Stock status summary

Relevant fisheries statistics and stock assessment results are summarized to inform the setting of a Total Allowable Catch (TAC) for the NSW purse seine Australian Sardine quota fishery. Where data are unavailable or insufficient to reliably inform a particular criterion the heading has been retained and the lack of information or alternative proxy indicated in the summary. This format has been maintained to transparently represent the data available and highlight areas where alternate data sources or analyses may be required to improve status determination in the future.

Biology and stock structure

Australian Sardine (*Sardinops sagax)* is distributed around the entire southern half of the continent where they inhabit continental shelf waters and the lower reaches of estuaries. The main spawning ground is located at the Queensland/New South Wales border during late winter and early spring, with a smaller summer spawning ground off eastern Tasmania and Victoria, extending into southern NSW (Sexton et al., in press). Peak spawning of east coast sardines is reported to occur in water temperatures between 18-22°C.

Australian Sardine in NSW matures at around 14 cm fork length (FL). Sardines grow rapidly, reaching a maximum length of 23 cm FL and maximum age of 8 years. The majority of Australian Sardine landed in the NSW commercial fishery are aged between 1-3 years old.

Mass mortality events of Australian Sardine occurred in 1995 and again in 1998 throughout southern Australia, apparently caused by a herpes virus. Closures were put in place during these periods preventing commercial catches of sardines. Since that time populations of Australian Sardine have recovered in most areas.

The population structure in Australian waters is complex, with evidence of broad separation between sardines in Western Australia, South Australia and eastern Australia. These areas comprise smaller size dependent shoals that effectively create a single semi-continuous Australian meta-population.

For the purposes of fisheries management, the Australian Sardine population is currently considered to be comprised of four separate biological stocks. Bass Strait separates the biological stock that occurs off eastern Australia from three biological stocks to the west. One stock occurs off South Australia and western Victoria, and the other two occur off the south and west coasts of Western Australia.

There is a growing body of evidence indicating the existence of two sub-stocks off eastern Australia (Sexton et al., in press; Izzo et al., 2017; Stewart et al., 2010; Ward and Staunton-Smith, 2002). Evidence includes two spatiotemporally distinct spawning areas in shelf waters off southern Queensland/northern NSW and off southern NSW/Tasmania. The more northern spawning area is the largest and spawning occurs mainly during August to October. Spawning at southern latitudes occurs mainly during January to March. The presence of a spawning discontinuity (or egg barren) between these two spawning areas between ~34–37°S is indicative of a separation between two separate sub-populations. The separation of

stocks is also supported by differences in otolith shape and chemistry and biological and fishery parameters of fish captured from northern and southern NSW.

Australian Sardine is currently assessed through the SAFS framework at the biological stock level—Eastern Australia, Western Australia west coast, Western Australia south coast and Southern Australia.

Stock status and assessment method

The 2016 Status of Australian Fish Stocks (SAFS) assessment for the Eastern Australian stock of Australian Sardine was a Sustainable stock (Ward et al., 2016). The rationale being that catches until that time were less than 10%of the estimated spawning biomass during 2014 of approximately 49,575 t and well below what was considered the sustainable exploitation rate at that time of 33%. Spawning biomass is estimated through the Daily Egg Production Method (DEPM). The evidence indicated that the stock was unlikely to be recruitment overfished and that the current level of fishing pressure unlikely to cause the stock to become recruitment overfished.

The Commonwealth currently assess Australian Sardine as not overfished and not subject to overfishing (Patterson et al., 2017).

Fishery statistics - summary underpinning assessment

The Commonwealth stock assessment for Australian Sardine does not rely on fishery statistics, other than reference to the total harvest from the stock in relation to the recommended biological catch (RBC). Therefore only data on total catch as reported by the Commonwealth is presented here.

Reference to 'Year' in the tables and figures presented in this summary refers to the first year of the financial year. For example, 2010 refers to the financial year 2010/11, unless otherwise stated.

