Australian Government
Australian Fisheries Management Authority

Redfish (*Centroberyx affinis*) Stock Rebuilding Strategy

2016-2021

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Executive Summary

This *Redfish Stock Rebuilding Strategy 2016* (the Strategy) has been developed to support the recovery of redfish to above 20 per cent of its unfished biomass, the biomass limit reference point that has been adopted for the stock. The *Commonwealth Fisheries Harvest Strategy Policy 2007* (HSP) requires a rebuilding strategy to be developed for all species below their biomass limit reference point.

Redfish was assessed in 2014 to have an estimated biomass at 11.7 per cent of unfished stock biomass in 2015.

Management actions in this Strategy focus on maintaining the overall low fishing mortality of redfish while continuing to monitor and assess the stock status. This will be done through:

- catch restrictions preventing targeted fishing of redfish. Incidental catches are managed under a low Total Allowable Catch (TAC) limit designed to cover the minimum unavoidable catch of redfish while targeting other species
- fishing effort restrictions through limited entry to existing fisheries. This means that no new fishing concessions are created, and in order to fish in a fishery, an existing concession must be leased or purchased
- an investigation of the costs and benefits of fishing gear modifications intended to reduce incidental catches of redfish, and increase the average size of redfish taken
- research and monitoring to investigate effects of environmental change on the productivity of the stock
- research and monitoring to support stock assessments and to measure the Strategy in meeting its objectives.

An annual review of redfish catch rates and biological information is conducted by the South East Resource Assessment Group (SERAG). SERAG will also report to AFMA on how stock status is tracking against the Strategy objectives. AFMA is required to report annually to the Department of the Environment on progress made under the Strategy. The management arrangements contained within the Strategy may be amended as required in response to changes in stock status or the ongoing monitoring by SERAG. The Strategy will be reviewed after five years.

Contents

Introduction

This *Redfish Stock Rebuilding Strategy 2016* (the Strategy) outlines measures to rebuild redfish stocks occurring in the Southern and Eastern Scalefish and Shark Fishery (SESSF).

A 2014 stock assessment estimated redfish (*Centroberyx affinis*) biomass to be at 11.7 per cent of its unfished biomass in 2015 (Tuck 2014). This is below the limit reference point for redfish of 20 per cent of the unfished biomass. The Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES), Fishery Status Reports 2015 (Patterson et al. 2015) classifies redfish as having an 'overfished' biomass, and as 'uncertain if subject to overfishing'.

The *Commonwealth Fisheries Harvest Strategy Policy 2007* (HSP) requires rebuilding strategies to be developed for all species below their biomass limit reference point. This Strategy has been developed to meet that requirement.

Objectives

Consistent with the *Fisheries Management Act 1991* (the Act) and the HSP, the broad objective of this Strategy is to return Commonwealth redfish stocks to ecologically sustainable levels and ultimately maximise the economic returns to the Australian community from the resource.

The rebuilding objectives are:

- to rebuild redfish in the area of the SESSF to the default limit reference point of 20 per cent of unfished biomass (B_{LIM}) within a biologically reasonable timeframe[1], being approximately 27 years (one mean generation time[2] plus 10 years)
- having reached B_{LIM}, rebuild redfish to the maximum sustainable yield level of 40 per cent of unfished biomass (B_{MSY}).

Background

Stock structure and distribution

Redfish occurs in continental shelf and upper slope waters in depths from 10 to 450 m from eastern Tasmania (including Bass Strait) to southern Queensland off Fraser Island. Juvenile fish occur in deeper bays and estuaries and over inshore reefs. Redfish is predominantly a schooling species, generally occurring over hard bottom types and other structures (e.g. shipwrecks) (Morison and Rowling 2001, NSW I&I 2010).

No formal stock discrimination studies for redfish have been done in Australia. Tagging studies suggested a single stock of redfish off New South Wales. However, studies of mean length at age suggest differences in growth rates between the 'northern' and 'southern' sectors of the fishery off eastern Australia (Morison, A. & Rowling, K. 2001). The redfish assessments of Thomson (2002) and Klaer (2005) assumed that the fishery exploits two separate populations, with the boundary between these 'stocks' being 36ºS (just north of Montague Island).

