Stock Status Summary – 2022/23

NSW Stock Status Summary – Blue Swimmer Crab
(Portunus armatus)

NSW GOVERNMENT

Assessment Authors and Year

Johnson, D.D. 2023. NSW Stock Status Summary 2022/23 – Blue Swimmer Crab (*Portunus armatus*). NSW Department of Primary Industries, Fisheries. 18 pp.

Stock Status

Current stock status	On the basis of the evidence contained within this assessment, Blue Swimmer Crabs are currently assessed as **depleting**

Stock structure & distribution

Blue Swimmer Crabs occur in coastal and estuarine waters along the length of the New South Wales coastline. The stock structure on the east coast of Australia is uncertain, involving overlapping stocks or a semi-continuous stock (Chaplin et al., 2001). Using a high-resolution oceanographic model coupled with a Lagrangian particle tracking framework to simulate larval dispersal, Hewitt et al. (2023) suggest populations of Blue Swimmer Crab in NSW and Queensland appear to constitute demographically separate stocks, supporting the current assessment and management at the state level.

Biology

New South Wales Blue Swimmer Crab populations are at the southern end of the species distribution along the east coast and have a limited spawning period rather than the year-round spawning that occurs in more northern latitudes (Johnson et al., 2010). The duration of the spawning period (>5% of mature females berried), proportion of mature crabs berried, and the size-structure of recorded catches of berried females from fishery-independent surveys varied between Wallis Lake, Port Stephens, and Lake Macquarie (Taylor et al., 2023).

Estimates of mean size sexual maturity (L_{50}) for Wallis Lake (50.9–52.5 mm) and Port Stephens (50.7-51.9 mm) from fishery-independent surveys (Taylor et al., 2023) exceed previous estimates for Wallis Lake (~46 mm Johnson et al., 2010). The size of the smallest functionally mature female (i.e., berried) recorded from fishery-independent survey trap catches (2018-2021) in Wallis Lake (47 mm) and Port Stephens (50 mm) was below the lower estimates of L_{50} from each estuary. Increasing the minimum legal length (MLL) for Blue Swimmer Crab in NSW from 60 to 65 mm (applied to commercial sector in 2017 and recreational in 2020) reduced fishing pressure on the spawning stock (Taylor et al., 2023).

FISHERY STATISTICS

Catch information

Commercial

Commercial catches of this species tended to fluctuate around a long-term average of about 144 t over the period 2000/01 to 2016/17. However, in 2019/20, 2020/21 and 2021/22, reported commercial landings declined to 56, 84 and 47 t, respectively. From 2012/13 to 2021/22 reported landings from the estuary general fishery (EGF) accounted for ~ 95% (range 91 – 98%) of total landings. Reported landings from Region-4 of the EGF account for approximately 75 per cent (range 61 - 83%) of commercial Blue Swimmer Crab landings in New South Wales (Figure S1). Within Region 4, the most important estuary is Wallis Lake accounting for approximately 80 per cent of reported landings (Figure S2. 47.2 t in 2020–21). The majority (~ 85%) of the catch from the EGF is reported for the method of fish and crab trapping. From 2012/13 to 2021/22 reported landings from fish and crab trapping accounted for approximately 65 and 10% of estuary landings, respectively. The annual catch composition by sex is biased towards males with reported landings of females accounting for approximately 35% of total landings from 2009/10 to 2021/22 (Figure S3).

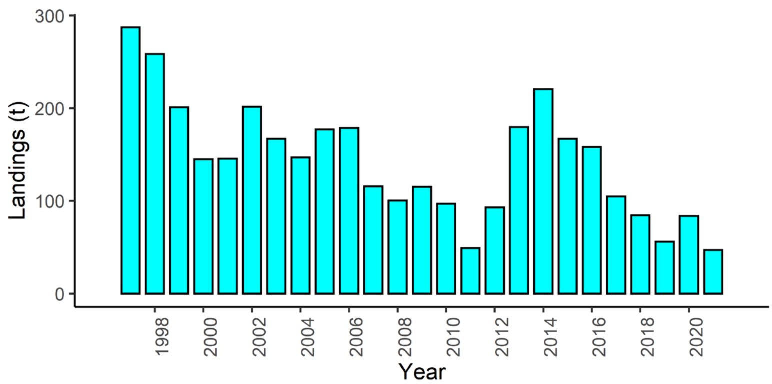

Figure 1. Annual reported commercial landings (t) from 1997/98 to 2021/22.

Recreational & Charter boat

Estimates of state-wide recreational catches are available from the National Recreational and Indigenous Fishing Survey completed in 2000/01(Henry & Lyle 2003) and New South Wales state-wide surveys completed in 2013/14 (West et al., 2015), 2017/18 (Murphy et al., 2020) and 2019/20 (Murphy et al. 2022).The 2013/14 estimate of 27 t is based on (i) an estimated recreational catch of 50 637 Blue Swimmer Crabs by NSW resident recreational anglers in 2013/14 (West et al. 2015); and (ii) an assumed mean weight of kept Blue Mud Crabs of 0.530 kg/ crab. This remains the most reliable estimate of annual recreational catch because survey estimates for 2017/18 (14 t) and 2019/20 12 t) applies only to 1-3 year recreational licence holders (Murphy et al. 2020, 2022).

Aboriginal cultural fishery

Although Indigenous fishers harvest Blue Swimmer Crabs throughout New South Wales, there are no state-wide estimates of harvest. It is however, acknowledged and understood that fishing practices have been undertaken by Aboriginal people of many groups throughout NSW for many thousands of years and that fishing and related practices are valued by Aboriginal people for a wide range of reasons including subsistence (Smyth et al., 2018).

Illegal, Unregulated and Unreported

The level of Illegal, Unregulated and Unreported (IUU) fishing is unknown.

Fishing effort information

Reported effort (days) crab trapping for Blue Swimmer Crab estimated from monthly catch and effort records slowly decreased from 10 900 days in 1997/98 to 6 900 days in 2003/04 then declined by ~50% in 2004/05 (3 462 days). Following the introduction of daily catch and effort reporting in 2009/10, reported effort has remained below 2 000 days per year (Figure 2). In contrast reported effort fish trapping increased from 2004/05 reaching a historical peak of 4 400 days in 2014/15. From 2015/16 (3 900 days) reported effort fishing trapping has continually declined with 2 100 days reported in 2021/22 (~50% of 2014/15). The trends in reported effort suggest a large proportion of the catch of Blue Swimmer Crabs reported from Crab trapping (pre 2004/05) is now reported from the method of fish trapping.

Figure 2. Reported days effort (Days) for the methods of crab trap and fish trap from all NSW estuaries from 1997/98 to 2021/22.

Catch Rate information

Nominal catch rates (kg.FisherDay^{-1}) for fish trapping averaged ~ 20 kg.day^{-1} before increasing to > 30 kg per day^{-1} from 2013/14 to 2016/17 (Figure 3). From 2016/17 to 2017/18 catch rates declined from ~32 kg.FisherDay^{-1} to ~19 kg.FisherDay^{-1} under revised management arrangement (i.e, MLL increase and quota management). Catch rates for crab trapping steadily declined from 2002/03 to 2011/12 and remained low until 2019/20 before increasing to ~13 and 9 kg.FisherDay^{-1} in 2020/21 and 2021/22, respectively (Figure 3).

