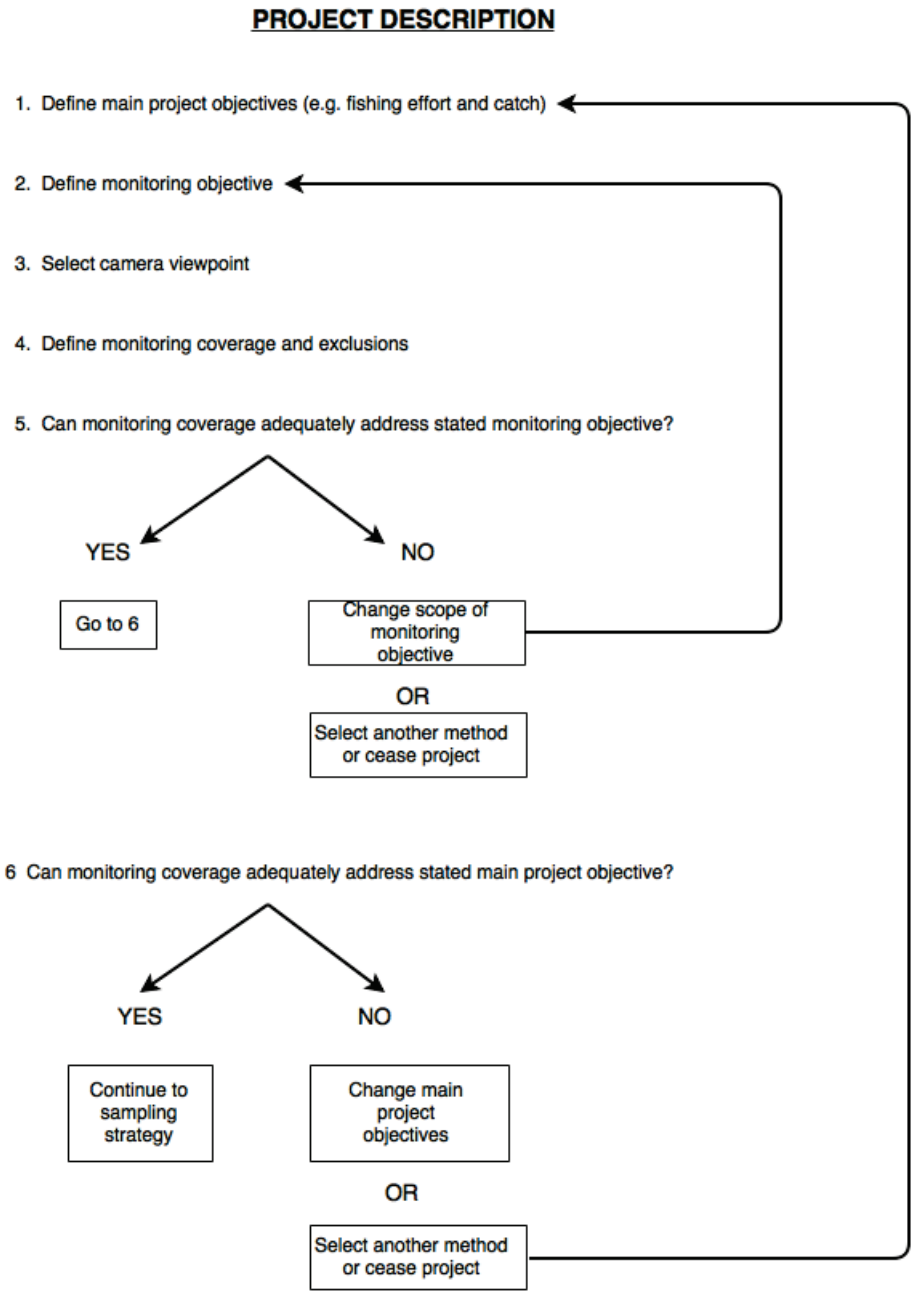

Figure A2.3. Schematic representation of the project description part of the framework

