Stock Status Summary – 2022/23

NSW Stock Status Summary – Beachworms (Onuphidae)

Assessment Authors and Year

Chick, R.C. and Fowler, A. M. 2023. NSW Stock Status Summary 2022/23 – Beachworms (Onuphidae). NSW Department of Primary Industries, Fisheries. 10 pp.

Stock Status

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

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

Stock structure & distribution

Beachworms are polychaete worms in the family Onuphidae. In NSW, they are predominantly *Australonuphis teres* (stumpy or kingworm) and are harvested for bait from intertidal sandy beaches. Their distribution ranges from South Australia to Queensland (Dakin et al. 1952; Paxton 1979). Other species of beachworms that occur in NSW and that are recognised as different species by fishers include *A. parateres* (slimy) and *Hirsutonuphis mariahirsuta* (wiry or white headed wiry), but they are less abundant than kingworms (Paxton 1996). A genomic study on *A. teres*, sampled from along 900 km of NSW coast, identified six genetic groups with no clear geographic pattern to their distribution, suggesting considerable gene flow among populations (Padovan et al. 2020). Little is known about the genetic structure of the other species of beachworms. However, it is likely they represent broad, interconnected populations. For the purposes of this assessment, beachworms in NSW are considered a multi-species stock or management unit.

Biology

Beachworms are dioecious i.e. separate male and female individuals. Sexual maturity is reached at 42 cm in length for *A. teres*, and 39 cm for *A. parateres* and they are presumed to be repeat spawners throughout their lifespan (Paxton 1979). Mature gametes have been observed throughout the year, with *A. teres* containing >100,000 eggs (Paxton 1986). As the size of beachworms increases, the number of gamete-bearing segments and fecundity also increases. Beachworms are broadcast spawners. Spawning occurs throughout the year (Paxton 1986) with possible reproductive peaks in February and October (Fielder and Heasman 2000). Ontogenetic changes in morphology have been observed throughout juvenile development of various onuphid species, but not in detail for beachworms (Paxton 1986).

Rates of growth of beachworms have not been recorded, but Paxton (1979) found *A. teres* grew up to 100 cm and *A. parateres* grew up to 300 cm in length. The smallest beachworms that have been collected were 30 mm in length (Paxton 1979). Independent surveys of *A. teres* from along the NSW coast included beachworms between 91 and 954 mm long and ranging in age from <1 year to 9 years old. Population size structure appeared to be normally distributed, with individuals weighing between <1 g and 35.5 g (DPI unpublished).

FISHERY STATISTICS

Catch information

Commercial

State-wide fishery catch increased between 1984/85 and 1996/97 during an apparent developmental phase in the fishery, reaching a peak >35 t in 1996/97 (Figure 1). From 1997/98, catch generally decreased from >20 $t.yr^{-1}$ to about 10 $t.yr^{-1}$ between 2006/07 – 2009/10. The pattern of declining annual catches continued from 2009/10 (1.3 t; noting this was the time of transition to the current reporting system) to 2015/16 (~5.5 t). Since 2015/16, catches have averaged about 5 $t.yr^{-1}$ including a total catch of 7.3 t in 2018/19 (the last year prior to implementation of a TAC). Total catch in 2021/22 was 3.1 t, the lowest catch since 1984/85, 1.9 t below that in 2020/21, and 5.4 t below the 2021/22 TAC (8.5 t; Figure 1). Importantly, these relatively recent (since 2009/10) patterns of change in catch for the state-wide fishery are not necessarily consistent with patterns at finer spatial scales.

Since 2009/10, catches of beachworms have been reported from all Regions defined within the EGHG Fishery (Regions 1-7), and all Regions had catch reported during 2021/22, with the exception of Region 5. Catch from Region 3 has dominated total catch each year, with the exception of two consecutive years (i.e. 2012/13 and 2013/14) when catches from Region 4 were higher. Catch from Region 3 has averaged 54% of total annual catches since 2009/10, with >60% of total state-wide catch within the last 4 years (Figure 2). Since 2010/11, catches from Region 4 have averaged 30% of total annual catch for the fishery, although in 2021/22 total catch in Region 4 was <1 t and 20% of total catch. Catch from Region 1 has averaged 12% of the total catch since 2009/10, and in 2021/22, despite relatively low catch (<500 kg) it remains 11% of the state-wide total. Catches from other regions have been <4% of total catch in any year and those from Regions 2 and 5 have been sporadic and commonly <1%. As a consequence, figures representing regional data have been limited to Regions 1, 3, 4 and 6. In 2021/22, catches from Regions 3 and 4 were 1.9 t and 0.6 t respectively, making up >80% of the total catch for the year.

