Department of Primary Industries
Department of Regional NSW

NSW Stock Status Summary – 2023/24

Pipi (*Donax deltoides*)

Assessment Authors and Year

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Stock Status

Current stock status	On the basis of the evidence contained within this assessment, Pipi are currently assessed as **sustainable.**

Stock structure & distribution

Results of a collaborative study which used microsatellite and mitochondrial DNA marker techniques on samples collected from sites along the New South Wales (NSW), Victoria and South Australian coasts indicated that there were three reproductively isolated populations of Pipis (Miller *et al*., 2013). There is a high level of bidirectional gene flow along the east coast of Australia resulting in a single panmictic population stretching along the NSW coast and most likely extending as far north as Fraser Island, Queensland (Murray-Jones & Ayre, 1997).

Scope of this assessment

This stock assessment report provides a determination of stock status of the NSW Pipi biological stock. The assessment synthesises available fishery and biological information to inform setting of the Total Allowable Catch (TAC) for 2024/25. The report relies heavily on catch and effort data which were available from July 1984 to June 2023.

Biology

For the population of Pipi in NSW, the size at which 50% (SAM_{50}), and 95% (SAM_{95}) were sexually mature was 3.4, and 4.4 cm, respectively (Murray-Jones 1999). A minimum legal length of 4.5 cm is in place in NSW to allow spawning to occur before recruitment to the fishery. Growth rates in Pipi are size dependent, maximum length (~8.0 cm) is reached after approximately 4 years (Murray-Jones 1999).

Fishery statistics

Catch information

Commercial

Total annual reported commercial catches of Pipi increased steadily from 15 tonnes (t) to 80 t from 1984/85 – 1988/89, and then increased rapidly to a peak of 670 t in 2000/01. Catches exceeded 250 t yr^{-1} from 1996/97 to 2005/06 then rapidly declined to 9 t in 2010/11 (Fig. 1). In response to the declines in landings a series of input controls including spatially explicit management strategies (i.e., conditional area closures), temporal closures of the commercial fishery (i.e., 6 months per-annum), minimum legal size limit (i.e., 4.5 cm total length) and output controls limiting catch to 40 kg per fisher per day were implemented by NSW DPI in an attempt to stabilize the fishery. Catches then increased to ~180 t in 2016/17 before declining to 155 t in 2018/19 (1st June - 31st December). Total reported commercial landings managed by a Total Allowable Catch (TAC) of 147.4 t (2020/21) and 156 t (2021/22) were 128.3 t and 82.5 t, respectively. Total reported quota usage during 2021/22 was 92.7 t (~60% of TAC), declining from 138.2 t in 2020/21 (~94% of TAC). In 2022/23, of the 156 t TAC, fishers reported landings of 99.8 t (~64% of TAC) and quota usage of 108.5 tonnes (~70% of TAC). Reported catches from Estuary General Handgathering (EGHG) regions 1-4 are shown in Fig. S1.

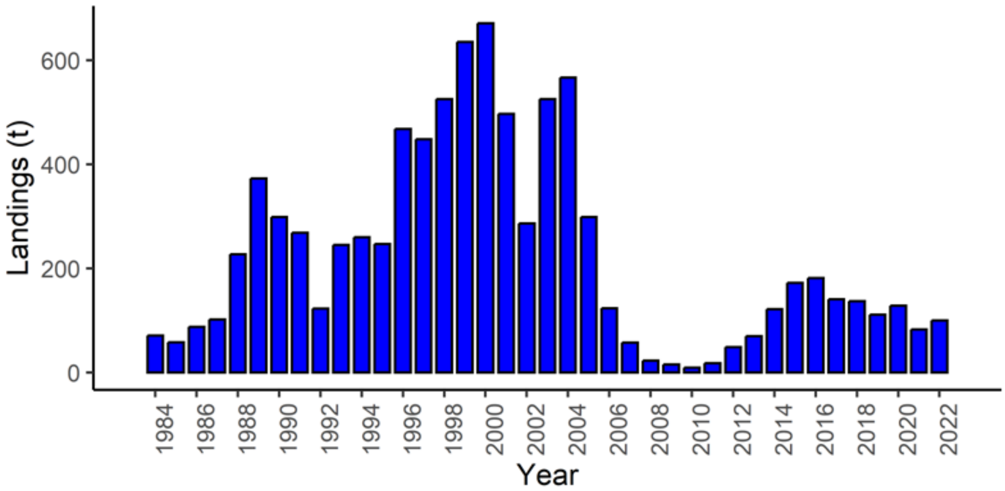


Figure 1. Annual reported commercial landings (t) from 1984/85 to 2022/23.

Recreational & Charter boat

Estimates of state-wide recreational harvest are available from the National Recreational and Indigenous Fishing Survey and NSW state-wide surveys completed in the 2000/01, 2013/14, 2017/18, 2019/20 and 2021/22 financial years, respectively (Henry & Lyle 2003, West *et al*. 2015, Murphy *et al*., 2020, 2022, 2024). In 2000/01, the catch from NSW was estimated to be 7 t (1, 076, 765 ± 169, 937 Pipis), representing one per cent of total harvest. In 2013/14 and 2017/18 the state-wide survey estimated the catch to be 1.3 t (87, 760 ± 31, 272 Pipis) and 1.1 t (75, 696 ± 42, 423 Pipis), respectively. In 2019/20 recreational anglers were estimated to retain 80, 604 (± 29, 362) Pipis weighing 1.2 t and in 2021/22, harvest declined to 45, 605 (± 23, 253) Pipis weighing 1.0 t (Murphy *et al*., 2024).

Indigenous

Although Indigenous fishers harvest Pipi throughout NSW, there are no state-wide estimates of Indigenous harvest. Onsite interviews of Indigenous fishers in the Tweed Heads region (Northern NSW) estimated an annual Pipi harvest in that region of 3, 056 – 7, 380 individuals (Schnierer 2011). Using a regional weight multiplier estimated at 14.81 g per Pipi (Murphy *et al*., 2020), indigenous harvest was estimated to be less than 0.12 t in the Tweed Heads region.

