Stock Status Summary 2021

NSW Stock Status Summary – Mulloway
(*Argyrosomus japonicus*)

Assessment Authors and Year

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Stock Status

Current stock status	On the basis of the evidence contained within this assessment, Mulloway is currently assessed as **Depleted** for the NSW component of the stock.

Stock Structure

Mulloway are widely distributed in estuaries and near-shore coastal waters (less than 200 m) of the Pacific and Indian Oceans, including subtropical and temperate waters of Australia [Griffiths & Heemstra 1995, Silberschneider & Gray 2008]. In Australia it has a wide distribution from the Gascoyne region on the west coast of Western Australia, around the southern coasts of the continent, and up to the Wide Bay–Burnett region on the east coast of Queensland [Kailola et al. 1993, Silberschneider & Gray 2008].

Biological stock structure for Mulloway in Australia is uncertain. It has been suggested that a single panmictic population occurs in Australia [Archangi 2008]. However, regional differences in genetics, and otolith morphology and chemistry suggest sub-structuring between populations in New South Wales (NSW), South Australia and Western Australia [Barnes et al. 2015, Ferguson et al. 2011].

The data presented in this summary relate to the NSW part of the stock.

Stock Status – New South Wales

Catch Trends - Commercial fisheries

Commercial landings of Mulloway in NSW have steadily declined from almost 400 t in the mid-1970s to a historic low of 37 t in 2008/09, and have been less than 100 t per year since the mid-1990s (Fig. 1). In 2018/19, the total State-wide commercial catch was 48 t.

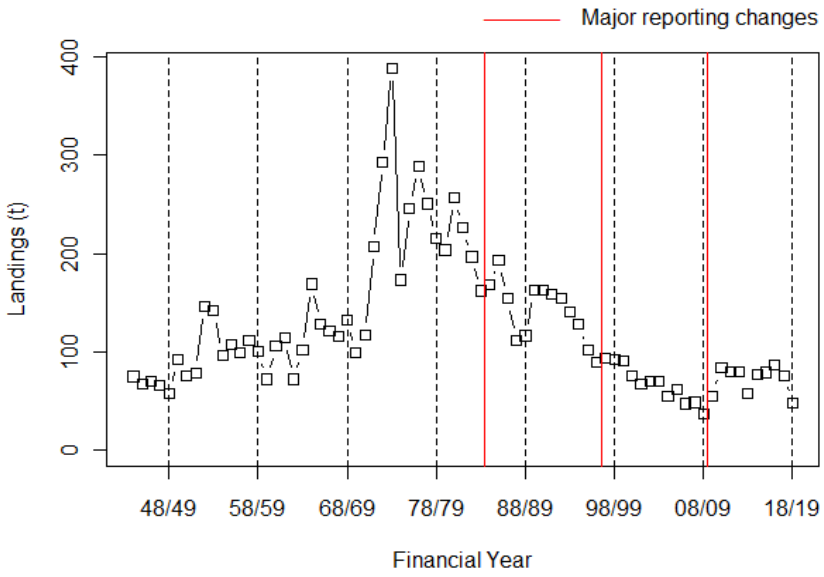


Figure 1. Commercial landings (including available historical records) of Mulloway for NSW from 1944/45 to 2018/19 for all commercial fishing methods.

Since 1997/98, the majority (~65%) of the commercial catch of Mulloway has come from the Estuary General (EG) mesh net fishery, however the most recent EG catch (2018/19) was one of the lowest recorded in the history of the fishery (Fig. 2). Catches from the Ocean Trap and Line (OTL) fishery made up around 40% of the catch between 1997-98 and 2003-04, but since this time have made a much smaller (10-20%) contribution to the overall catch. Ocean Haul (OH) catches are generally a small component of commercial landings (<10%), but high catches do periodically occur (e.g. 2005-06 & 2010-11; Fig. 2).

