Stock Status Summary – 2022/23

NSW Stock Status Summary – Estuary Cockle (*Anadara trapezia*)

Assessment Authors and Year

Chick, R.C. 2023. NSW Stock Status Summary 2022/23 – Estuary Cockle (*Anadara trapezia*). NSW Department of Primary Industries, Fisheries. 11 pp.

Stock Status

Current stock status	On the basis of the evidence contained within this assessment, Estuary Cockles are currently assessed as **undefined**.

Importantly, this classification is made understanding that available but limited data from a number of estuaries show a recent redistribution of catch, supporting the 45 t TAC, to estuaries other than key estuaries (by total catch) and patterns of catch in some key estuaries consistent with serial depletion and likely depleting or depleted local stocks, with this understanding generally in contrast with state-wide measures that compose the aggregate of available, finer scale, data and also narratives from stakeholder feedback over the last 2-3 years.

This stock status summary outlines the more detailed information available in the NSW stock assessment report for Estuary Cockles (Chick 2023).

Stock structure & distribution

The stock structure of Estuary Cockles is likely a complex of populations, functioning at a local (estuary) scale. This understanding is largely based on known biology and the reported genetic structure described by Yardin (1997). Yardin (1997) studied genetic variation in the Estuary Cockle (*A. trapezia*) and sampled populations across macro (1000 km), intermediate (within estuaries) and micro (within patches - 50 m to 6 km – within estuaries) scales within NSW and Victoria, from Tweed River estuary, Wallis Lake, Hawksbury River, Burrill Lake and Corinella (Western Port Bay, Victoria). That study identified significant differences in the genetic structure of populations among the six sites sampled. Further, finer spatial scale sampling at sites within the Hawkesbury River showed complex patterns of genetic variation within the 6 km area sampled (including at scales <100s m). Yardin (1997) concluded that, despite the high potential for gene flow through larval dispersal and panmixis at small and large scales, there is a high degree of heterogeneity among populations, even at a local scale, and the complex population structure is likely supported by discrete ecological processes and the ability of larvae to remain together through to settlement. Given this understanding of population structure, Yardin (1997) commented that management strategies that assume broad-scale biologically functional populations may lead to the depletion of local populations.

Biology

Cockles are dioecious, broadcast spawning, bivalve molluscs that form a large component of the macroinvertebrate infauna assemblage in large parts of low-energy estuarine environments throughout the Australian east coast, from Cairns in northern Queensland to the south-eastern regions of Victoria (Dixon 1975, cited in Yardin 1997), and form a small population near Albany in Western Australia (Kendrick and Wilson 1959, cited in Yardin 1997; Yardin and Richardson 1996).

Cockles are sedentary as adults, typically spawning in late summer, coinciding with increases in water temperature and food availability (Hadfield and Anderson 1988). Larvae develop in the plankton for up to six weeks, with likely active dispersal (larval behaviour affecting dispersal; Yardin 1997). Cockles are more abundant in unvegetated (bare) habitat than in sediment inhabited by seagrass (Wright et al. 2007). Recruitment of Cockles is positively influenced by the presence of conspecific adults, with recruits showing a preference to settle on adult conspecifics than on alternate substrates provided by locally occurring vegetation (seagrass). However, recruit survival in vegetated habitat is greater than on adults in bare habitat, likely because the vegetation provides a refuge from predation (Gribben and Wright 2006, Gribben et al. 2009).

FISHERY STATISTICS

Catch information

Commercial

Total annual reported commercial catches of Cockles increased from <1 t to >80 t between 1984/85 and 1993/94, peaked at 93.4 t in 1991/92 and declined to 30–55 t.yr^{-1} between 1994/95 and 2001/02. From 2002/03 to 2008/09, annual catches averaged 25 t.yr^{-1}, with the lowest annual catch of 16.3 t recorded in 2008/09. From 2009/10 to 2017/18, annual reported commercial catches generally increased from about 30 t.yr^{-1} to levels among historical highs and ≥70 t.yr^{-1}, harvested by ~10 fishers (Figure 1). In 2018/19, the year immediately preceding the implementation of a TAC, total reported catch was 51.5 t, harvested by 10 authorised fishers. Importantly, for assessment purposes, from 2013/14 to 2018/19, the annual catch and percent of total catch with no reported hourly effort (effort$_{hr}$) increased substantially (Figure 1). Between 2016/17 and 2018/19, the percentage of reported catch with no effort$_{hr}$ was >50% for each year. In 2019/20, this dropped to 9%, but returned to 55% and 34% in 2020/21 and 2021/22, respectively. Importantly, total reported catch in 2021/22 was 27.7 t. This is in contrast with the 2021/22 TAC of 45 t and quota usage reports indicating 98% of the quota being reportedly used (i.e. 44.2 t DPI unpublished). Together the reported catch data (27.7 t) and quota usage data (44.2 t) indicate it is highly unlikely that fisher monthly logbook returns of daily fishing activity (i.e. reported data including catch and effort) presented in this report, accurately represent the total levels of catch and effort and there is high uncertainty if derived fishery-dependent measures are representative of the broader fishery used to assess fishery performance and stock status for the 2021/22 fishing period. It is also important to note that the pattern of change in levels of annual catch for the state-wide fishery are not consistent with patterns of catch at finer spatial scales (estuaries).