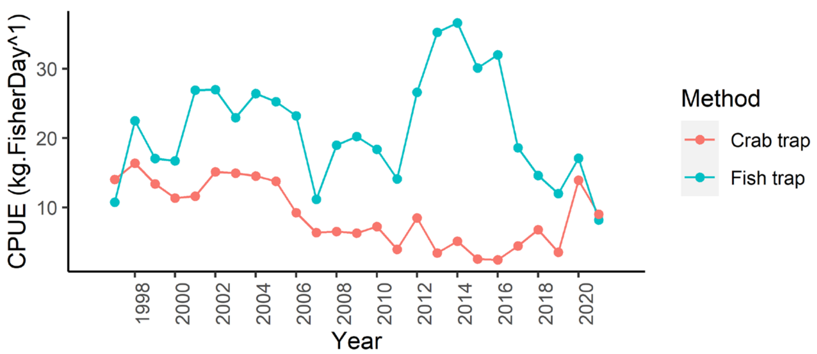

Figure 3. Nominal commercial catch rates from crab and fish trapping in the EGF.

STOCK ASSESSMENT

Stock Assessment Methodology

Year of most recent assessment:

2023

Assessment method:

Weight of evidence approach, including standardised commercial catch rates, Catch-MSY assessment, catches rates of legal and undersize crabs from fishery-independent surveys, size-structure of observed catches and predictions of CPUE and harvest.

Main data inputs:

Key model structure & assumptions:

1. Standardised catch rates. Annual catch rates were standardised using Generalised Linear Models (GLM) to account for the effects of month and fisher (i.e., authorised fisher ID). Models were fit using a lognormal distribution, with CPUE as the response variable, and year, month and fisher as explanatory terms (which were considered categorical variables). Estimated marginal mean values for each year and associated confidence limits were then calculated using the 'emmeans' package (Lenth, 2020) and rforCPUE (https://github.com/haddonm/rforcpue) in R (R Development Team, 2019). *Assumptions*: that annual catch rates are a relative index of abundance and not unduly influenced by other factors that are not accounted for through standardisation.
2. Catch-MSY model-assisted catch-only assessment (Martell & Froese, 2013) using the 'simpleSA' package in R (Haddon et al., 2018). This uses population productivity (*r*) and carrying capacity (*K*) parameters of an underlying Schaefer production model, applied to total annual catches, to estimate the ranges in biomass and harvest rate that could have resulted in the annual catches. *Assumptions*: Estimated ranges of the population growth rate parameter (r) and carrying capacity (*K*) of the stock are pre-determined through an assumed resilience; the underlying population biomass model is very generic and simplistic, with parameters that remain constant through time; the model outcomes are quite dependent on the lower bound of *r* selected (Martell and Froese 2013). 'Resilience' was set to low in the Catch MSY model specification, which allows for a possible range in population growth rate (*r*) of 0.1 - 0.6.
3. Catch rates and size-structure of catches from fishery independent surveys in Walls Lake from 2018/19 to 2021/22 (see Taylor et al., 2023 for a full description).
4. Predictions of summer (January – April) CPUE for Wallis Lake from a linear model fitted to the previous year's summer CPUE (kg scaled fisher day-1), the total catch taken the previous winter (June – November; kg), and the mean PDO index from November –January leading into the fishing season (see Schilling *et al*., 2023 for a full description).
5. Quadratic discrimination analysis using the previous summer (January – April) CPUE and the winter (June – November) catch to classify years as above or below average (see Schilling et al., 2023 for a full description).

Sources of uncertainty evaluated:

The effect of four different constant catch scenarios ranging from 100 t to 200 t on the 5-year projections of estimated biomass and harvest rate trajectories on Catch-MSY outputs.

The impact of recreational harvest ranging from 10-30% of reported commercial landings on Catch-MSY outputs.

Status Indicators - Limit & Target Reference Levels

Biomass indicator or proxy	None specified in a formal harvest strategy. This assessment used a weight-of-evidence approach, with data including: - standardised catch rates from Wallis Lake and other main estuaries (combined) for the methods of fish and crab trapping - catch rates from fishery-independent surveys in Wallis Lake - the mean estimated biomass depletion (as a percentage of the estimated maximum biomass) from modified Catch-MSY analyses - predictions of summer (January – April) CPUE and catches from Wallis Lake.
Biomass Limit Reference Point	None specified in a formal harvest strategy.
Biomass Target Reference Point	None specified in a formal harvest strategy.
Fishing mortality indicator or proxy	None specified in a formal harvest strategy. This assessment used a weight-of-evidence approach, with data including: - Catch (state-wide)
Fishing mortality Limit Reference Point	None specified in a formal harvest strategy.
Fishing Mortality Target Reference Point	None specified in a formal harvest strategy.

Stock Assessment Results

Standardised commercial catch rates

For recent data analysed as mean daily catch rates (available from 2009/10), catch rates (in mean CPUE kg-day^{-1}) for fish and crab trapping in Wallis Lake increased from 2011/12 and were ≥ mean catch rate from 2012/13 to 2016/17 (Figure 4). For other main estuaries, catch rates for fish trapping increased from 2011/12 and exceeded mean catch in 2013/14 before declining below average in 2015/16 and 2016/17. In contrast, catch rates for crab trapping in other estuaries fluctuated around mean catch rate from 2013/14 to 2015/16 and exceeded mean catch rate in 2016/17. Standardised catch rates sharply declined under revised management arrangements in 2017/18.From 2017/18 standardised catch rates for fishing trapping in Wallis Lake (~60% of average landings) and other main estuaries (15% of average landings) have declined. Catch rates in Wallis Lake and other main estuaries in 2021/22 were 54% and 25% lower than 2017/18, respectively (Figure 4).