Catch information

State catches of Australian Sardine comprise most of the total catch. State catches increased substantially from 2001/02 to 2009/10, contributing to reductions to the Commonwealth TAC. Total sardine catch from Commonwealth and state fisheries (other than that taken in South Australia) peaked in 2008/09 at 4,787 t and decreased to 893 t in 2014/15. The total catch in 2015/16 was 1,434 t. The Commonwealth catch for 2016–17 was 131 t (Fig. 1) (Patterson et al., 2017).

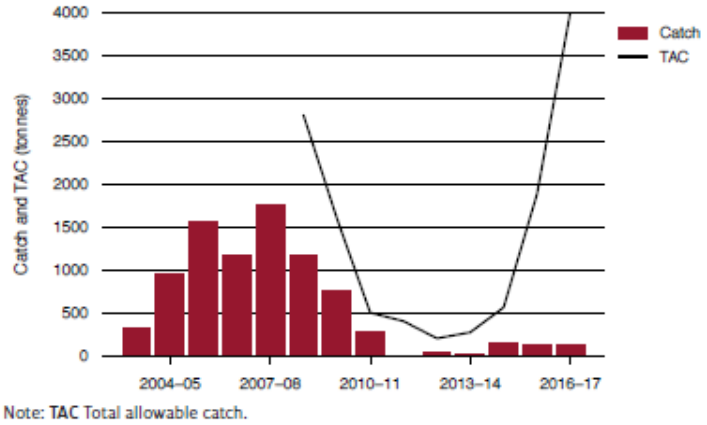

Figure 1 Commonwealth Australian Sardine catch and TAC in the SPF, 2003/04 to 2016/17 (from Patterson et al. 2017).

Stock assessment methodology (Risk Assessment Methodology) (List of Indicators)

Year of most recent assessment	2014 – Daily Egg Production Method (DEPM) biomass estimate. 2015 – Population model and MSE testing.
Assessment method	Daily Egg Production Method (DEPM) biomass estimates (Ward et al., 2015a, b). Management Strategy Evaluation (MSE) of the Commonwealth SPF Harvest Strategy (Smith et al., 2015).
Main data inputs	Egg survey August/September 2014 between Sandy Cape, Queensland and Batemans Bay, New South Wales. Egg survey January 2014 around northern Tasmania and southern Victoria. The surveys produced estimates of Australian Sardine egg abundance, egg age and spawning area. Other inputs included adult reproductive parameters: average

Stock assessment methodology (Risk Assessment Methodology) (List of Indicators)	
	weight, sex ratio, batch fecundity, spawning fraction. MSE: Growth, maturity, weight and selectivity by age. Natural mortality and stock-recruitment relationship.
Main data inputs (rank)[1]	Egg survey - 1 – High Quality Adult reproductive parameters - 1 – High Quality MSE: Growth, maturity, weight and selectivity by age. Natural mortality and stock-recruitment relationship - 2 – Medium Quality, growth and maturity estimates from the SA stock.
Key model structure and assumptions	NA for DEPM MSE operating model is age-structured, and recruitment is driven by spawning stock biomass and uses values for biological parameters (natural mortality, growth, maturity, stock-recruitment and selectivity).
Sources of uncertainty evaluated	Considerable uncertainty exists around key input data for the Australian Sardine DEPM assessment. Sensitivity analyses were done for all parameters to determine which had the largest influence on estimated spawning biomass. These were done by varying each individual parameter whilst keeping the others constant at the value used to calculate spawning biomass. Conclusions were drawn based on the most precautionary parameter estimates, resulting in the spawning biomass likely

[1] 1 – High Quality: data have been subjected to documented quality assurance and peer review processes, are considered representative and robust and provide a high level of confidence to support fisheries management decisions.

2 – Medium Quality: data have been subjected to some internal quality assurance processes, have some documented limitations, but are still considered sufficiently accurate and informative to be useful to inform management decisions with some caveats.

3 – Low Quality: data have been subjected to limited or no quality assurance processes, may be compromised by unknown or documented limitations that have not been fully explored, but are considered the best available information and require a high level of precaution to be exercised when interpreted to inform management decisions.

Stock assessment methodology (Risk Assessment Methodology) (List of Indicators)	
	to be under-estimated. MSE testing of various potential SPF harvest strategy control rules to examine the probability of the biomass falling below the limit reference point of 20% of unfished levels with a less than 10% chance.

