

## Assessment Authors and Year

Stewart, J. 2023. NSW Stock Status Summary 2022/23 – Australian Sardine (*Sardinops sagax*). NSW Department of Primary Industries, Fisheries. 14 pp.

## Stock Status

Current stock status	On the basis of the evidence contained within this assessment, Australian Sardine is currently assessed as <b>sustainable</b> .
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## Stock structure & distribution

Australian Sardine (*Sardinops sagax*) is distributed around the entire southern half of the continent where it inhabits continental shelf waters and the lower reaches of estuaries. 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. Australian Sardine off southern Australia is a meta-population (Whittington et al. 2008), with effective isolation of four separate biological stocks: the South-western (off Western Australia); Southern (off South Australia); South-Eastern (off Victoria, Tasmania and southern NSW) and Eastern (off northern New South Wales and southern Queensland) Australian stocks (Izzo et al. 2017, Sexton et al. 2019).

While east coast Australian Sardine is currently assessed through the Status of Australian Fish Stocks (SAFS) framework at the biological stock level— Eastern Australia and South Eastern Australia, the Commonwealth assesses and manages Australian Sardine as a single east coast stock. The NSW Ocean Hauling (Purse Seine) quota fishery for Australian Sardine (*Sardinops sagax*) is similarly managed as a single stock.

This stock status summary details stock assessment results and relevant fisheries statistics to inform the setting of a Total Allowable Catch (TAC) for the NSW Ocean Hauling Purse Seine (OHPS) Australian Sardine quota fishery for the 2023/24 fishing season. Assessment of stock status for Australian Sardine is principally based on the Commonwealth Small Pelagic Fishery (SPF) derived assessment that utilizes estimates of spawning biomass from periodic egg surveys using the Daily Egg Production Method (DEPM).

## Biology

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., 2019). 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.

### FISHERY STATISTICS

#### Catch information

##### Commercial

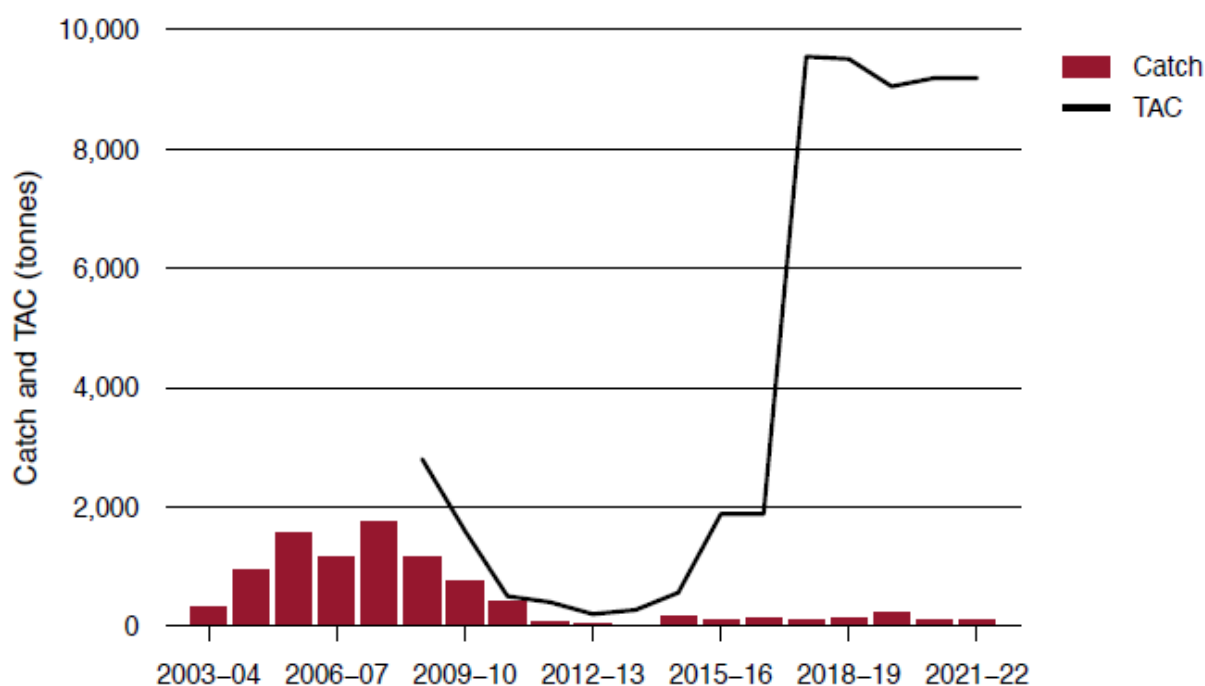
The AFMA-defined sardine sub-area off eastern Australia is the only area of the SPF that is fished for Australian Sardines, that is assessed and managed as a single east coast stock (see Patterson et al., 2022 for a map of this area). As such the data presented do not separate the Eastern and South Eastern Australia stocks.

