Department of Primary Industries
Department of Regional NSW

NSW Stock Status Summary – 2023/24

Luderick (*Girella tricuspidata*)

Assessment Authors and Year

Schilling, H. T., Helidoniotis F. 2024. Stock assessment report 2023/24 – Luderick (*Girella tricuspidata).* NSW Department of Primary Industries - Fisheries: 46 pp.

Stock Status

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

Stock structure & distribution

Luderick are distributed throughout the estuaries and inshore zones of eastern and south-eastern Australia including South Australia and Tasmania. Animals have been shown to undertake extensive northward migrations at considerable speed, which likely facilitates dispersal and mixing in the population (Cadiou, 2016). Investigation of genetic stock structure showed there was no genetic structure across central NSW bioregion (Curley *et al.*, 2013), but broader stock structure has not yet been investigated using genetic analyses or other potential biomarkers such as otolith chemistry. Network analysis of continental adult movement data for the species, however, showed there was strong connectivity across the length of the NSW coast (Lédée *et al.*, 2021).

Scope of this assessment

The aims of the current report are to: 1) summarise the biology and stock structure of the species within NSW; 2) summarise fishery statistics and additional data sources to inform the assessment; 3) assess and determine the biological status of the NSW stock; 4) outline data limitations and uncertainty in the assessment; 5) indicate future research and assessment directions; and 6) inform determination of the 2024-25 TAE.

The current report represents the first assessment for Luderick in NSW and will be incrementally improved in future years.

Biology

Luderick are a herbivorous and occasionally omnivorous species. Within estuaries, the species uses various habitats including seagrasses and rocky reefs/oyster reefs, with seagrasses being particularly important for juveniles (Swadling *et al.*, 2024). Like many estuarine species, Luderick spawn in and around estuary mouths and adjacent surf zones, and movement of maturing animals out of estuaries occurs in late winter and early spring, however age at 50% maturity exceeds 4 years for both sexes (Gray *et al.*, 2012). Age-growth studies showed females as old as 24 years in the NSW population, but there were few fish older than 10 years in the sampled population (Gray *et al.*, 2010).

Fishery statistics

Catch information

Commercial

Luderick are predominantly caught in Estuary General commercial fishery (≈90% in 2022/23) with a smaller amount caught in the Ocean Haul fishery (≈10% in 2022/23) within NSW. During the 1998 – 2023 period, total landings in of Luderick have ranged from 574t in 2001 to 222t in 2022. The majority of landings come from Estuary General Region 4 and have done so since the 1950s (Figure 1). Between the 1950s and 1990s, commercial catch fluctuated around an approximately stable level (Figure 2). It has since declined which was likely at least partially driven by a general reduction in fishing effort across this fishery and the introduction of recreational fishing havens which removed commercial fishing either partially or wholly from 30 estuaries.

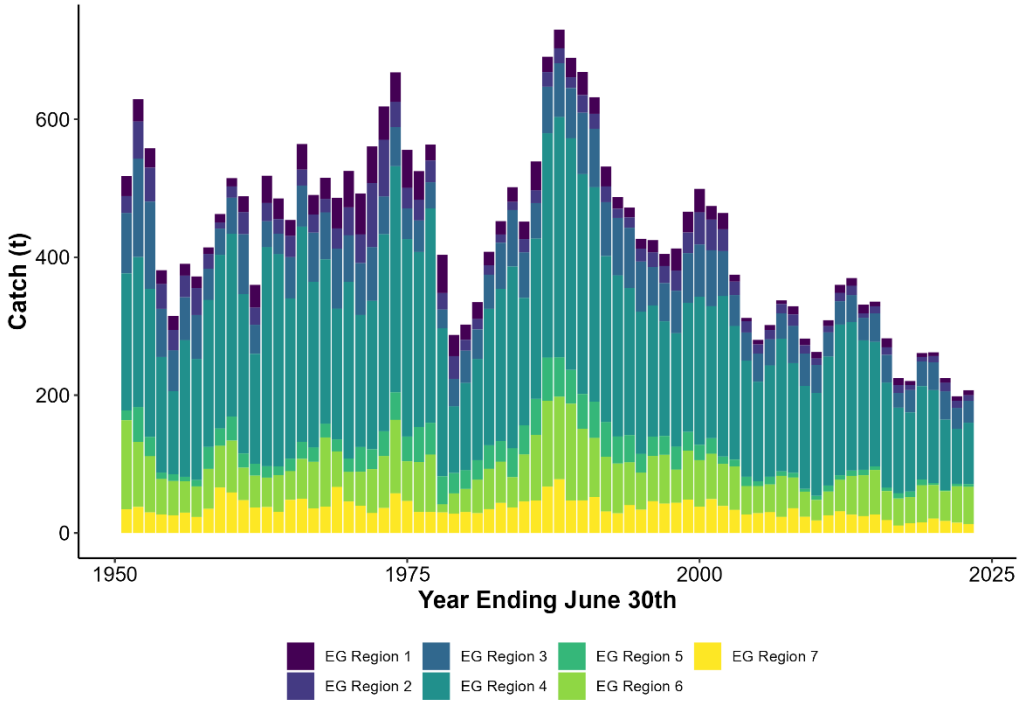

Figure 1 Annual commercial catch (t) of Luderick from the NSW Estuary General Fishery by region from 1953 to 2023. Years shown are financial years ending June 30th.