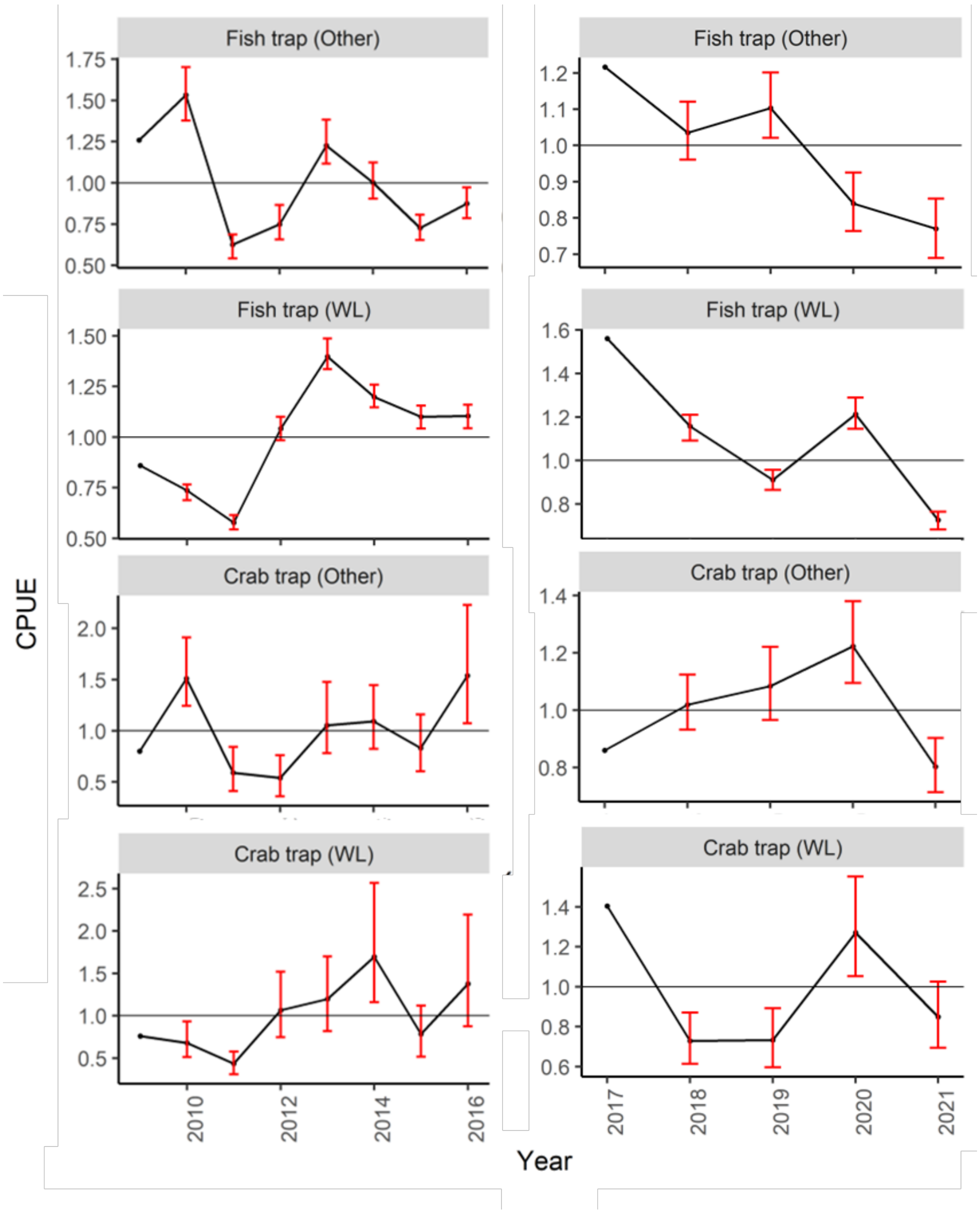

Figure 4. Standardised commercial catch rates (nominal scale) for fish trapping and crab trapping with 95% confidence intervals from main estuaries (Other - excluding Wallis Lake) and Wallis Lake (WL) in CPUE kg day^{-1} from daily records for 2009/10 to 2016/17 and 2017/18 to 2021/22. The horizontal line represents the average catch rate for each period.

Fishery-independent surveys (FIS)

Catch rates (number.crabs.trap^{-1}) of undersize and legal sized crabs vary temporally with the patterns generally consistent across years (Figure 5). Catches of undersize crabs in 2018/19, 2019/20 and 2020/21 peaked in mid-late summer (January or February). Catches of legal sized crabs were less variable but generally declined throughout the fishing season reaching a minimum from July to September. Catch rates of legal crabs calculated for the main fishing period (November to June) have declined from ~1.73 (± 0.08) crabs per trap. lift^{-1} in 2018/19 to 0.94 (±

0.04) crabs per trap lift^{-1} in 2021/22 (Figure 6). Similarly, annual catch rates of undersize crabs from November to March (Main) declined from 9.50 (± 0.49) crabs per trap lift^{-1} in 2018 to 3.37 (± 0.16) crabs per trap lift^{-1} in 2021/22 (Figure 6).

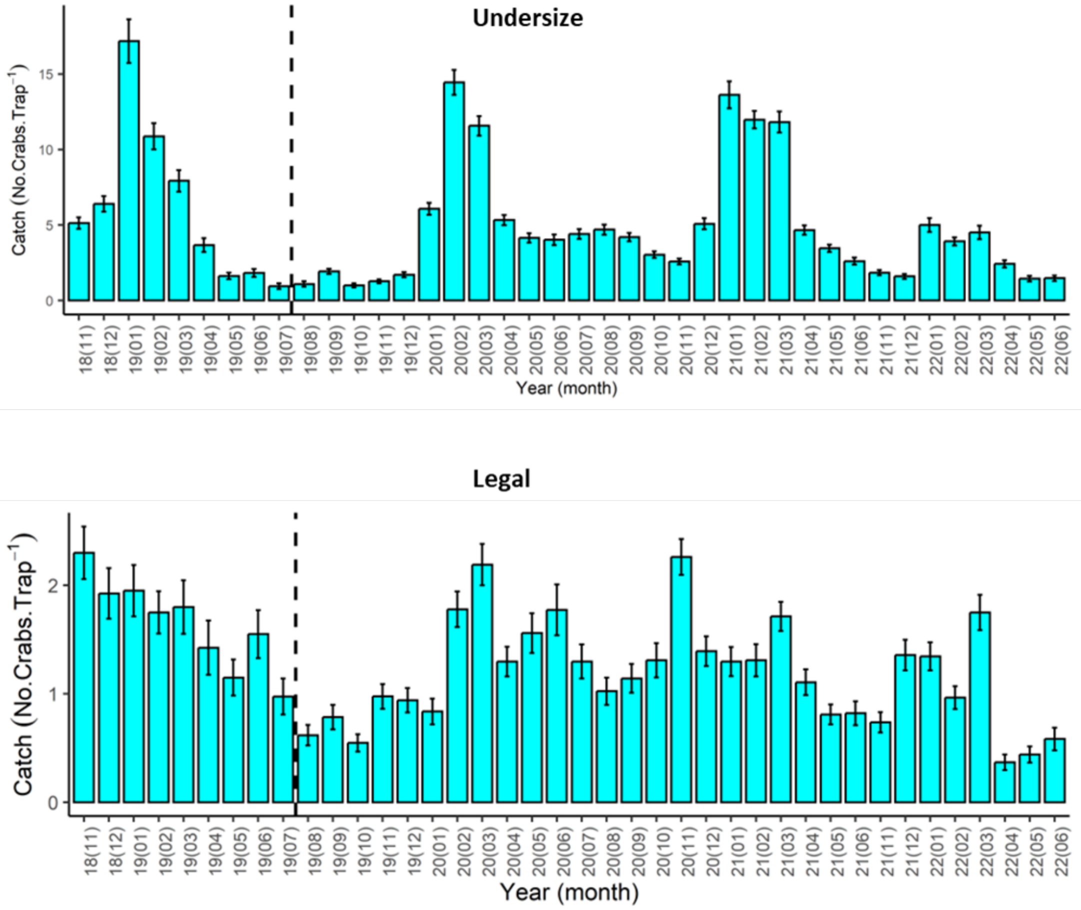

Figure 5. Mean (± SE) monthly catch rate (number.crabs.trap^{-1}) of undersize and legal crabs (pooled across sites). Dashed vertical line indicates change in sampling design.