Illegal, Unregulated and Unreported

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

Fishing effort information

Reported days effort ($effort_{dy}$) in 2022/23 (1, 989) was ~10% lower than 2021/22 (2, 219 days) and was ~35% of the historical peak of 5, 610 days in 2001/02 (Fig. 2). From 2009/10, with the introduction of daily catch and effort reporting, fishers have reported hours spent hand-gathering per fishing day. From the recent minimum of 1, 802 hours in 2010/11, $effort_{hr}$ increased to 13, 688 hours in 2015/16 and was 6, 780 hours in 2019/20 (Fig. 2). Under revised management arrangements from 2019/20, $effort_{hr}$ declined to 7, 670 (2020/21), 5, 841 (2021/22) and 5, 617 in 2022/23 (Fig. 2).

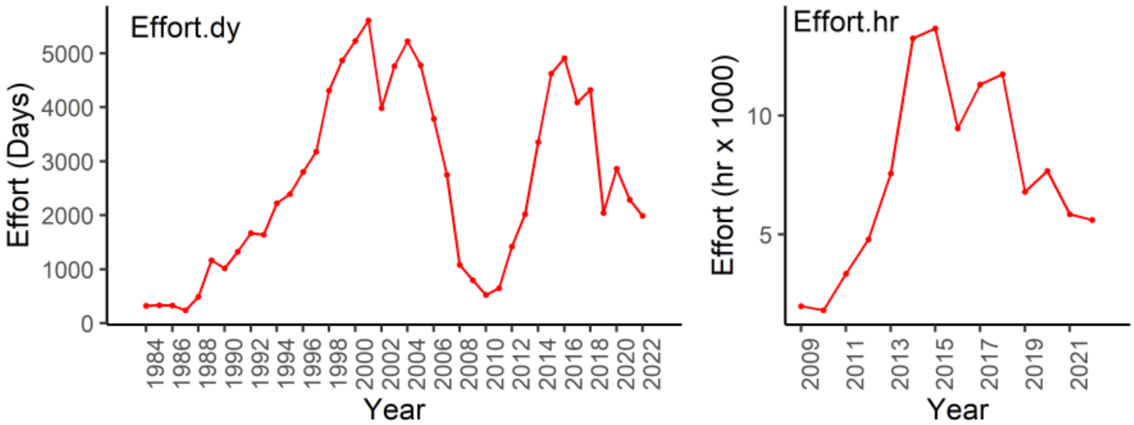


Figure 2. Reported days effort (left plot) and hours (right plot) spent handgathering.

Catch rate information

Catch per-fisher-day ($CPUE_{dy}$, 50.1 kg) and catch per-hour ($CPUE_{hr,}$ 16.4 kg) in 2022/23 were greater than $CPUE_{dy}$ (36.9 kg) and $CPUE_{hr}$ (12.7 kg) in 2021/22 (Fig. 3). Historically, $CPUE_{dy}$ increased from less than 100 kg.day^{-1} (1984/85-1987/88) to a maximum of 218 kg.day^{-1} in 1990/91 then declined to 58 kg.day^{-1} in 1995/96 (Fig. 3). From 1996/97 to 2000/01 $CPUE_{dy}$ exceeded 100 kg.day^{-1}, then rapidly declined to 17 kg.day^{-1} in 2010/11. The trend in $CPUE_{hr}$ is similar to that of $CPUE_{dy}$ from 2009/10 - 2019/20. From a minimum of 5.0 kg.hr^{-1}, $CPUE_{hr}$ increased to 18.6 kg.hr^{-1} in 2016/17, but then declined again to 13.2 kg.hr^{-1} in 2018/19 (Fig. 3). Following the removal of the 40 kg daily possession limit in 2019/20, $CPUE_{dy}$ and $CPUE_{hr}$ increased to 55.1 kg and 16.0 kg.hr^{-1}, respectively (Fig. 3). However, in 2019/20 a total of 154 fishing events (~7.5% of total) reported a total catch of 8.58 t with nil effort (i.e. zero hours spent handgathering) which were omitted from analyses. The number of fishing events with nil effort declined to 51 in 2020/21 (1.55 t catch), 39 in 2021/22 (1.62 t catch) and 14 in 2022/23 (0.49 t catch).

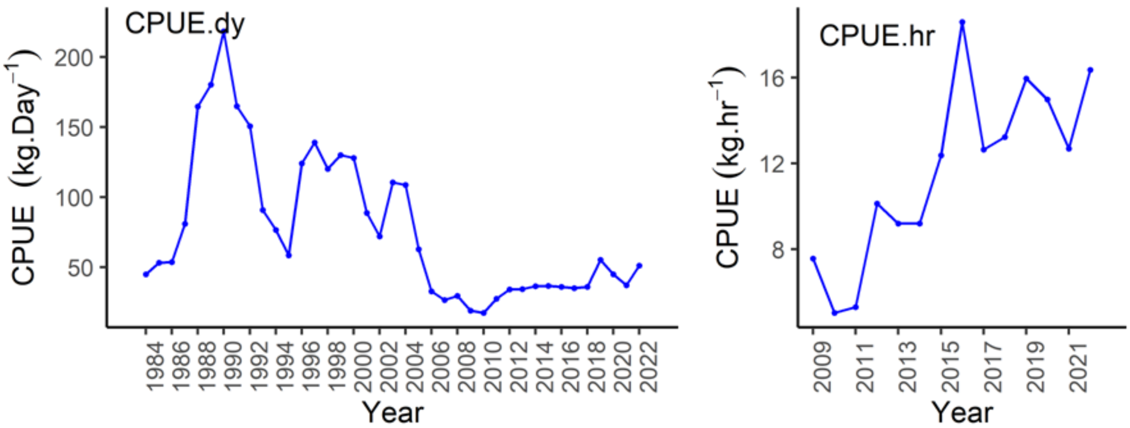


Figure 3. CPUE in kg/ day^{-1} (left plot) and kg/ hr^{-1} (right plot).