State catches of Australian Sardine comprise most of the total catch.

Australian sardine catch for 2021/22 was 525 t, comprising 112 t of Commonwealth catch and 413 t from New South Wales (Patterson et al., 2022).

The Commonwealth fishery landed less than 1.5% of the proposed TAC for 2021/22 of 7,980 t (Fig. 1, noting that the actual TAC for 2021/22 including 10% overcatch was set at 8,767 t).

The NSW Ocean Hauling Purse Seine catch has averaged around 521 t p.a. since 2009, substantially less than the current NSW TAC of 2,744 t (Fig. 2).



Note: **TAC** Total allowable catch.

Figure 1. Commonwealth Australian Sardine catch and TAC in the SPF, fishing seasons 2003/04 to 2021/22 (from Patterson et al. 2022).

## Recreational & Charter boat

The recreational catch of Australian Sardine is considered to be minor and is not considered in the assessment.

## Indigenous

There is no information available on the Aboriginal catch of Australian Sardine in NSW waters.

## Illegal, Unregulated and Unreported

The level of Illegal Unregulated and Unreported (IUU) fishing is unknown.

## **Fishing effort information**

Fishing effort is not a consideration for the stock assessment.

## **Catch Rate information**

Catch rate is not a consideration for the stock assessment.

## **STOCK ASSESSMENT**

Australian Sardine is assessed in terms of harvest as a fraction of spawning biomass. Spawning biomass is estimated through Daily Egg Production Method (DEPM) surveys. Management Strategy Evaluation (MSE) of the Commonwealth SPF Harvest Strategy (Smith et al., 2015) established that an exploitation rate of up to 33% was 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%, applied to maintain the stock in the vicinity of the target reference point of 50% of unfished levels and therefore ensuring a very low probability of the stock falling below 20% of unfished levels.

## **Stock Assessment Methodology**

Year of most recent assessment:

2022

2019 - Daily Egg Production Method (DEPM) biomass estimate Eastern Australian Stock

2014 - Daily Egg Production Method (DEPM) biomass estimate South Eastern Australian Stock

2015 - Management Strategy Evaluation (MSE) of the Commonwealth SPF Harvest Strategy

Assessment method:

Daily Egg Production Method (DEPM) spawning biomass estimates (Ward et al., 2021; Ward et al., 2015).

# Stock Status Summary – 2022/23



## NSW Stock Status Summary – Australian Sardine (*Sardinops sagax*)

### Main data inputs:

Egg survey during September 2019 between Sandy Cape, Queensland and Ulladulla, NSW. The survey produced estimates of Sardine egg abundance, egg age and spawning area.

Egg survey during January 2014 around northern Tasmania and southern Victoria. The survey produced estimates of Sardine egg abundance, egg age and spawning area.

Adult reproductive parameters: average weight, sex ratio, batch fecundity, spawning fraction.

Catch data.

MSE: Growth, maturity, weight and selectivity by age. Natural mortality and stock-recruitment relationship.

### Key model structure & assumptions:

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 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 - Limit & Target Reference Levels

Biomass indicator or proxy	DEPM derived estimate of spawning biomass.
Biomass Limit Reference Point	20% of unfished levels with a less than 10% chance.
Biomass Target Reference Point	50% of unfished levels
Fishing mortality indicator or proxy	Catch as a proportion of spawning biomass.
Fishing mortality Limit Reference Point	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.  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.

# Stock Status Summary – 2022/23



## NSW Stock Status Summary – Australian Sardine (*Sardinops sagax*)

	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.
Fishing Mortality Target Reference Point	As above. The exploitation rate is applied to maintain the stock around the target reference level of 50% of unfished biomass.

### Stock Assessment Results

Recent harvests of east coast Australian Sardine have been well below the reference level of 20% of the 2019 derived DEPM estimate of spawning biomass (~ 42,724 t) (Ward et al., 2021) with the RBC calculated as 20% x 42,724 t ~8,454 t. Total landings (Commonwealth and state combined) in recent years have been < 2% of the estimated spawning biomass in 2019. This level of fishing mortality is unlikely to have substantially reduced spawning biomass. On this basis, the Australian Sardine stock is classified as not overfished and not subject to overfishing (Patterson et al., 2022).