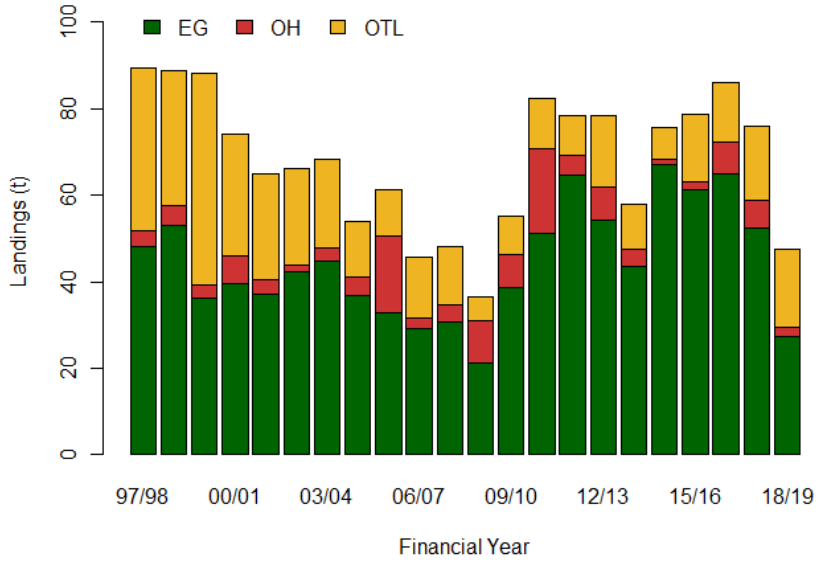


Figure 2. Landings by Fishery (including available historical records) of Mulloway in NSW for years 1997/98 to 2018/19. EG = Estuary General, OH = Ocean Haul, OTL = Ocean Trap & Line.

Recreational and Indigenous

The most recent estimate of the recreational harvest of Mulloway in NSW was approximately 12,000 fish weighing an estimated 90 t during 2017/18 (Murphy et al. 2020); greater than the commercial catch (72 t) in the same period (Fig. 1). This estimate encompassed harvest from NSW households within which a long-term (1-3 year) Recreational Fishing Fee licence holder resided (RFL household). Re-analysis of the previous survey done during 2013/14 for all NSW residents (West et al. 2015), to allow a comparison with the recent survey, produced an estimate of approximately 19,000 Mulloway harvested by RFL households during 2013/14 (Murphy et al. 2020). In 2000/01 the National Recreational and Indigenous Fishing Survey (Henry and Lyle 2003) estimated a recreational harvest by all fishers in NSW waters (including interstate visitors) at approximately 117,000 fish, noting that this estimate was for the species grouping 'Mulloway/jewfish' which included related species, in particular teraglin (*Atractoscion atelodus*). While these survey results are not directly comparable due to different sampling frames, the two most recent surveys likely represent a decline in recreational harvest through time.

There are no data on the indigenous harvest of Mulloway in NSW.

Fishing effort trends

Effort mesh netting in the EG fishery showed a decline from 11,000 days fished per year in 2002/03 to 5,500 days in 2008/09, followed by an increase almost 9,000 days in 2014/15 (Fig. 3). Since this time, effort mesh netting has declined sharply to just 3,000 days in 2018/19.

Effort handlining in the OTL fishery showed a steady decline from more than 5,000 days fished per year in 1997/98 to 1,000 days in 2008/09 (Fig. 3). Since this time, effort handlining has remained reasonably stable at around 1,300 days fished per year.

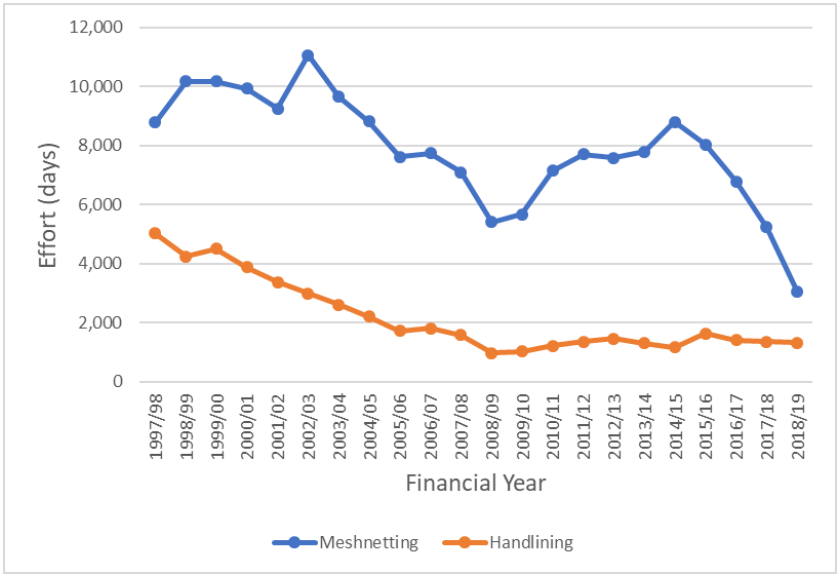


Figure 3. Annual reported days fished for Mulloway (mesh netting and handlining methods) 1997/98 to 2018/19.

Catch rate trends

Commercial fisheries

Commercial catch rates mesh netting (median kg per day) was stable at approximately 1 kg.day^{-1} between 1990/91 and 2008/09 (Fig. 4). Between 2009/10 and 2018/19, median CPUE mesh netting has not shown any discernible trend and has fluctuated around approximately 3 kg.day^{-1}.