Stock Assessment

Stock Assessment Methodology

Year of most recent assessment:

2024

Assessment method:

A weight-of-evidence approach has been used to assess the NSW Pipi stock. It incorporates the results from standardised catch rates (2009/10 to 2022/23) for the main regions of the fishery, simple stock depletion models applied at the scale of regions and beaches, estimates of relative abundance from fishery-independent surveys (FIS), length-based spawning potential ratio, optimized catch-only model outputs, and analyses of commercial catch.

Main data inputs:

The following raw data inputs were used in analyses:

- Commercial catch rates in kg.h^{-1} derived from fisher-reported daily records (2009/10 – 2022/23);
- Commercial catches – reported annual catches by fiscal years (1984/85–2022/23);
- Length composition of commercial catches of Pipis for the periods from 2005/06, 2008/09, 2013/14 to 2015/16 and 2019/20;
- Historical estimates of biological parameters derived from a combination of modal progression analyses and tag recapture studies (Murray-Jones 1999); and
- Estimates of relative abundance from FIS completed across the main commercial fishing areas on South Ballina (EGHG1), Killick (EGHG3), Yagon (EGHG4) and Stockton (EGHG4) beaches to assess spatial variability in the distribution and relative abundance of Pipis.

Key model structure & assumptions:

1. Standardised catch rates (https://github.com/haddonm/rforcpue). *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. Depletion models; Leslie and DeLury models (each including the Ricker modification) were applied to seasonal Pipi catch and effort data and involve regression fits of linear models (Hilborn & Walters 2001). *Assumptions*: i) a closed population (no recruitment, natural mortality, immigration or emigration); (ii) constant catchability; (iii) sufficient removals such that CPUE is substantially reduced; (iv) equal vulnerability of individuals to capture; (v) independence of units of effort and (vi) the assumptions associated with linear regression (Liggins 2018). Depletion analyses estimate depletion of the component of the stock above the selectivity point, not depletion of the spawning stock.
3. The length-based spawning potential ratio (LBSPR) method uses maximum likelihood methods to find the values of relative fishing mortality (*F*/*M*) and selectivity-at-length that minimise the difference between the observed and the expected length composition of the catch and calculates the resulting spawning potential ratio (SPR) (Hordyk *et al*., 2015, 2016). LBSPR is an equilibrium-based method with the following assumptions: (i) asymptotic selectivity, (ii) growth is adequately described by the von Bertalanffy equation, (iii) a single growth curve can be used to describe both sexes, (iv) length-at-age is normally distributed, (v) rates of natural mortality are constant across adult age classes, (vi) recruitment is constant

over time, and (vii) growth rates remain constant across the cohorts within a stock (Hordyk *et al*., 2015, Pons *et al*., 2020). The size composition of commercial landings is also assumed to be representative of the stock.

4. The optimized catch-only model (OCOM) uses time series of catches and employs a stock reduction analysis using priors for *r* and stock depletion derived from natural mortality and saturation estimated using the Zhou-BRT method, respectively (Zhou *et al*., 2018). The stock reduction analysis employs a Schaefer biomass dynamics model and an algorithm for identifying feasible parameter combinations to estimate biomass, fishing mortality, and stock status. *Assumptions*: include those associated with the use of the simple Schaefer surplus production model, such as limited variation in many parameters over time. For more information on assumptions refer to Martell and Froese (2013), Froese *et al*., (2017) and Zhou *et al*., (2018).

Sources of uncertainty evaluated:

The utility of the LBSPR model was tested using a number of robustness tests to understand the sensitivity of the model to various values of the input parameters.

To understand the sensitivity of the OCOM model to various values of the input parameters, analyses were completed for a range of natural mortalities.

Status Indicators - Limit & Target Reference Levels

Biomass indicator or proxy	None specified in a formal harvest strategy. In the interim, for the purposes of this stock assessment a weight-of-evidence approach was used, which included: annual standardised catch rates from the fishery and three main regions; estimated biomass and the depletion of this biomass over the season from stock depletion models; estimates of relative abundance from FIS; and the mean estimated biomass depletion (as a percentage of the estimated unfished biomass) from OCOM analyses.
Biomass Limit Reference Point	None specified in a formal harvest strategy. For the purpose of this stock assessment, 20% of the estimated unfished biomass was selected for the limit reference point (B_{lim}).
Biomass Target Reference Point	None specified in a formal harvest strategy. For the purpose of this stock assessment, 48% of the estimated unfished biomass was selected as the target reference point (B_{targ}).
Fishing mortality indicator or proxy	None specified in a formal harvest strategy. For the purposes of this stock assessment a weight-of-evidence approach was used, which included: estimates of exploitation rate (calculated as catch/initial biomass) from stock depletion models; estimates of relative fishing pressure (*F*/*M*) and SPR from length based spawning potential ratio.

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 (in mean CPUE kg h^{-1}) is likely to be the most reliable index of relative abundance for Pipi. For data analysed as mean daily catch rate from 2009/10 to 2018/19, fishery catch rates (EGHG regions combined) remained stable and above average from 2012/13 to 2018/19. However, catch rates within the three main regions of the fishery were variable (Fig. S2). From 2019/20, standardised catch rates for the fishery (Fig. 4) and EGHG1 (Fig. S2) and EGHG3 (Fig. S2) have fluctuated around the mean. Standardised catch rates from EGHG4 have continually declined from 2018/19 to 2022/23 (Fig. S2).

