

Monitoring and assessment of the impact of management changes under the Mulloway recovery program

Background

Mulloway have been classified as Overfished in NSW since 2004/05 and a Recovery Program (RP) to assist the stock to rebuild was implemented on the 1st November, 2013.

Assessment of the mulloway stock indicated that the number of spawning fish was below the level considered critical for ongoing replenishment of the stock. More detailed analyses indicated that fishing-related mortality on the adult (> 70 cm fish) part of the stock was excessive and that fishing-related mortality on juveniles greatly excessive.

The goal of the mulloway recovery program was therefore to increase the spawning stock size of mulloway by reducing fishing mortality on both the adult and juvenile parts of the stock.

The changes in management as part of the recovery program were directly related to reducing this fishing mortality proportionally amongst sectors that contribute to this mortality.

New fishing rules for mulloway in NSW after 1st November 2013

- The recreational bag limit for mulloway was reduced from 5 to 2 fish.
- The minimum legal length for recreational and commercial fishing was increased from 45 cm to 70 cm.
- Commercial Estuary General fishers using meshing nets have a by-catch allowance (possession limit) of 10 fish between 45 and 70 cm.
- A 500 kg possession limit for commercial Ocean Hauling endorsement holders.

The Department is committed to best practice regarding species recovery programs which includes regular reviews to ensure that the predicted outcomes are occurring. Monitoring of the mulloway stock as well as the commercial and recreational fisheries for them has occurred after implementation of the new rules.

The information presented in this report summarizes these monitoring and program assessments after nearly three years of the recovery program being in place.

Monitoring methods

Information on the fisheries for mulloway is obtained from a range of sources.

Commercial Logbooks

Commercial fishers in NSW are required to report their daily fishing activities. Analysis of these daily fishing reports provides for an understanding of the quantities being landed by commercial fishers in NSW as well as where, when and by which method. The commercial logbooks do not report on fish discarded or the sizes of fish landed.

The mulloway recovery program commenced on the 1st November 2013. Comparisons of commercial landings before and after the recovery program were therefore analysed for a November to October yearly period. The data used was extracted from the Departmental database on the 6th September 2016. There is a time lag between fishing and logbook submission and database entry, as such the catch figures for 2015/16 will be incomplete.

Commercial Landings Monitoring

NSW DPI runs a scientifically designed long-term monitoring program which documents the sizes of more than 30 fish species landed by the commercial fishing industry each year. This work is done at regional Fishermen's co-operatives and at the Sydney Fish Markets. Sampling is detailed and

stratified into different latitudes, estuary and ocean fisheries and monthly periods. Sampling effort on mulloway was increased following implementation of the mulloway recovery program.

Recreational survey data

Information on the numbers of mulloway caught (retained and released) by recreational fishers in NSW is obtained through recreational fishing surveys. An Australia-wide survey was completed in 2000/01 and a similar comprehensive statewide NSW survey completed in 2013/14 (survey period June 2013 to May 2014).

Research Angler Program

The NSW Research Angler program utilizes keen recreational fishers to contribute to stock assessments. The program was initiated with mulloway and focussed on fish frame donations from which biological information (including fish age) could be extracted. The program also has mulloway tagging (run collaboratively with ANSA NSW) and fishing diary components.

Scientific Assessment

Scientists from NSW DPI assess the status of all exploited marine species annually. The annual assessment for mulloway considers all the information gathered from the above sources.

Results

Commercial Logbooks

Commercial landings of mulloway peaked during the 1970s at nearly 400 t p.a., followed by a 30 year decline (Fig. 1). Landings have increased slightly following 2009/10.

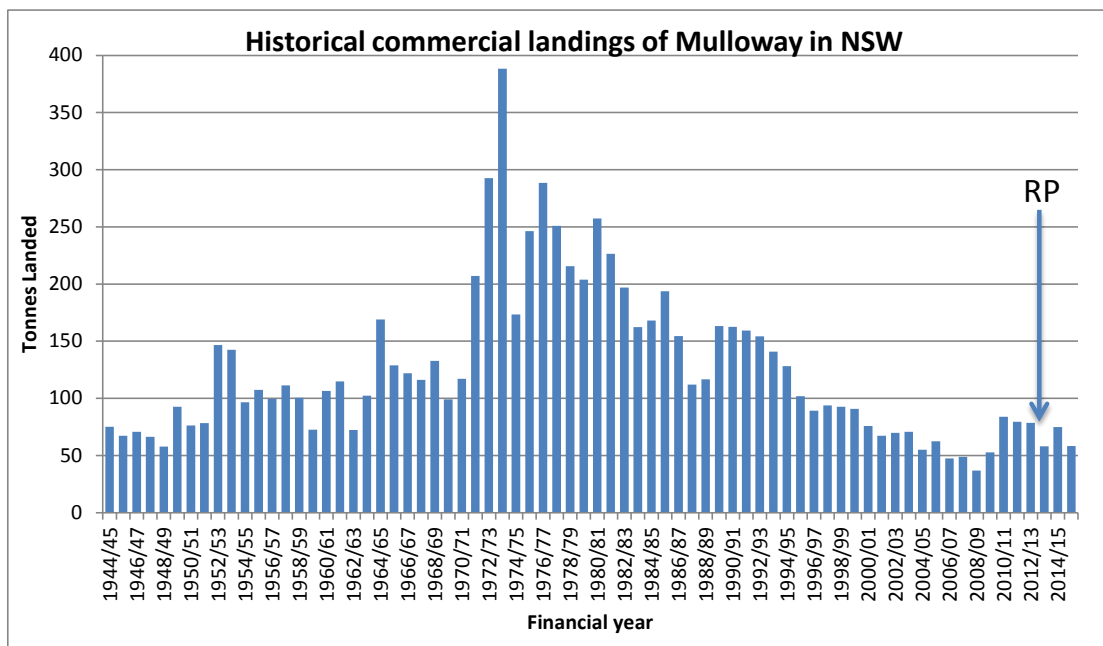


Figure 1. Total reported commercial landings of mulloway in NSW. RP indicates the mulloway Recovery Program.