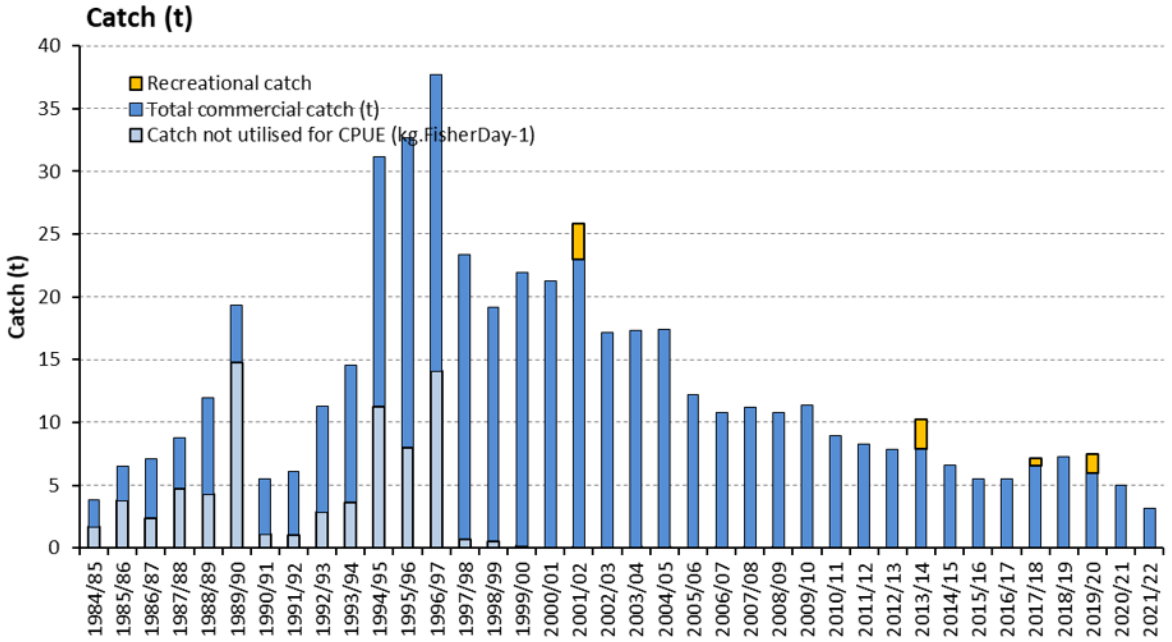

Figure 1. Total annual commercial catch (t) of Beachworms from 1984/85 to 2021/22 and survey estimates of recreational catch (t) in 2000/01, 2013/14, 2017/18 and 2019/20.