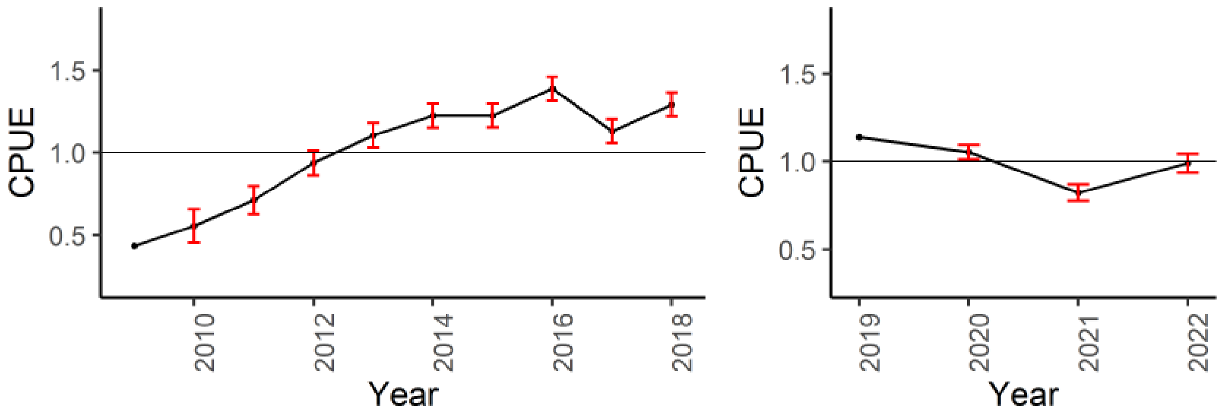
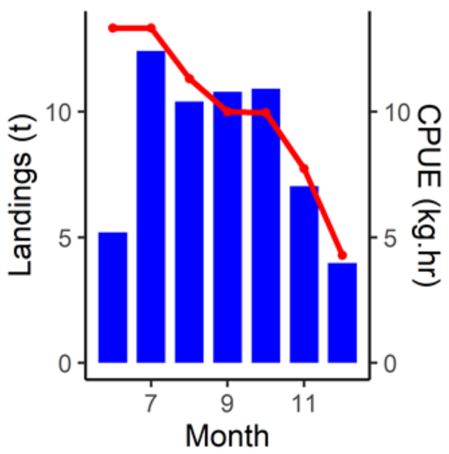


Figure 4. Standardised commercial catch rates for the fishery (nominal scale) for 2009/10 to 2018/19 (left plot) and 2019/20 to 2022/23 (right plot).

Simple stock depletion models were applied to 23 beach/ season combinations from 2009/10 to 2022/23. Estimates of exploitation rate (calculated as catch/initial biomass) for individual beaches ranged between 0.20 and 0.83 from 2009/10 to 2018/19. In 2018, reported landings of 73.2 t from Stockton Beach (Fig. 5) were estimated to remove 40 – 46% of the biomass of Pipis (≥ 4.5 cm) during the fishing season (June - December). For the most recent fishing season (2022/23), estimates of exploitation rate on individual beaches ranged from 48 - 55% (South Ballina), 19 – 32% (Crowdy) and 21 - 22% (Yagon). For the 2021/22 fishing season, estimates of exploitation rate on individual beaches ranged from 20 - 23% (South Ballina), 23 - 26% (Gooloowah), 51 – 52% (Killick) in Region 3, and 49 - 55% (Yagon) and 51 - 53% (Stockton) in Region 4.



Fishery-independent surveys

For data pooled across zones, the abundance of legal sized Pipis in the dry area on killick (3.6 ± 0.7 ind.m^2) was greater than South Ballina (1.2 ± 0.3 ind.m^2), Yagon (0.8 ± 0.3 ind.m^2) and Stockton (0.9 ± 0.2 ind.m^2) beaches (Fig. 6). The abundance of undersized Pipis in the swash area on Stockton (11.3 ± 1.0 ind.m^2) was greater than Yagon (6.1 ± 0.9 ind.m^2), South Ballina (4.0 ± 0.4 ind.m^2) and Killick (1.3 ± 0.2 ind.m^2) beaches (Fig. 6). In contrast, the abundance of undersize Pipis in the dry area on South Ballina (12.0 ± 2.2 ind.m^2) and Killick (11.7 ± 1.6 ind.m^2) beaches was greater than Stockton (6.8 ± 1.0 ind.m^2) and Yagon (1.2 ± 0.3 ind.m^2) beaches (Fig. 6). Pre-recruits comprised 87% (South Ballina), 70% (Killick), 90% (Yagon) and 96% (Stockton) of the size frequency distribution in October-November 2023, indicating low abundance of legal sized Pipis (Fig. S2).

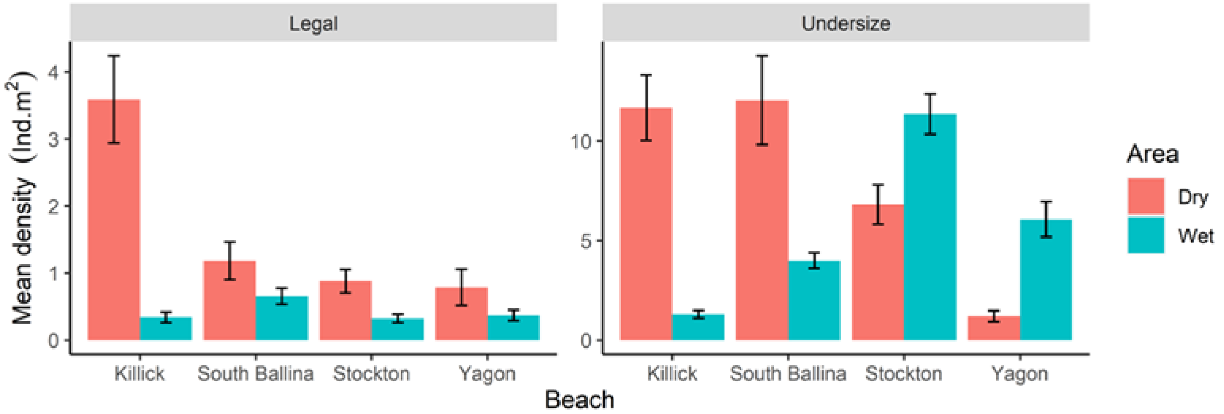


Figure 6. Mean catch rate (individuals.m^2) of legal (left plot) and undersize (right plot) in the dry and swash areas (pooled across zones).

For the optimized catch-only analyses current estimates of mean B/B_0 for the fishery (0.20 CI: 0.04-0.52) and main regions are all below the proxy reference point of 48% of the estimated unfished biomass (B_{targ}). For analyses at the fishery level (i.e., regions combined), B/B_{msy} remained above 1 from 1984 to 1999, after which it decreased substantially to a minimum of 0.07 (0.06 – 0.10) in 2008/09 (Fig. 7). For the range of *M* examined (1.0 - 1.4), B/B_{msy} in 2022/23 was estimated to range between 0.57 to 0.64. The trend in F/F_{msy} was mostly similar between analysis completed for the fishery and the three main regions separately.