Commercial catch rates for handlining (median kg per day) has fluctuated around 4.5 kg.day^{-1} between 1990/91 and 2008/09 (Fig. 5). Between 2009/10 and 2016/17, median CPUE handlining has fluctuated around 5 kg.day^{-1}. Since this time CPUE handlining has increased slightly to 7.2 kg.day^{-1} in 2017/18 and 6.8 kg.day^{-1} in 2018/19 (Fig. 5).

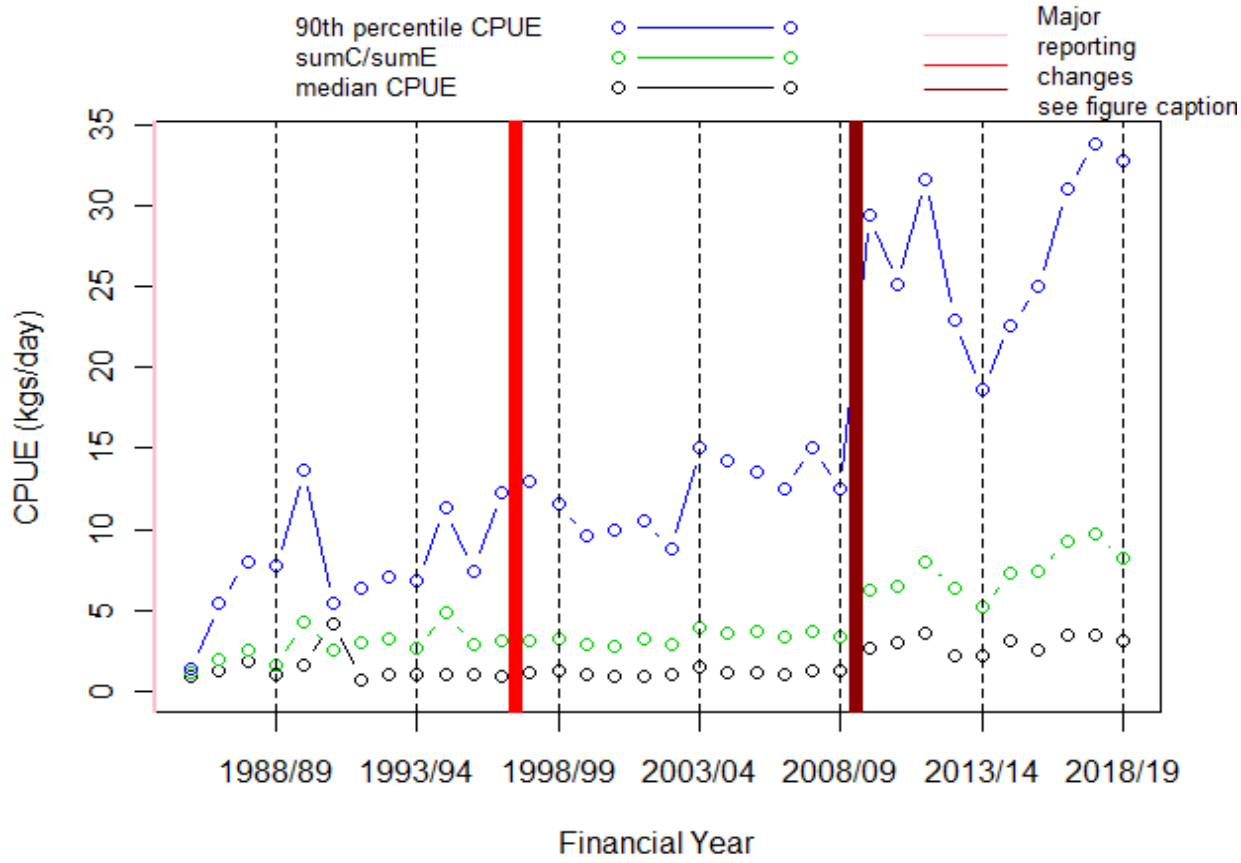


Figure 4. Commercial catch rates of Mulloway mesh netting for years 1984/85 to 2018/19 in NSW. Three indicators are provided: (1) median catch rate from available monthly records (black line); (2) sum of the catch divided by the sum of the effort (green line); and (3) 90th percentile of the catch rate from available monthly records (blue line). Records with a zero-catch rate (i.e. no catch recorded) are not included in these analyses.[1]