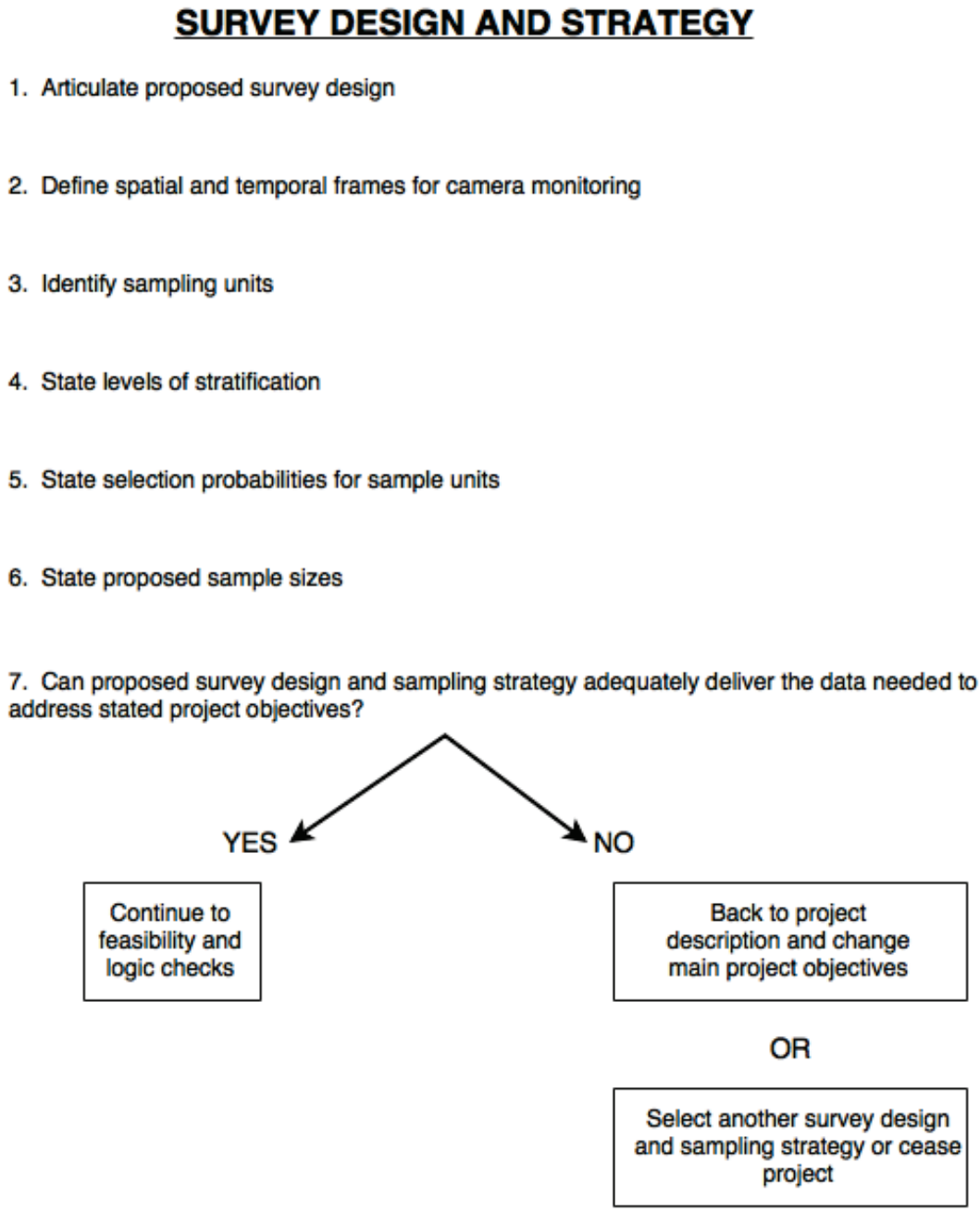

Figure A2.4. Schematic representation of the survey design part of the framework

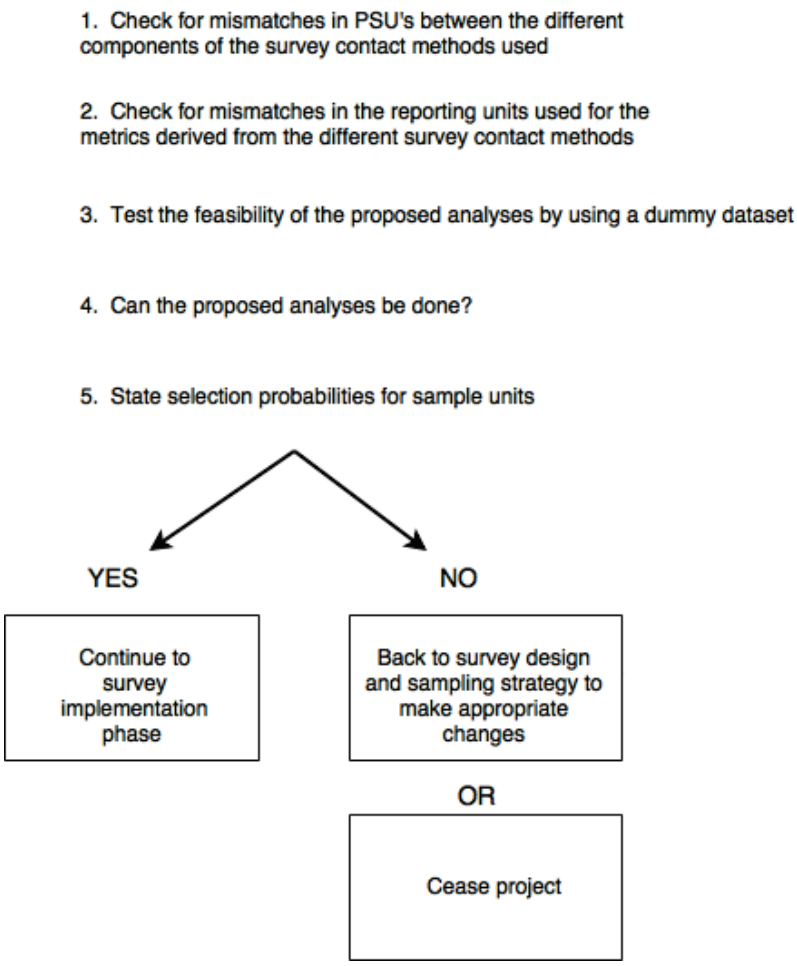

Figure A2.5. Feasibility and logic checks for proposed analyses

Table A2.2. Timeline for determining the footprint of recreational scoop-net fishing in Peel Harvey Estuary

		2017				2018				2019				2020	
Condition component	Activity	Q1	Q2- Audit 1	Q3	Q4	Q1	Q2 – Audit 2	Q3	Q4	Q1	Q2- Audit 3	Q3	Q4	Q1	Q2- Audit 4
Determine footprint of recreational scoop-net fishing in Peel Harvey Estuary	Compile manuscript on the fixed-location thermographic cameras														
	Assess whether thermographic cameras can be incorporated into roving creel survey														
	Discuss project plan with CAB														
	Determine level of scoop-netting activity across the entire estuary														
	Read data from fixed-location thermographic cameras														
	Present results at 2nd audit.														
	If SG80 met, no further surveys required.														
	If SG80 not met, ongoing monitoring at high-use areas during peak times*														
	Present results at 3rd audit.														
	Analyze survey data and estimate scooping footprint														
	Review all scooping footprint and survey data (incl. from iSurvey) for incorporating in a risk assessment														
	Final condition														

*Timing of this monitoring dependent on the results of the survey across the entire estuary. Provisionally listed as Q3 & Q4 in 2019

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Determining the distribution of habitats in the Peel-Harvey Estuary

Objectives and Methods

Broad-scale remote sensing habitat maps will be developed for the shallow water environments (<1 m depth, i.e. which are accessed by scoop net fishers) of the Peel-Harvey Estuary to determine habitat distributions. The maps will be developed using available bathymetric, satellite and airborne imagery and data including, but not limited to, LandSat, LiDAR and aerial photograph.