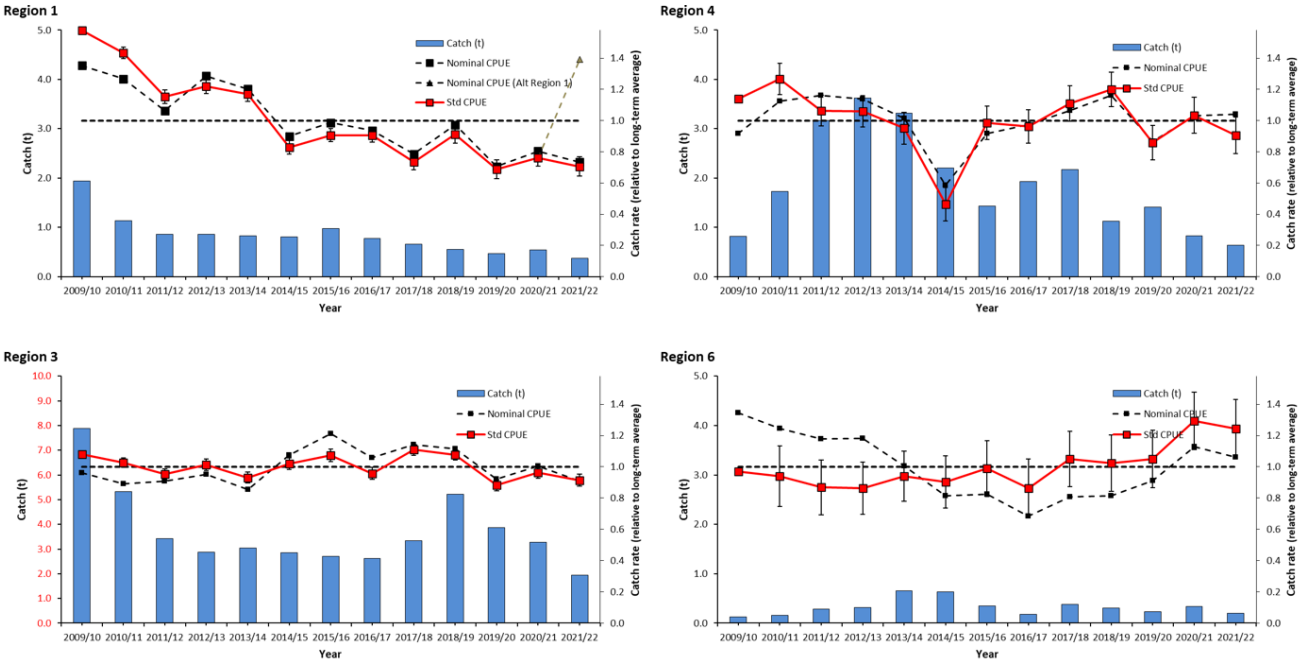

Figure 2. Annual commercial catch (t, blue bars), standardised commercial catch rates (red lines with 95% confidence intervals) and nominal catch rates (dashed black lines) scaled to the 13-year average (horizontal dashed black line) for each of the top 4 regions (by catch) from 2009/10 to 2021/22. Note: Y-axes in red are greater than others.

It is notable that the pattern of change in the levels of annual catch, effort and CPUE for the state-wide fishery are not necessarily consistent with patterns of catch at finer spatial scales (e.g. Regions).

Recreational & Charter boat

In 2000/01, the recreational harvest (kept numbers) was estimated to be 285,663 ± 72,697 worms (mean ± SE). At an average weight of 10 g (as defined for the conversion of commercial numbers of Beachworms to weight), the 2000/01 estimate equates to a total recreational harvest of ~2.9 ± 0.7 t.yr^{-1}. In 2013/14, 2017/18 and 2019/20 the state-wide survey estimated the retained recreational catch of Beachworms at 239,085 ± 85,662; 54,046 ± 20,044; and 150,299 ± 96,222 Beachworms (i.e. ~2.4 ± 0.9 t.yr^{-1}; ~0.5 ± 0.2 t.yr^{-1}; and 1.5 ± 0.96 t.yr^{-1}, respectively (Figure 1). The 2017/18 and 2019/20 NSW surveys sampled one- and three-year licence holders present in the NSW Recreational Fishing Fee (RFF) Licence database, whereas the previous NSW survey in 2013/14 sampled households from the White Pages (West et al. 2015). Corrections made to the 2013/14 survey outcomes, to account for differences in survey designs, indicate the comparable recreational catch was 1.5 t ± 0.8 t (Murphy et al. 2020). Notably, Beachworm estimates from state-wide surveys are typically from a low sample size and the estimate from 2013/14 was associated with relatively high standard error (i.e. >40%; Murphy et al. 2020). Estimates of recreational catch represent 13%, 30%, 8% and 25% of the reported commercial catch for each of the years, respectively.