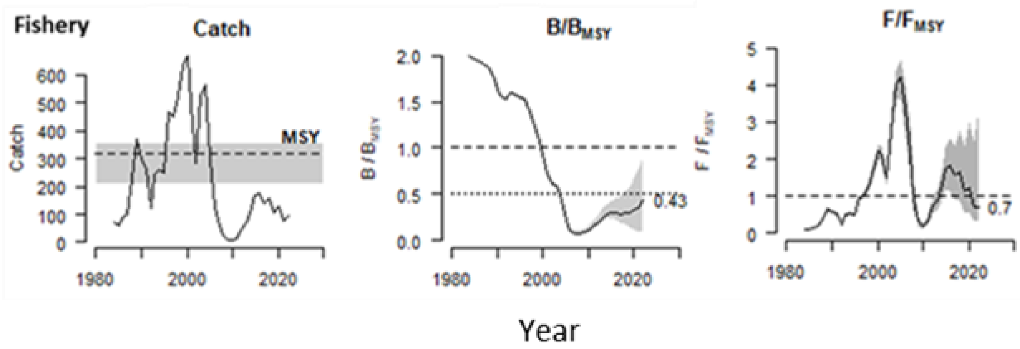


Figure 7. OCOM outputs for the historical commercial catch series of Pipi for *M* = 1.2. Grey shading indicates uncertainty (95% confidence intervals) in parameter estimates.

LBSPR: The size of selectivity (SL_{50} ~5.1 cm) relative to the size of maturity (L_{50} ~3.4 cm) indicates that a high level of spawning potential of the Pipi stock is protected from fishing pressure (Fig. 8). Despite estimates of relative fishing mortality (*F/M*) being high (2.7–4.2), moderate levels of spawning potential (SPR) are being conserved (0.43 – 0.45). The expected size composition of catches at SPR targets of 60 and 75% include a greater number of individuals in all size classes > 6 cm but are dominated by individuals in the 6 – 7 cm size class.

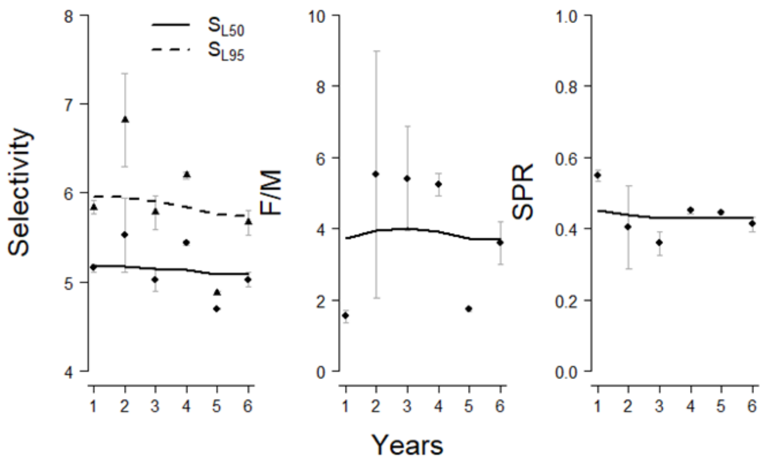


Figure 8. LBSPR model outputs including length at 50% (SL_{50}) and 95% (SL_{95}) selectivity, estimates of fishing/ natural mortality (*F/M*) and Spawning Potential Ratio (SPR).

Stock Assessment Result Summary

Biomass status in relation to Limit	For recent data analysed as mean catch rates (kg.hr^{-1}), standardised catch rates (regions combined) remained stable and above the average from 2012/13 – 2018/19, and fluctuated around the mean from 2019/20 to 2022/23. However, catch rates within the three main regions of the fishery are variable with large declines in catch rates in EGHG4 from 2019/20 to 2022/23. Estimates of exploitation rate for individual beaches ranged between 34 and 63% for beaches examined in EGHG3 and between 20 and 84% for the beaches examined in EGHG4. For the most recent fishing season (2022/23), estimates of exploitation rate on individual beaches ranged from 48 - 55% (South Ballina), 19 – 32% (Crowdy) and 21 - 22% (Yagon). For the 2021/22 fishing season, estimates of exploitation rate on individual beaches ranged from 23 - 26% (Gooloowah) to 51 – 52% (Killick) in Region 3, and 49 – 55% (Yagon) and 51 – 53% (Stockton) on Region 4 beaches. Current estimates of mean B/B_0 for the fishery and main regions are all below the proxy reference point of 48% of the estimated unfished biomass (B_{targ}). Estimates of mean B/B_0 for the fishery and Regions 1 and 3 are below the limit reference point of 20% of estimated unfished biomass (B_{lim}). However, using the upper 95% confidence intervals of estimated biomass (B_{95}), estimates of B_{95}/B_0 for the fishery, EGHG1 and EGHG3 are > B_{lim} < B_{targ}. For EGHG4, estimates of B_{95}/B_0 for *M* = 1.0 – 1.4 are > than B_{targ}.

	Preliminary FIS recorded low abundance of legal-sized Pipis on South Ballina, Stockton and Yagon beaches (< 1.5 ind.m^2). However, pre-recruits were recorded at all sampling locations on South Ballina, Killick, Yagon and Stockton beaches at densities up to 40.8 ± 9.7 individuals.m^2.
Biomass status in relation to Target	Biomass depletion estimates from OCOM analyses were ≤ the target reference point of 48%.
Fishing mortality in relation to Limit	Estimates of exploitation rate of Pipis > 4.5 cm on individual beaches ranged from 23 - 55% in 2021/22 and 22-55% in 2022/23. Despite estimates of relative fishing pressure (*F*/*M*) being high (2.7 – 4.2), moderate levels of spawning potential (SPR) are being conserved (0.40 – 0.58) for the range of natural mortalities examined.
Fishing mortality in relation to Target	NA
Current SAFS stock status	Sustainable (Ferguson *et al*., 2021)

Fishery interactions

Nil interactions have been reported between Estuary General Handgathering fishers and species protected under the Environment Protection and Biodiversity Conservation *Act 1999*.