[1] The HSP states that if a stock is below the biomass limit reference point, any fishing is classified as overfishing unless the stock will recover within a biologically reasonable timeframe. HSP examples of biologically reasonable timeframes are the shorter of:

a) a period equal to a mean generation time plus 10 years; or
b) three times the mean generation time.

[2] A mean generation for redfish is estimated to be 16.7 years (Tuck 2014)

However Shelf Resource Assessment Group (RAG) (2014) considered there was not a sufficient basis for assuming two separate stocks and agreed that the assessment should be based on a one stock model (Tuck 2014).

Life history

Redfish are slow growing and long-lived fish, which may reach a maximum length of 51 cm and an age of about 44 years. Most aspects of the species' biology are reasonably well understood (Morison and Rowling 2001, NSW I&I 2010).

Key threats

Redfish are a long lived, schooling species making them vulnerable to fishing (particularly to trawl methods). Redfish comprised a significant proportion of Commonwealth and NSW trawl landings off south-eastern Australia during the 1980s (Figure 1), with catches peaking twice since 1986, dropping away to much lower levels in between these times (Haddon 2014).

The impacts on redfish from recreational fishers are not well known. However, it was estimated in 2003 that the annual recreational harvest in NSW was likely to be around 20-40 tonnes (Henry and Lyle 2003). Recent estimates of recreational catch have fallen to 4-10 tonnes in 2013-14 (West 2015). Recreational catches may be a significant source of mortality, especially when Commonwealth catch is constrained by a low incidental TAC. Improved estimates of mortality from the recreational sector could assist in improving the estimate of total fishing mortality.

While fishing is considered to have had a significant historical impact on redfish, environmental variability, including climate change or a change in stock productivity, can also affect fish population dynamics and availability to fishing gear. Recent modelling of the oceanic conditions and water temperature in south eastern Australia shows it to be one of the most variable and rapidly changing regions in the world. South-eastern Australian marine waters have experienced some of the greatest levels of warming observed around Australia and are expected to continue to warm more than other areas (Hobday and Lough 2011, Lough et al. 2012). Such environmental changes could potentially have contributed to the apparent decline of redfish and may continue to limit their rate of recovery and/or distribution. The potential impacts of environmental variability on fish stocks, including redfish, are not well understood. Policy and management must develop strategies to take account of future productivity changes. Past patterns in the ecosystem or fishery behaviour may not be suitable predictors for future change (Hobday and Pecl 2013)

The Marine Climate Change in Australia Report Card (Booth, 2012) summarises current knowledge of marine climate change for Australia, highlighting key knowledge gaps and adaptation responses and found:

- Australian ocean temperatures have warmed, with south-west and south-eastern waters warming fastest
- the flow of the East Australian Current has strengthened, and is likely to strengthen by a further 20 per cent by 2100
- marine biodiversity is changing in south-east Australia in response to warming temperatures and a stronger East Australian Current
- there may be replacement of small cool-temperate species in southern waters by sub-tropical and tropical species driven by warmer temperatures
- southward range expansions in south-eastern waters are linked to warming temperatures and a strengthening of the East Australian Current

These factors may be important in the future management of redfish stocks and might require reconsideration of the target and limit reference points based on data from the 1980s and 1990s. Further work in this area could provide a greater understanding of the species and any threats to the species recovery.

Concerns have been expressed regarding growth over-fishing of redfish (Rowling 1999, 2001; Wise 2002; Knuckey 2010). Growth overfishing occurs when large numbers of small fish are taken at a size or age before the improved yield from growth is matched by the reduced yield from mortality (Knuckey in Tuck, 2014). Due to the selectivity of standard 90mm diamond codends (50 per cent selectivity at ~13cm), a large proportion of redfish are captured below the size of optimum yield (Tuck 2014).

Status of resource and stock assessments

Catch based modelling indicates that redfish have been depleted to a level below which optimum yields can be taken

Previous assessment models for eastern redfish are those of Chesson (1995), Thomson (2002) and Klaer (2005). The first comprehensive assessment of redfish was carried out in 1993 (Chesson, 1995). This assessment concluded that stock biomass was low in the late 1980s (less than 20 per cent of that in 1969) but increases in catch and catch per unit of effort (CPUE) from 1990 to 1993, especially of small fish, suggested an increase in recruitment.