The majority of the commercial landings of mulloway are reported in the Estuary General fishery (Fig. 2). The proportion of ocean-caught mulloway (Ocean Hauling and Ocean Trap & Line) has declined steadily. Recent increases in total landings have been driven mainly by increases in the Estuary General Fishery.

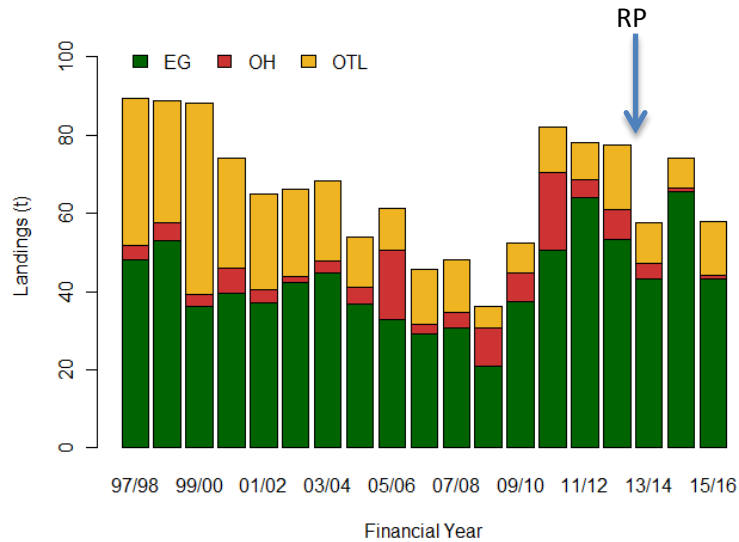


Figure 2. Landings of mulloway by commercial fishery since 1997/98. EG = Estuary General, OH = Ocean haul and OTL = Ocean Trap and Line. RP indicates the mulloway Recovery Program.

Commercial landings November to October yearly time step

Total annual commercial landings of mulloway declined in the year following the recovery program implementation (Fig. 3). Landings subsequently increased in 2014/15 to approximately 80 t. Initial indications of the total commercial landings for the first 10 months of 2015/16 period suggest that there will be a decline since 2014/15. Landings in the Ocean Trap & Line fishery declined substantially from 16 t in 2012/13 to approximately 8 t in 2013/14 and were around 10 t in each of the most recent years.

Landings in the Estuary General fishery declined slightly from 52 t to 46.7 t the year following the recovery program. Landings then increased substantially in 2014/15 to 67 t, initial data for 2015/16 period suggest that a decline will be evident.

Landings in the Ocean hauling fishery declined to less than 2 t in the year following the recovery program and have been very low at less than 1 t p.a. since that time.