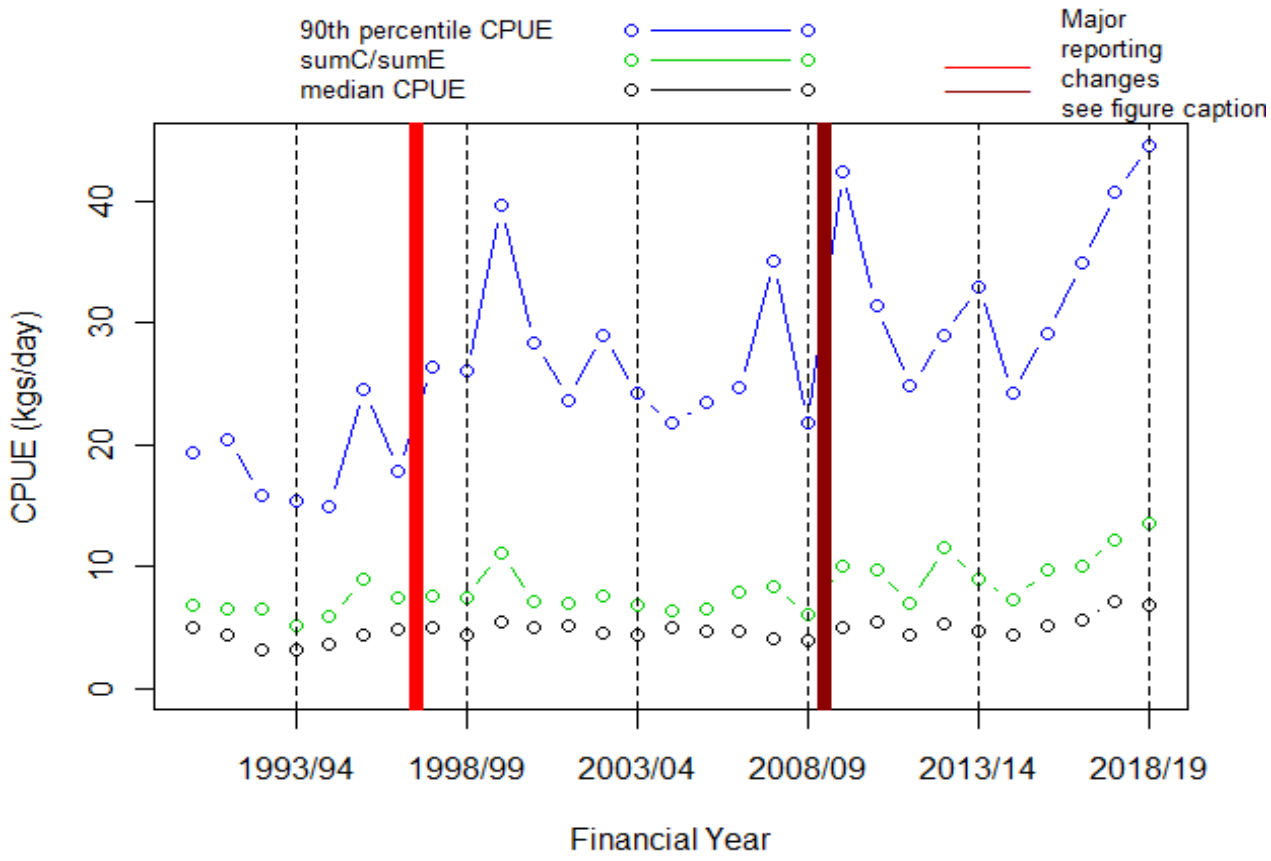


Figure 5. Commercial catch rates of Mulloway using Handlining for years 1990/91 to 2018/19 in NSW. Three indicators are provided: (1) median catch rate from available monthly records (black line); (2) sum of the catch divided by the sum of the effort (green line); and (3) 90th percentile of the catch rate from available monthly records (blue line). Records with a zero-catch rate (i.e. no catch recorded) are not included in these analyses.[1]

[1]From July 2009 onwards, catch rates were estimated from the number of distinct fishing dates entered on daily catch returns in a month where the method was used irrespective of whether the species was reported on those days, to be consistent with the July 1997 to June 2009 logbooks. From July 1997 to June 2009, catch rates were estimated from the days fished, by method, as entered on the monthly catch return. Therefore, joining the dots from 1996/97 to 1997/98 OR 2008/09 to 2009/10 may not be an accurate representation of change in CPUE across these years. CPUE trends within each reporting period may also not be an accurate representation of change in CPUE if the relationship between days using specified fishing methods and targeting Mulloway changed or there were misreporting issues).