Stakeholder engagement

NSW DPI Fisheries presented the current stock assessment to stakeholders in the Estuary General Fishery on the 1st March 2024, to outline the assessment process and provide an opportunity for feedback.

Qualifying Comments

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 spatial scale to which the assessment is applied effects the determination of stock status. For example in EGHG4, large declines in landings (~95%), declining standardised catch rates from 2019/20 to 2021/22 (~60% decline), large declines in estimated biomass on Stockton beach from ~160 to 180 t in 2018/19 to 14 to 15 t in 2021/22, stock depletions estimated to remove ~50% of the deleting biomass on Stockton Beach in 2021/22, preliminary FIS recorded low abundance of legal-sized Pipis on Stockton and Yagon/ treachery beaches (< 1 ind.m^2) , current estimates of B/B_0 and, B/B_{msy}, and reported harvest of < 1 t from EGHG4 in 2023/24 (June – December) support the classification of depleted. In contrast in EGHG3 despite current mean estimates of B/B_0 <48% of the estimated unfished biomass and, B/B_{msy} <1 there has been limited evidence of stock depletions in recent years, catches and standardised catch rates have been relatively stable and FIS on Killick beach recorded the highest abundance of legal-sized Pipis (3.6 ± 0.7 ind.m^2), and pre-recruits were recorded across all sampling locations supporting the classification of sustainable.

The depletion analyses presented estimate depletions of the component of stock above the selectivity point. As the SAM_{50} (~3.4 cm) for Pipi is below the MLL (4.5 cm) and the SL_{95} (~5.1 cm), depletion analyses do not estimate depletion of the spawning stock.

The modelling approaches used in the current assessment are very simplistic and generic; therefore, results should be interpreted with caution. Production models are most applicable when exploitable biomass (or more accurately exploitable biomass that is above selectivity point) lines up with spawning biomass. The results of the LBSPR analyses illustrate a disconnect between exploitable and spawning biomasses for Pipis.

The relationship between CPUE and abundance is often disproportional and nonlinear (Harley *et al*., 2001). Aggregations of fish and fishing effort have been shown to produce hyperstability in the CPUE- abundance relationship, in which CPUE remains stable while actual abundance declines (Harley *et al*., 2001, Ferguson *et al*., 2015). Management regulations that restrict harvest to 40 kg of Pipi per fisher day (2011 - 2018) may have produced hyperstable catch rates. The potential for re-aggregation of Pipi following fishing suggests that the abundance of Pipi may decline faster than CPUE as the stock is depleted (Defeo, 2003). If fishers succeed in finding aggregations of Pipi, large declines in CPUE will only be observed when the number of aggregations is greatly reduced and catching operations become more random. Simple estimates of commercial CPUE remain a poor predictor of Pipi relative biomass compared to those obtained from fishery-independent surveys in South Australia (Ferguson *et al*., 2015).

References

Defeo, O. (2003) Marine invertebrate fisheries in sandy beaches: an overview. *Journal Coastal Research* 35:56-65.

Ferguson, G.J., Gorman, D., Ward, T.M. (2015) Recovery of a Surf Clam, *Donax deltoides* (Lamarck 1818) population in southern Australia: successful outcomes of fishery-independent surveys. North American Journal of Fisheries Management 35: 1185-1195.

Ferguson, G., Johnson, D., Victorian Fisheries Authority. (2021) Pipi *Donax deltoides*, in Toby Piddocke, Crispian Ashby, Klaas Hartmann, Alex Hesp, Patrick Hone, Joanne Klemke, Stephen Mayfield, Anthony Roelofs, Thor Saunders, John Stewart, Brent Wise and James Woodhams (eds) 2021, Status of Australian fish stocks reports 2020, Fisheries Research and Development Corporation, Canberra.

Froese, R., N. Demirel, G. Coro, K. M. Kleisner, Winker, H. (2017) Estimating fisheries reference points from catch and resilience. Fish and Fisheries 18:506-526.

Harley, S.J., Myers, R.A., Dunn, A. (2001) Is catch-per-unit-effort proportional to abundance? *Canadian Journal of Fisheries and Aquatic Sciences* 58, 1760-1772.

Henry, G.W., Lyle, J.M. (2003) The national recreational and Indigenous fishing survey, Fisheries Research and Development Corporation, Canberra.

Hilborn, R., Walters, C.J. (2001) Quantitative Fisheries Stock Assessment: Choice Dynamics and uncertainty. Chapman Hall, New York, NY, Second edition.

Hordyk, A.R., Ono, K., Valencia, S.R., Loneragan, N.R., Prince, J.D. (2015) A novel length-based empirical estimation method of spawning potential ratio (SPR), and tests of its performance, for small-scale, data-poor fisheries. ICES J. Mar. Sci. 72: 217 – 231.

Hordyk, A., Ono, K., Prince, J.D., Walters, C.J. (2016) A simple length-structured model based on life history ratios and incorporating size-dependent selectivity: application to spawning potential ratios for data-poor stocks. Can. J. Fish. Aquat. Sci. 13: 1– 13. doi: 10.1139/cjfas-2015-0422.

Martell, S., Froese, R. (2013) A simple method for estimating MSY from catch and resilience. *Fish and Fisheries* 14: 504-514.

Miller, A. D., Versace, V. L., Matthews, T. G., Montgomery S., Bowie K. C. (2013) Ocean currents influence the genetic structure of an intertidal mollusc in southeastern Australia - implications for predicting the movement of passive dispersers across a marine biogeographic barrier. *Ecology and Evolution* 3(5): 1248-1261.

Murphy, J.J., Ochwada-Doyle, F.A., Hughes, J.M., West, L.D., Stark, K.E. (2020) The NSW Recreational Fisheries Monitoring Program - Survey of recreational fishing, 2017/18. NSW DPI - Fisheries Final Report Series No. 158.

Murphy, J.J., Ochwada-Doyle, F.A., West, L.D., Stark, K.E., Hughes, J.M. and Taylor, M.D. (2022) Survey of recreational fishing in NSW, 2019/20 – Key Results. NSW DPI - Fisheries Final Report Series No. 161.