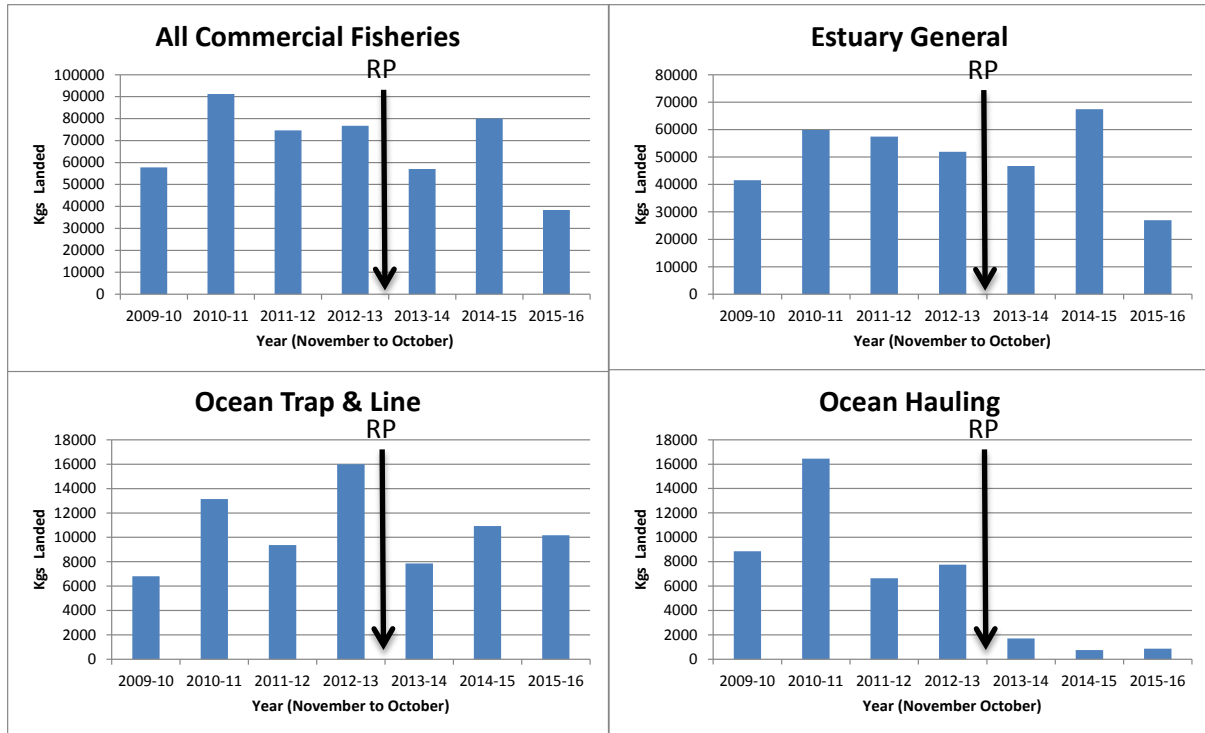


Figure 3. Reported commercial landings of mulloway since 2009/10 (November to October). Note that 2015/16 is November 2015 to August 2016 and will also be an under-estimate due to a lag between fishing and records being entered into the DPI database. RP indicates the mulloway Recovery Program.

Commercial landings by estuary

Since 2008/09 the major commercial landings of mulloway have come from the Hawkesbury, Clarence, Shoalhaven, and Hunter rivers (Fig. 4).

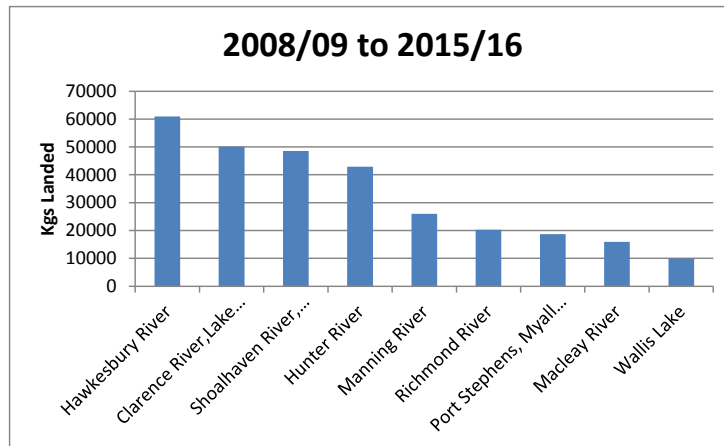


Figure 4. Major commercial estuaries for mulloway landings 2008/09 onwards.

The major estuaries for commercially landed mulloway did not show any marked declines in landings following the recovery program, with the exception of the Macleay River from which landings declined by around 50%. The largest mulloway producing estuaries the Hawkesbury, Clarence and Shoalhaven rivers in particular showed no real declines beyond the normal year to year variation seen for these estuaries, with the exception of the 2013/14 year in the Hawkesbury which was substantially lower than the year preceding the recovery program. Landings for the first 10 months of the 2015/16 period indicate that a decline is expected.

Commercial Landings Monitoring

Sampling commercial landings of mulloway has increased since the recovery program was introduced (Fig. 5). Since 2013/14, 472 different catches of mulloway have been sampled across the state and more than 5,000 fish measured. Sampling has been comprehensive and has resulted in a high degree of confidence that the data represents landings by commercial fishers in NSW.

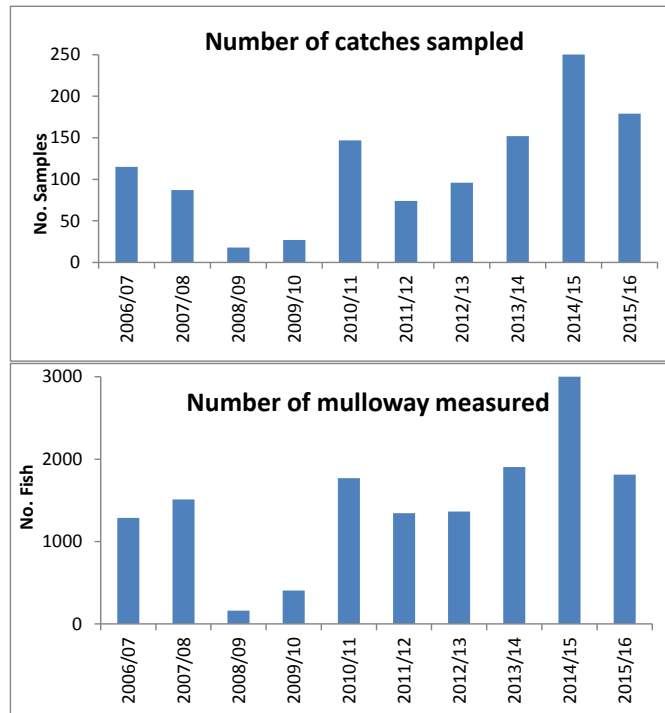


Figure 5. The numbers of commercial catches of mulloway sampled and the number of mulloway measured as part of the commercial fishing port monitoring program since 2006/07.

The sizes of mulloway landed by the commercial fishery have fluctuated each year since 2011/12 (Fig. 6). Variations are driven by the relative abundance of strong cohorts (for example those 45 to around 55 cm fish represent the 2 year old cohort and those 65 to 75 cm fish mainly represent the 3 year old cohort) and the relative activity of the different fishing sectors (mesh netting, hauling and line fishing). There has been a slight change in the sizes of mulloway being landed, with larger fish (> 90 cm) more apparent in recent years. These larger fish have been observed in both the estuarine and offshore fisheries.