### Stock Assessment Result Summary

Biomass status in relation to Limit	Smith et al. (2015) reported an exploitation rate of up to 33% was 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.
Biomass status in relation to Target	As above
Fishing mortality in relation to Limit	Recent harvests of east coast Australian Sardine have been well below the reference level of 20% of the 2019 derived DEPM estimate of spawning biomass (~ 42,724 t) (Ward et al., 2021). Total landings (Commonwealth and state combined) in recent years have been < 2% of the estimated spawning biomass in 2019.
Fishing mortality in relation to Target	As above
Current SAFS stock status	Sustainable in 2020
Current Commonwealth stock status	Not overfished and not subject to overfishing

## 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. 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.

## Qualifying Comments

The DEPM-based estimates of Eastern Australian Sardine spawning biomass are highly likely to be under-estimates, due to any potential biases in terms of key parameters (such as spawning area and the assumption that surveys are done at the peak spawning time) always leading to under-estimating spawning biomass. In addition the SPF harvest strategy is deliberately precautionary in terms of exploitation rates in recognition of the importance of small pelagic species to ecosystem functioning, uncertainty in DEPM-derived estimates of spawning biomass, the fact that many of the MSE tested scenarios suggested quite high depletion levels, and the assumption that Australian Sardines, like many other small pelagic stocks globally, undergo huge fluctuations in abundance as a result of environmental factors beyond the control of fishery managers. As an example, Australian Sardines suffered two mass mortality events during 1995 and 1998, during which time the biomass was substantially reduced.

Despite these conservative assessment and management practices by the Commonwealth, there remain some low level risks in exploiting Australian Sardines along eastern Australia. Fishing tends to be focussed on a couple of key areas and the potential for localized depletions to occur therefore exists. The fact that neither the Commonwealth nor NSW recognize the existence of two biological stocks in terms of management increases the risk of localized overfishing. The lack of consideration of Victorian catch, that can at times exceed all other jurisdictions, by the Commonwealth is an additional risk to understanding harvest rates (note that this is not a criticism of AFMA, rather identification of risk resulting from Victorian landings often considered to be confidential due to a low number of active fishers, and therefore unavailable).

Countering this risk is an updated spawning biomass estimate of the eastern component of the South Eastern biological stock of Australian Sardines (Ward et al., 2022a). Derived from an egg survey done during the summer of 2019 (15<sup>th</sup> Jan to 7<sup>th</sup> Feb) in south-eastern Australia (south-eastern Tasmania to central NSW), primarily to estimate spawning biomass of Jack Mackerel, the spawning biomass was estimated at approximately 185,000 t. Given the precautionary nature of the DEPM analysis, Ward et al. (2022a) suggested that the spawning biomass was likely in excess of 200,000 t. This newly identified very large and relatively unexploited resource is now the subject of a proposed Tasmanian sardine fishery (Ward et al., 2022b). Clearly any increased exploitation of the South Eastern biological stock of Australian Sardines will have implications for the southern NSW fishery.

A related and morphologically similar species, Maray (*Etrumeus teres*) is also caught and retained by NSW purse seine fishers. Currently approximately 20 t p.a. are reported; however the degree of mixed catches and mis-reporting is unknown. Maray are not under any form of quota management.

## References

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- Sexton, S. C., Ward, T., Stewart, J., Swadling, K. M. and Huveneers, C. 2019. Spawning patterns of sardines (*Sardinops sagax*) provide further evidence for multiple stocks off eastern Australia. *Fisheries Oceanography* 28:18-32. DOI: 10.1111/fog.12383
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- Ward, T.M. and Gardner, C. 2022b. Review of Australia's small pelagic fisheries; insights to inform the development of a potential new Tasmanian Sardine Fishery. Report prepared for the Department of Natural Resources and Environment Tasmania by the Institute for Marine and Antarctic Studies, University of Tasmania, Hobart, 57pp. [IMAS-Review-Pelagic-Fisheries-for-NRE-Tasmania-Final-Version-12-July.pdf \(utas.edu.au\)](#).
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- Ward, T.M., Burnell, O., Ivey, A., Carroll, J., Keane, J., Lyle, J. and Sexton, S. 2015. Summer spawning patterns and preliminary daily egg production method survey of jack mackerel and Australian sardine off the east coast, Final report, FRDC project 2013/053, SARDI Aquatic Sciences, Adelaide.
- Whittington, RJ, Crockford, M, Jordan, D and Jones, B 2008. Herpesvirus that caused epizootic mortality in 1995 and 1998 in pilchard, *Sardinops sagax neopilchardus* (Steindachner), in Australia is now endemic, *Journal of Fish Diseases*, 31: 97–105.