Murphy, J.J., Ochwada-Doyle, F.A., West, L.D., Hughes, J.M., Fowler, A.M, Miles, N.G., Stark, K.E., Taylor, M.D. Survey of recreational fishing in NSW, 2021/22 – Key Results. NSW DPI - Fisheries Final Report Series No.(in press).

Murray-Jones S. (1999) Conservation and management in variable environments: The surf clam, *Donax deltoides*. The University of Wollongong, Wollongong.

Murray-Jones, S., Ayre, D.J. (1997) High levels of gene flow in the surf bivalve *Donax deltoides* (Bivalvia: Donacidae) on the east coast of Australia. *Marine Biology* 128:83-89.

Pons, M, Cope, J. M., Kell, L. T. (2020). Comparing performance of catch-based and length-based stock assessment methods in data-limited fisheries. Canadian Journal of Fisheries and Aquatic Sciences, 77, 1026-1037.

R Development Core Team 2017. R: A Language and Environment for Statistical Computing. Vienna: Foundation for Statistical Computing. http://www.R-project.org.

Schnierer, S. (2011) Aboriginal fisheries in New South Wales; determining catch, cultural significance of species and traditional fishing knowledge need. Final report to Fisheries Research and development Corporation, Project No. 2009/038, Canberra.

West, L.D., Stark, K.E., Murphy, J.J., Lyle, J.M., Ochwada-Doyle, F.A. (2015) Survey of recreational fishing in New South Wales and the ACT, 2013/14. Fisheries Final Report Series No. 149. NSW Department of Primary Industries, Wollongong.

Zhou, S. J., Punt, A. E., Smith, A. D. M., Ye, Y. M., Haddon, M., Dichmont, C. M., Smith, D. C. (2018). An optimized catch-only assessment method for data poor fisheries. Ices Journal of Marine Science, 75, 964-976.