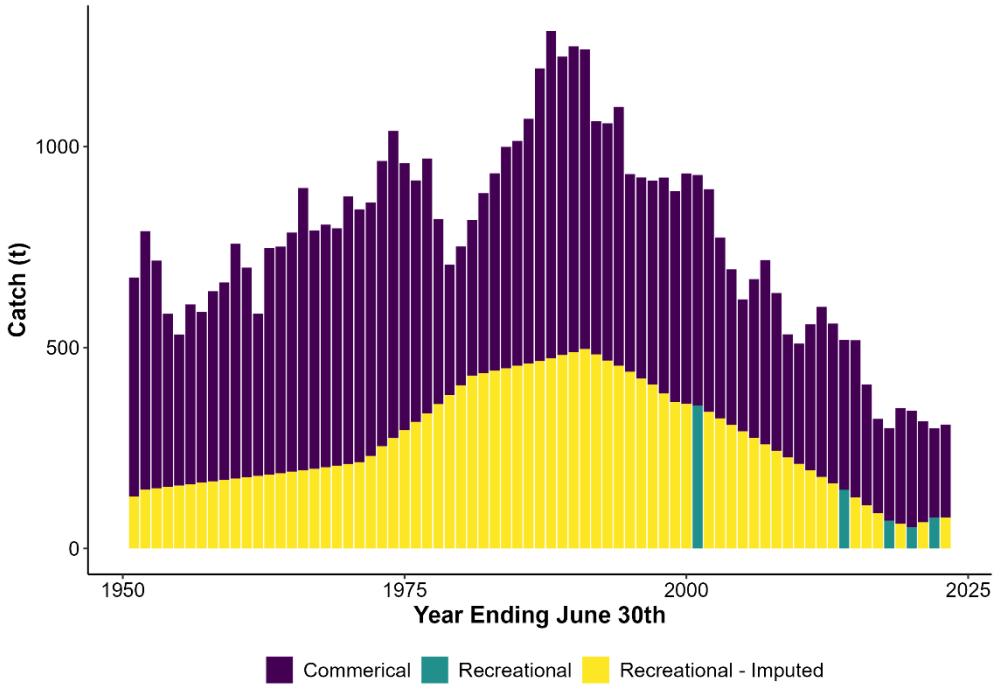

Figure 2 Historical catch series of Luderick (from 1950/51 onward), including commercial and recreational landings from NSW. Years are financial years ending June 30th of the given year. Recreational catches have been imputed based on methods in the text to provide a more representative catch history.

Recreational & Charter boat

Surveys of recreational fishing have been conducted at the state-wide level in NSW. Catch and release of Luderick is popular with over half of captured fish released. Retained landings by recreational fishers in NSW have remained relatively stable since 2013/14 with landings estimated from off-site telephone/diary surveys of NSW Recreational Fishing Fee (RFF) Licence holders declining from approximately 108,620 fish in 2013/14, to 51,272 in 2017/18 and 39,577 in 2019/20. The most recent estimate of retained catch is 2021/2 is higher at 57,175 individuals (West *et al.*, 2015; Murphy *et al.*, 2020, 2022).

Estimated retained catch weights (using a mean weight of 583g) made from the number of individuals are 44 t during 2013/14, 25 t in 2017/18, 19 t in 2019/20, and 33.4 t in 2021/22, based on average body weights of individuals sampled from recreational catches in both estuarine and coastal locations (NSW DPI, unpublished data).

The 2017/18, 2019/20 and 2021/22 NSW surveys sampled one- and three-year licence holders present in the NSW RFF Licence database, whereas the previous NSW survey in 2013/14 sampled households from the White Pages (including a subset of RFF households) (West *et al.*, 2015). The extent to which differences in the sampling frames between the 2013/14 and later surveys have influenced catch estimates is unknown but it is clear that the RFF based surveys may not represent the full recreational fishing pressure in NSW. A previous survey was conducted in 2000/01 but it is not directly comparable due to a variety of reasons, most importantly a different sampling methodology (Henry & Lyle, 2003). This survey estimated a high retained catch of 609,992 fish (Henry & Lyle, 2003). In this assessment we have used all available estimated and attempted to standardise the sampling frame by multiplying the later (2013/14 onward) estimates up by 2.3x. This value was taken from a re-analysis of the 2013/14 survey comparing the proportion of respondents that in the white pages survey frame with those households holding a RFF (ratio of 1:0.434). The use of this scaling factor approximates total recreational catch across NSW after accounting for a number of demographics not required to hold a RFF, e.g. Pensioners. Estimates for years between these estimates were interpolated using linear interpolation. Historical recreational catch Prior

to 2000/01 was hindcast using the method from Kleisener et al. (2015) back to 1951. After 2000/01, harvest was assumed to follow a linear path between each survey, with the estimate for 2022/23 being set as the same as in 2021/22.

Indigenous

Aboriginal cultural catch of Luderick has not been quantified in NSW.

Illegal, Unregulated and Unreported

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

Fishing effort information

As Luderick are caught in the multi-species Estuary General and Ocean Haul Fisheries, effort is difficult to quantify due to changes in fisher behaviour as they target different species, and targeting behaviour is not recorded in log-books. Given this limitation, the most reliable indicator of fishing effort is likely to be the number of days fishing conducted within a month by fisherman who recorded using a general Mesh Net or Haul Net.

Fishing effort (days) in the use of Estuary Mesh Nets has declined 72.4% between 1998 and 2023 (Figure 3). Effort has similarly declined 90.2% for the General Haul Nets (Figure 3). 'Metres of net' used is the nominal effort unit required on catch returns using mesh nets following reporting changes implemented in 2009, however this is not a useful metric for quantifying fishing effort so days of effort were back calculated from catch returns by totalling the number of daily reports using each method in a month. Haul nets now record number of shots and this similarly shows a 71.5% decline from its peak in 2014 (Figure 4).