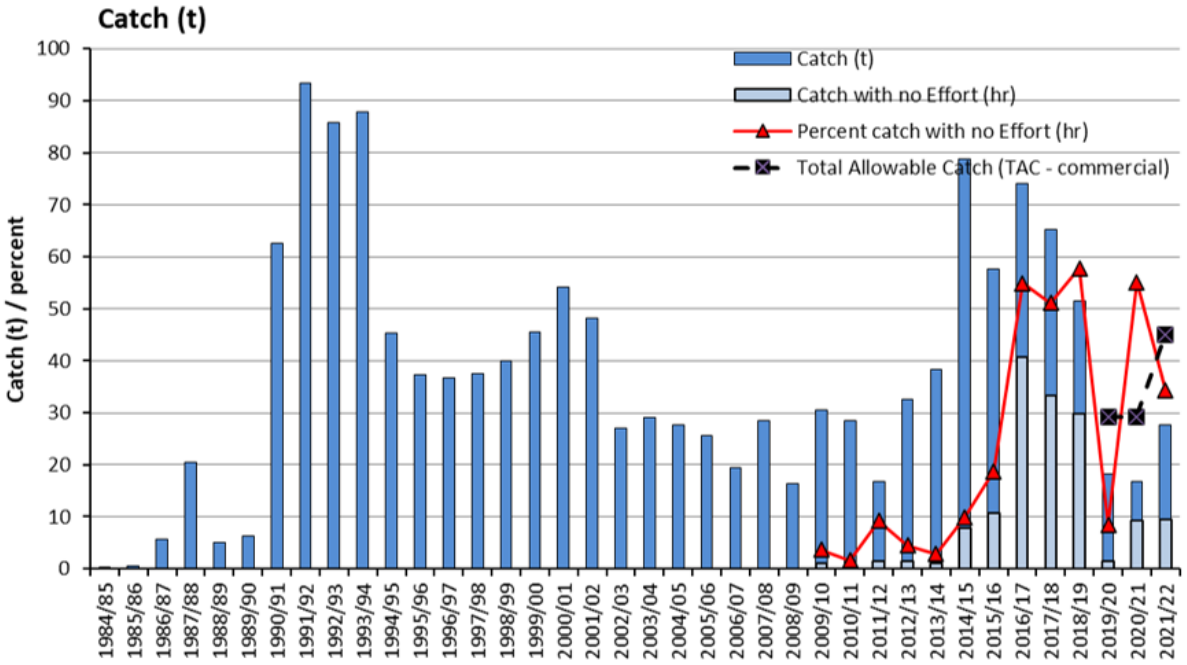

Figure 1. Total annual commercial catch (t) and catch with no reported effort of Estuary Cockles from 1984/85 to 2021/22.

Since at least 2010/11, the spatial distribution of annual commercial catches has been dominated by catches from five estuaries located within Regions 4, 6 and 7, with the very recent exception of distribution in 2021/22, where ~36% of the total reported catch was from 'Other' estuaries. 2021/22 is also the first year in which any one of the top five estuaries has contributed less than ~40% of the total annual reported catch. Spatial distribution of catch among estuaries through time has not been consistent. Peaks in annual catch, that are three times average annual catch levels since 2009/10 have occurred sequentially in Pambula Lake (2010/11), Merimbula Lake (2014/15) and Wallis Lake (2017/18). Further, within 3-5 years of these historical peaks, annual catch in each Estuary has declined to at or among historically low levels. In Merimbula Lake and Wallis Lake these declines in catch have occurred whilst measures of catch rate (from data contributed to by >1 fisher) have either been maintained at or fallen below long-term average levels. These patterns of fishing more likely indicate a combination of small levels of fishable stock remaining in small areas and knowledgeable fishers maximising their effort to target them, resulting in increased risk of depleting or depleted local stocks.