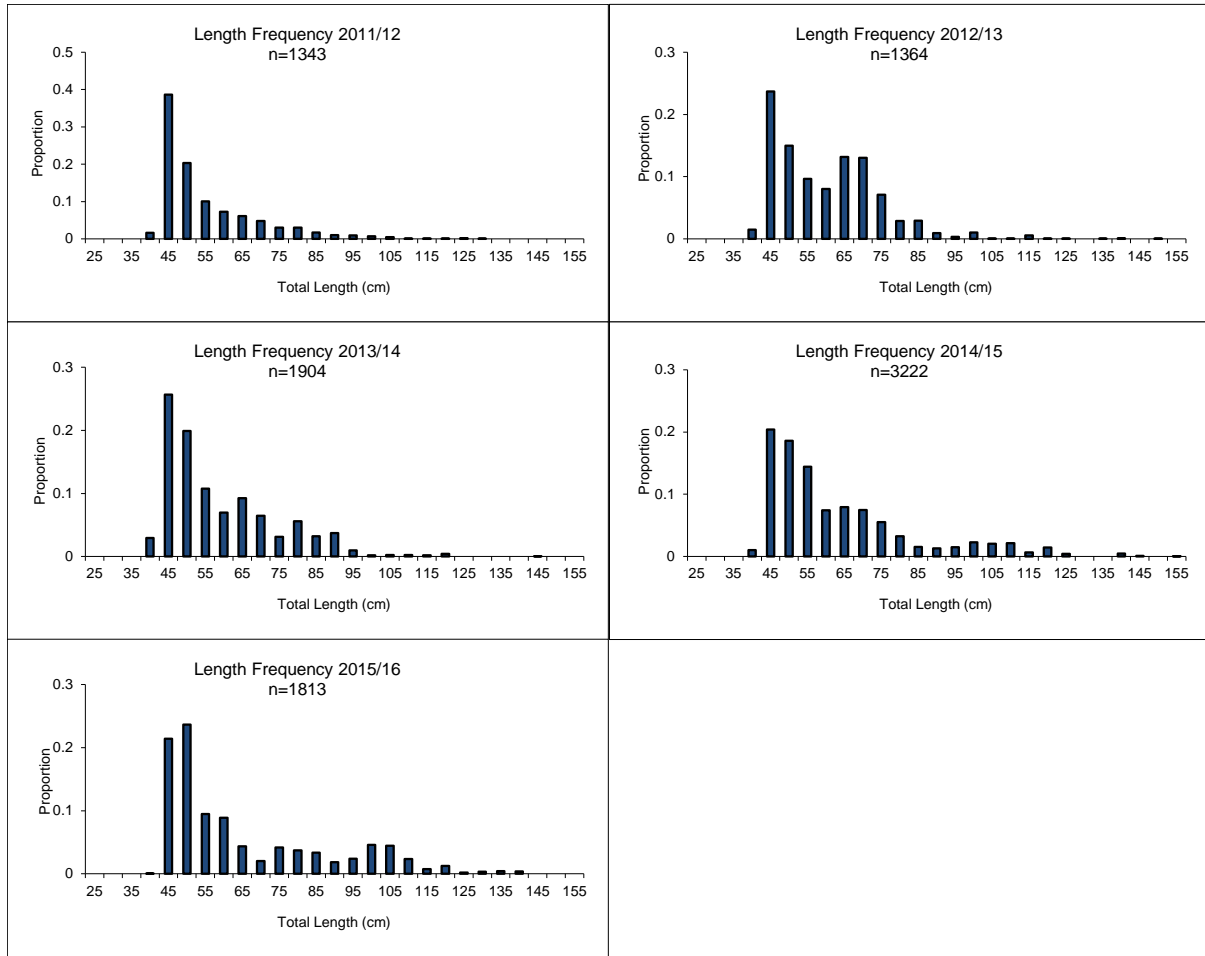


Figure 6. The sizes of mulloway landed by the commercial fishing industry since 2011/12. The length frequencies are representative of the entire industry across all fisheries and methods.

Estuary General mesh net fishery

The majority of commercial landings (88% in 2014/15 and 74% in 2015/16) are landed by the Estuary General fishery with almost all those (>95%) being caught in mesh nets.

The sizes of mulloway being landed by the Estuary General mesh net fishery has not changed substantially since the implementation of the recovery program (Fig. 7). More than 85% of the landed catch is smaller than 70 cm total length. Note that these data contain landings from a mix of mesh sizes and it is not possible to associate a catch with a particular net mesh size. It is not surprising that the sizes of fish being landed from mesh netting has not changed markedly if the mesh sizes being used has not changed.