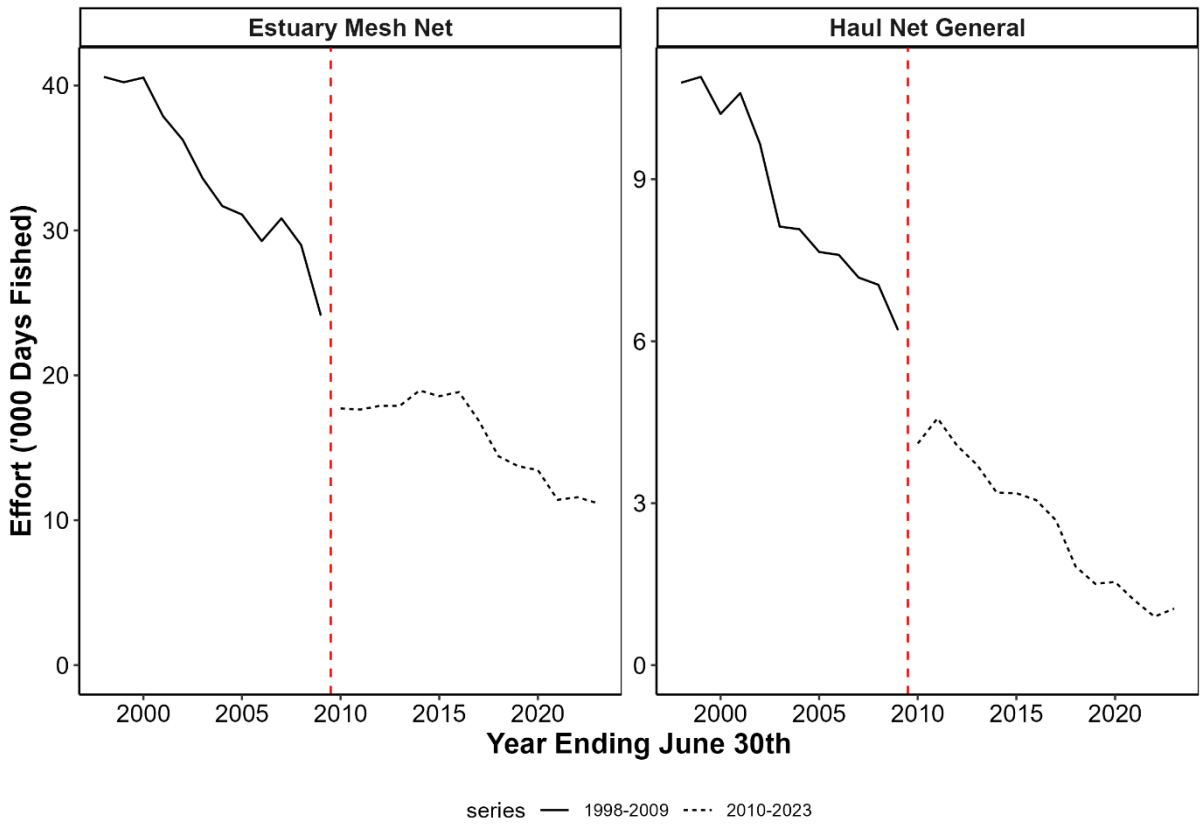

Figure 3 Fishing effort (Days Fished) over time for the Estuary Mesh Net (Estuary General Fishery) and Haul Net General (Ocean Haul Fishery). Dashed red line shows major reporting change.

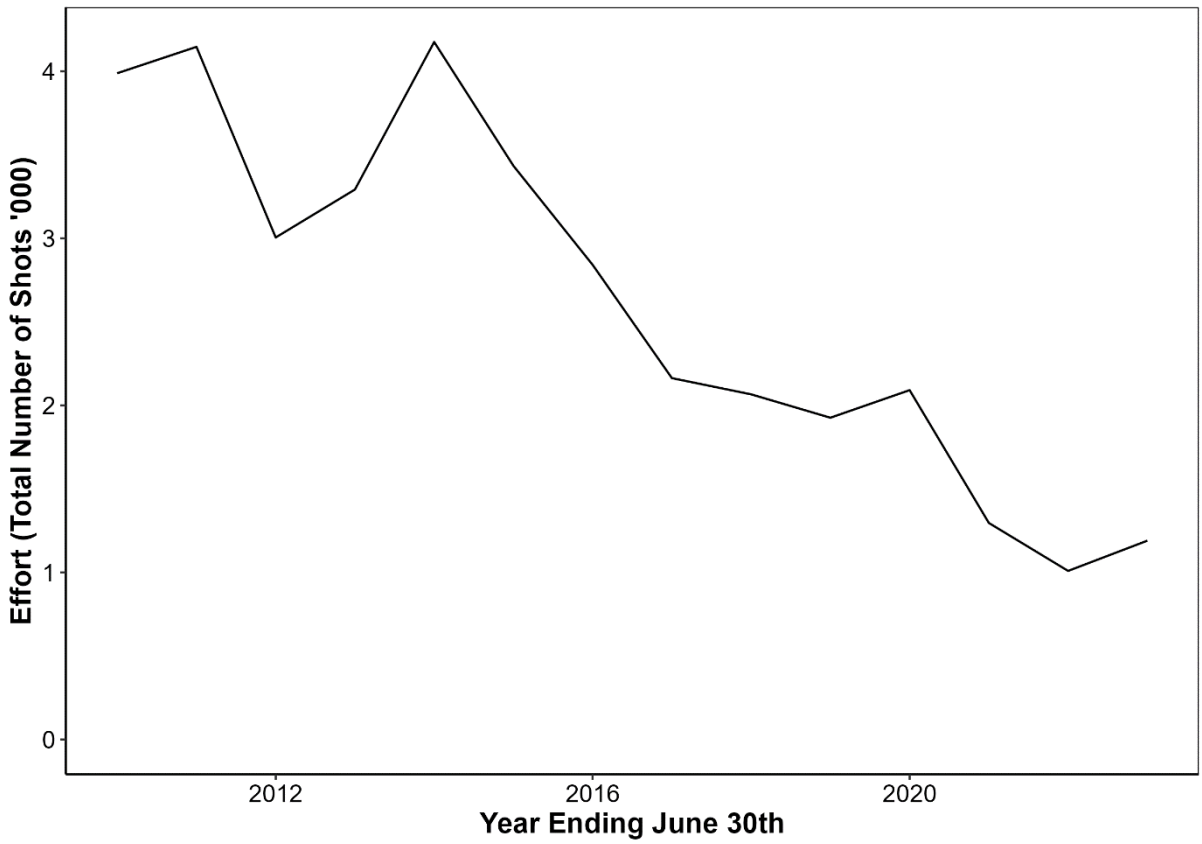

Figure 4 Fishing effort (number of shots) over time for the Haul Net General (Ocean Haul Fishery).

Catch rate information

Standardised catch rates were calculated from commercial estuary mesh nets used in the Estuary General Fishery and from a fisheries independent citizen science diver survey called the 'Reef Life Survey' (RLS; Edgar *et al.*, 2020).

Standardised Commercial Catch-Per-Unit-Effort rates were calculated for two time periods 1998 – 2009 and 2010 – 2023 using the logbook data for Commercial Estuary Mesh Nets. The final standardisations used generalised additive mixed models (GAMMs) and accounted for the following terms:

- Estuary;
- Authorised FisherID;
- Month;
- Fishing Effort (either days fished for monthly data or m of net used for daily data);
- Lunar phase (only the 2010-2023 period due to a need for daily resolution).