Recreational & Charter boat

Recreational fishers harvest Cockles either for personal consumption or for use as bait. Estimates of recreational catch are unknown. Information from The National Recreational and Aboriginal fishing Survey completed in 2000/01 (Henry and Lyle 2003) describes recreational and Aboriginal cultural catches of Cockles restricted to the category of 'Bivalves (other)' - consisting of clams (unspecified), Cockles (*Anadara* and *Katelysia* spp.), Cockles – mud and Cockles – unspecified). The NSW state-wide recreational fishing survey completed in 2013/14 (West et al. 2015) further limited the categorisation of recreational catch of Cockles into a more diverse category i.e. 'Other taxa'. The two most recent NSW state-wide recreational fishing surveys (2017/18 and 2019/20); Murphy et al. 2020, 2022) did identify Cockles as an optional self-reported species. Further, the 2017/18 sampling frame resulted in an estimate for the state-wide recreational harvest of Cockles of ~10 kg. Whereas the 2019/20 survey did not report a recreational catch of Estuary Cockles. There is anecdotal evidence of relatively high levels of recreational harvests of Cockles from

specific NSW estuaries. As such, the state-wide recreational fishing surveys underrepresent the actual recreational harvest and is likely a function of this species being a relatively niche species for recreational fishers and highlights some of the challenges these types of species pose for such large-scale surveys.

Despite the lack of information to quantify the recreational catch and its spatial distribution, there is strong and persistent anecdotal evidence, through NSW Fisheries Compliance information (via increasing incident reports and increasing numbers of Cockle seizures from fishers exceeding bags limits (see Illegal, Unregulated and Unreported fishing)) and social media postings, of relatively high and increasing levels of recreational catch at various NSW estuaries. The magnitude and/or variation in these levels of harvest have not been quantified.

Indigenous

Estuary Cockles are a notable species identified in Aboriginal middens in NSW (4.5% of species in middens at 13 locations in NSW), supporting the understanding that they contributed an important food source for Indigenous people in south-east Australia, at least within the last 3000 years (Schnierer and Egan, 2016).

Cockles have been harvested by Indigenous people in the Tweed region for many generations. In a survey based in the Tweed region (Schnierer 2011; Schnierer and Egan 2016), annual catch by Indigenous fishers was estimated to be between 731 and 1810 Cockles. Based on logbook data from 2010 in the Tweed region, Cockles were listed as an important species but were not among the top 10 culturally most important species. Schnierer (2011) reports that the total effort of the Indigenous fishery in the Tweed region was 542 hours or 92 days. Cultural catch of Cockles was seen to be important in delivering benefits to the community.

Illegal, Unregulated and Unreported

The level of Illegal Unregulated and Unreported (IUU) fishing has not been quantified.

There are anecdotal reports of IUU fishing occurring at the scale of estuaries, related to commercial fishers misreporting and recreational fishers exceeding bag limits or fishing without a licence. Further, NSW Fisheries Compliance provide annual summaries of seizures of fish and invertebrates due to non-compliance. These reports indicate regular seizures of Cockles each year from 2010/11 to 2020/21 (most recent report), ranging between 8 897 and 25 110 individual Cockles. In 2020/21, 23,085 Cockles were seized due to non-compliance (link here - Fisheries compliance enforcement).

Fishing effort information

Commercial

Effort in days fished ($Effort_{dy}$) increased from <50 days (1984/85–1990/91) to 205 days in 1993/94, before declining to <50 days again in 1996/97. During this period fishers were required to report their catch monthly and effort (days) by gear type, not linked to catch unless only a single gear type was used and then not linked to species catch. Therefore, prior to 1997/98 total $effort_{dy}$ reported within the EGHGF cannot be allocated to a species catch and is the total $effort_{dy}$ reported by the EGHG fisher for each month where one method was reported, and the species of interest was also reported in that month (Appendix 1). In 1997/98, 292 days were fished. $Effort_{dy}$ increased 55% to 452 days in 2000/01, decreased to 304 days over the following two years before increasing each year to the maximum recorded level of 850 days in 2005/06, and subsequently declining each year to 302 days in 2008/09. The substantial changes in days fished between 1996/97 and 2008/09 was concurrent with changes to commercial fishery reporting requirements. As such, substantial