Status Indicators and Limits Reference Levels	
Biomass indicator or proxy	Depletion estimates (Smith et al., 2016).
Biomass limit reference level	Biomass falling below the limit reference point of 20% of unfished levels with a less than 10% chance.
Fishing mortality indicator or proxy	Catch as a percentage of spawning biomass.
Fishing mortality limit reference level	Annual catch is less than 20% of the DEPM derived estimate of spawning biomass. This is the Tier 1 exploitation rate in the Commonwealth SPF Harvest Strategy for setting a Recommended Biological Catch (RBC) for each of five fishing seasons following a DEPM assessment. Note that Smith et al. (2015) recommended an exploitation rate of 33% was acceptable for Eastern Australian Sardine. Five years after a Tier 1 assessment, the RBC is set at the Tier 2 level that is 10% of the DEPM derived estimate of spawning biomass. Five years after a Tier 2 assessment, if no updated DEPM is done, the RBC is set at the Tier 3 level that is 5% of the DEPM derived estimate of spawning biomass.
Target reference level	NSW does not have target reference levels for Australian Sardine, however, the Commonwealth has a target reference point of 50% of unfished levels.

Stock Assessment Results (Risk Assessment Results) (Results of Review of Indicators)	
Biomass status in relation to limit	Smith et al. (2015) reported an exploitation rate of up to 33% may be suitable for Eastern Australian Sardine under the Commonwealth SPF harvest strategy. The current harvest strategy exploitation rate following a Tier 1 assessment is only 20%, ensuring a very low probability of the stock falling below 20% of unfished levels. Catches have always been low relative to the estimated spawning biomass and as a result, fishing is not believed to have substantially reduced spawning biomass.
Fishing mortality in relation to limit	The most recent estimates of Australian Sardine biomass off eastern Australia were done via DEPM surveys in 2014. The first survey done during August/September 2014 between Sandy Cape, Queensland and Batemans Bay, NSW estimated the spawning biomass in that area to be approximately 49,575 t (95% confidence intervals 24,200 to 213,300 t) (Ward et al, 2015a). A second survey done during January 2014 around northern Tasmania and southern Victoria estimated the spawning biomass in that area to be approximately 10,962 t (95% confidence intervals 8,000 to 15,000 t) (Ward et al, 2015b), noting that the entire southern spawning area was not believed to have been surveyed. Recent harvests of Australian Sardine have been well below the reference level of 20% of the 2014 derived DEPM estimate of spawning biomass (estimated to be around 49,575 t) (Ward et al., 2015a) with the RBC calculated as 20% x 49,575 ~9,915 t. The 2016/17 catch from all jurisdictions was 2,887 t, representing < 6% of the spawning biomass in 2014. Total harvest from all sectors peaked during 2009 at approximately 5,000 t representing ~ 10% of the spawning biomass in 2014.
Previous SAFS stock status	Moderately Fished in NSW assessments 2005/06 to 2007/08. Fully Fished in NSW assessments 2008/09 to 2010/11. Uncertain in NSW assessments 2011/12 to 2013/14. Moderately Fished in NSW assessment 2014/15.

Stock Assessment Results (Risk Assessment Results) (Results of Review of Indicators)	
	SAFS 2012 Sustainable. SAFS 2014 Sustainable. SAFS 2016 Sustainable.
Current SAFS stock status	The above evidence indicates that the stock is unlikely to be recruitment overfished, and that the current level of fishing pressure is unlikely to cause the stock to become recruitment overfished. On the basis of the evidence provided above, the Eastern biological stock is classified as a sustainable stock.

Fishery Interactions
Commonwealth Small Pelagic Fishery – purse seine and midwater trawl, interacts with the NSW commercial fishery. The SPF has TACs based on RBCs derived from the SPF harvest strategy rules and then subtracting state catches. The RBCs are set at extremely precautionary levels. Several NSW endorsed fishers also hold Commonwealth SPF endorsements. NSW Estuary General Fishery – only minor landings of Australian Sardines. Recreational fishers - only minor landings of Australian Sardines; however a very large user of sardines as bait.

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