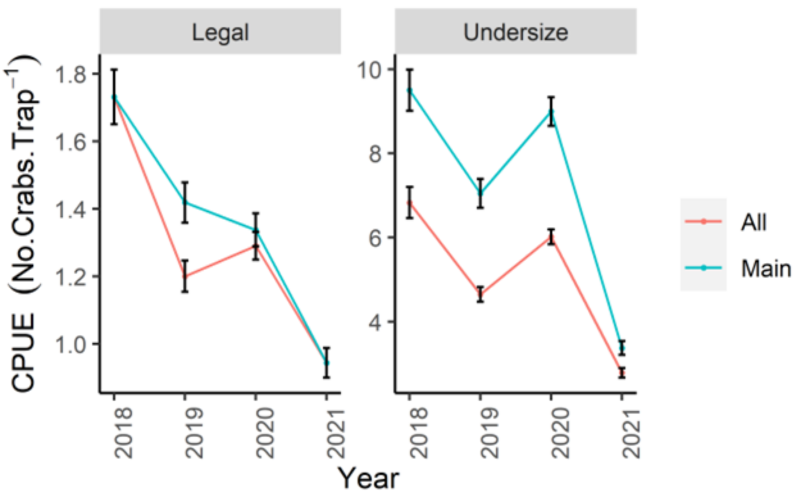

Figure 6. Mean catch rate (± SE) of legal crabs and undersize crabs for all months and November to June (Main) for legal crabs and November to March for undersize (Main).

Catch-MSY

The assessment estimated maximum sustainable yield (MSY) to be around 150 t. Average combined commercial and recreational harvest over the last six years was approximately 100 t (90 and 12 t respectively), with estimated total harvest (assuming recreational catch 10-20% of commercial) in 2014/15 (240-260 t) ≥ to the upper 95% confidence interval of MSY (Figure 7). Five-year projections at a constant catch of 150 t (~mean catch 1997/98 - 2018/19) indicate that B is predicted to remain stable at that catch level (Figure 8). However, if the level of fishing mortality permitted under existing management arrangements (i.e. TAC 225 t) is combined with recreational catches estimated at 20% of total harvest, Catch-MSY model outputs include a range of trajectories that deplete biomass to less than 20% of unfished levels within five years.

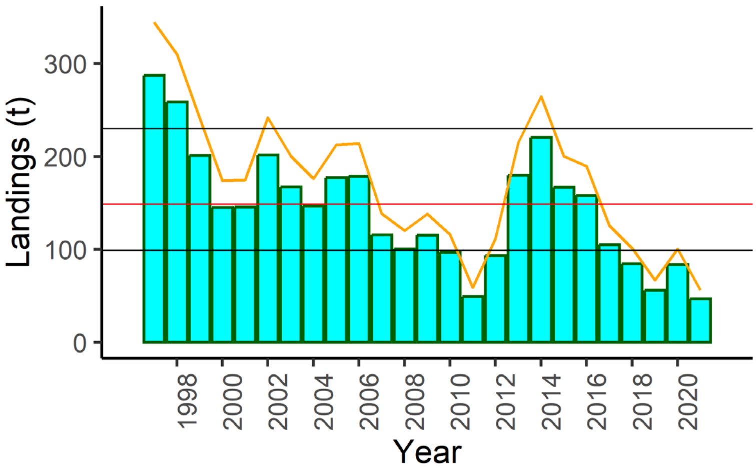

Figure 7. Catch-MSY assessment results showing annual reported landings (t) and estimated total catch (orange line, assuming recreational harvest 20% of commercial) with estimated MSY (red line) and 95% confidence intervals (black lines).

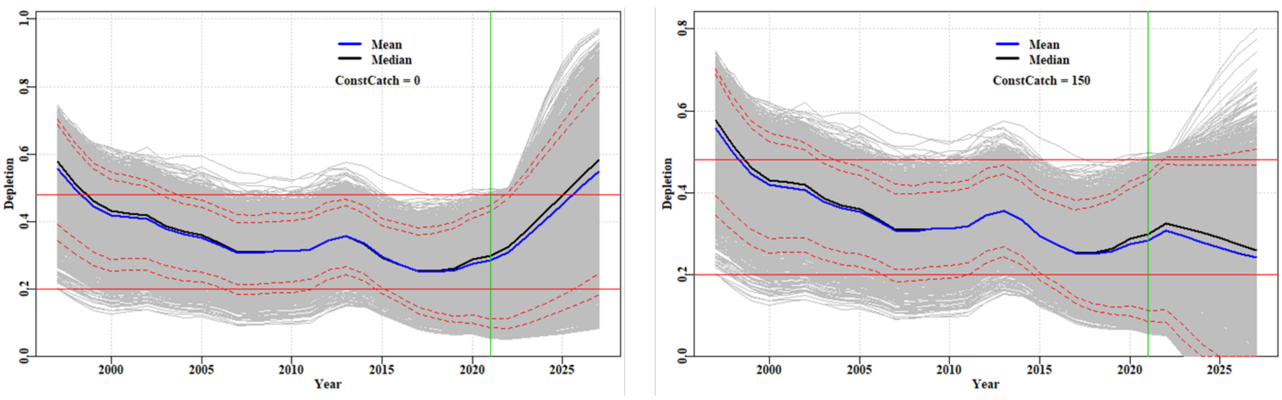

Figure 8. Range of depletion trajectories for successful *r-K* pairs (left) and 5-year constant catch projections (right), showing mean and median annual depletion and 80th and 90th percentiles (dashed lines).The lower solid red line is the $0.2B_0$ limit reference point, while the upper is B_{MSY} ($0.48B_0$) target reference point.

Size-structure of observed catches

Increasing the minimum legal length (MLL) from 60 to 65 mm in 2017 increased protection of the spawning stock. The size-structure of observed catches from Wallis Lake trap fishery indicate that ~60% of the total catch of both berried and female Blue Swimmer Crabs were below the current MLL (Figure 9). Approximately 55 and 64% of the total observed catch of male Blue Swimmer Crabs from 2018/19 and 2019/20 were undersized, respectively (Figure 10). The proportion of the observed annual catch of undersized Blue Swimmer Crabs ≥60<65 mm ranged from 59.6% for males to 65.9% for females (Fig. 9- Fig. 10). Within individual months, the proportion of female and male crabs ≥60<65 mm ranged from 17.3 to 49.3% and 12.2 to 46.6%, respectively (Figure S4).

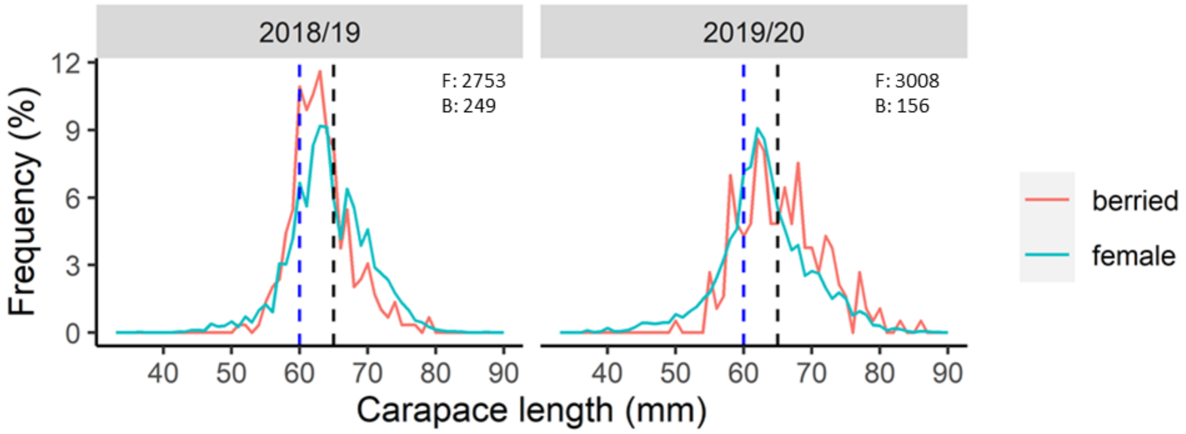

Figure 9. Size-frequency distribution of berried female and female Blue Swimmer Crabs recorded from observer-based survey of Wallis Lake from 2018/19 to 2019/20. The number of female (F) and berried female (B) crabs measured is shown. Dashed line represents historic (blue - pre December 2017) and current (black) MLL.