Standardisation of Commercial Mesh Net data from 1998 – 2009 showed a largely cyclical pattern with no clear trend (Figure 5). Standardisation of Commercial Mesh Net data from 2010 – 2023 showed an overall increasing trend with a dip from 2013 – 2018 (Figure 6). When both time-series of CPUE are viewed together it suggests that Luderick biomass has likely increased over the last 25 years, largely driven by recent increases.

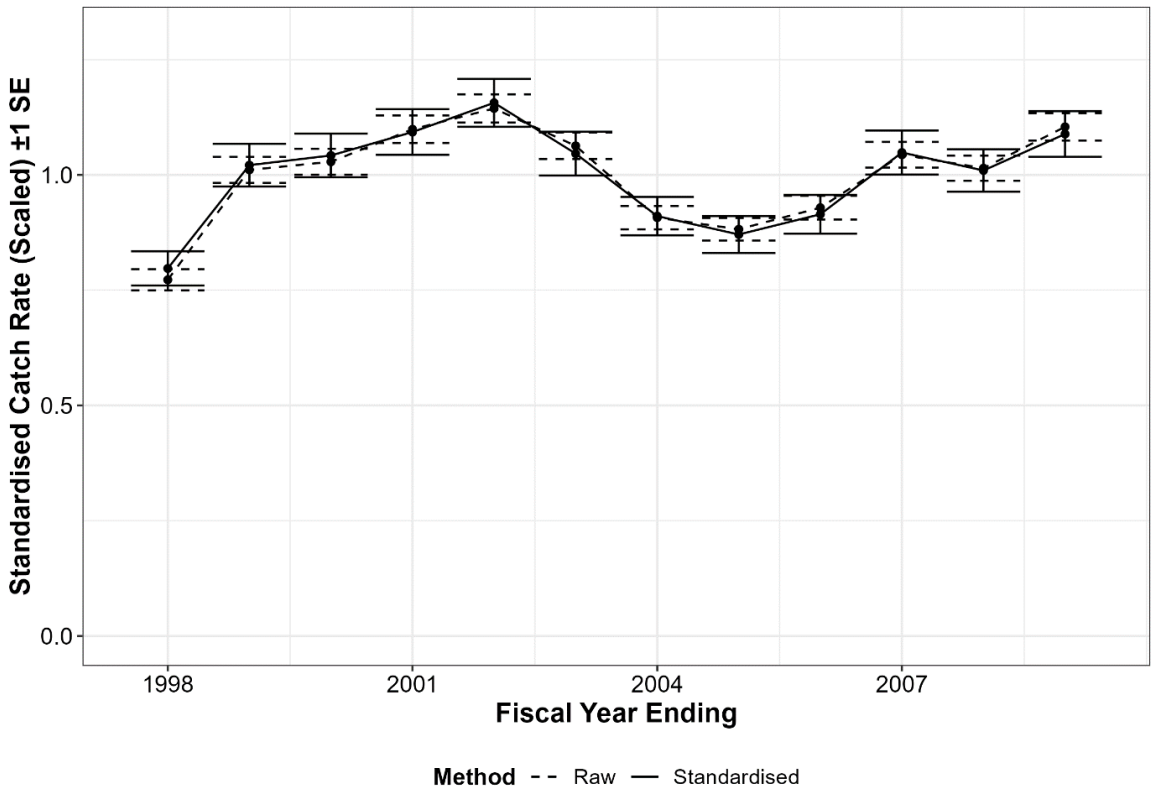

Figure 5 Standardised catch rates from commercial mesh net data from 1998 -2009.

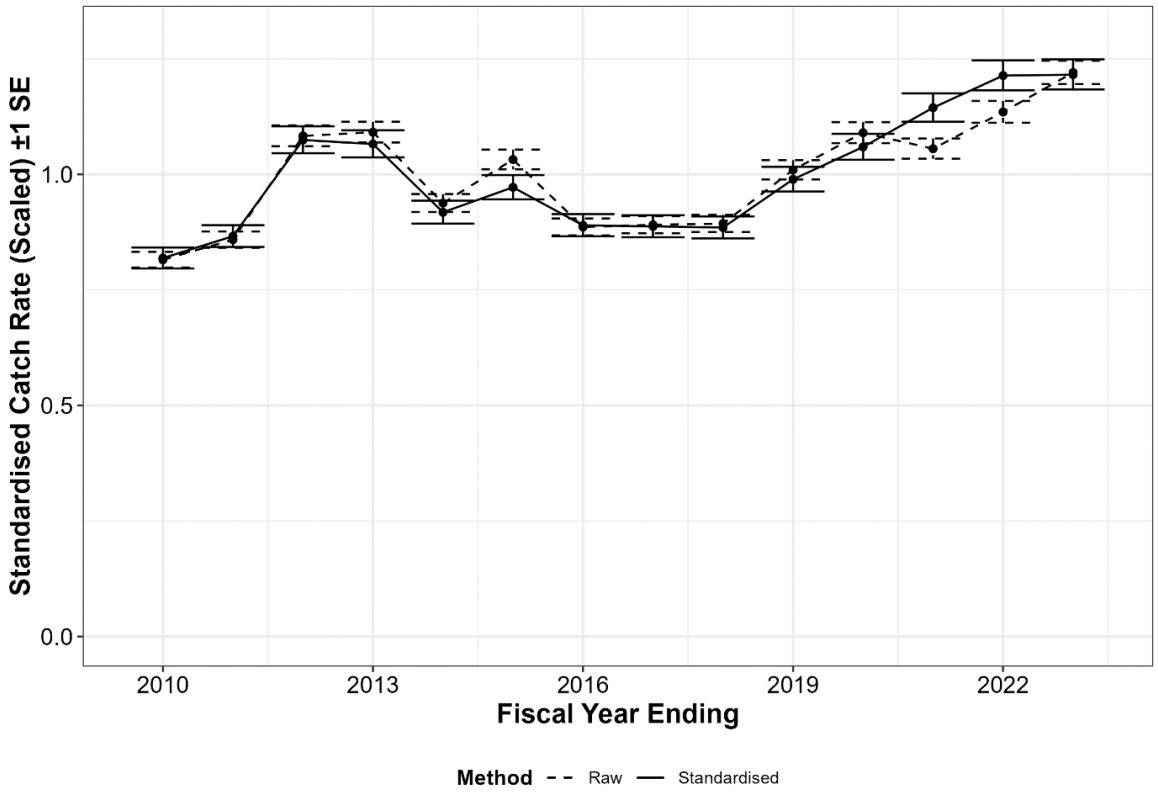

Figure 6 Standardised catch rates from commercial mesh net data from 2010 -2023.