The model of Thomson (2002) showed a considerable decline in stock biomass for both northern and southern regions (~25 per cent of initial biomass in 2001). However, there were concerns regarding fits to catch at length data; namely a consistent tendency to over-estimate the proportion of large fish in the catches since 1995 and to under-estimate them prior to 1995.

Klaer (2005) focussed on the effect of changes in mesh selectivity on the future stock status of redfish. Klaer (2005) largely used the biological parameters, catch and discard rate information provided by Thomson (2002), with updates of recent catch rate, catch and discard estimates to 2004. Results for the northern and southern regions, under the nominated base-case parameter set, showed stock status of less than 20 per cent of initial biomass (Tuck, 2014). Uncertainties in the model structure, assumptions and the data on which they were based were reflected by a wide range of estimates for biomass, to the extent that ShelfRAG was not able to class it as a Tier 1 or 2 assessment.

There are generally good ageing samples of redfish, which have allowed the species to be assessed as a Tier 3 species (Morison, A. et al 2013). A Tier 3 assessment of redfish was performed during 2012 (Klaer 2011). The information required for this assessment included parameters that define: selectivity-at-age, length-at-age, weight-at-age, age-at-maturity and natural mortality (Table 1).

Table 1. Redfish parameters used in the Tier 3 assessment (adapted from Klaer 2012a).

Species	*M*	*H*	*Linf*	*k*	*t0*	*a*	*b*	*l25*	*L50*	*lmat*	*amax*	*ccamax*	*S25*
Redfish	0.1	0.75	25.28	0.224	-0.719	0.0577	2.77	15.94	17.25	19	40	20	3.727

Although relatively good ageing data are available to support Tier 3 assessments, Tier 4 assessments have also been conducted for redfish to monitor catch rates against reference years. The Tier 4 assessments showed that catches and CPUE have been decreasing consistently over the last decade and the CPUE indicator was below the limit reference point (Haddon 2012b).

The 2014 assessment is the first full quantitative assessment (Tier 1) for redfish to be implemented using Stock Synthesis (SS). The use of SS allows the implementation of a model very similar to that used in previous assessments, but additionally presents an opportunity to improve the estimation of length-based selectivity. SS can be fitted simultaneously to several data sources and types of information available for redfish (Tuck 2014).

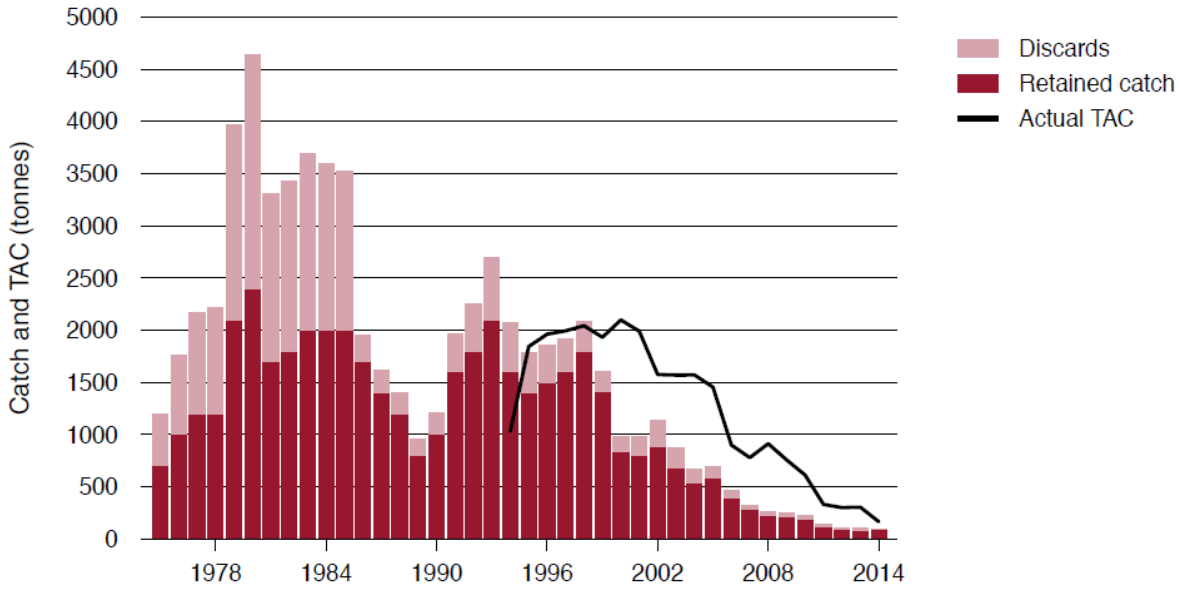
The estimate of 2015 spawning biomass from the 2014 assessment is below the limit reference point and is most likely in the range of 8-12 per cent of unfished biomass. The long term