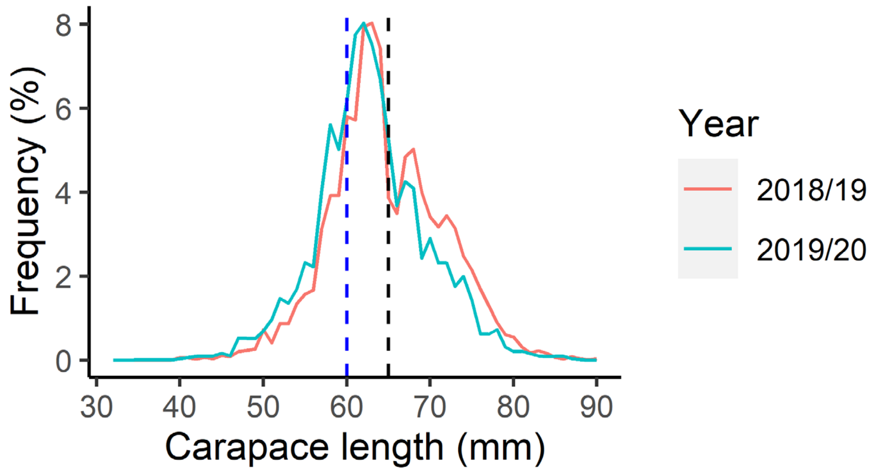

Figure 10. Size-frequency distribution of male Blue Swimmer Crabs recorded from observer-based survey of Wallis Lake for 2018/19 (n = 6 673) to 2019/20 (n = 8 153). Dashed line represents historic (blue - pre December 2017) and current (black) MLL.

CPUE and catch prediction for Wallis Lake (Schilling et al., 2023)

Following integrative analysis drawing together information to test specific hypotheses of a variety of factors that could influence Blue Swimmer Crab commercial fisheries harvest in Wallis Lake, Schilling et al., 2023 used a single ecologically relevant regression model to predict the summer (January – April) CPUE (the period when most of the blue swimmer crabs are harvested). The model predicted CPUE (January in April) in 2022/23 (18.7 kg day^{-1}) to be greater than 2021/22 (10. 6 kg day^{-1}), but below long-term average (Figure 12, 24.7± 2.0 kg day^{-1}). However, predicted CPUE in 2021/22 was lower than observed (18.9 kg day^{-1}).

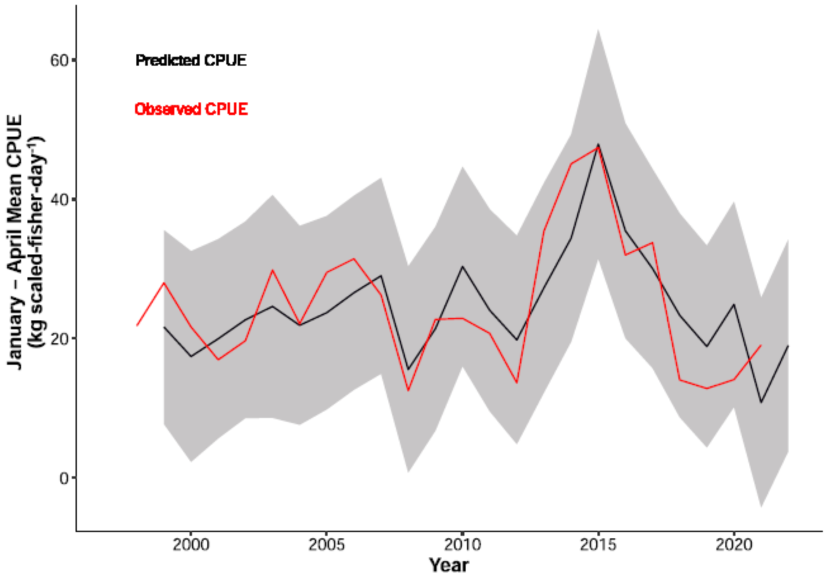

Figure 11. Hindcast predictions of summer (January – April) CPUE (kg scaled Fisher Day^{-1}) for Blue Swimmer Crab in Wallis Lake. The red line shows observed CPUE while the black line shows the predicted CPUE. The grey ribbon shows the 95% prediction interval using the linear model (Source Schilling *et al*., 2023).

Quadratic discrimination analysis was successful (83.3% accuracy) at using the previous summer (January – April) CPUE and the winter (June – November) catch to classify most years as above or below mean total harvest (78.7 t) calculated from reported landings for Wallis Lake from 1998 – 2021 (Figure 13, Schilling et al., 2023). The classification analysis showed that the when the previous summer harvest was high, the forecast season was likely to be above average but if the winter harvest was too large then there was a risk of a below average harvest (Schilling et al., 2023). The magnitude of winter harvest has declined in recent years (2017/18-2021/22).

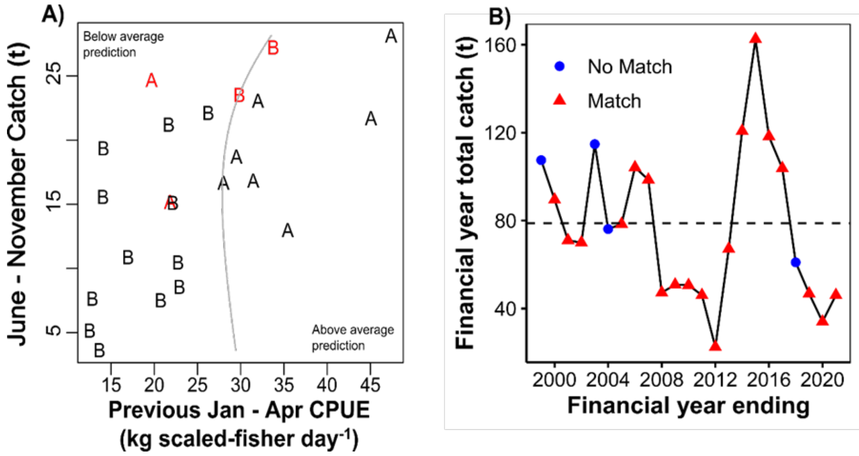

Figure 12. Visual representation of classification of above- and below-average seasons based upon the quadratic discrimination analysis using winter (June – November) catch and the previous summer (January – April) CPUE (kg scaled fisher day^{-1}). Panel A shows the outcomes of the discrimination analysis. Letters represent the predicted outcome for the season (A = above average, B = below average) and colour represents whether the prediction was correct (black = correct, red = incorrect). The grey line shows the prediction boundary based upon the two variables. Panel B shows the performance of the predictions over time relative to the observed financial year catch (year ending June 30th). The dashed line represents the mean total catch (source Schilling et al., 2023).