Indigenous

The benefits (and costs) of fishing generally and professional fishing to the cultural, broader social, health, wellbeing and economic value to Indigenous people and communities are substantial (Voyer et al. 2016). Schnierer and Egan (2012) described a case study in NSW of the impact of management changes on the viability of Indigenous commercial fishers and the contribution commercial fishing and aquaculture makes to Indigenous communities. Included in this case study are estimates of the contribution Indigenous commercial fishers make to Indigenous communities, including the contribution of between 5% - 20% of their annual commercial catch. The contribution made to Indigenous communities by Indigenous commercial fishers was, on average, 9.8% of annual catch and the contribution from broader Indigenous commercial fishers was greater than that made by fishers in the EGHG Fishery, with this being a consequence of hand gathering being a "…traditional skill that is widely practiced by coastal families so they can fulfil their own needs." (Schnierer and Egan 2012). Moreover, Schnierer and Egan (2012) reported substantial harvests of hand gathered species (principally Pipi) by Aboriginal fishers that were either not reported in commercial catch records, or reported as 'other' species and went unrecorded as species specific catches and were utilised for personal and community use.

Synthesis of catch composition from Indigenous cultural fishing in NSW indicated that there are at least 18 species in the Estuary General Fishery that overlap with Indigenous fisheries (Schnierer and Egan 2016). In a survey based in the Tweed region, annual catch of beachworms by Indigenous fishers was estimated at between 1,869 and 4,350 worms (Schnierer 2011). Based on an average weight of 10 g, the catch from Aboriginal fishers in the Tweed region in NSW is estimated at <0.5 $t.year^{-1}$. Schnierer (2011) described beachworms as among the top 10 culturally most important species but they consisted of less than 5% of the total cultural catch in terms of total numbers of species. Total effort estimated from this area for the Aboriginal fishery was 542 hours or 92 days (Schnierer 2011). Cultural catch of bait including beachworms was also seen to be important in delivering economic benefits to the community (Schnierer 2011).

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 beaches, related to minor incidents in both the commercial and recreational fishing sectors. NSW Fisheries Compliance provide annual summaries of seizures of fish and invertebrates due to non-compliance. These reports do not indicate IUU activity related to seizures specific to non-compliance regarding Beachworms for the years 2010/11 to the most recent report in 2020/21 (https://www.dpi.nsw.gov.au/fishing/compliance/fisheries-compliance-enforcement).

Fishing effort information

Commercial

Reported $effort_{dy}$ has generally reflected that of catch over the history of the fishery. It has increased from 945 FisherDays in 1984/85 to a peak of 7,442 FisherDays in 1996/97 (Figure 3). Noting that during this period fishers were required to report their catch monthly and effort (in days fished) by gear type, not linked to catch unless only a single gear type was used and then not linked to species catch within a gear type. 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 EGHG fishers for each month where one method (hand gathering) was reported (Appendix 1). From 1997/98 to 2008/09, $effort_{dy}$ generally decreased from >6,000 FisherDays to about 4,000 FisherDays. Since 2009/10, $effort_{dy}$ has continued to decline from ~3,000 FisherDays to

1,238 FisherDays, reported in 2021/22, the lowest effort$_{dy}$ since 1984/85 (Figure 3). Similarly, effort in hours fished (effort$_{hr}$) has also generally declined from >10,000 hours in 2009/10 to 3,228 hours in 2021/22, again, the lowest level since 1984/85 (Figure 3).