Appendices

Supplementary figures

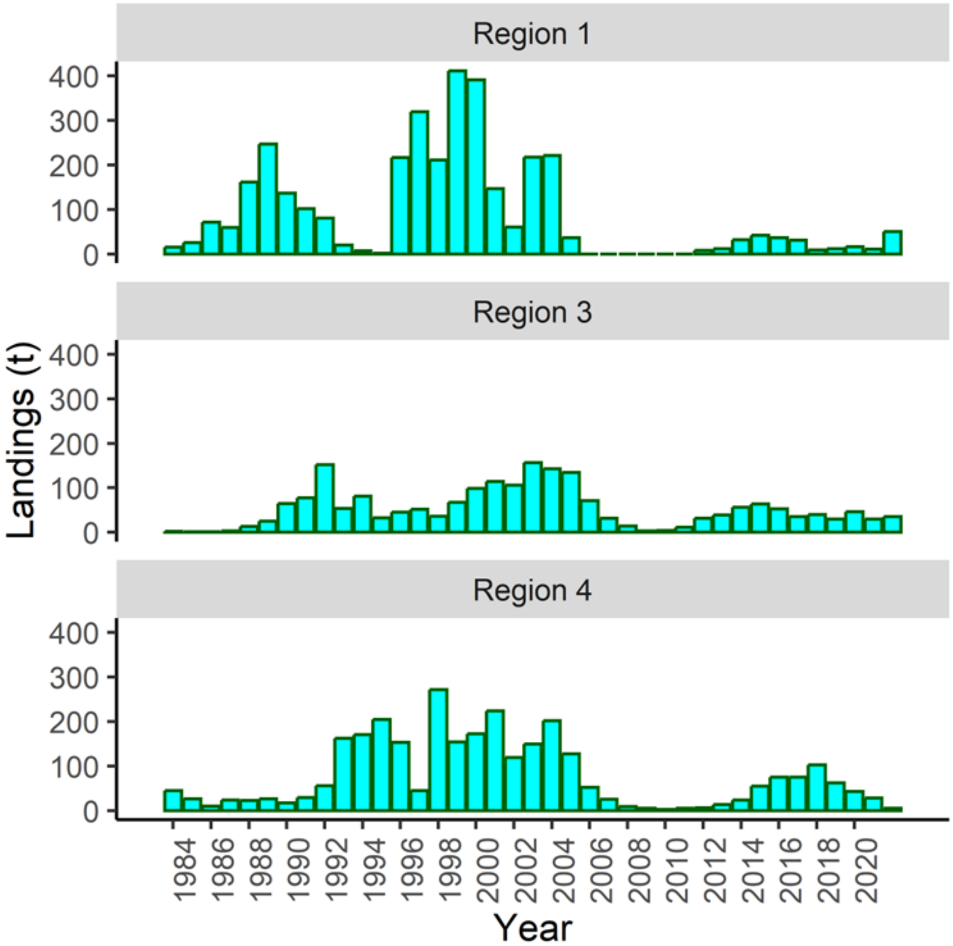


Figure S1 Annual catch (t) from EGHG1, EGHG3 and EGHG4 from 1984/85 to 2022/23

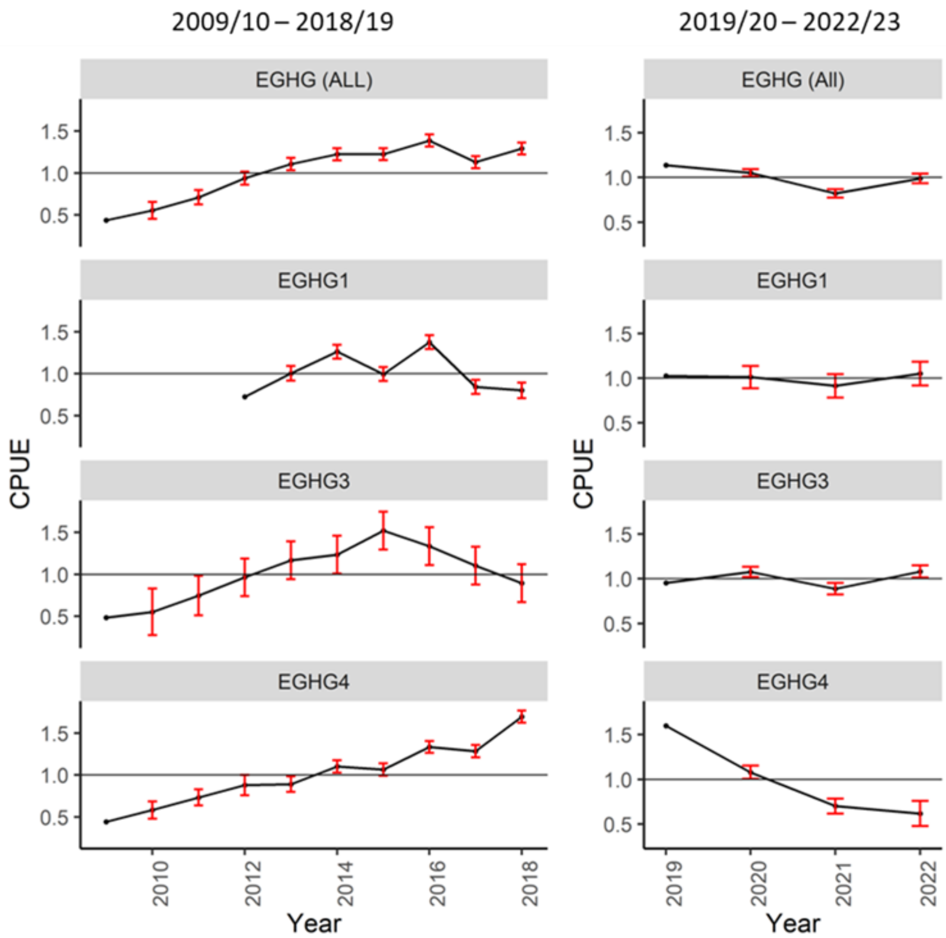


Figure S2 Standardised commercial catch rates (nominal scale) of Pipi for the fishery (EGHG ALL) and EGHG1, EGHG3 and EGHG4 for 2009/10 to 2018/19 (left panel) and 2019/20 to 2022/23 (right panel).

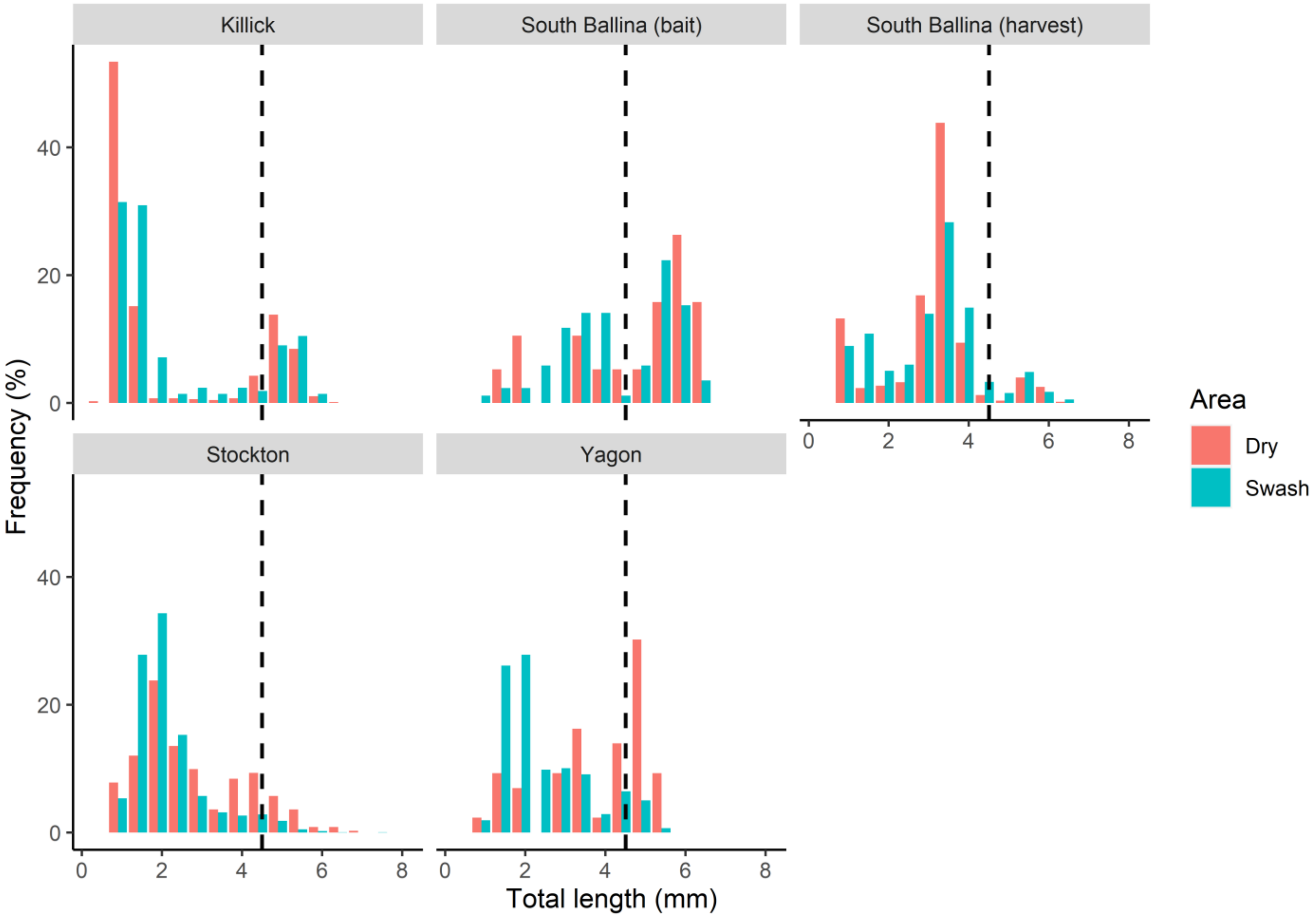


Figure S3 Size-structure of catches by beach in the dry and swash areas. For south Ballina, catches from the bait only and harvest zones are shown separately. The dashed vertical line indicates the minimum legal length (i.e., 4.5 cm).

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