Stock Assessment Result Summary

Biomass status in relation to Limit	NA – no biomass limits has been set. Weight-of-evidence is sufficient to support an understanding that the biomass of this stock is unlikely to be depleted and that recruitment is unlikely to be impaired. However, for the period 2017-18 to 2021-22 the biomass declined, but the stock is not yet considered to be recruitment impaired. The status is based on: For recent data analysed as mean catch rates (kg.day^{-1}), standardised catch rates for fish trapping in Wallis Lake have declined by more than 50% in the four most recent years. Similarly, for other estuaries standardised catch rates for fish trapping declined from 2017/18 to 2021/22. Catch rates for crab trapping in Wallis Lake and other estuaries fluctuated around the mean from 2012/13 to 2020/21. In 2020-21, average catch rate of legal and undersized crabs from FIS declined by 30% and 65%, respectively.

	Summer peaks in catches from FIS rapidly declined by the end of autumn and supported high catch rates for only a single month in 2019, two months in 2020, and three months in 2021. The model predicted CPUE (January in April) in 2022/23 (18.7 kg.day^{-1}) to be greater than 2021/22 (10.6 kg.day^{-1}), but below long-term average (24.7 kg.day^{-1}). The magnitude of winter harvest has declined in recent years. ~60% of the total observed catch of both berried and female Blue Swimmer Crabs were below the current MLL.
Biomass status in relation to Target	NA – no biomass target has been set.
Fishing mortality in relation to Limit	NA – no fishing mortality limit has been set. Weight-of-evidence provided is sufficient to support an understanding that fishing mortality is at a level to avoid the stock being recruitment impaired.
Fishing mortality in relation to Target	NA – no fishing mortality target has been set.
Previous SAFS stock status	Sustainable (Johnstone *et al. et al*., 2021)

Fishery interactions

Of the ~51 incidental species recorded from a fishery-wide observer-based assessment of the Blue Swimmer Crab trap fishery in Wallis Lake completed over two fishing season, only one individual of two protected species: a green turtle (*Chelonia mydas*) and a pied cormorant (*Phalacrocorax varius*) (both deceased), and two alien species, including 11 *Carcinus maenas*, and one *Charybdis japonica* were caught (Barnes et al., 2022).

Qualifying Comments

On the basis of the evidence contained within this assessment, Blue Swimmer Crabs are currently assessed as **depleting.** The weight of evidence provided supports an understanding that the biomass of Blue Swimmer Crabs has decreased, but recruitment is not yet impaired. Declining biomass is a result of fishing mortality and substantial environmental changes in recent years.

Known or likely uncertainties in the key indicators were taken into consideration in ranking of the quality of key indicators, and in reaching a conclusion regarding stock status.

The impact of recent management changes (i.e. quota management) on catch rates has not been fully quantified. However, the results of the observer-based survey of the Wallis Lake trap fishery indicate the increased MLL has likely resulted in increased levels of discarding reducing retained catches (Barnes et al., 2022, Johnson 2023). NSW estuaries are subject to periodic flooding events which have the potential to limit catches during large-scale floods, the most recent occurring in 2018, 2021 and 2022.The impact of factors other than changed population dynamics, including changed fishing practices, locations, catch reporting and catchability need to be investigated further.

The size-structure of catches from the fishery and fishery-independent surveys suggests that either crabs are rapidly removed by fishers as soon as they enter the fishery, or crabs are emigrating from the estuary with Taylor et al. (2023) reporting catches of large crabs (70-80 mm CL) from inshore waters adjacent to Wallis Lake from May to August. Due to reduced fishing pressure on mature female crabs following the MLL increase, and declining winter harvest the stock is unlikely to be recruitment impaired.

The increased minimum legal length and, the implementation of daily possession limit for all ocean fisheries (25 kg) has reduced fishing pressure on the spawning stock, resulting in a decline in harvest rate over the last two years. However, Schilling et al., 2023 found that winter harvesting in Wallis Lake disproportionally impacts large females which negatively impacts the following January to April harvest. The negative relationship between increased fishing mortality on mated pre-spawning females during winter and, a declining summer harvest aligns with previous research on Blue Swimmer Crabs in Western Australia (Johnston et al., 2011).

The modelling approaches used in the current assessment are very simplistic and generic; therefore, results should be interpreted with caution. There is high uncertainty in the estimates of biomass depletion, harvest rate and MSY derived from catch data using Schaefer production model-assisted Catch-MSY analysis.

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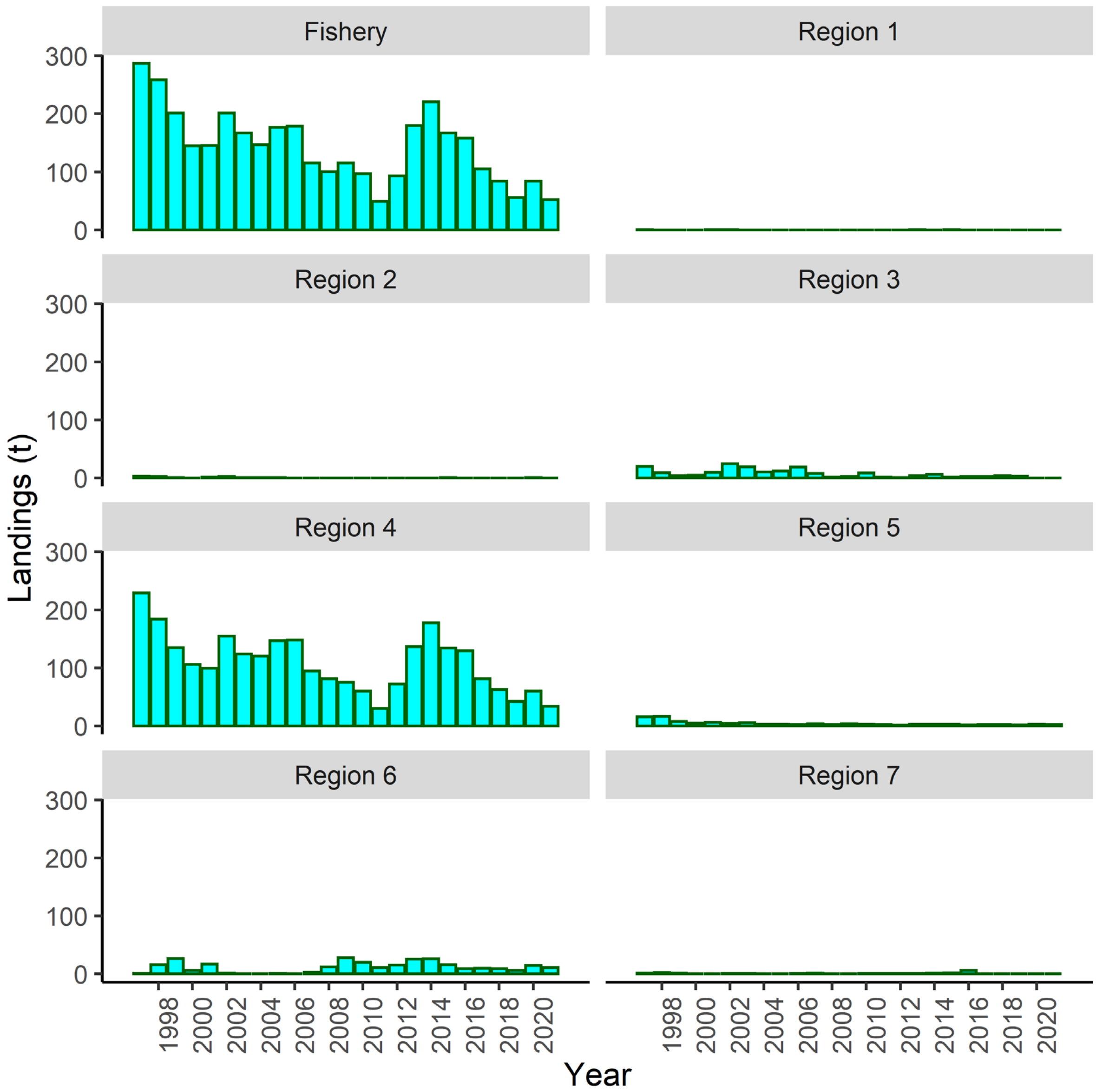