## Appendix 1

### Status of Australian Fish Stocks (SAFS)

Australian Sardine in eastern Australia is assessed at the biological stock level within the national Status of Australian Fish Stocks (SAFS) assessments. The 2020 SAFS assessments were done for the Eastern Australia and South Eastern Australia biological stocks (Ward et al., 2020).

#### Eastern Australia stock

The 2020 SAFS assessment for the Eastern Australian stock of Australian Sardine was a Sustainable stock (Ward et al., 2020). The rationale being that catches until that time were less than 2% of the estimated spawning biomass during 2019 of approximately 42,724 t and well below what was considered the sustainable exploitation rate at that time of 33%. 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.

#### South Eastern Australia stock

The 2020 SAFS assessment for the South Eastern Australia stock of Australian Sardine was a Sustainable stock (Ward et al., 2020). Two DEPM surveys have been done on this stock: one during 2014 from eastern Tasmania, through eastern Bass Strait and eastern Victoria to southern NSW suggested that the spawning biomass in the eastern portion of the South Eastern Australia stock was approximately 11,000 t (Ward et al. 2015), with another in 2016/17 between western Kangaroo Island and south-western Tasmania suggesting that the spawning biomass in the western portion of the South Eastern Australia stock was at least 30,000 t. Both are likely to have under-estimated the total spawning biomass of the South-eastern Australia stock of Australian Sardine as neither covered the entire spawning distribution.

Landings from southern New South Wales have averaged approximately 120 t per annum since 2011/12, after a fire destroyed the processing factory in Eden during late 2010. Reported landings from eastern Victoria exceeded 2,000 t during 2010/11 and also in 2016/17, but fluctuate annually. Recent catches equate to exploitation rates of less than 20% of the estimated spawning biomass for the more eastern component of this stock of ~11,000 t, which is well below the level considered safe for this species (~33%) (Smith et al. 2015).

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.



## Appendix 2

### New South Wales fishery statistics for Australian Sardine.

The stock status summary for Australian Sardine summarizes information mainly from the Commonwealth assessment. Here, additional information is presented that may assist in understanding the dynamics of the NSW fishery for Australian Sardine.

#### Quota usage

Landings of Australian Sardine reported through the real-time quota reporting system, and the mandatory logbooks, were similar each year (fishing season May to April), (Fig. 2). Quota used by the NSW fishery is a small percentage of the available quota (2,744 t), being only 14% during 2021/22.

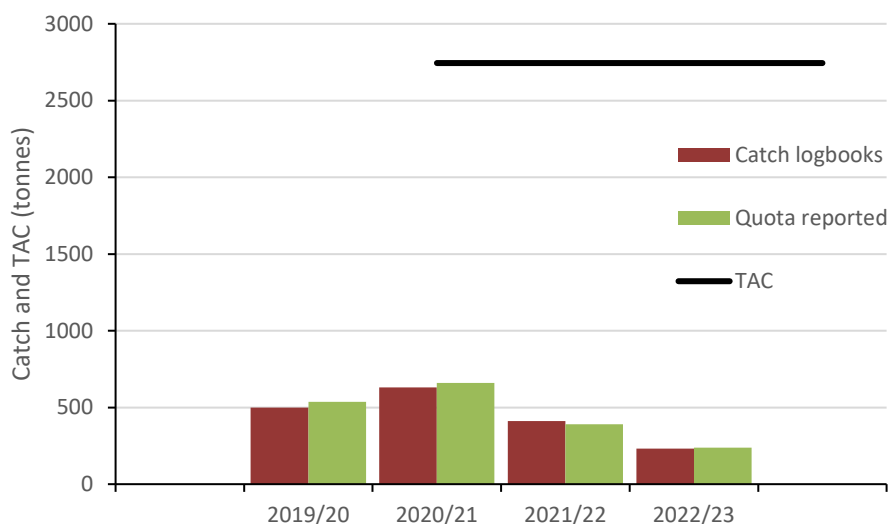


Figure 2. New South Wales Ocean Hauling Purse Seine landings of Australian Sardine and TAC 2009/10 to 2022/23. Note that the 2022/23 fishing season was only 6 months completed when these data were collated.