The unsupervised habitat maps will be validated with ground truthing surveys, using geo-referenced tow, drop and diver operated video. The design of the ground truthing surveys will incorporate any existing habitat data (e.g. Valesini et al. 2009), location of areas used by wading birds and areas of low, medium and high recreational scoop-net fishing activity. Video data will be analysed using the image processing software to identify and quantify habitat types, with this data then statistically grouped into distinct habitats for producing the final validated habitat maps.

Timeline

A timeline for determining the distribution of habitats in the Peel-Harvey Estuary is provided in Table A2.3.

References

Valesini, F., Coen, N., Wildsmith, M., Hourston, M., Tweedly, J., Hallett, C., . . . & Potter, I. (2009). Relationships between fish faunas and habitat type in south-western Australian estuaries. FRDC Final Report Project 2004/045. Murdoch University, WA.

Table A2.3. Timeline for determining the distribution of habitats in the Peel Harvey Estuary

		2017				2018				2019				2020	
Condition component	Activity	Q1	Q2- Audit 1	Q3	Q4	Q1	Q2 – Audit 2	Q3	Q4	Q1	Q2- Audit 3	Q3	Q4	Q1	Q2- Audit 4
Determine the distribution of habitats in the Peel Harvey Estuary	Develop unsupervised maps														
	Design ground truthing survey														
	Present progress at 2nd audit														
	Conduct and analyse ground truthing surveys														
	Present progress at 3rd audit														
	Produce final supervised habitat maps														
	Risk assessment & reporting														

Determining the habitat use of wading birds in the Peel-Harvey Estuary

Background

Information on the habitat use of wading birds in the Peel-Harvey Estuary is available from the Shorebirds 2020 program. These annual bird counts are undertaken by 60-70 volunteers at a number of fixed locations in the Peel Inlet, Harvey Estuary and surrounding areas of the Ramsar wetland during the peak nesting season (February).

The bird counts are coordinated by Birdlife WA Peel Branch and the Peel-Harvey Catchment Council, who are custodians of the data. Discussions with Peel Harvey Catchment Councils' Steve Fisher and Thelma Crook have confirmed the data will be available on request to help address the MSC condition relating to the recreational scoop net fishery.

Timeline

It is proposed that the data are requested and explored prior to the second audit (July 2018) to determine if it will be sufficient to address the MSC condition through a risk assessment.