The Reef Life Survey (RLS; Edgar *et al.*, 2020), is a large, structured citizen science program where trained divers lay out 50 m transect lines, and all fishes observed within 5 m either side of the transect (total area of 500 m^2) are identified and tallied into 28 size class bins as divers swim along the line. To extract a suitable dataset for analysis

of Luderick abundance and biomass (abundance in each size class by mean weight from a length-weight relationship), all RLS data from the NSW region was downloaded from the Australian Ocean Data Network up to the end of June 2023 (https://portal.aodn.org.au/). Sites were subset to only include sites where at least one Luderick has been observed. By excluding other sites the dataset is no longer representative of absolute abundances but it does enable modelling of relative abundance and biomass at sites where Luderick have been observed. This dataset was further filtered to exclude samples with no visibility (or no data recorded for visibility). This resulted in 7,479 replicate surveys across 139 sites from 1996 to 2023.

A standardised index of relative biomass was generated by financial year (year ending June 30th) by using generalised linear mixed models with a Tweedie error distribution implemented with the 'GLMMTMB' package within R (Brooks *et al.*, 2017). To account for dependencies within the data such as repeated sampling at sites, multiple samples on the same day and potential latitudinal differences three random intercept effects were included in the model. These were:

- Ecoregion;
- Site Code; and
- Survey Date.

The models also included an offset for visibility. Month was tested for inclusion in the models but it showed no improvement when added at the model (delta-AIC = 6.09).

Standardisation of the RLS data from 1998 – 2023 showed an overall increasing trend overlaid on a cyclical pattern (Figure 7). Low biomasses were observed between 2005 and 2008, and 2019 – 2021 while high biomasses were observed from 2011 – 2013 and in 2018 and 2023. (Figure 7).

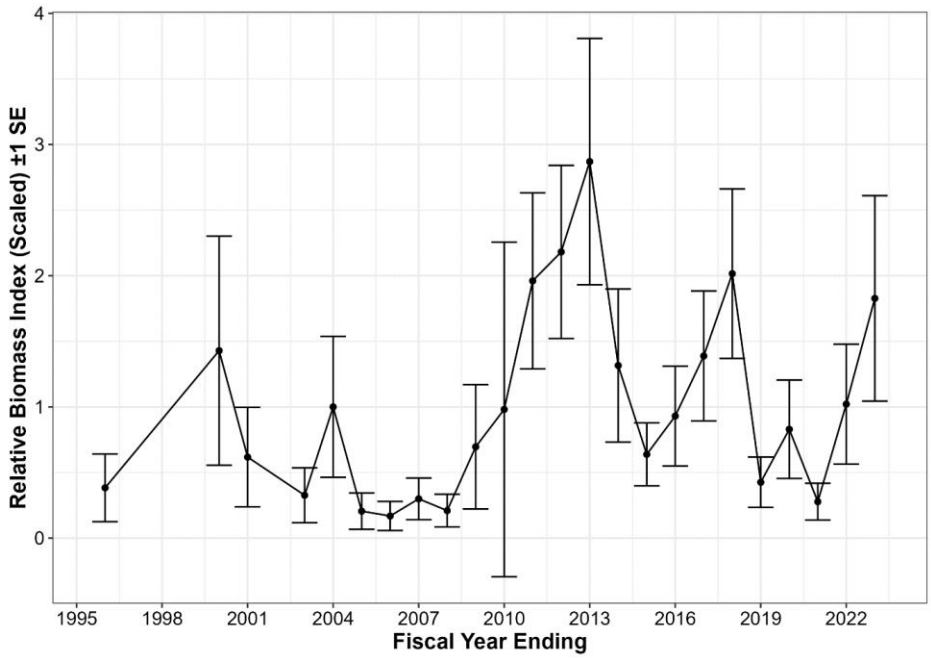

Figure 7 Standardised biomass index from the Reef Life Survey.

Stock Assessment

Stock Assessment Methodology

Year of most recent assessment:

2024 – Using data up to July 2023

Assessment method:

A weight of evidence approach was taken in this assessment including the following lines of evidence:

1. Inspection of commercial length frequency data and length frequency data from a fisheries-independent (diver-survey) dataset.
2. Standardised catch-rate analyses using both commercial fisheries and a fisheries-independent (diver-survey) dataset.
3. Inspection of commercial fisheries age frequencies.

Main data inputs:

The following raw data inputs were used in analyses:

- Reported commercial catch (kg) and effort (days) derived from fisher-reported monthly records (1998/99 – 2008/09);
- Reported commercial catch (kg) and effort (m of net) derived from fisher-reported daily records (2009/10 – 2022/23);
- Fish size and abundance data from the Reef Life Survey for surveys conducted within NSW (1995/95 – 2022/23);
- Representative length compositions of NSW commercial catch sampled in some years;
- Age at length data derived from otolith analyses taken as a subsample of the length composition monitoring (2007/08 onwards).

Key model structure & assumptions:

- Standardised catch rates

Key model structure: The standardisation process for the commercial mesh net data used Generalised Additive Mixed Models accounting for Estuary (random effect), Authorised FisherID (random effect), Month (cyclical smoother), Fishing Effort (either days fished for monthly data or m of net used for daily data), and Lunar phase (only the 2010-2023 period due to a need for daily resolution).

The standardisation process for the RLS data used Generalised Linear Mixed Models accounting for Ecoregion, Site Code, Survey Date, and visibility during the survey.

Assumptions: Annual catch rates are a relative index of abundance and not unduly influenced by other factors that are not accounted for through standardisation. The RLS biomass index similarly assumes that this is a relative index of biomass and that the sites surveyed are representative of a larger population.

- Length compositions

Assumptions: Lengths sampled from the commercial fisheries are representative of the wider luderick population (above a minimum size). RLS sites are representative of all Luderick habitats and all sizes of Luderick are detected consistently via visual survey.