recommended biological catch is in the range of 750 – 850 tonnes. This is below the limit reference point of 20 per cent of unfished biomass.

Catch, targeting and discards

Catches of redfish peaked in the 1990s at around 2 000 tonnes per year, with significant discards occurring in some years. Landed catch (Commonwealth and State combined) has declined steadily since the late 1990s remaining well below the Total Allowable Catch (TAC) (Figure 1).

Figure 1: Redfish annual catches (Commonwealth Trawl Sector, Gillnet Hook and Trap Sector and state combined) and fishing season TACs, 1974 to 2014. Note: 2014 excludes discards and State catch. Source ABARES Fishery Status Reports 2015.



Companion species analysis indicates that redfish are caught incidentally when targeting flathead (Klaer and Smith 2012). Noting that flathead is a key economic driver in the fishery, restrictions on redfish catch may constrain catches of flathead and impact on the economics of the fishery.

Most recreational catch of redfish occurs in waters off the NSW coast. The most recent estimate of recreational catch in NSW is approximately 4-10 tonnes (West et al. 2015).

Monthly Commonwealth catch and TAC information for all SESSF quota species, including redfish, can be accessed through AFMA's 'Catchwatch' reports at http://www.afma.gov.au/fisheries-services/catchwatch-reports/.

Gear Selectivity

A quantitative assessment of redfish was run in 2005 using integrated analysis to evaluate different harvest strategies (TAC or mesh size changes) for this species. While uncertainty prevented the use of model results for absolute biomass predictions, the model was still useful for understanding relative importance of different harvest strategies on future biomass projections. The harvest strategy evaluation compared the use of a range of larger mesh or square mesh codends and found that increased mesh size resulted in average biomass increase across scenarios as well as lower portions of the catch being discarded in the future (Knuckey et al. 2009, Bax et al. 2004).

Rebuilding timeframes

AFMA has adopted the biologically reasonable rebuilding timeframe to the limit reference point of one mean generation time plus 10 years, in line with the example given in the HSP.

A mean generation for redfish is estimated to be 16.7 years (Tuck 2014). Management measures implemented under the Strategy aim to recover redfish to its limit reference point within a generation time plus 10 years – that is 26.7 years from 2015, being approximately 2042. The most recent biomass projections from the 2014 assessment (Tuck 2014) predict the stock to recover to a biomass larger than its limit reference point by 2018 or 2019 under an incidental catch of 50 tonnes, 100 tonnes or 150 tonnes (Tuck 2014). However, projections from the assessment assume average recruitment (which may not occur) and do not account for any environmental influences such as climate change.

Recreational and State commercial catch also have the potential to impact on recovery times. Although estimates of catch from both of these sectors are available they have been unreliable.

Management actions to achieve the objectives

Current management

The primary mechanism available to AFMA to promote recovery is restricting Commonwealth commercial catches. Accordingly, management measures focus on preventing targeting and limiting the bycatch of redfish.

A number of current management measures support redfish recovery.

- Incidental catch TAC - the HSP and the Strategy provide for zero targeted catch of redfish. As such, the redfish TAC will be set based on the minimum amount required to cover the catch of redfish taken incidentally while targeting other species. An incidental catch TAC of 100 tonnes has been implemented since 2015-16. The incidental catch TAC is reviewed by SERAG annually (see Appendix A) and may be increased or decreased depending on information about targeting behaviour or changes to fishing mortality and biomass.