Stock Assessment Methodology

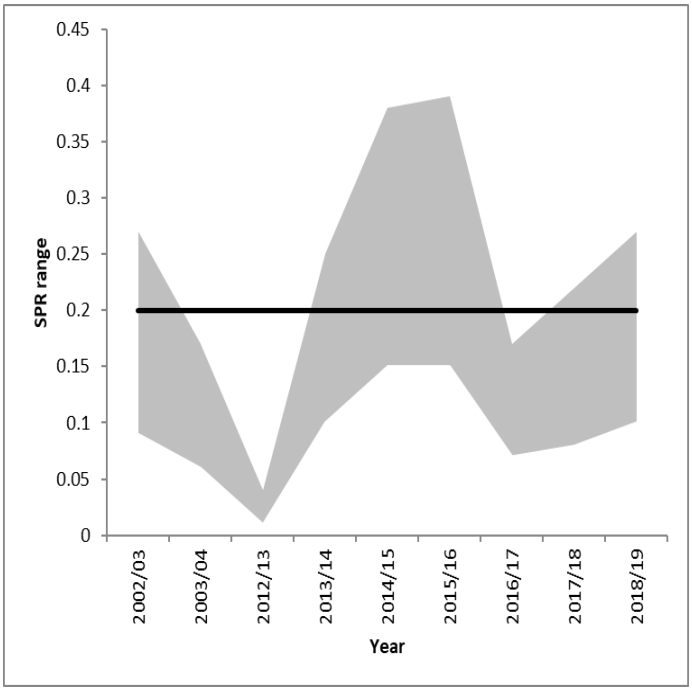
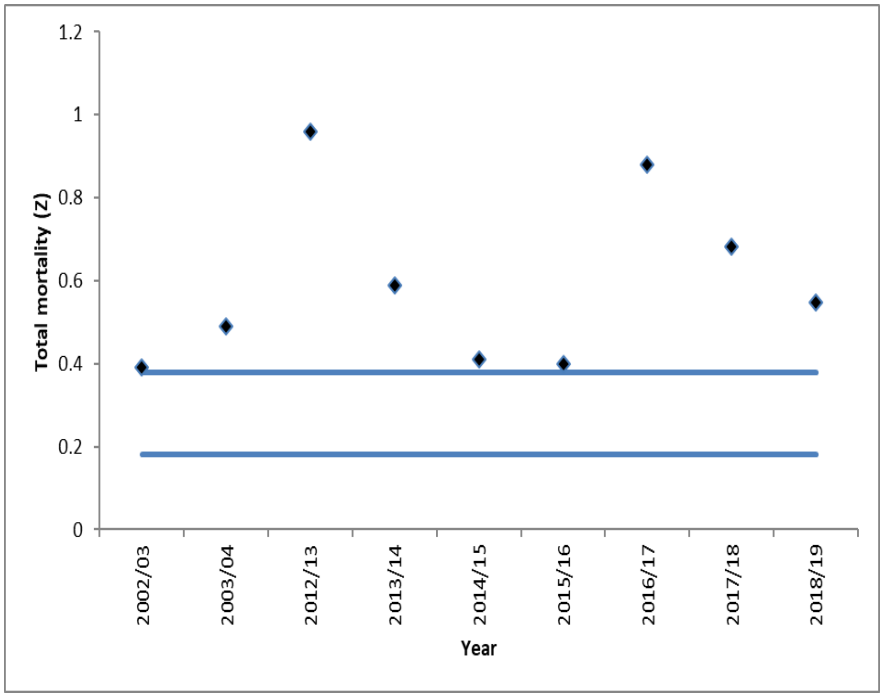
Year of most recent assessment	2020
Assessment method	Weight-of-evidence, including: 1. Reported commercial catch 1944/45-2018/19 2. Estimated recreational catch 2000/01, 2013/14, 2017/18 3. Commercial catch rates 1990/91-2018/19 4. Length composition 1986/87-2018/19 5. Mortality estimates 2002/03-2003/04, 2012/13-2018/19 6. Spawning potential ratio (SPR) analyses 2002/03-2003/04, 2012/13-2018/19 7. Yield-per-recruit (YPR) analyses 2002/03-2003/04, 2012/13-2018/19
Main data inputs	1. Reported commercial catch 1944/45-2018/19 2. Estimated recreational catch 2000/01, 2013/14, 2017/18 3. Commercial catch rates 1990/91-2018/19 4. Length composition 1986/87-2018/19 5. Mortality estimates 2002/03-2003/04, 2012/13-2018/19 6. Spawning potential ratio (SPR) analyses 2002/03-2003/04, 2012/13-2018/19 7. Yield-per-recruit (YPR) analyses 2002/03-2003/04, 2012/13-2018/19
Key model structure and assumptions	<u>Length composition</u> The length composition of commercial catches is used in calculation of mortality rates (see “Catch curve analysis” below) and subsequent SPR and YPR modelling. *Assumptions:* If the size composition of commercial landings is not representative of size composition of the stock, then these mortality estimates and subsequent calculations of SPR and YPR may affect the assessment of biomass and fishing mortality levels derived from these models. <u>Catch curve analysis</u> Total mortality estimates (Z) were made using age-based catch curve analysis [Chapman & Robson 1960] by applying annual age-length keys to commercial length frequency distributions (see ”Length composition” above) to generate annual age frequency distributions. Where an annual age-length key was unavailable (2017/18 & 2018/19), Z was estimated using the length-converted catch curve method outlined in Caddy [1983]. Mortality estimates were made using a plausible range of values for natural mortality (M). *Assumptions:* Sampling is from a population not affected by