#### Catch

##### Commercial

Australian Sardine in NSW is mainly caught by the Ocean Hauling Fishery in purse seine nets. Smaller quantities are also taken using general purpose hauling nets and bait nets (which are modified hauling nets). The largest landings occur during winter/spring in northern NSW and autumn/winter in southern NSW.

Commercial landings of Australian Sardines in NSW were historically below 500 t p.a. until the early 2000s, when industry investment in processing and marketing, coupled with a considerably larger purse-seine vessel being introduced to the fishery, resulted in annual landings increasing rapidly to more than 2,000 t (Fig. 3). Landings declined considerably following the destruction of the main processing factory in late 2010 and the subsequent departure of the main catching vessel from the fishery, averaging around 550 t p.a. since 2009/10. Landings of east coast Australian Sardines during the past 13 years by the Commonwealth SPF have been relatively minor when compared to NSW landings, whereas Victorian state catches are generally greater (Fig. 4).

# Stock Status Summary – 2022/23



## NSW Stock Status Summary – Australian Sardine (*Sardinops sagax*)

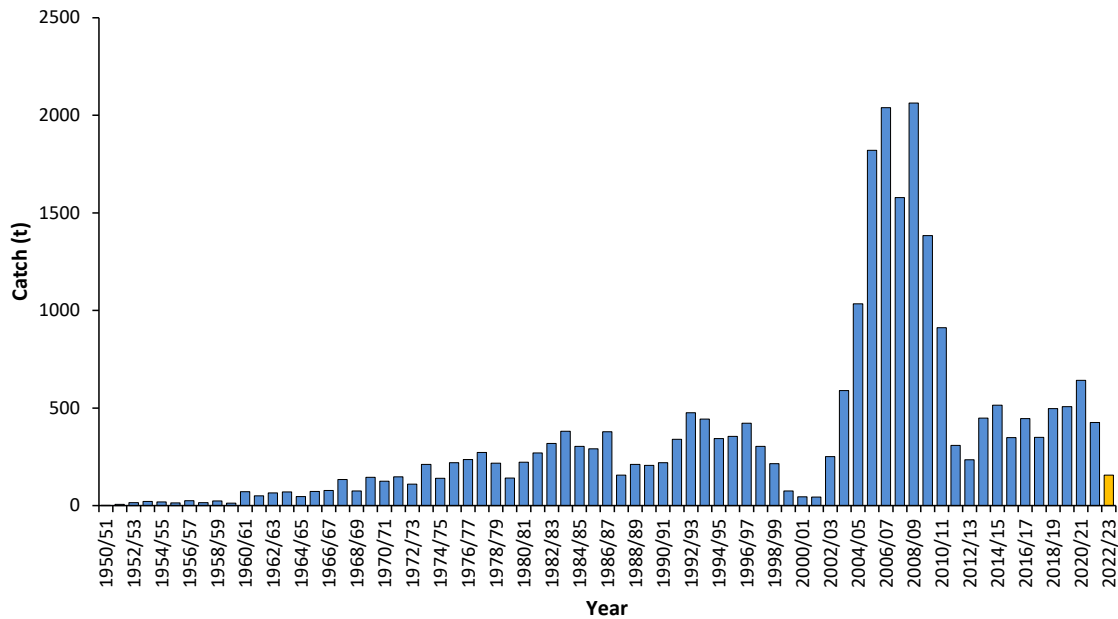


Figure 3. Commercial landings in NSW of Australian Sardine for NSW from 1950/51 to 2022/23 for all fishing methods. Note that the data for 2022/23 is for a partial year having been extracted during November 2022.