changes in $effort_{dy}$ are less likely a function of the effort to catch Cockles. Rather, the peak in effort reflects changes in effort to catch other species (likely Pipis) by the same fishing method, while also harvesting Cockles in the same month. Therefore, $effort_{dy}$ reported each month by hand gathering has been attributed to each species reportedly harvested that month, including Cockles. In 2009/10, $effort_{dy}$ was 257 days. From 2009/10, the number of days fished generally increased to a recent peak of 472 days, in 2014/15, reflecting a similar peak in catch. Over the last 5-6 years $effort_{dy}$ had been decreasing substantially, reaching a 20 year low of 44 days in 2020/21. In 2021/22, $effort_{dy}$ more than doubled from 2020/21 to 116 days, coinciding with a quota increase from 29.2 t to 45 t (Figure 2), but belies the fact that ~37% of the reportedly used 45 t quota, and its effort, has not been reported in logbooks.

Effort (hr; $effort_{hr}$) has changed substantially since 2009/10. Importantly, between 2016/17 and 2018/19, and in 2020/21, the percent of reported catch with no reported $effort_{hr}$ was >50% for each year, and in 2021/22 that percentage was 34% (Figure 2). To provide a more probable estimate of recent $effort_{hr}$ per year for reported catch, average annual $hours.day^{-1}$, from records with hours reported, was multiplied by reported annual days fished (Figure 2). These data suggest hours harvesting Cockles increased substantially from 2013/14 and was in excess of 1200 $hr.yr^{-1}$ in each year from 2014/15 to 2017/18, peaking at ~1700 hr in 2014/15. In 2018/19, estimated $effort_{hr}$ was ~950 hr (i.e. about double the reported $effort_{hr}$) and in 2021/22 estimated $effort_{hr}$ was 335 hr, and whilst ~100 hr more than that reported (Figure 2), suffers from being inaccurate given the discrepancy between reported catch and used quota.

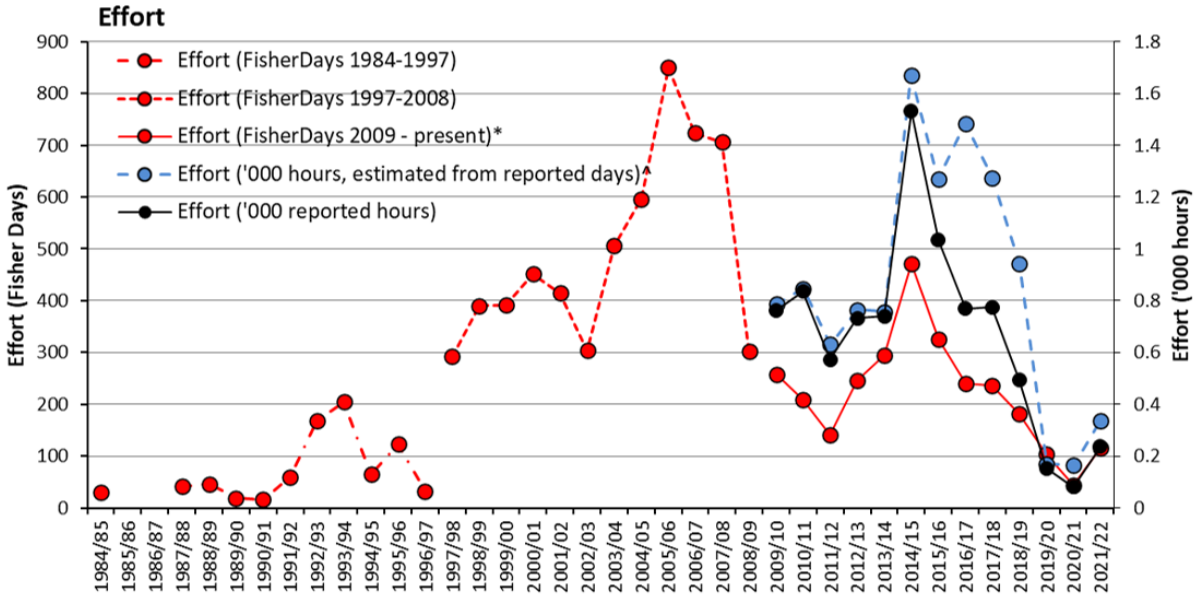

Figure 2. Total annual commercial effort (days and hours) fishing for Estuary Cockles from 1984/85 to 2021/22.