- Limited entry – access to the SESSF is limited by boat Statutory Fishing Rights or permits. This limits expansion of Commonwealth managed effort directed at redfish.

- Trawl gear selectivity – in 2006 codend mesh size was increased (minimum of 90 mm mesh size) and bycatch reduction devices were implemented to decrease the number of juvenile fish caught in trawl nets. These bycatch reduction measures are now implemented as a condition on each trawl operator's fishing licence.

- Existing fishery closures – fishery closures in the SESSF, while not specifically implemented to protect redfish, overlap with the distribution of the species. Approximately 86 per cent of the Commonwealth Trawl Sector (CTS) area is closed to trawling (Pitcher 2015).

- Monitoring - catches and discards are monitored by onboard AFMA observers. Approximately three per cent of fishing effort in the CTS is observed by AFMA observers and, amongst other things, is used to estimate discard rates across the fishery. Port sampling is used to supplement on board observer coverage.

- Fishery Independent Surveys (FIS) – FISs are undertaken to help provide an independent index of abundance of as many SESSF quota species as possible (see Monitoring and evaluation).

Management arrangements for the current fishing season can be accessed in the 'SESSF Management Arrangements Booklet', which is sent out to all concession holders before the start of each fishing season. A copy of the booklet is available on the AFMA website.

Future management and information needs

Improvements in data collection are required to provide a better understanding of the status of the stock and its recovery. This will in turn inform future management measures to ensure the objectives of this Strategy are achieved. With increased amounts of data becoming available, targeted management arrangements will be developed for redfish that may include:

- development and evaluation of trawl net design to maximize yields and reduce the amount of incidental catch of small redfish
- targeted monitoring (onboard observer or electronic monitoring) when fishing in areas of high historical redfish catch
- implementation of trigger and move-on provisions for vessels reporting large catches of redfish if annual analysis by SERAG indicates that boats are targeting redfish
- spatial and temporal closures if appropriate areas are identified and modelling shows that the resultant reduced catches will have a material effect on rebuilding
- improved estimates of recreational catch to assist in improving estimates of total fishing mortality. Recreational stakeholders have representation on the South East Management Advisory Committee (SEMAC)
- engagement with State Government agencies to discuss complementary management measures, including alignment of the Commonwealth/NSW Wales Offshore Constitutional Settlement (OCS) and actions to protect redfish outside of AFMA's jurisdiction.

A number of eastern Australian species, including redfish, have shown lower than average recruitment over the last decade (SlopeRAG, 2015). Data are required to quantify and evaluate changes to recruitment patterns and effects of climate change. SESSF Resource Assessment Groups have identified the following information needs:

- explore the effect of different recruitment scenarios on redfish rebuilding times
- investigate the most efficient methods of gathering fishery dependent environmental data, including temperature profiles
- monitor redfish size to estimate size composition through length frequency sampling
- undertake an analysis of redfish targeting and trends.

Monitoring and evaluation

Stock assessments and data collection

Stock assessments are undertaken on a regular basis to monitor stock status and the recovery of redfish. Redfish are currently assessed using a full quantitative Tier 1 assessment.

The most recent redfish stock assessment was conducted in 2014 and indicated a declining biomass that had probably been below the limit reference point since the late nineties. For further information see 'Status of resource and stock assessments' in this document.

Integrated Scientific Monitoring Program

The Integrated Scientific Monitoring Program (ISMP) is a data collection program that places independent observers on commercial fishing vessels and in ports to collect fishery dependent and verifiable information on fishing operations, catch and discards in the SESSF. The program has provided information on the quantity, size and age composition of quota species caught in sectors of the SESSF since 1994.

The sampling design of the ISMP was reviewed in 2009. The observer coverage plan to meet the requirements of the ISMP design is updated each year to ensure that data collection is representative of fishing effort and supports AFMA's ecosystem-based approach to fisheries management. The new sampling regime was implemented on 1 July 2014.