- Catch curve analysis

Assumptions: Recruitment and mortality is constant over time. Catchability is constant for all ages above age of recruitment to the fishery. Age and length sampling are both representative of the population.

Sources of uncertainty evaluated:

No model-based assessments were conducted so there was no additional quantitative analysis of uncertainty.

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 visual survey data from the Reef Life Survey
Biomass Limit Reference Point	None specified in a formal harvest strategy. In the interim, for the purposes of this stock assessment current catch rates were assessed relative to long-term averages of each time series.
Biomass Target Reference Point	NA
Fishing mortality indicator or proxy	None specified in a formal harvest strategy. For the purpose of this assessment, estimates of fishing mortality (F) relative to nature mortality were made from catch curve analyses.
Fishing mortality Limit Reference Point	NA
Fishing Mortality Target Reference Point	None specified in a formal harvest strategy. For the purposes of this stock assessment, F ≈ M was assumed to represent an acceptable level of F.

Stock Assessment Results

The NSW Luderick stock is classified as **sustainable**. The status is based on:

1) No evidence of detrimental changes to the size structure with possible improvements in the size structure since the early 2000s as observed by increasing large fish observed as part of the Reef Life Survey;

2) Inspection of age frequencies in the commercial harvest suggest that total mortality (Z) declined between 2009 and 2019 and that fishing mortality is likely to be at a sustainable level (Z = 0.323, F = 0.098); and

3) Inspection of fishery dependent and fishery independent catch rates suggesting an increase in relative biomass since the early 2000s driven by an increase in recent years.

Catch Rates

Standardisation of Commercial Mesh Net data from 1998 – 2009 showed a largely cyclical pattern with no clear trend (Figure 5). Standardisation of Commercial Mesh Net data from 2010 – 2023 showed an overall increasing trend with a dip from 2013 – 2018 (Figure 6). When both time-series of CPUE are viewed together it suggests that Luderick biomass has likely increased over the last 25 years, largely driven by recent increases.

Standardisation of the RLS data from 1998 – 2023 showed an overall increasing trend overlaid on a cyclical pattern (Figure 7). Low biomasses were observed between 2005 and 2008, and 2019 – 2021 while high biomasses were observed from 2011 – 2013 and in 2018 and 2023. (Figure 7).

Length Compositions

The observed length frequencies from the commercial fisheries monitoring (all methods and estuaries pooled) showed that while the left side of the distribution became truncated, likely due to increased efforts to avoid retaining small Luderick, the right-hand side of the distribution appears to be relatively stable through time (Figure 8). The most recent year of length data (2018/19) appears to show a larger cohort progressing through the population. The mean length of Luderick appears to be stable over time with a small dip in 1988/89 and 1989/90 but these years had a very low sample size. Length compositions were investigated separately for Clarence River, Port Stephens, Tuggerah Lakes and Wallis Lake and the length compositions in each estuary appeared to be relatively stable. The Clarence River in the most recent year 2018/19 showed a larger proportion of larger fish than previously potentially suggesting increased survival of larger fish in the population or a strong cohort moving through the population.

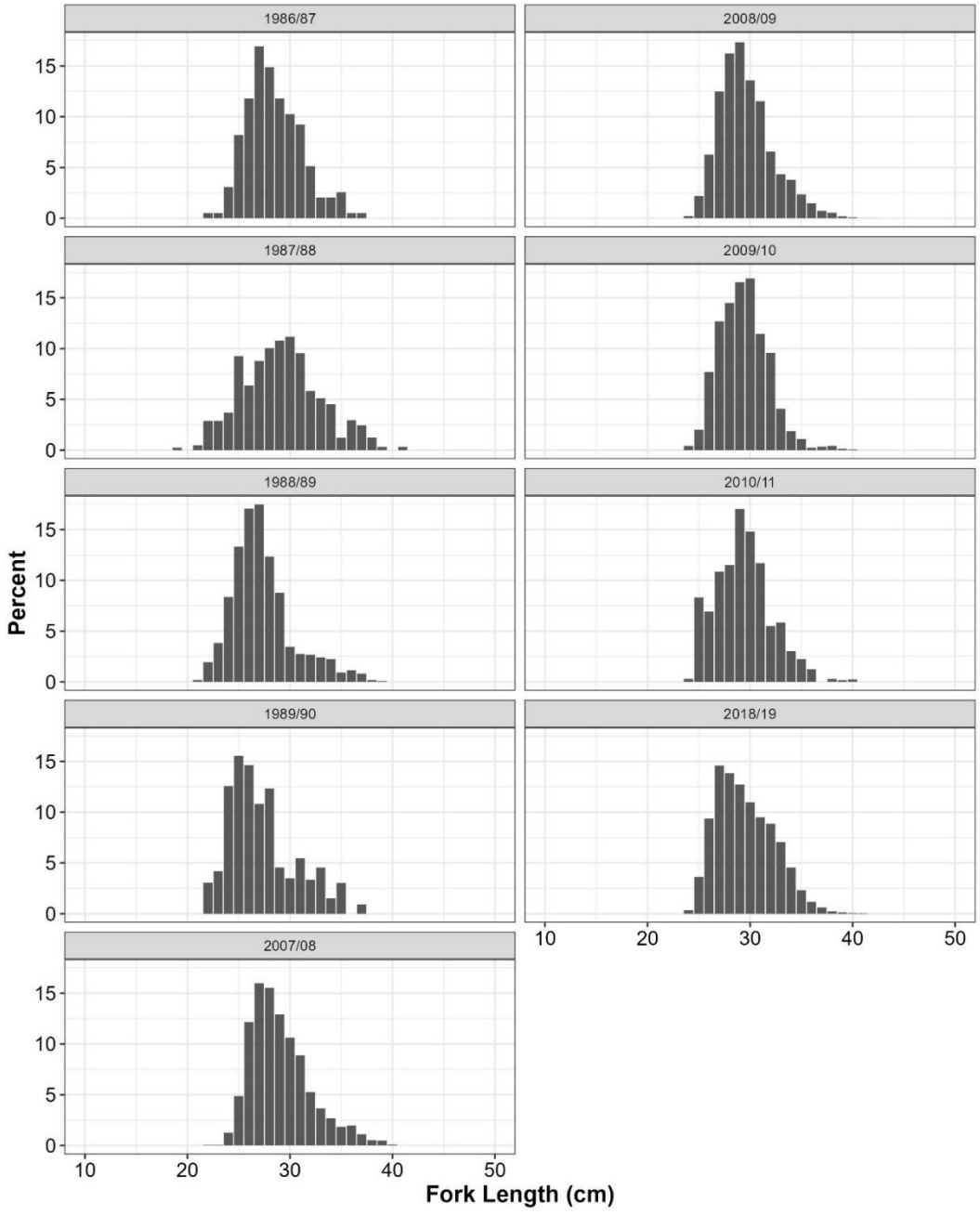

Figure 8 Observed length frequencies from the commercial fisheries monitoring.