Catch Rate information

Catch per FisherDay ($CPUE_{dy}$) is a problematic metric to define and interpret prior to 2009/10, for reasons outlined for the $effort_{dy}$ time series. Nonetheless, $CPUE_{dy}$ fluctuated substantially between 1984/85 and 1994/95, ranging between 17 and 151 $kg.day^{-1}$, with low rates possibly reflecting drivers of catch and effort other than abundance (as described for $effort_{dy}$; Figure 3). $CPUE_{dy}$

increased from 77 kg.day^{-1} in 1997/98, to 116 kg.day^{-1} in 2001/02, then decreased each year until 2006/07, reaching 24 kg.day^{-1}. Relatively low $CPUE_{dy}$ throughout the early to mid-2000s is likely a function of EGHG days fished being allocated to relatively low catches of Estuary Cockle per month, where Cockles and other species (likely Pipis) were caught by the same method in the same month, in addition to likely reductions in Estuary Cockle abundance preceding years of historically high periods of harvest. So, changes in catch rate are complicated by challenges in defining targeted fishing effort and any changes in abundance during this time. From 2009/10 to 2021/22 $CPUE_{dy}$ has not changed significantly and despite moderate increases in the average catch from 115 kg.day^{-1} (2009/10) to >150 kg.day^{-1}, over the last 3 years these measures of average annual $CPUE_{dy}$ are associated with substantial variation and do not consistently represent patterns at finer spatial scales (i.e. estuaries) (Figure 3).

Average catch per hour ($CPUE_{hr}$) within the last 3 years has increased substantially, in excess of 150 kg.hr^{-1} and was 172 kg.hr^{-1} in 2020/21, the highest level since required daily reporting of species-specific effort in 2009/10. Prior to 2019/20, $CPUE_{hr}$ had averaged ~44 kg.hr^{-1} (range 28 – 51 kg.hr^{-1}). Notably, measures of $CPUE_{hr}$ are associated with substantial variation that has increased in recent years with fewer fishers and a high proportion of incomplete reports (Figure 3) and as fishery operations have changed either coincident with or in response to share management and a TAC. Further, possible erroneous reporting of very small quantities of effort for relatively small quantities of catch are contributing to the high state-wide levels of $CPUE_{hr}$ and their high variability.

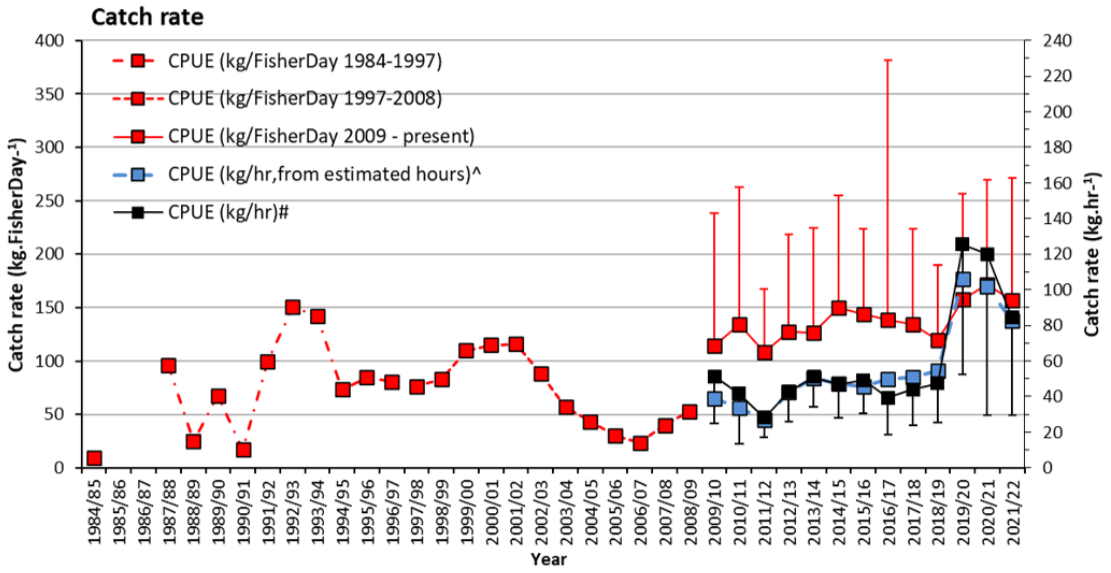

Figure 3. Average annual catch rate (kg.hr^{-1} and kg.FisherDay^{-1}, plus or minus one standard deviation) from 1984/85 to 2021/22.