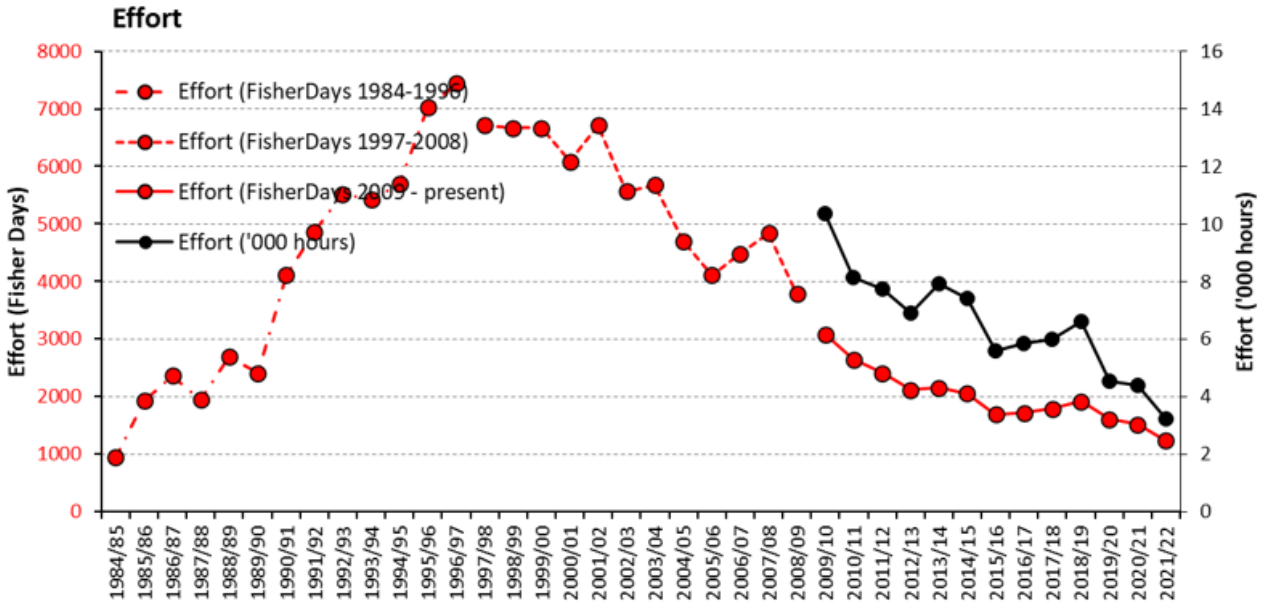

Figure 3. Total annual commercial effort on fishing for Beachworms from 1984/85 to 2021/22.

Catch Rate information

Catch per FisherDay (CPUE$_{dy}$) is a problematic index to estimate and interpret prior to 2009/10, for reasons outlined for the effort$_{dy}$ time series. Using daily effort calculated as explained above, three distinct time periods, with clearly different CPUE trends, can be distinguished (Figure 4). CPUE$_{dy}$ was relatively low but highly variable (between 1 and 2.9 kg.day^{-1}) from 1984/85 to 1993/94. From 1994/95 to 2008/09, CPUE$_{dy}$ generally remained between 3-3.5 kg.day^{-1}, except between 2006/07 and 2008/09 when it declined below 3 kg.day^{-1} and to a 14-year low of 2.3 kg.day^{-1} in 2007/08. Since 2009/10, CPUE$_{dy}$ has been maintained above 3 kg.day^{-1}, with the exception of the most recent year, where CPUE$_{dy}$ was 2.5 kg.day^{-1} and noting the substantial variation around the annual average (Figure 4). Catch per hour (CPUE$_{hr}$) from 2009/10 to 2021/22 has averaged 1.06 kg.hr^{-1}, reaching a recent peak of 1.23 kg.hr^{-1} in 2018/19. In 2021/22, CPUE$_{hr}$ was 1.02 kg.hr^{-1}, and in line with the 13-year average from 2009/10. It is notable that the pattern of change in the levels of annual catch, effort and CPUE for the state-wide fishery are not necessarily consistent with patterns of catch at finer spatial scales (e.g. Regions).

In Region 1, CPUE$_{hr}$ has decreased substantially, from 0.85 kg.hr^{-1} in 2009/10, to an average of 0.5 kg.hr^{-1} over the last 5 years, 0.46 kg.hr^{-1} in 2021/22 and below the long-term average (0.63 kg.hr^{-1}) from 2009/10 (Figure 2). StdCPUE$_{hr}$ has reflected that of nominal CPUE$_{hr}$ and remained below the long-term average since 2014/15 (Figure 2). In Region 1, the difference in the 3-year average levels of StdCPUE$_{hr}$ from the first 3 years in the series to the 3 most recent years indicate StdCPUE$_{hr}$ has declined by ~48% throughout the series. In Region 3, CPUE$_{hr}$ has averaged 1.25 kg.hr^{-1} since 2009/10 and annual measures have been relatively stable close to the average. In 2021/22, CPUE$_{hr}$ was 1.13 kg.hr^{-1}, the lowest level for 8 years. The StdCPUE$_{hr}$ series is more stable but generally reflects the pattern observed in nominal CPUE$_{hr}$, with the level in 2021/22 being marginally below the long-term average (Figure 2). In Region 4, StdCPUE$_{hr}$ and