Figure S1. Reported landings (t) from NSW (Fishery) and estuary general management regions from 1997/98 to 2021/22.

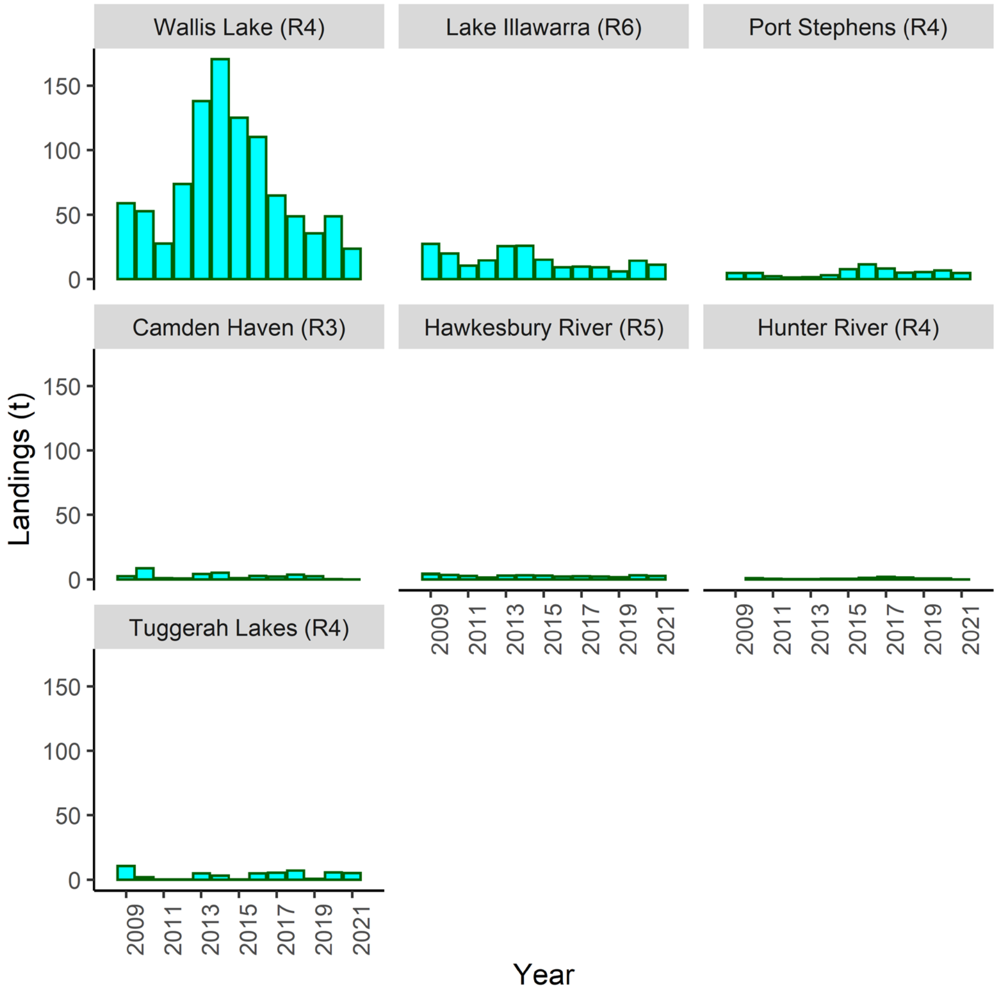

Figure S2. Reported landings (t) from main estuaries from 2009/10 to 2021/22. Estuary general regions shown in parentheses.

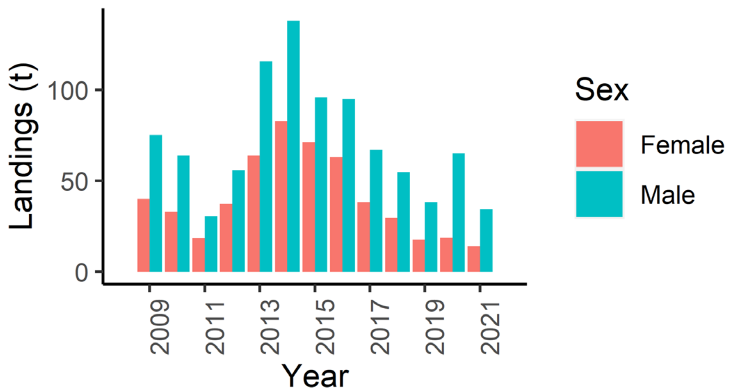

Figure S3. Reported landings of female and male Blue Swimmer Crabs from 2009/10 to 2021/22.