	immigration or emigration, mortality is constant across ages and years, and sampling is not biased regarding any age classes.
Sources of uncertainty evaluated	Length composition. The size composition of commercial catches is used calculation of mortality rates (catch curve analysis) and subsequent estimates of SPR and YPR. If the size composition of commercial landings is not representative of size composition of the part of the Mulloway stock which occurs in NSW waters, then mortality estimates, SPR and YPR analysis models based on them, may not accurately reflect changes in biomass and fishing mortality levels derived from them. A non-representative commercial length composition could occur if: • Fishers selectively target small fish and/or selectively avoid larger fish (e.g. for marketing reasons – price) • Large fish are less catchable than smaller fish because of gear selectivity, behaviour or distribution • Routine port-based sampling does not sample large fish (e.g. small fish are sent to market where they are measured, but large fish are sold locally) • Age has been systematically underestimated in old age classes (the age-length relationship is incorrect). Catch curve analysis Mortality estimates were made using a plausible range of values for natural mortality (M). These estimates came from the methods of Pauly [1980], Hoenig [1983] and Then et al. [2015], which provided an upper (M=0.19; [Then et al. 2015]) and lower value (M=0.09; [all others]) for M. Subsequent mortality rate comparisons and YPR and SPR analyses were therefore done using this range of M.

Status Indicators and Limits Reference Levels

Biomass indicator or proxy	Current SPR Commercial catch rates
Biomass Limit Reference Level	SPR <20% virgin level indicator of low spawning stock biomass (SSB) and exploitable biomass [Goodyear 1993, Mace and Sissenwine 1993]
Fishing mortality indicator or proxy	Current mortality estimates (Z, F & M) Current YPR estimate Length composition (auxiliary indicator)
Fishing mortality Limit Reference Level	F>>M (through time) YPR > minimum legal length MLL (through time)

Stock Assessment Results

Commercial CPUE	Refer Figures 4 – 5
SPR modelling Figure 6. Range of spawning potential ratio (SPR) estimates for Mulloway in NSW (grey shaded area) for the periods 2002/03-2003/04 & 2012/13-2018/19 using a plausible range of M. The horizontal line represents the 20 per cent SPR limit reference point.	
Mortality estimates Figure 7. Total mortality (Z) estimates for Mulloway in NSW estimated from catch curve analysis of size frequencies generated from commercial landings for the periods 2002/03-2003/04 & 2012/13-2018/19. The area between the horizontal blue lines represents 2 x M (range using upper and lower estimates as described above).	

Length composition

Figure 8.Average total length (cm ± SE) of the NSW commercial catch of Mulloway from 2004/05 to 2018/19.

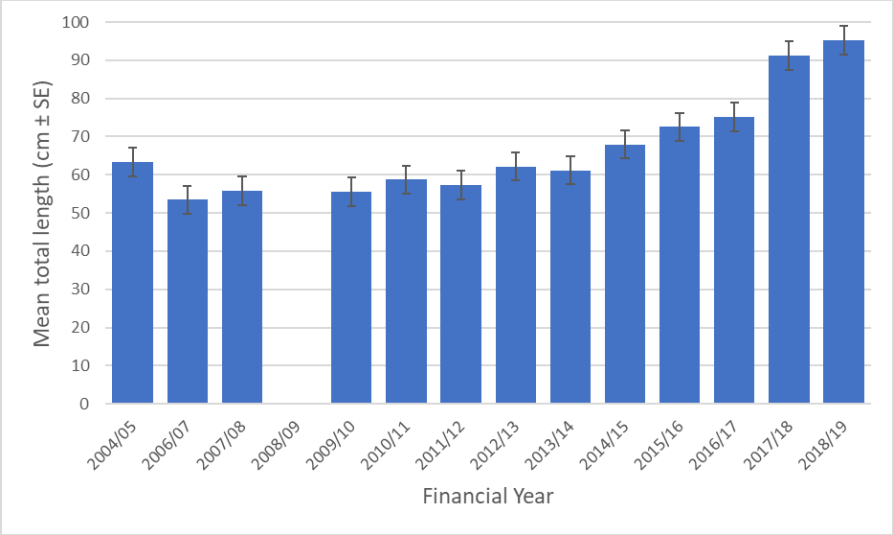


Figure 9. Size composition of the NSW commercial catch of Mulloway from 2004/05 to 2018/19.