The observed length frequencies from the RLS appears relatively stable through time (Figure 9). There are years with increased observations of small Luderick, potentially reflecting good recruitment years/cohorts (e.g. 2005 and 2008). There also appears to possibly be increased large Luderick with no Luderick in the 40cm bin prior to 2008 and regular observations after this time, noting sampling effort has increased over time.

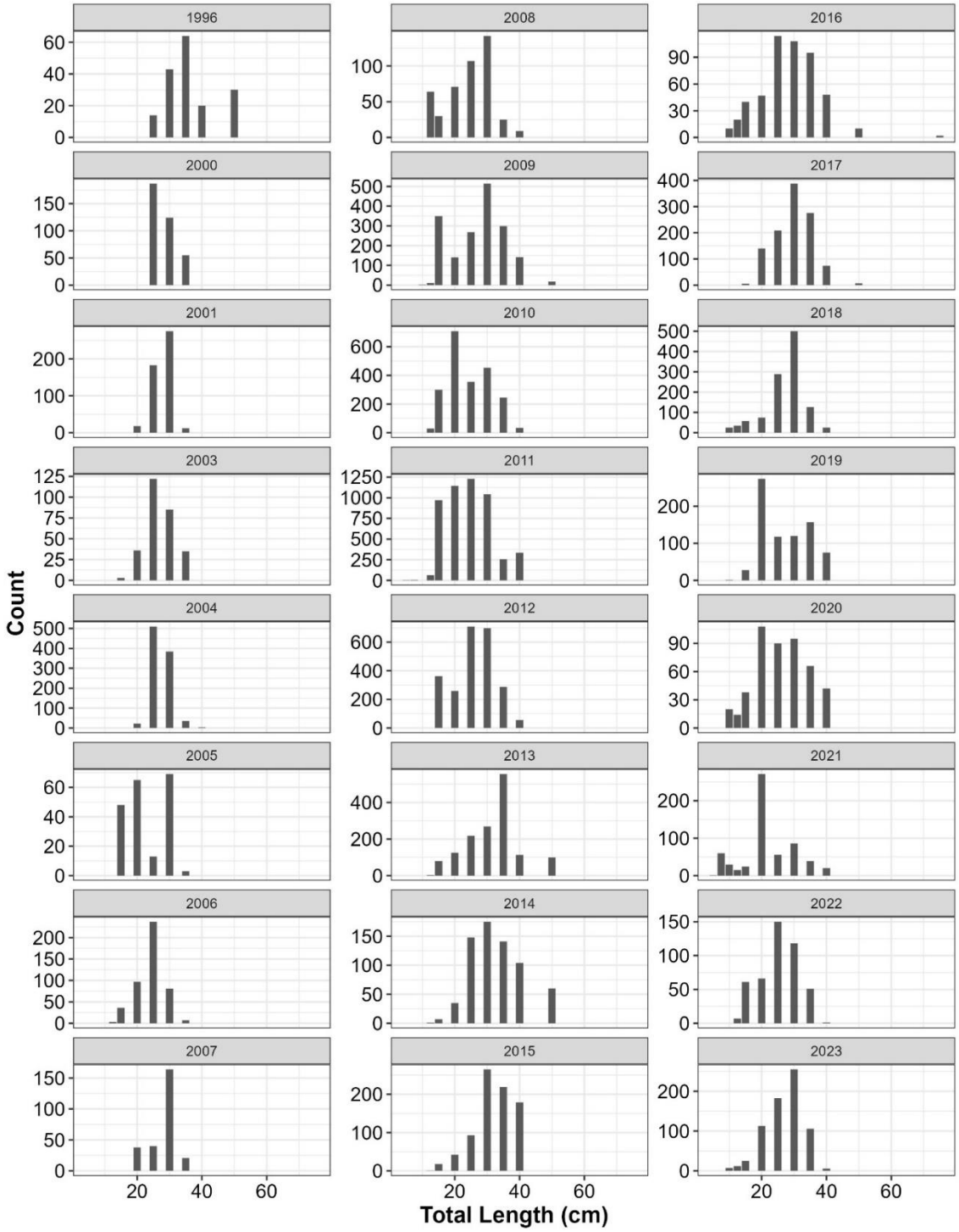

Figure 9 Observed length distributions from the Reef Life Survey. Note fish were assigned into bins of unequal sizes so these histograms are approximate size distributions.

Age Compositions

The commercial harvest of Luderick (calculated using annual age-length keys) was dominated by fish aged between 2 and 6 for most years for which age and length data were available (Figure 10). 2010/11 showed a relatively higher proportion of fish aged 7. Most years showed a long tail of older fish up to at least 17 years in all years except 2007/08. The modal age varied between years suggesting strong recruitment pulses are occurring.