STOCK ASSESSMENT

Stock Assessment Methodology

Year of most recent assessment:

2022/23 (using data to end of June 2022)

Assessment method:

A weight-of-evidence approach was used to assess the status of the NSW Estuary Cockle stocks. There are insufficient data available to support more quantitative stock assessment methods.

Main data inputs:

- Catch (commercial) (t) – 2009/10 to 2021/22
- Catch (recreational) (t) 2000/01, 2013/14, 2017/18, 2019/20
- CPUE ($kg.hr^{-1}$) – 2009/10 to 2021/22

Data interpreted at state-wide and estuary scales.

Key model structure & assumptions:

NA – no model-based quantitative assessment approach was used.

Sources of uncertainty evaluated:

General data limitations and uncertainty was considered in the weight-of-evidence approach.

Defining the status of the Estuary Cockle resource with any level of reasonable certainty is not possible due to various issues primarily relating to the unavailability and/or inaccuracy of available data, from all fishing sectors.

Since 2009/10, commercial fishery statistics from mandatory logbook reporting are incomplete and reported data have high levels of uncertainty. For example, since 2019/20 and the introduction of quota, there are substantial discrepancies between the reported levels of quota used and levels of catch from logbooks, including Fishing Businesses that have regular catch reports in logbook returns prior to 2019/20 and quota usage reports from 2019/20 but no logbook returns. Further, of the catch that is reported in logbooks there are high proportions with no complementary effort data reported, with the scale of this problem atypical for other species logbook returns in the EGHG Fishery. Uncertainty in these data is further exacerbated by fewer active commercial fishers contributing to fishery-dependent data since 2017/18. Of these fishers, some (active since at least 2009/10) have either inconsistently or not reported effort for a number of years or have more recently (within the last 2-3 years) regularly reported relatively very low (seemingly erroneous) levels of effort (≤1 hr) for levels of catch that previously required substantially greater effort. These data are not excluded from the limited data available, yet they substantially influence measures of catch rate, and result in more recent measures substantially greater than those previously reported. Similarly, these inconsistencies and associated uncertainties are continued, and often magnified at the estuary scale. Since at least 2009/10 the majority (>90%) of annual catch has been from five NSW estuaries. However, patterns of catch and effort within these estuaries do not reflect patterns at the whole fishery scale. It is unlikely that logbook returns of daily fishing activity i.e. catch and effort, presented in this report, accurately represent total levels and there is high uncertainty surrounding the representativity of derived fishery-dependent measures (e.g. catch rate) to assess fishery and stock performance.

There are no recreational or Indigenous cultural fishing data available to quantify the levels of harvest from these fishing sectors. Anecdotal evidence and limited studies describing small-scale spatial and temporal patterns of fishing by some sectors of the fishery indicate that fishing activities other than commercial fishing may make a substantial contribution to the levels of fishing mortality on Estuary Cockles, particularly at a local scale.

Similarly, it is not possible to quantify the level of IUU catch. The level of IUU fishing, or its detection varies throughout the spatial distribution of the stocks, with evidence of high and increasing IUU catch at local scales over relatively short periods of time (DPI unpublished data).

Factors other than fishing, including environmental factors, likely affect changes in the abundance and biological functioning of Estuary Cockles through time, and at spatial scales that likely vary through time. There are a variety of studies that have investigated the effects of environmental changes on Estuary Cockles, including heavy metal contamination and freshwater influx. Further, it is likely that environmental factors would affect the productivity of these populations through time. Understanding the interaction of these factors with the effects of fishing will be important in informing the role of fishing in influencing the abundance of Estuary Cockles. Further, market disruption as a consequence of the COVID-19 pandemic and other associated social impacts (FAO 2021) are not well known and the impact of these extraneous factors on this assessment has not been quantified.

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: • Nominal $CPUE_{hr}$ (state-wide and estuary) • Nominal $CPUE_{dy}$ (state-wide)
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 and estuary scale)
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

The status of the NSW Estuary Cockle stock is classified as **undefined.** This classification is made both in terms of the level of biomass and fishing mortality.

Importantly, this classification is made understanding that available but limited data from a number of estuaries show a recent redistribution of catch, supporting the 45 t TAC, to estuaries other than key estuaries (by total catch) and patterns of catch in some key estuaries consistent with serial depletion and likely depleting or depleted local stocks, with this understanding generally in contrast with state-wide measures that compose the aggregate of available, finer scale, data and also a narrative from stakeholder feedback.