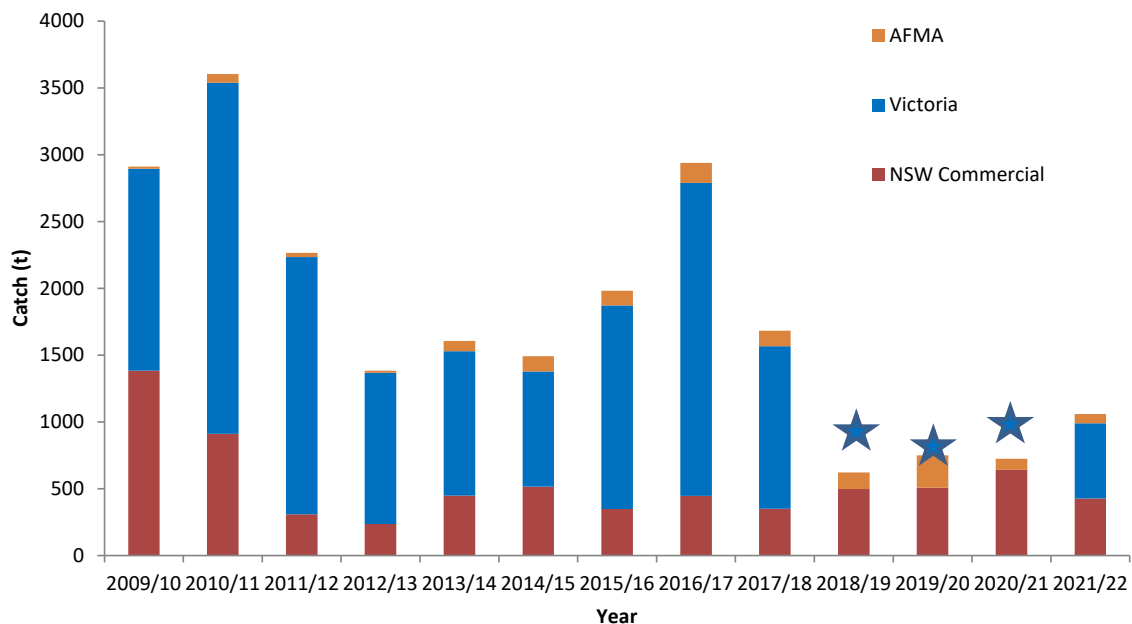


Figure 4. Commercial landings of east coast Australian Sardine from 2009/10 to 2021/22 by NSW fishers, Victorian fishers and the Commonwealth Small Pelagic Fishery (SPF). Note that stars indicate Victorian landings for those years are confidential

# Stock Status Summary – 2022/23

## NSW Stock Status Summary – Australian Sardine (*Sardinops sagax*)

Landings of Australian Sardine by NSW fishers since 2011/12 have generally been from two distinct areas, with approximately 75% being from ocean zone 2 (the eastern Australian biological stock) and 20% being from ocean zones 9 and 10 (the south-eastern Australian biological stock), with relatively little catch between (Fig. 5).

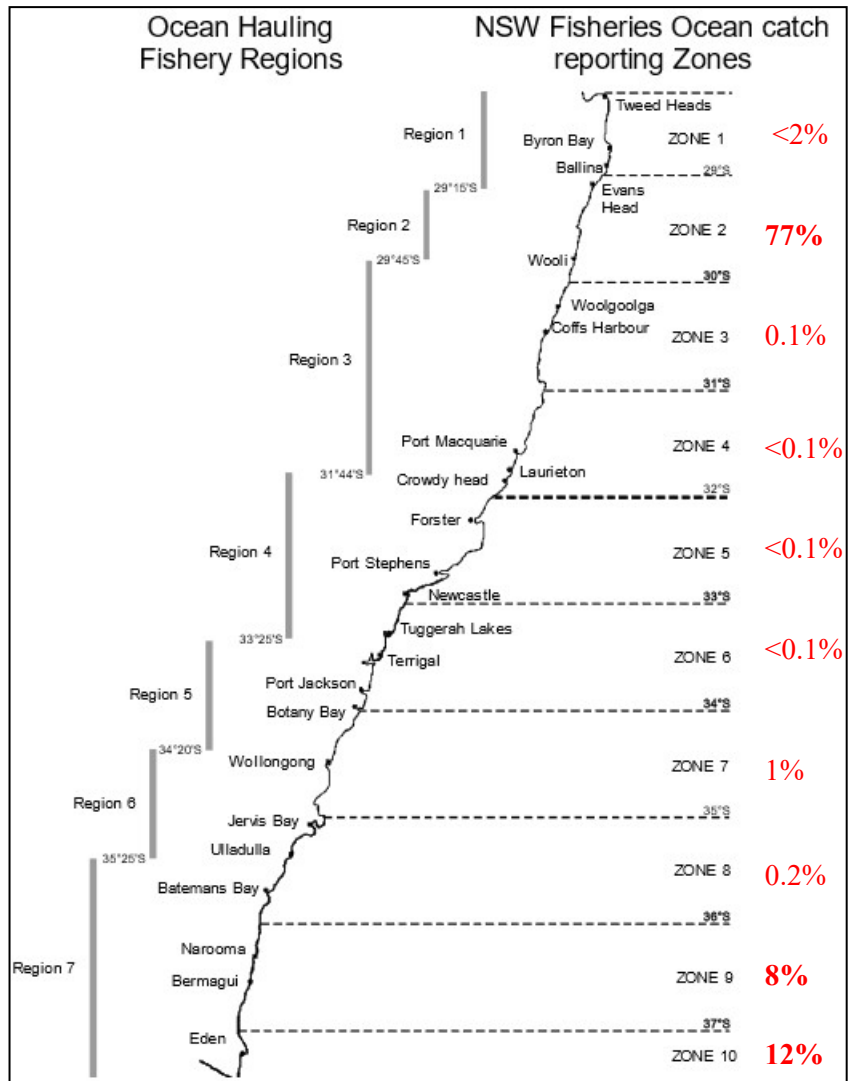


Figure 5. NSW commercial landings percent of total by ocean zone of Australian Sardine 2011/12 to 2021/22.