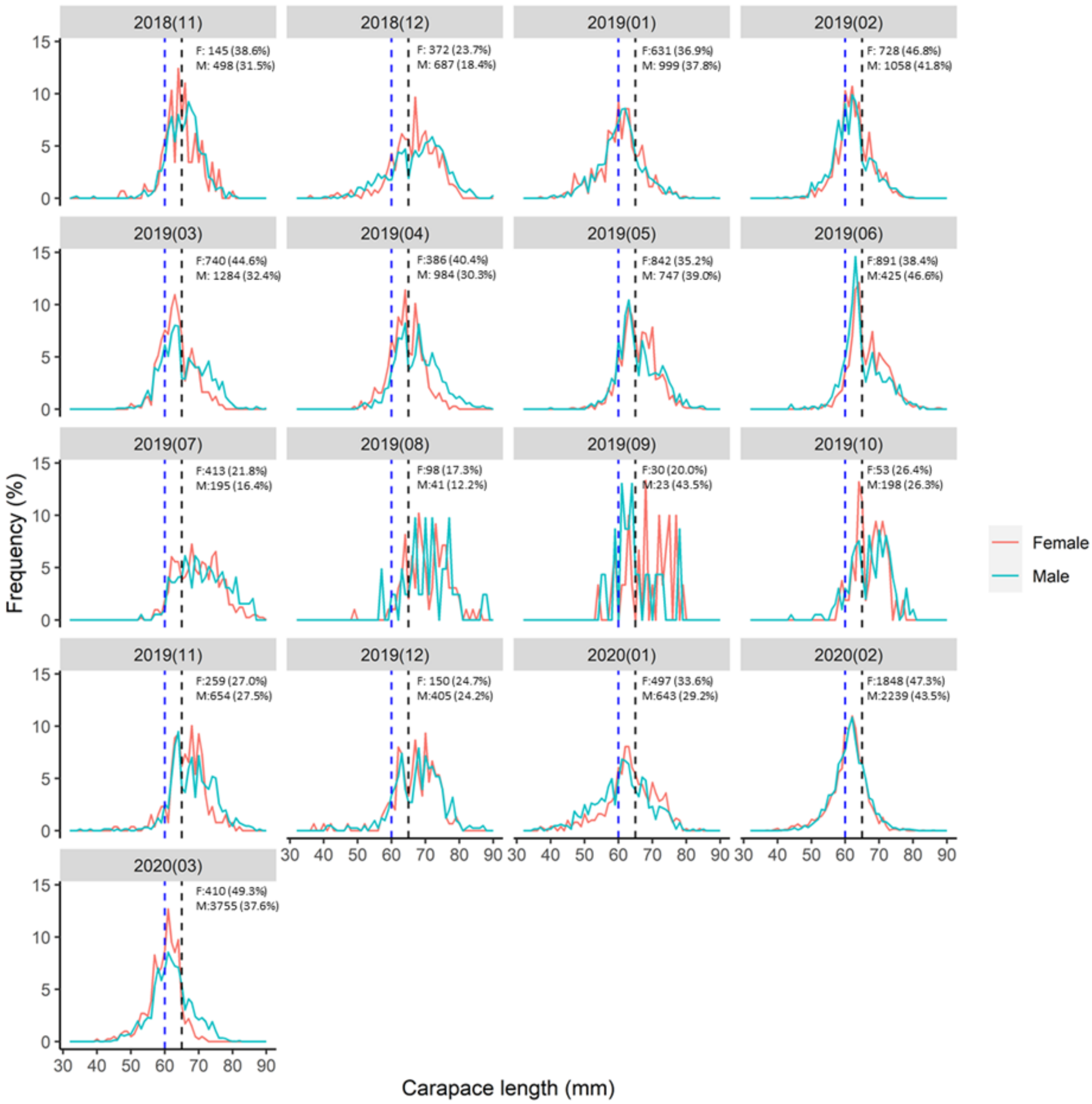

Figure S4. Monthly size-frequency distribution of female and male Blue Swimmer Crabs for observed catches from November 2018 to March 2020. The number of female (F) and Male (M) crabs measured and proportion of catch ≥60<65 mm is shown in parenthesis (%). Dashed lines indicate historic (blue 60 mm) and current (black 65 mm) MLL.

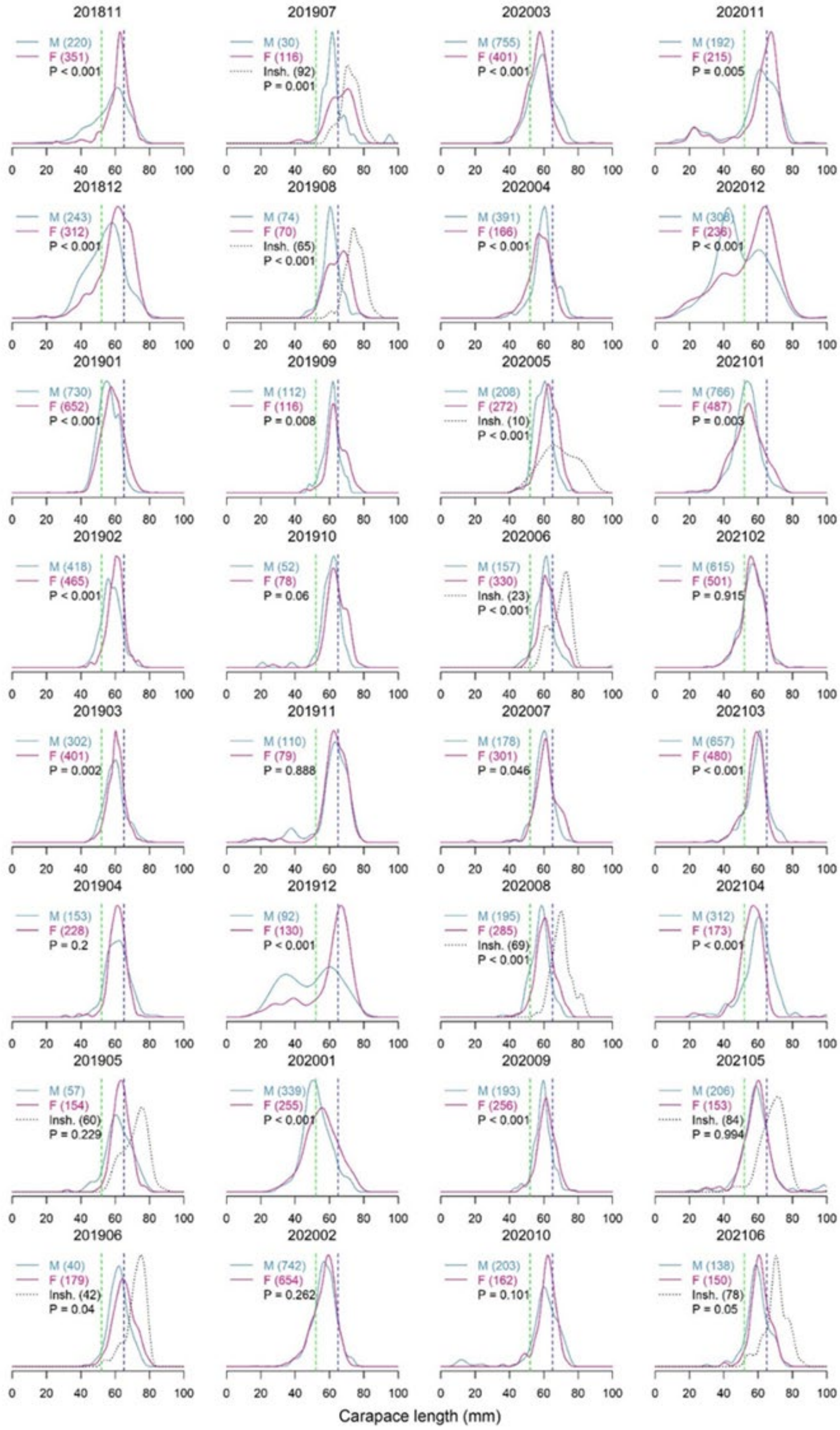

Figure S5. Monthly sex-specific size structures for fishery-independent surveys in Wallis Lake, expressed as kernel density estimates (including sanctuary zone samples [SZ], not split by sex). Panel headers indicate sampling period (YYYYMM). Sample sizes are indicated in brackets, and the P-value from a K-S test of differences between male and female size structure is indicated in the legend panel. The green and blue vertical dashed lines indicate female size at maturity, and the MLL respectively. Source Taylor et al., 2023.