Under the regime, AFMA observers in the Commonwealth Trawl Sector cover approximately three per cent of trawl effort. This level of coverage has been statistically determined to be sufficient to provide robust estimates of catches and discard rates across the fishery.

Further changes are made as required to annual observer targets to best capture data on redfish and other SESSF species.

Fishery Independent Surveys

The fourth Fishery Independent Survey (FIS) for the SESSF was run in 2014. The primary objective of the FIS is to estimate the relative abundance of fish stocks with reasonable coefficients of variation (CVs) (<0.3) (Knuckey et.al. 2015). Results for redfish (Table 2) show that although CVs have mostly been less than 0.3, there has been a high level of inter-annual variability in relative abundance.

This is important because for some species, CPUE data (fisheries dependent data) may not be a good index of abundance. This is the case for species under rebuilding strategies, such as redfish, where commercial fishers actively avoid catching the species, thereby making it difficult to determine if low CPUE is a result of fisher's behaviour or low stock size.

Table 2. Abundance indices and CV estimates for redfish for 2008, 2010, 2012 and 2014

Year	Abundance	CV
2008	14.37	0.23
2010	26.89	0.23
2012	1.14	0.31
2014	13.2	0.26

At the time of writing the SESSF FIS is under review as part of the research project 'SESSF Monitoring and Assessment – Strategic Review' with results expected during 2016. If the SESSF FIS does continue it could provide a means of monitoring future trends in the abundance of redfish but the high level of inter-annual variability recorded in surveys to date means that a long time series would be needed before any trends could be reliably identified.

Discarding

Although redfish can be targeted, it is generally caught as a byproduct species when fishing for other species. AFMA will continue to work with industry to reduce discarding as well as monitor discard levels through the AFMA observer program. AFMA is assessing ways to improve the precision of discard information recorded by operators in catch and effort logbooks.

Reporting to the Department of the Environment and Energy

AFMA reports annually on the effectiveness of the Strategy to the Department of the Environment and Energy. AFMA also reports on the level of observer coverage.

The SESSF is an accredited Wildlife Trade Operation (WTO) under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). WTO accreditation recognises that a fishery is being managed in an ecologically sustainable manner, and allows the export of product derived from the fishery. Reporting on the status of redfish and the effectiveness of the Strategy is a part of the approval process to maintain a WTO accreditation.

Reviewing and evaluating the Strategy

SERAG and AFMA will annually review the status of redfish and performance against the objectives of the Strategy. A template outlining the minimum items for consideration by SERAG each year is included at Appendix A.

The Strategy itself will be reviewed by AFMA, with input from SERAG and South East Management Advisory Committee (SEMAC), every five years.

Impacts of the Strategy

Economic impact

Economic impacts associated with the recovery process for redfish include the costs of monitoring, research and the stock assessment process. Management costs are apportioned between industry and the Australian Government under AFMA's Cost Recovery Impact Statement.

Gear modifications to minimise catches of redfish may impact on the catches of companion species like flathead. There is an additional impact on the fishing industry because no targeted fishing is permitted and only an incidental catch is set.

Any reduction in catch that may occur as a result of implementing this Strategy will be considered in the context of the risk, catch cost framework.

Consultation

The Strategy has been developed with the assistance of:

- SESSFRAG, ShelfRAG and the SEMAC
- the South East Trawl Fishery Industry Association and individual operators, particularly those in the Commonwealth Trawl Sector.

Management arrangements may be changed in consultation with SEMAC as required in response to ongoing monitoring or stock assessment outcomes.

Environmental impacts

Environmental impacts from the implementation of the Strategy are anticipated to be positive. As previously stated the broad objective of this Strategy of returning redfish to ecologically sustainable levels is consistent with AFMA's objectives and requirements under the EPBC Act.

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Appendix A - SERAG redfish annual report template

Item	Actions
Indications of how stock status is tracking against the Strategy objectives.	
Analysis of management measures implemented.	
Data collection • Current data • Gaps and needs.	
Recommended changes to management measures or data collection.	
Any targeting analysis results and number of shots containing greater than 250kg of redfish compared to previous years.	
Catches by the top 10 boats (boat names not provided) as an indication changes to fishing operations.	
Confidential catch 'heat' maps over time.	