$CPUE_{hr}$ show similar patterns through time and general stability close to the long-term average (~1 $kg.hr^{-1}$), with the exception of a significant decline in 2014/15 (Figure 2). $StdCPUE_{hr}$ in 2021/22 is slightly below the long-term average. In Region 6, $StdCPUE_{hr}$ has generally increased since 2009/10 and within the last 2 years, to levels above the long-term average (Figure 2).

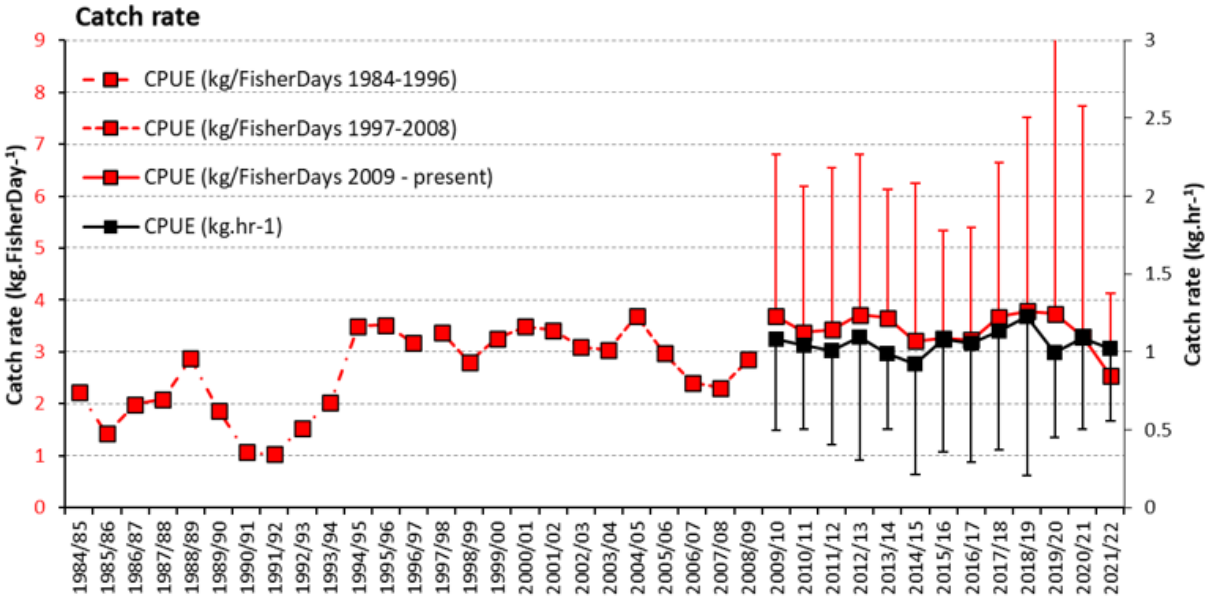

Figure 4. Average annual catch rate ($kg.hr^{-1}$ and $kg.FisherDay^{-1}$; plus or minus one standard deviation, respectively from 2009/10) from 1984/85 to 2021/22.

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 Beachworm stock. Information used in the assessment included: knowledge of biology and population and stock structure; and patterns of catch and standardised catch rate across the fishery and within key regions.

Main data inputs:

- Catch (commercial) (t) – 2009/10 to 2021/22
- Catch (recreational) (t) 2000/01, 2013/14, 2017/18 and 2019/20
- Commercial Standardised CPUE ($kg.hr^{-1}$) – 2009/10 to 2020/21

Data interpreted at state-wide and estuary scales.

Key model structure & assumptions:

- Standardised catch rates (using cede v. 0.04) (Haddon, 2018). Assumption: annual catch rates are a relative index of abundance not unduly influenced by factors other than those accounted for through standardisation.