A weight-of-evidence approach has been taken to assess the EGHG Fishery – Estuary Cockle. This includes: i) the current understanding of stock structure indicating there are a complex of populations, likely functioning at a local (estuary) scale and a paucity of information on biology and population dynamics; ii) high uncertainty in the commercial fishery data, particularly over the last 5-

6 years (i.e. no reported catch for an average of 38% of the reportedly used quota in 2019/20, 2020/21 (29.2 t TAC) and 2021/22 (45 t TAC); and logbook returns of fishing activity with no effort$_{hr}$ reported for an average of 41% of the reported catch over the last 5 years); iii) the discontinuous time series of commercial effort data over the history of the fishery; iv) fishery-dependent, estuary-scale data, available from 2009/10, are noisy (low number of fishers) and incomplete. Despite this, patterns of reported data in some of the top estuaries (by catch) support an inference of serial depletion and depleting local stocks. This inference is further supported by reported catch in 2021/22, in "Other' estuaries (notably the Clyde River) contributing ~10 t to the annual harvest. Together with generally low levels of catch from key estuaries, despite levels of CPUE$_{hr}$ at or above long-term averages, this change in the distribution of catch further suggests Estuary Cockle populations from key estuaries are unable to support the sustainable harvest of the 45 t TAC; v) anecdotally, substantial, yet unquantified levels and distribution of recreational catch; vi) unknown levels of Indigenous cultural fishing; and vii) unquantified levels of illegal, unregulated and unreported fishing. These lines of evidence identify substantial uncertainty in interpreting change in possible fishery and stock performance indicators, and limited confidence in inferring change in biomass and fishing mortality, and hence determination of a stock status other than undefined (Chick 2023).

Stock Assessment Result Summary

Biomass status in relation to Limit	NA – no biomass limits has been set. Weight-of-evidence provided is insufficient to support an understanding of the level or trend in biomass.
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 insufficient to support an understanding of the level or trend in fishing mortality.
Fishing mortality in relation to Target	NA – no fishing mortality target has been set.
Current stock status	**Undefined**

Fishery interactions

Fishing for Estuary Cockles in the EGHG Fishery is done by hand with hand collection of individuals. There are limited, if any interactions with other fisheries.

Estuary Cockles inhabit seagrass habitat in addition to sandy/muddy substratum and there is anecdotal evidence of fishers (from all sectors) interacting with seagrass habitat. There are no recorded interactions with TEPS or other protected habitats.

Qualifying Comments

Defining the status of the Estuary Cockle resource with any level of reasonable certainty is not possible due to various issues primarily relating to the unavailability and/or inaccuracy of available data, from all fishing sectors.

Interpretations of patterns of increasing catch at higher than long-term average catch rates at the state-wide level suggesting Estuary Cockle stocks are being fished sustainably and possibly increasing substantially discount the high levels of uncertainty in the available data and the contrast between peak catches and subsequent very low levels of catch within some estuaries – "…coincident increasing catches and catch rates indicate that the resource is able to sustain recent catch levels and appears to be increasing." (NSW TAFC 2022). Some uncertainty in these data include the influence of a small but increasingly high proportion of active fishers and changes in their reporting of daily catch and effort data, substantially influencing changes in catch rate at the whole fishery and estuary scale. Importantly, anomalous peaks in annual catch within estuaries (i.e. three times the long-term average) have occurred sequentially in Pambula Lake (2010/11), Merimbula Lake (2014/15) and Wallis Lake (2017/18), with annual catches declining to, and being maintained at, or among, historical lows in the 3-5 years thereafter. In Merimbula Lake and Wallis Lake these declines in catch have occurred whilst measures of catch rate (from data by >1 fisher) have declined to below long-term average levels. In Pambula Lake, catches declined to zero within 5 years of the historical peak, despite catch rates increasing during this time, although with low levels of reported effort, also suggests hyperstability in the catch rate series. These available but limited and uncertain data from key estuaries, that contributed the majority of the annual catch in the fishery, indicate serial depletion and likely depleting or depleted local stocks.

Despite the recent change in the TAC for Estuary Cockles (29.2 t in 2020/21 to 45 t in 2021/22; NSW TAFC 2021), the issues above, in particular persisting low catches in historically important estuaries, together with data in 2021/22 demonstrating an increase in catch from 'Other', previously unreported estuaries, suggests stocks in key estuaries may be unable to support the catch contribution they previously made to historical catch levels. This, combined with continued uncertainty and low levels of reported data, may prompt more precautionary management approaches, reenforcing the onus of providing required fishery-dependent data, onto the fishers, leading to a more certain evidence base for future assessments. Precautionary harvest levels are below those demonstrably capable of being sustained whilst supporting an ongoing stock status of 'sustainable', informed by reliable indicators and reference levels of biomass and fishing mortality. Quota usage reports since 2019/20 indicate ~95% of the TAC is being harvested each year, including the 45 t determined for 2021/22, up from 29.2 in previous years. However, the time series of uncertain and unreported data that continues and necessitates the stock status of 'undefined' (both in terms of the level of biomass and fishing mortality), by definition, indicates there is insufficient information to reliably inform a status of sustainable.