Based on the ocean zone of reported landings (zones 1 to 6 being the Eastern Australian biological stock and zones 7 to 10 the South-eastern Australian biological stock) landings from NSW fishers have oscillated between the two stocks (Fig. 6). During the past three years (since the implementation of quota management) almost the entire catch is being taken from the more northern Eastern Australian stock.

# Stock Status Summary – 2022/23



## NSW Stock Status Summary – Australian Sardine (*Sardinops sagax*)

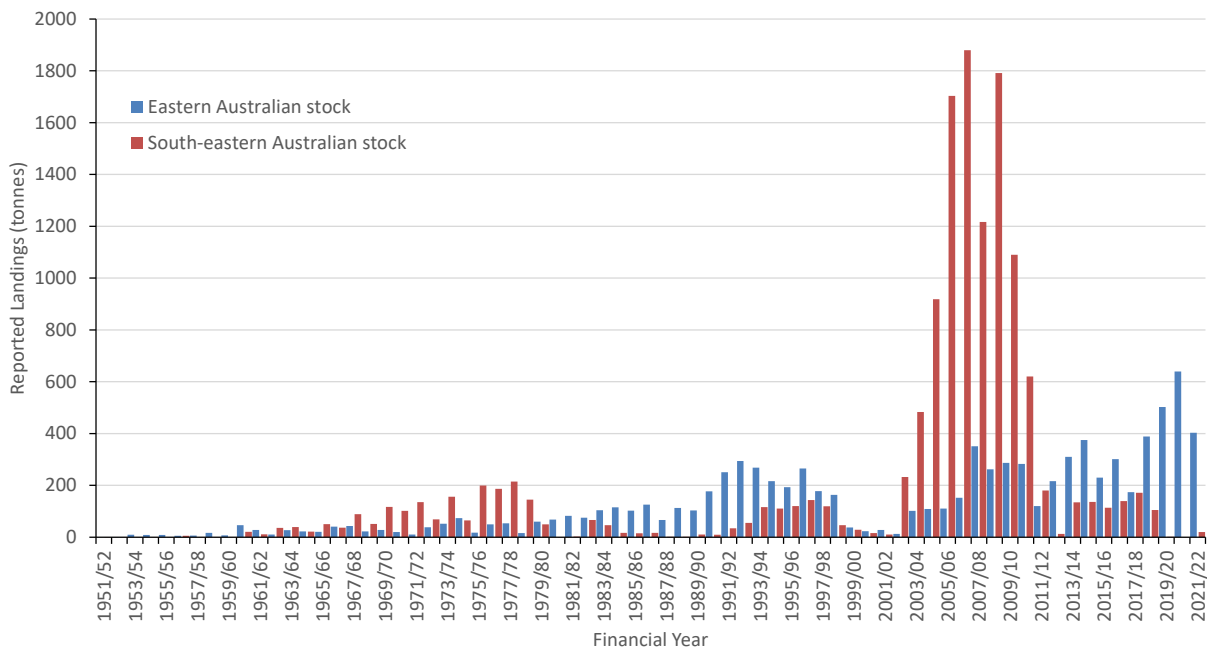


Figure 6. Commercial landings of east coast Australian Sardines by biological stock from NSW fisheries.

### Recreational

The recreational harvest of Australian Sardine is thought to be minor. Recent surveys have detected very small numbers of retained 'pilchards' (Murphy et al., 2022, Murphy et al., 2020, West et al., 2015).

### Indigenous

There are no data available on Aboriginal harvest.

### Illegal Unregulated and Unreported (IUU)

The level of Illegal Unregulated and Unreported (IUU) fishing is unknown.

### **Effort**

#### Commercial

Days fished in the NSW purse seine fishery when Australian Sardine were landed have fluctuating between approximately 100 and 200 days per year since 2009/10 but declined from over 200 days to around 160 during 2021/22 (Fig. 7).