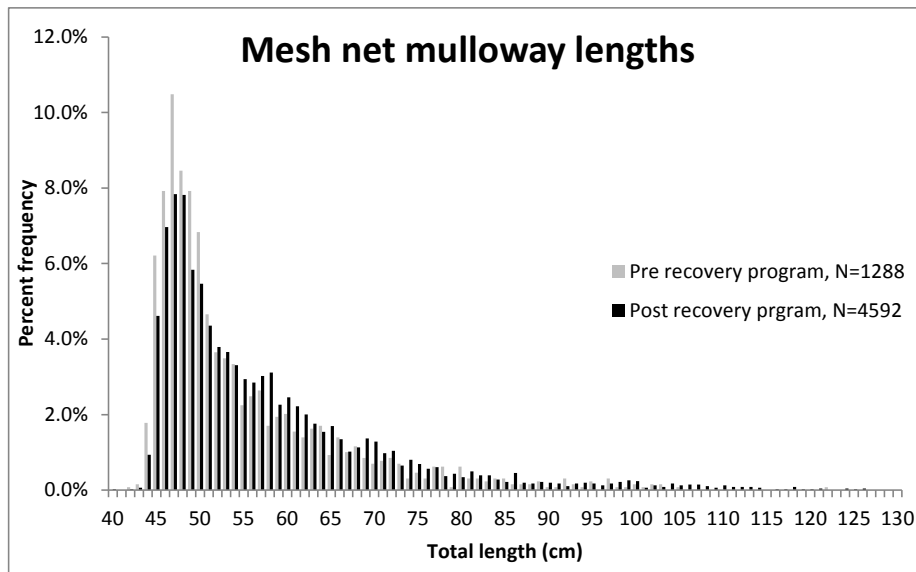


Figure 7. The sizes of mulloway landed by commercial fishers using the method of mesh netting before (August 2011 to October 2013) and after (November 2013 onwards) the mulloway recovery program was implemented.

Assessment of the by-catch allowance (possession limit) of 10 fish between 45 and 70 cm for commercial mesh net fishers

Mulloway were sampled from 417 different mesh net catches after implementation of the recovery program. Of these, 102 catches (~25%) had in excess of 10 mulloway between 45 and 70 cm (Fig. 8).

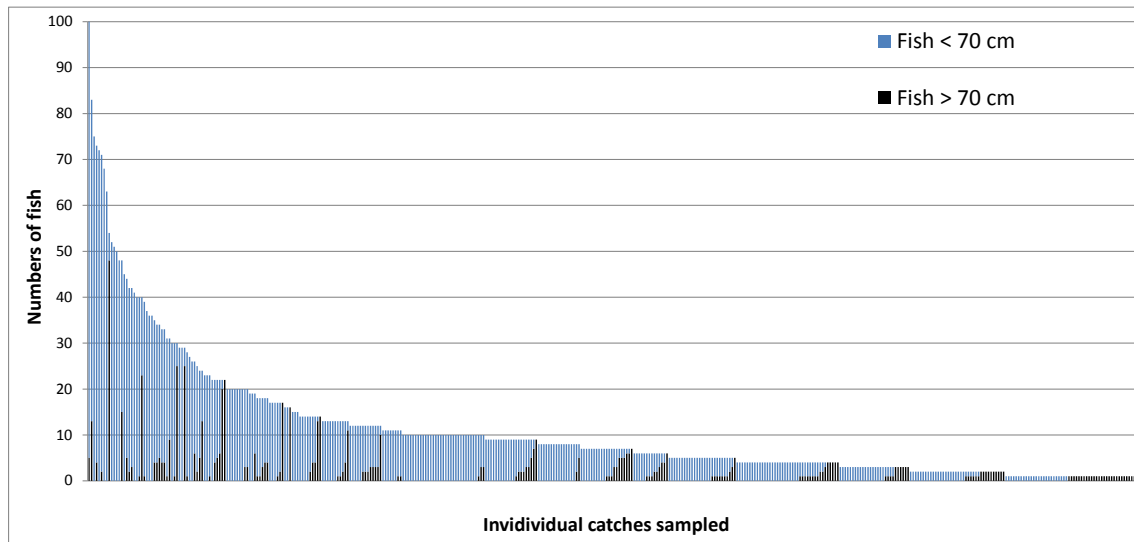


Figure 8. The number of 45 cm to 70 cm mulloway (blue) and greater than 70 cm mulloway (black) in each of the 417 mesh net catches monitored since implementation of the mulloway recovery program. The catches have been sorted from highest to lowest in terms of numbers of fish.

Recreational survey data

The National Recreational and Indigenous Fishing Survey done in 2000/01 estimated a total harvest (kept and released) of approximately 109,400 mulloway. In 2013/14 it was estimated that in NSW recreational fishers caught approximately 111,500 mulloway,

approximately 21,000 were retained and approximately 90,000 were released (Table 1). This estimate suggests that the numbers of mulloway caught by recreational fishers in NSW has not changed markedly between 2000/01 and 2013/14 (West et al., 2015).

Table 1. Recreational catch estimates of mulloway 2000/01 and 2013/14.

Survey Year	Total	Kept	Released	%Released
2000-01	109400	79095	30305	28%
2013-14	111573	21360	90213	81%

Note that the 2013/14 survey spanned the recovery program management changes implemented in November 2013 (the survey ran from June 2013 to May 2014). As such the survey was split into two components, before the recovery program (June 2013 to October 2013) and after the recovery program (November 2013 to May 2014). The recreational harvest was estimated using the survey numbers and applying average weights for retained mulloway derived from historical access point surveys and commercial monitoring data and were split into oceanic and estuarine components (Table 2).

The 2013/14 survey indicated that the percentage of mulloway released by recreational fishers increased substantially following the recovery program, up to 89% of estuarine caught fish being released (Table 2). Research conducted by the NSW DPI on survival of recreationally caught Mulloway indicates that the majority of line caught Mulloway survive after being released (NSWDPI, 2013).

The total recreational harvest of mulloway during the 2013/14 survey period was estimated to be 102.66 t (Table 2).

Table 2. Summary of the numbers and weights of mulloway estimated kept and the numbers released by recreational fishers in NSW during 2013/14 before and after the recovery program. RP is recovery Program.