There are inadequate data describing the fisheries biology of Estuary Cockles (e.g. size-at-maturity and rates of growth). Existing data describing their population structure is not from the primary literature. However, it does provide direct descriptions of genetic population structure for Estuary Cockles in NSW estuaries. Levels and distribution of recreational, Indigenous cultural fishing and IUU catch are not quantified. However, anecdotal evidence suggests recreational catches contribute substantially to levels of fishing mortality at local/estuary scales. Environmental factors likely affect changes in the abundance and biological performance of Estuary Cockle populations and these factors likely vary among estuaries and through time. The paucity of data and its limitations provide high uncertainty in any conclusions and strongly supports the need for alternate data sources (i.e. fishery-independent data) to inform a data monitoring and assessment plan to inform a harvest strategy, determination of stock status and a TAC determination with high confidence. Such a plan would support management actions to deliver positive outcomes for the development of the fishery and Estuary Cockle resource in NSW.

References

Chick, R.C. 2023. Stock assessment report 2022/23 – Estuary General Fishery (Hand Gathering) – Estuary Cockle (*Anadara trapezia*). NSW Department of Primary Industries. Fisheries NSW, Port Stephens Fisheries Institute. 37 pp.

FAO. 2021. The impact of COVID-19 on fisheries and aquaculture food systems, possible responses: Information paper, November 2020. Rome. https://doi.org/10.4060/cb2537en

Gribben, P. E. and Wright, J.T. 2006. Invasive seaweed enhances recruitment of a native bivalve: roles of refuge from predation and the habitat choice of recruits. Marine Ecology Progress Series, 318: 177–185.

Gribben, P.E., Wright, J.T., O'Connor, W.A. and Steinberg, P., 2009. Larval settlement preference of a native bivalve: the influence of an invasive alga versus native substrata. Aquatic Biology, 7: 217-227.

Hadfield, A. J. and Anderson, D. T. 1988. Reproductive cycles of the bivalve mollusks *Anadara trapezia* (Deshayes), *Venrupis crenata* Lamarck and *Anomia descripta* Iredale in the Sydney Region. Australian Journal of Marine and Freshwater Research, 39(5): 649–660.

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

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. https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0005/1394969/NSW-Recreational-Fisheries-Monitoring-Program-Survey-of-recreational-fishing-in-NSW-201920-~-Fisheries-Final-Report-Series-No-161.pdf

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

NSW TAFC (Total Allowable Fishing Committee). 2022. Estuary General Fishery - Hand Gathering Sector (Pipi, Cockles, Ghost Nippers, Beachworms). Determination for the 2022/23 Fishing Period. 19 April 2022. https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0010/1420948/Estuary-General-Hand-Gathering-Fishery-Report-and-Determinations-for-the-2022-23-fishing-period.pdf

Schnierer, S. 2011. Aboriginal fisheries in New South Wales: determining catch, cultural significance of species and traditional fishing knowledge needs. Project No. 2009/038. Report to the Fisheries Research and Development Corporation, Canberra.

Schnierer, S. and Egan, H. 2016. Composition of the Aboriginal harvest of fisheries resources in coastal New South Wales, Australia. Reviews in Fish Biology and Fisheries, 26: 693–709.

West, L. D., Stark, K. E., Murphy, J. J., Lyle, J. M. and 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.

Wright, J. T., McKenzie, L. A. and Gribben, P. E. 2007. A decline in the abundance and condition of a native bivalve associated with *Caulerpa taxifolia* invasion. Marine and Freshwater Research, 58: 263–272.

Yardin, M. R. 1997. Genetic variation in *Anadara trapezia* (Sydney cockle): implications for the recruitment of marine organisms. PhD thesis. University of Western Sydney, Hawkesbury.

Yardin, M. R. and Richardson, B. J. 1996. Status of *Anadara trapezia* (Deshayes) (Bivalvia: Arcodia) from Oyster Harbour, Albany (Western Australia) as compared with east Australian populations. Records of the Western Australian Museum, 18: 121–127.