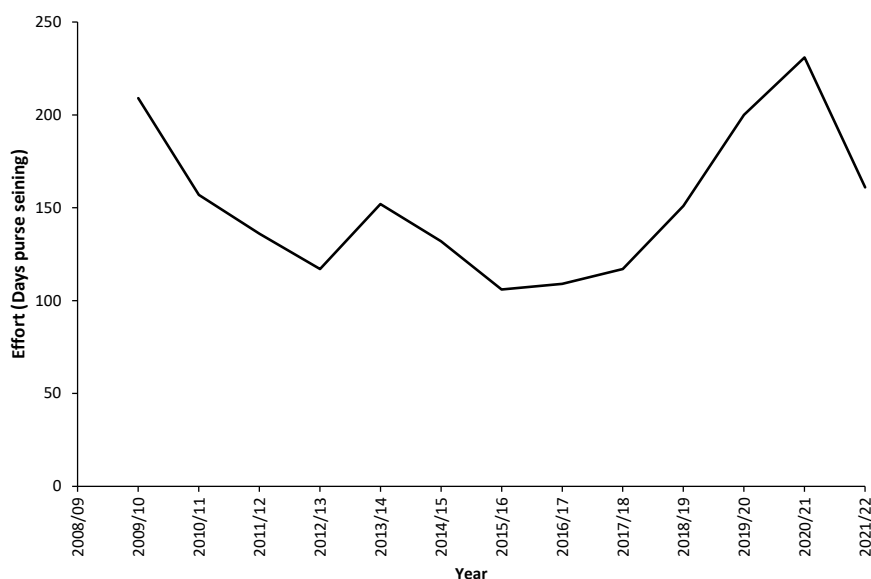


Figure 7. Effort (days fished) for purse seine fishers that reported landing Australian Sardine in NSW 2009/10 to 2021/22

### Recreational

There is little information on directed effort by recreational fishers, but it is believed to be very low. Overall saltwater fishing effort declined between 2000/01 and 2013/14 by roughly 37% (West et al., 2015) and then again by roughly 8% in 2017/18 (Murphy et al., 2020).

### Indigenous

There are no data available on Aboriginal fishing effort towards Australian Sardine.

### **Catch Rates**

#### Commercial

Catch rates of Australian Sardine by the method of purse seine are unlikely to be useful for inferring relative abundance due to: (i) the schooling nature of the species; (ii) the ability of the gear to encircle entire schools of fish, and; (iii) the market driven nature of fishing operations for this species. Nevertheless, median catch rates of Australian Sardine (kg per day purse seining) have fluctuated considerably between 2009/10 and 2021/22, and have been relatively high during the past 2 years Fig. 8).

# Stock Status Summary – 2022/23



## NSW Stock Status Summary – Australian Sardine (*Sardinops sagax*)

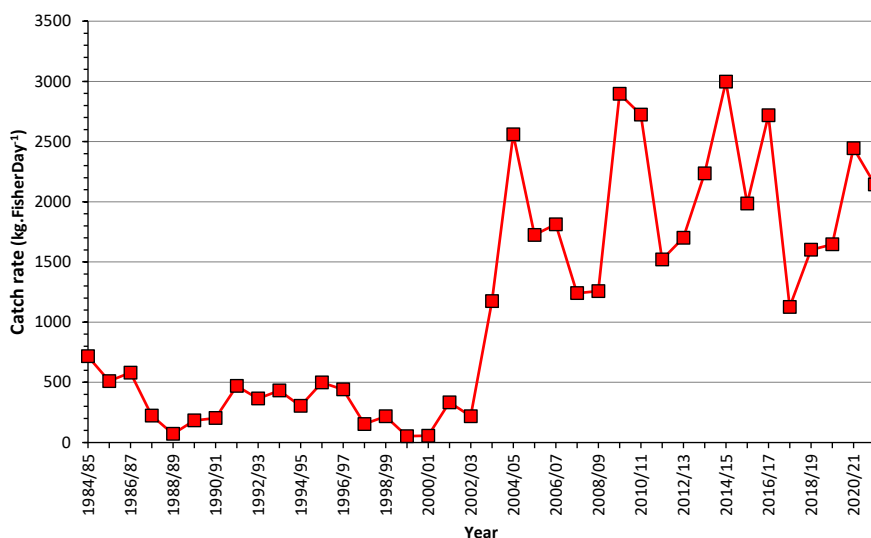


Figure 8. Commercial catch rates (kgs per day) of Australian Sardine using Purse Seining for years 2009/10 to 2021/22 in NSW.

### Recreational

N/A

### Indigenous

N/A

### **References**

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