	Waterbody	Total	Kept	Released	% Released	Average weight kg	Harvest tonnes
Pre RP change	Estuary	19,289	5,638	13,651	70.8%	2.53	14.27
Pre RP change	Ocean	8,259	4,095	4,164	50.4%	2.90	11.86
Post RP change	Estuary	77,757	8,543	69,214	89.0%	6.65	56.85
Post RP change	Ocean	6,269	3,086	3,183	50.8%	6.38	19.68
Total		111,574	21,362	90,212	80.9%		102.66

Research Angler Program

The NSW Research Angler Program has had 1,138 mulloway frames donated by recreational fishers (as of October 2016). These fish ranged in size from 70 cm (the minimum legal length) up to 168 cm, with a gradual decline in abundance from smallest to largest (Fig. 9). Note that these frames are not expected to be representative of the recreational harvest of mulloway but to provide biological data.

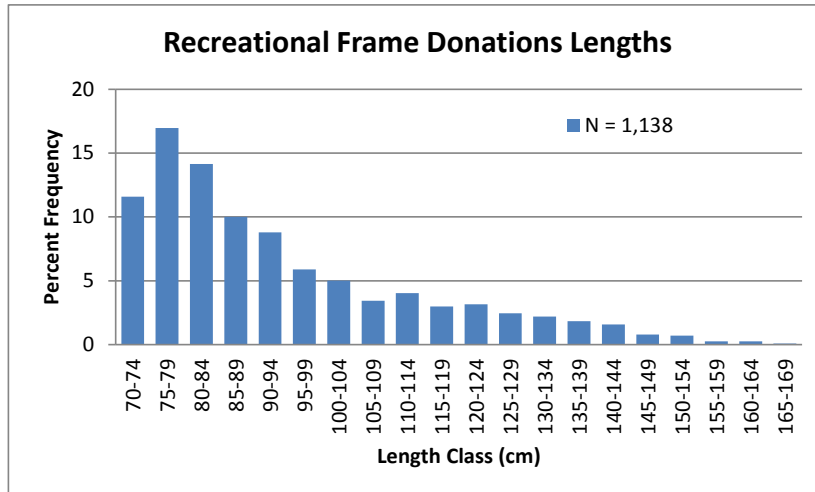


Figure 9. The sizes of mulloway donated to the NSW Research Angler Program.

The ages of the mulloway donated were generally 3 to 6 years old, with a notable mode at 12 to 14 years (Fig. 10). Again, these ages as presented are not considered to be representative of the recreational harvest of mulloway, rather just those frames donated. These data are incorporated into the scientific assessment (see below).

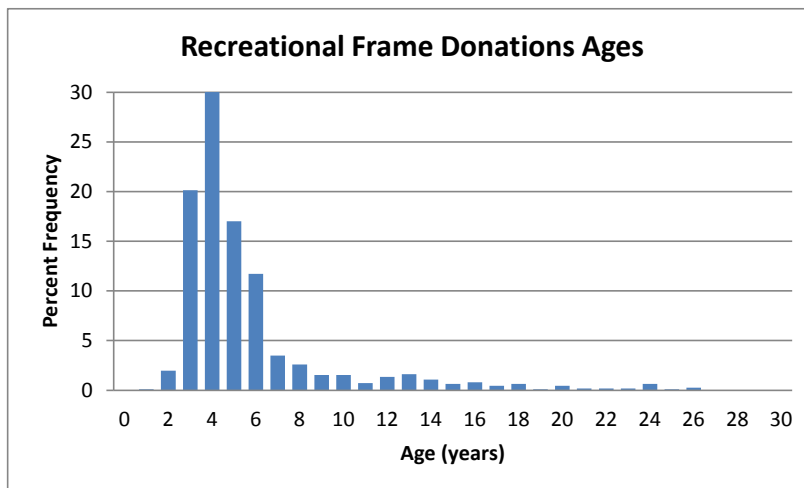


Figure 10. The ages of mulloway donated to the NSW Research Angler Program.

The diary component of the research angler program aims to collect data on the numbers and sizes of mulloway captured by recreational fishers. The diaries ask for records on where fish were caught (estuary/ocean beach and rocks/offshore) and whether they were kept or released. Preliminary data from 22 diarists reporting 1,038 mulloway captures suggest that the vast majority (approximately 77%) of mulloway are released; either because they are smaller than the minimum legal length, the fish were tagged and released or personal choice (Fig. 11). This 77% release rate is similar to that estimated from the 2013/14 recreational survey data of 81%.

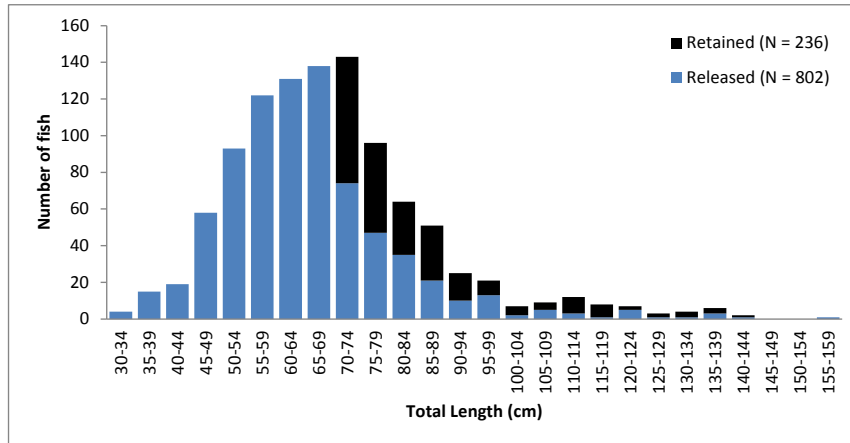


Figure 11. Preliminary data on the numbers and sizes of mulloway retained and released from the Research Angler Diary program.