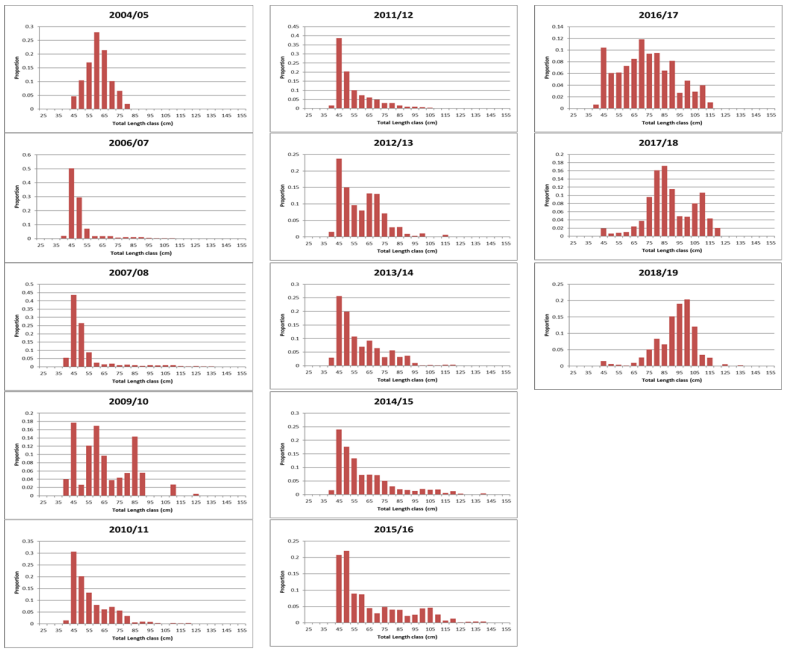
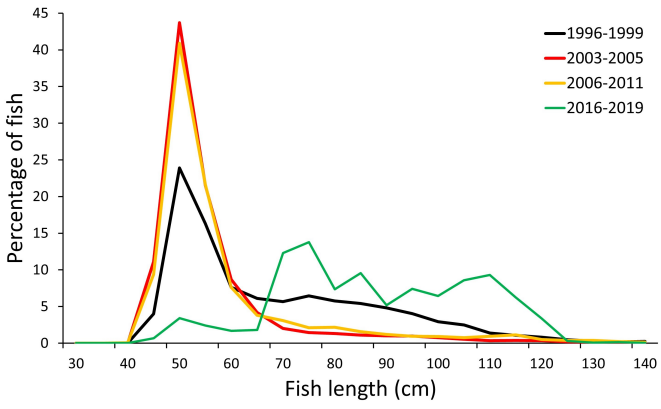
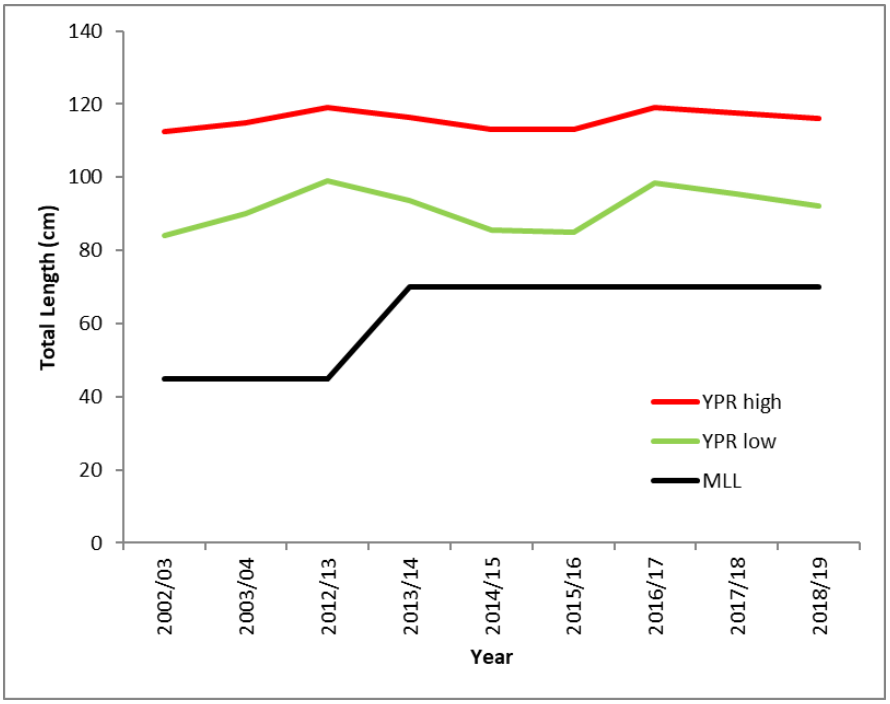


Figure 10. Size composition of the NSW commercial catch of Mulloway for the periods 1996-1999, 2003-05, 2006-2011 and 2016-19.