Sources of uncertainty evaluated:

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

The assessment is for the species complex of NSW beachworms, principally utilising data related to *A. teres*, and assuming they represent the broader species complex. State-wide total catches within the last three years have been substantially below the TAC determined for the commercial fishery. Patterns of catch and catch rate among key regions are inconsistent, indicating beachworm populations functioning within these scales may be responding differently to different pressures, including fishing pressure.

The use of catch rates to inform relative change in biomass though time becomes more uncertain when processes other than changes in population biology influence them. It is possible that there has been some inconsistent reporting of effort (searching time included or excluded with actual time catching) and also some operating practices of fishers targeting beachworms has been influenced by market or economic factors.

There are inconsistencies in the methodology used to estimate recreational fishery catches through the time series that provides some uncertainty around direct comparison of catch estimates from different times (noting, estimates from 2013/14 have been modified to provide direct comparison with those from 2017/18).

Levels of Indigenous cultural fishing are not well quantified. Available studies indicate Beachworms are an important species and are seen to be important in delivering economic benefits to communities (Schnierer 2011).

Factors other than fishing, including global disruptions (e.g. COVID-19 pandemic and associated social impacts (FAO 2021)), large scale, state-wide disruptions (e.g. natural disaster bushfires in 2019/20) and also, more local factors (e.g. land-use influences and environmental factors), may affect change in the abundance and productivity of beachworms and/or the operations of the fishery. How these factors may influence the reliability of the available data is not well known and are not considered in this assessment beyond their acknowledgement.

Despite and whilst including consideration of these uncertainties, the weight of evidence provided is sufficient to support an understanding that the biomass of Beachworms is at a level sufficient to ensure that on average, future levels of recruitment are adequate and fishing mortality is at a level to avoid the stock being recruitment impaired, resulting in a classification of the Beachworm stock status of **sustainable**.

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) • Standardised $CPUE_{dy}$ (key Regions)

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 NSW stock status of beachworms is classified as **sustainable**.

The weight of evidence provided supports an understanding that the biomass of beachworms is at a level sufficient to ensure that on average, future levels of recruitment are adequate and fishing mortality is at a level to avoid the stock being recruitment impaired.

A weight-of-evidence approach has been taken to support a stock status determination of 'sustainable' for the NSW Beachworm stock. This classification is supported by: i) standardised catch rates close to long-term average levels within Regions 3 and 4, that together have consistently contributed >80% of the state-wide catch; ii) standardised catch rate in Region 6 that is above the long-term average level with stable (albeit low) levels of catch; iii) commercial fishing occurring on between 21 and 36 beaches each year from a total of 56 commercially fished beaches since 2009/10, with multiple beaches within Regions 3, 4 and 6 consistently contributing to annual catches; iv) reduced uncertainty regarding levels of recreational catch and its spatial distribution; v) fishery-independent population survey and commercial size structures that demonstrate distributions of a broad size (weight) of worms and likely recruitment events at fished beaches and inform fishing selectivity; and vi) knowledge of strong genetic connectivity among NSW Beachworm populations (Chick and Fowler 2023).

A balanced interpretation of the weight of evidence provided supports an understanding that the biomass of Beachworms is at a level sufficient to ensure that on average, future levels of recruitment are adequate and fishing mortality is at a level to avoid the stock being recruitment impaired – and hence the NSW Beachworm stock is classified as **sustainable**.

Stock Assessment Result Summary

Biomass status in relation to Limit	NA – no biomass limits has been set. Weight-of-evidence supports an understanding that the biomass of Beachworms is at a level sufficient to avoid the stock being recruitment impaired.
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.
Current stock status	**Sustainable**

Fishery interactions

Fishing for Beachworms in the EGHG Fishery is done by hand with hand collection of individuals. There are limited, if any interactions with other fisheries and no interactions have been reported between the EGHG Fishery and species protected under the Environment Protection and Biodiversity Conservation *Act 1999*.