Scientific Assessment

The scientific assessment of the status of the mulloway stock uses all sources of data. The assessment is underpinned by the age composition in the mulloway population, from which scientists infer a mortality rate. The existing assessment produced mortality estimates that indicated excessive mortality, with too few mulloway surviving to contribute to the spawning stock. This finding, in combination with long-term declines in landings, declining offshore catch rates and reductions in the sizes of fish being landed contributed to an Overfished assessment for the mulloway stock. In addition, mulloway are considered 'Growth Overfished', a situation where they are being, on average, harvested at too great a rate and too small a size to optimize yield from the stock. Growth Overfishing may be sustainable in some instances, but evidence suggests it was not for the mulloway population.

The mulloway assessment is updated annually with new data, such as that presented in this summary. The age composition in the population is estimated using the age data from the Research Angler Program and generating what is called an age-length key. An age-length key records the yearly variation of size at any age and can be used to infer age compositions from length composition data. The mulloway age-length key is currently applied to commercial length frequency data to estimate an age composition. The decline in abundance of each age class is then used to infer a current overall mortality rate.

The age compositions generated from this approach are presented in Fig. 12. They indicate an improvement in age composition since 2002-2005, with many more 3 to 6 year old fish in landings. Note that this improvement became apparent in 2012/13 which was before the mulloway recovery program was implemented. Mulloway recruitment levels are affected by rainfall/river flow during the spawning period and it is believed that higher river flows from 2008 onwards improved recruitment in those years.

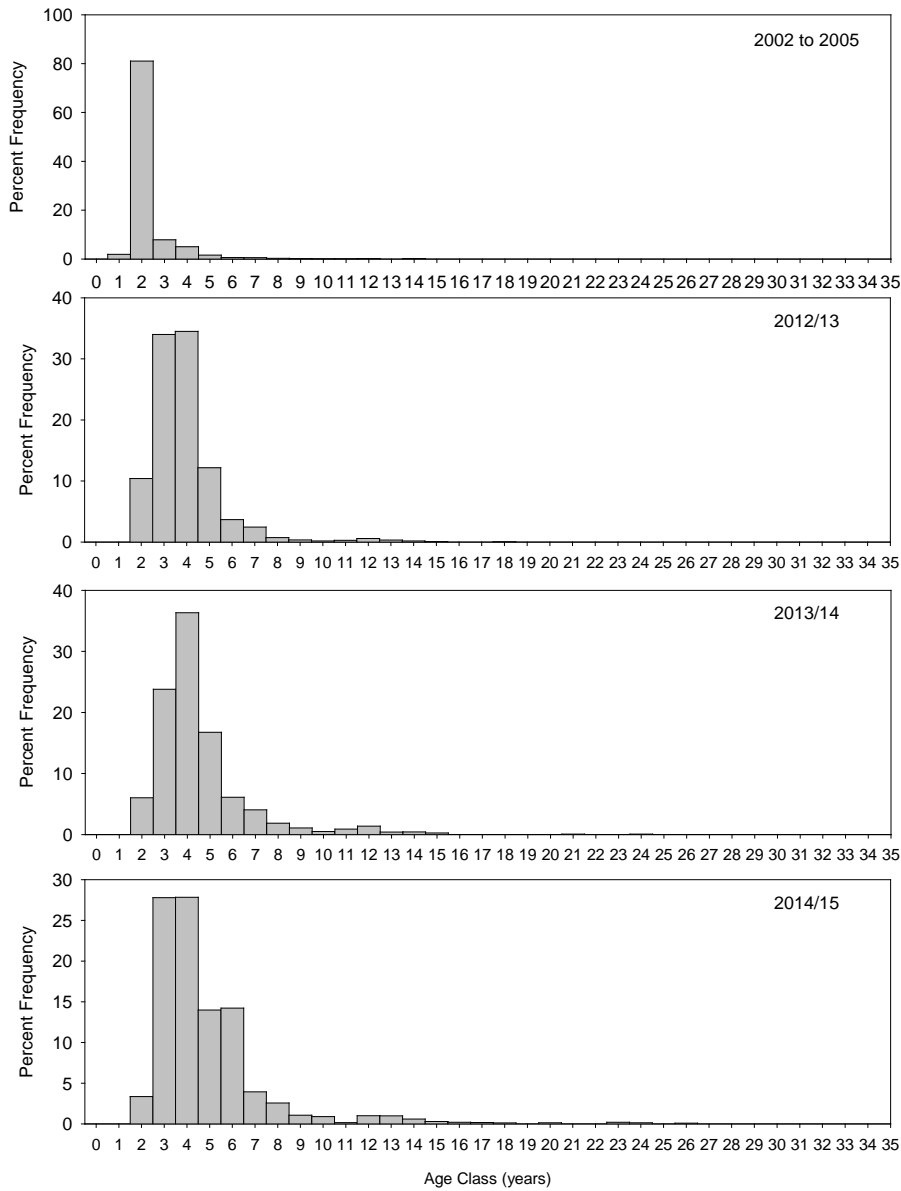


Figure 12. Mullet age frequency distributions from 2002-2005, 2012/13, 2013/14 and 2014/15.