YPR modelling Figure 11. Range of total lengths (cm) which would produce maximum yield-per-recruit (YPR) for Mulloway in NSW depending on the estimate of M used (low M – red line, high M – green line) for the period 2002/03 to 2018/19. The black line represents the minimum legal length.	
Biomass status in relation to Limit	Commercial catch rates No trends are evident in commercial CPUE for the main fishing method, estuary mesh netting (Fig. 4), however a slight increase in CPUE for line fishing since 2009 suggests a possible increase in relative abundance in the ocean fishery (Fig. 5). SPR modelling SPR range for Mulloway has been consistently estimated to be below the limit reference point of 20% with reasonable probability for most years (Fig. 6). This suggests that under fishing levels for most years that the long-term spawning stock biomass (SSB) would be below the limit reference level and that there may be a risk of recruitment failure [Goodyear 1993, Mace and Sissenwine 1993]. Current SPR is between 10 and 27% of virgin level and infers likely low SSB and exploitable biomass.
Fishing mortality in relation to Limit	Mortality estimates Total mortality rates (Z) have been estimated to be between 0.40 and 0.96 since 2012/13 (mean 0.64). These values indicate that fishing mortality rates (F) have been consistently estimated to be several times greater than M since 2012/13 (Fig. 7). Current estimated Z is 0.51, at which point F is between 0.32 and 0.42 (M=0.09-0.19).

	Length composition The annual average lengths of Mulloway landed by the commercial fishery have declined since the mid-1990s, but have been stable since the mid-2000s except for the effect of increasing the minimum legal length (MLL) from 45 cm total length (TL) to 70 cm TL in 2013 (Fig 8-10). The commercial Mulloway fishery was historically based largely on juveniles, and the truncated length composition of fish in commercial landings since the mid-2000s was indicative of a heavily fished stock (around 80 per cent of the catch was <70 cm TL, the approximate length at maturity for female Mulloway; Figs 8-10). Despite the increase to the MLL in 2013, the commercial fishery (primarily the estuarine mesh net fishery) continued to be based on juveniles up until 2016/17 (Figs 8-10). Only since 2015/16 has the average lengths of Mulloway in the commercial fishery increased to be >70 cm TL (Figs 8-9) and only since 2017/18 has the proportion of fish in the landed catch <70 cm TL fallen below 10% (Fig. 9). YPR modelling Mulloway in NSW are harvested at an average size that is considerably smaller than the size that would produce the maximum yield per recruit at all estimates of M. Even after the increase to the MLL in 2013, maximum YPR occurs at a length of between 91 and 116 cm. This is between 20 and 50 cm larger than the current MLL indicating that Mulloway in NSW are likely to be "growth overfished" (Fig. 10).
Previous SAFS stock status	"Overfished" in NSW assessments 2004/05 – 2014/15 New South Wales stock "Overfished" SAFS 2014 New South Wales stock "Overfished" SAFS 2016 New South Wales stock "Depleted" SAFS 2018
Current SAFS stock status	Weight-of-evidence in relation to biomass: • Commercial CPUE for the main fishing method (mesh netting) since 1997/98 shows no discernible trend and infers stable abundance of juvenile individuals. Commercial CPUE for ocean linefishing infers slightly increased abundance in this fishery, but only for the past two years. • The Spawning Potential Ratio (SPR) has been below the limit reference point with reasonable probability for most years since the early 2000s. • Current SPR is between 10 and 27% of virgin levels, which is below the limit reference level (20%) with reasonable probability inferring low spawning stock and exploitable biomass and a risk of recruitment failure.

	Weight-of-evidence in relation to mortality: • Fishing mortality (F) has been consistently estimated to be several times higher than natural mortality (M) in recent years and F is currently >2M. • Length composition of the commercial catch indicates that fishery has been based largely on juveniles since at least the 1990s and only in the last 2-3 years has the catch been dominated by mature-sized fish. • The MLL is considerably smaller than the size that would produce the maximum yield per recruit at all estimates of M ("growth overfished"). Summary The above evidence indicates that the biomass of this stock is likely to be depleted and that recruitment is likely to be impaired. The above evidence indicates that current fishing mortality is constrained by management to a level that should allow the stock to recover from its recruitment impaired state; however measurable improvements are yet to be detected. On the basis of the evidence provided above, this stock is classified as a **Depleted** stock.

Qualifying Comments

The weight-of-evidence approach used here to assess stock status reveals some uncertainty due largely to the lack of data on size composition from historical landings (commercial and recreational) and the historic recreational harvest. Nevertheless, outputs from SPR modelling provides confidence that the current biomass of the stock is likely to be below the limit reference point of 0.2 unfished biomass (B_{lim}) with reasonable probability. Mortality estimates of F>2M indicates likely excessive historic mortality to due to fishing. Commercial length compositions indicate that the commercial fishery has been largely based on juveniles for at least the past 30 years. Under current management arrangements, commercial length compositions over the past 2-3 years indicates the catch to be dominated by mature fish, which should allow the stock to recover from its recruitment impaired state; however measurable improvements in biomass or mortality are yet to be detected.

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