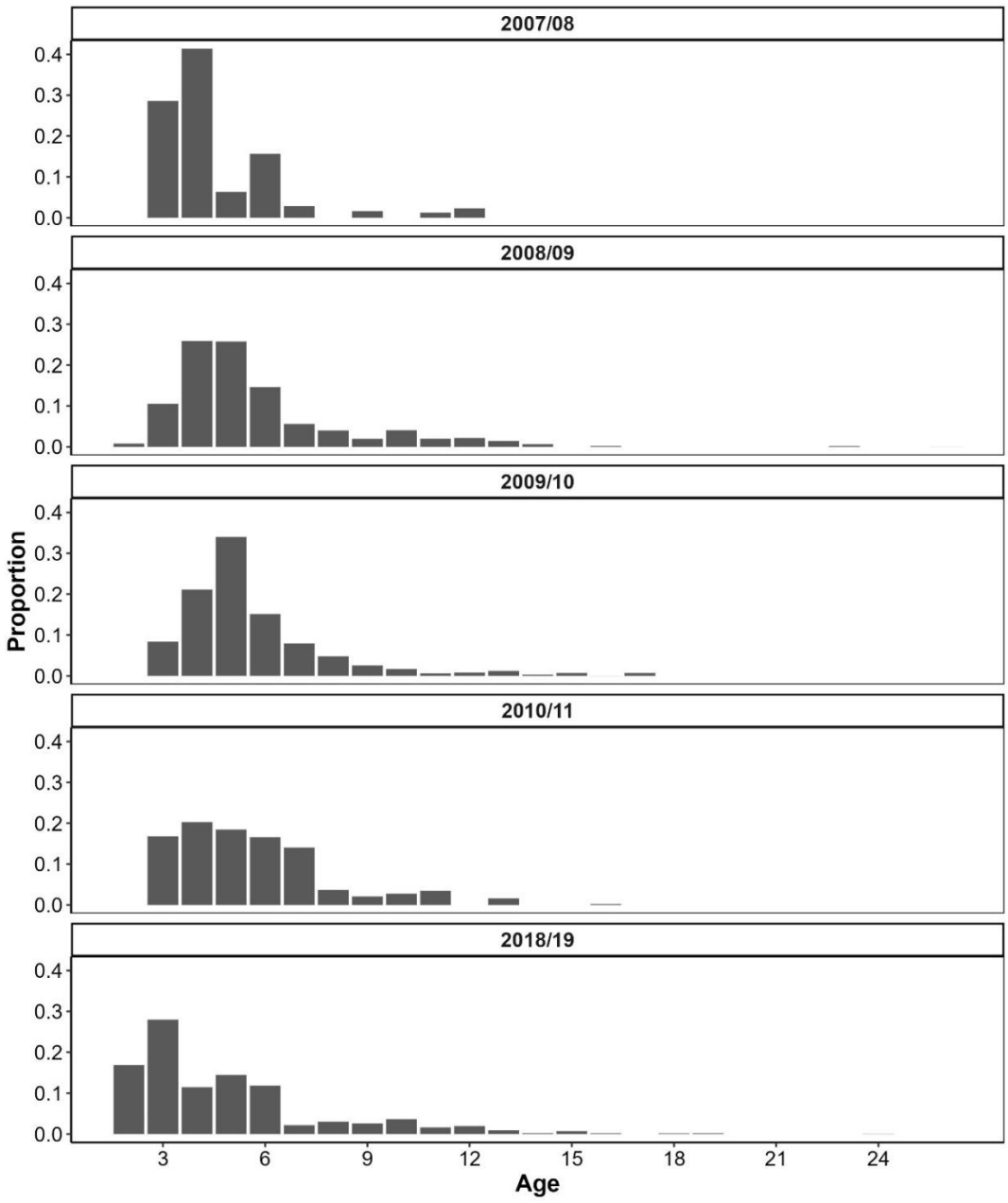

Figure 10 Age distributions of Luderick from the commercial fisheries monitoring program.

Total mortality (Z) as calculated from a catch curve analysis appears to have decreased between 2007/08 and 2018/19. The most recent estimate of Z (2018/19) is 0.323 (0.029 SE). Assuming the natural mortality (M) estimate of 0.225 (based on maximum age methods from Hamel & Cope (2022)), estimated fishing mortality (F) is 0.098 which is less than half of M.

Stock Assessment Result Summary

Biomass status in relation to Limit	Based on analysis of commercial catch rates, relative abundance appears to be stable with possible recent increases above the long term (1998-2023) average.
Biomass status in relation to Target	NA
Fishing mortality in relation to Limit	NA
Fishing mortality in relation to Target	Fishing mortality was estimated as 0.098. This was based a catch-curve analysis (Z = 0.323 + 0.029 SE in 2018/19) and an assumed natural M of 0.225 (Hamel & Cope, 2022). F is therefore less than M (0.098 < 0.225) based on an estimated Z of 0.323.
Current stock status	Sustainable (New South Wales)
SAFS stock status	SAFS (2020): Sustainable

Fishery interactions

Luderick are primarily caught in the Estuary General fishery but are also taken by the Ocean Hauling fishery and the recreational sector. There are currently no formal resource sharing agreements for Luderick.

Stakeholder engagement

Preliminary results from this assessment were presented at two online presentations to members of the Estuary General Fishery. No major concerns were raised at these meetings and follow-up conversations were held with some fishers.

Qualifying Comments

The current assessment represents a starting point for the assessment of NSW Luderick and is the first step of an evolving process of assessment and continual improvement of both data and models. A major assumption of this assessment is the reliance on CPUE trends and the RLS biomass index. Our assessment assumes these reflect real changes in biomass but these are potentially biased by operational, economic and social factors. Such biases may result in data and trends that do not reflect the biology of the stock. Using the length and age data as an alternative line of evidence reduces the impact of these biases in the overall analyses but integrating these lines of evidence in an integrated model with additional fisheries independent data could improve future assessments.

The current (post-2009) reporting requirements for effort in the use of Mesh Nets and Flathead Nets is the length of the net used which does not provide any information regarding the actual amount of effort or mesh size used. This increases uncertainty in the CPUE analyses of mesh net data. The change in reporting in 2009 also limits the conclusions that can be made around that time. While the harvest in the Ocean Haul fishery is smaller, it would be worth investigating the construction of standardised catch-rates for luderick from this fishery in addition to the mesh net CPUE.

There is uncertainty around the catch time-series, particularly the recreational catch. Factors other than fishing, including environmental factors, may affect abundance and biological functioning of fish stocks through time. Temporal and spatial variations in estuarine and nearshore oceanic conditions may influence available trophic resources, growth, population connectivity and ultimately recruitment. Knowledge of the interaction of these factors with fishing activity will be important for isolating the role of fishing on changes in the biomass of Luderick.

Fishing operations over the past four years are likely to have been affected to some extent by the COVID-19 pandemic, the severe bushfires during 2019/20, subsequent high rainfall and resulting flooding. These events showed clear impacts on estuaries and while they may have reduced fishing effort and catch in the most recent years they also potentially impacted fish population health.

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