Despite some improvement in the age composition data with more 3 to 6 year old fish apparent in recent years (Fig. 12), the estimates of mortality remain excessive. The rate of decline of ages from age 3 to age 15 indicates that on average between approximately 30% and 40% of the stock between those ages is dying (from both natural and fishing-related causes) each year.

Summary

The data presented in this report suggests that there has been some improvement in the mulloway population since it was first declared Overfished in 2004/05. This improvement has been a result of naturally improved recruitment since 2008 as a direct result of suitable environmental conditions (i.e. increased rainfall and river flow during the spawning period). This improvement was therefore apparent prior to implementation of the mulloway recovery program.

The mulloway recovery program has been in place for almost 3 years which is insufficient time to adequately assess the stock response to the management changes. However, the data presented here does allow assessment of the current management changes and whether they are achieving the goal of reducing fishing-related mortality on both juvenile and adult mulloway.

The recreational bag limit for mulloway was reduced from 5 to 2 fish.

- The management change has probably had a relatively small positive effect of reducing fishing-related mortality from the recreational sector. Recreational survey data indicated that very few recreational fishers retained more than 2 fish on a trip before the recovery program.
- The management change has had no effect on reducing fishing-related mortality on adults as there was a bag limit of 2 fish greater than 70 cm already in place.

The minimum legal length for recreational and commercial fishing was increased from 45 cm to 70 cm.

- The management change has had a positive effect of reducing mortality on juveniles from all fisheries except the Estuary General mesh net fishery (see below). The commercial Ocean Hauling and Ocean Trap & Line fisheries have reduced their landings of mulloway, possibly as a result of reduced targeting. As such any discard-related mortality of juveniles in these fisheries is likely to have had a minor impact on the stock.
- Similarly for the recreational sector, while the majority of the catch is of juvenile fish less than 70 cm, improvements in understanding methods of reducing release mortality through better handling and release methods will assist in a reducing fishing mortality of juveniles from this sector.

Commercial Estuary General fishers using meshing nets have a by-catch allowance (possession limit) of 10 fish between 45 and 70 cm.

- Data collected during the 3 years following implementation of the mulloway recovery program indicate that this management change has not had the desired effect of reducing fishing-related mortality by the mesh net sector.
- Landings from the major estuaries have not declined beyond normal annual fluctuations and have increased in some areas.
- The possession limit of 10 fish between 45 and 70 cm has been breached in 25% of observed catches.
- There is no evidence of a systematic discarding of mulloway between 45 and 70 cm as a result of the 10 fish possession limit.
- The reason for this possession allowance was to encourage Estuary General mesh net fishers to change their fishing practices to avoid mulloway. It was acknowledged that even with altered fishing practices that juvenile mulloway would be captured at certain times and places and the possession allowance was designed to minimise waste of these fish. While anecdotal evidence indicates some fishers have changed fishing practices when mesh netting, it is apparent from the data that the changes in fishing practices by

the Estuary General mesh net sector as a whole have not been effective at avoiding or minimising mulloway catch

- An improved understanding of catch by each sector as a result of recreational fishing surveys indicates that the Estuary General mesh net fishery is responsible for the majority of fishing-related mortality on juvenile (between approximately 35 and 70 cm) mulloway.

A 500 kg possession limit for commercial Ocean Hauling endorsement holders

- Landings of mulloway by the Ocean Hauling fishery have historically been relatively minor, however in some years fairly substantial catches of large adult fish have been made. This management change has been associated with 3 years of very low landings in this fishery which will have had a positive effect of reducing mortality on the mulloway stock and of reducing social conflict that can occur when this fishery lands mulloway.

Table 3. Summary of the performance of each major sector in reducing fishing-related mortality on mulloway since the recovery program was implemented in November 2013. EG = Estuary General, OH = Ocean Haul and OTL = Ocean Trap and Line. RP indicates the mulloway Recovery Program.

Sector	Reduced mortality on juveniles	Comment	Reduced mortality on adults	Comment
Commercial EG	No	Fishery is based on juveniles. No real declines in landings. No change in sizes of fish landed. Bycatch allowance requires review.	No	Minor part of catch. No increased targeting apparent
Commercial OH	Yes	No take as 70 cm MLL. Discard mortality considered of acceptable level.	Yes	Very low landings since RP
Commercial OTL	Yes	No take as 70 cm MLL. Discard mortality considered of acceptable level.	Yes	Reduced landings since RP
Commercial Trawl	Unknown	Flood-associated bycatch of mulloway when targeting school prawns unresolved.	N/A	Very minor catches
Recreational	Yes	Reduced bag limit from 5 to 2. No take as 70 cm MLL. Discard mortality considered of acceptable level.	No	No change to previous bag limit of 2 'adult' fish.

Note: Guidelines to manage and minimise the bycatch of juvenile mulloway in the NSW Ocean Trawl Fishery continue to be developed by NSW DPI in consultation with the commercial fishing industry. The Guidelines contains strategies to be pursued by DPI and industry to contribute to the overall recovery program for Mulloway including:

- Implementing a highly selective net configuration for reducing bycatch of juvenile Mulloway.
- Promoting best practice post-harvest handling techniques.
- Closing waters pursuant to these Guidelines when bycatch remains high.

Literature cited

Department of Primary Industries (2013). NSW Recreational fishing catch and release handbook. http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0009/478053/nsw-recreational-fishing-catchand-release-handbook.pdf

West, L.D, Stark, K.E., Murphy, J.J., Lyle J.M .and Doyle, F.A., 2015. Survey of recreational fishing in New South Wales and the ACT, 2013/14. Fisheries Final Report Series.