Qualifying Comments

There is uncertainty in the determination of stock status presented in this report. The assessment is for the species complex of NSW beachworms, principally utilising data related to the species *A. teres*, and assuming they represent the broader species complex. State-wide total catches within the last three years have been substantially below the TAC determined for the commercial fishery. Patterns of catch and catch rate among key regions are inconsistent, indicating beachworm populations functioning within these scales may be responding differently to different pressures, including fishing pressure. Uncertainty in the data contribute to uncertainty in understanding changes in biomass and fishing mortality at relevant scales.

Factors other than fishing, including global disruptions (e.g. COVID-19 pandemic and associated social impacts (FAO 2021)), large scale, state-wide disruptions (e.g. natural disaster bushfires in 2019/20) and also, more local factors (e.g. land-use influences and environmental factors), may affect change in the abundance and productivity of Beachworms and/or the operations of the fishery. How these factors may influence the reliability of the available data is not well known and are not considered in this assessment beyond their acknowledgement. Influences at local scales are likely to be spatially and temporally variable. Identifying and quantifying (where possible) the likely effect of these otherwise unaccounted for factors in limiting the potential of the Beachworm fishery (e.g. through a risk assessment) would inform the relative effects of fishing.

References

Chick, R.C. and Fowler, A. M. 2023. Stock assessment report 2022/23 – Estuary General Fishery (Hand Gathering) – Beachworms (Onuphidae). NSW Department of Primary Industries. Fisheries NSW, Port Stephens Fisheries Institute. 49 pp.

Dakin, W.J., Bennett, I. and Pope, E.C. 1952. Australian seashores. Angus and Robertson, Sydney.

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

Fielder, D. and Heasman, M. 2000. Status of the New South Wales Beachworm Fishery 1990/1–1995/96. Fishery Resource Assessment Series No. 8. NSW Fisheries Research Institute, Cronulla.

Haddon M., A Punt and P. Burch (2018) simpleSA: A package containing functions to facilitate relatively simple stock assessments. R package version 0.1.18.Henry, G.W. and Lyle, J.M. 2003. The national recreational and Indigenous fishing survey. Fisheries Research and Development Corporation, Canberra.

Haddon, M. Burch, P., Dowling, N. and R. Little, R. 2019. Reducing the Number of Un-defined Species in Future Status of Australian Fish Stocks Reports: Phase Two - training in the assessment of data-poor stocks. FRDC Final Report 2017/102. CSIRO Oceans and Atmosphere and Fisheries Research Development Corporation. Hobart. 125 p.

Martell, S. and R. Froese (2013) A simple method for estimating MSY from catch and resilience. Fish and Fisheries 14: 504-514.McLachlan, A and Brown, A.C. 2006. The ecology of sandy shores, 2nd edn. Elsevier, Amsterdam.

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.

Padovan, A., Chick, R.C., Cole, V.J., Hutchings, P.A., Jack, C., Dutoit, L. and Fraser, C.I. 2020. Genomic analyses suggest strong population connectivity over large spatial scales in the commercially important baitworm, *Australonuphis teres* (Onuphidae). Marine and Freshwater Research 71(11) 1549-1556 https://doi.org/10.1071/MF20044.

Paxton, H. 1979. Taxonomy and aspects of the life history of Australian beachworms (Polychaeta: Onuphidae). Australian Journal of Freshwater Research 30: 256–294.

Paxton, H. 1986. Generic revision and relationships of the Family Onuphidae (Annelida: Polychaeta). Records of the Australian Museum 38: 1–74.

Paxton, H. 1996. *Hirsutonuphis* (Polychaeta: Onuphidae) from Australia, with a discussion of setal progression in juveniles. Invertebrate Taxonomy 10: 77–96.

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. 2012. Impact of management changes on the viability of Indigenous commercial fishers and the flow on effects to their communities: Case study in New South Wales, Final report to the Fisheries Research Development Corporation, Canberra. Lismore: Southern Cross University.

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.

Voyer, M., K., Barclay, A. McIlgorm and N. Mazur (2016). Social and Economic Evaluation of NSW Coastal Professional Wild-Catch Fisheries: Valuing Coastal Fisheries (FRDC 2014-301). Canberra, Australia, Fisheries Research and Development Corporation (FRDC). July.