

PIRSA



DRAFT Management Plan for the South Australian Commercial Sardine Fishery



Draft Management plan for the South Australian Commercial Sardine Fishery

Information current as of 19 October 2022

All enquiries

Fisheries and Aquaculture
Department of Primary Industries and Regions (PIRSA)
2 Hamra Avenue, West Beach
GPO Box 1671, Adelaide SA 5001

Front cover image courtesy of South Australian Sardine Industry Association.

Disclaimer:

This Management Plan has been prepared pursuant to the *Fisheries Management Act 2007* (the Act) for the purpose of the administration of that Act. The Department of Primary Industries and Regions SA (and the Government of South Australia) make no representation, express or implied, as to the accuracy or completeness of the information contained in this Management Plan or as to the suitability of that information for any particular purpose. Use of or reliance upon information contained in this Management Plan is at the sole risk of the user in all things and the Department of Primary Industries and Regions SA (and the Government of South Australia) disclaim any responsibility for that use or reliance and any liability to the user.

Copyright Notice:

This work is copyright. Copyright in this work is owned by the Government of South Australia. Apart from any use permitted under the *Copyright Act 1968* (Commonwealth), no part of this work may be reproduced by any process without written permission of the Government of South Australia. Requests and enquiries concerning reproduction of this work should be addressed to the Chief Executive, Department of Primary Industries and Regions SA, 25 Grenfell Street, Adelaide, SA, 5000 (marked attention Executive Director, Fisheries and Aquaculture Division).

The South Australian Fisheries Management Series

Paper number XXX: Management Plan for the South Australian Commercial Sardine Fishery (2023)

ISBN: xxxx

ISSN: xxxx

Contents

1	Fishery to which this plan applies	4
2	Consistency with other management plans.....	4
3	Term of plan	4
4	Description of the fishery	5
4.1	Historical overview	6
4.2	Threatened, endangered and protected (TEPS) species.....	8
4.3	Ecosystem and habitat.....	9
4.4	Biology of key species	9
4.5	Biological status of Australian Sardines	10
4.6	Economic characteristics	10
5	Ecologically sustainable risk assessment	11
6	Goals and Objectives.....	12
7	Co-management arrangements	23
8	Allocation of access between sectors	24
8.1	Current allocated shares of the resource	24
8.2	Information for adjusting allocations of access in future	25
8.3	Allocation triggers	25
8.4	Review of allocations of access in future.....	25
9	Harvest Strategy.....	28
9.1	Introduction.....	28
9.2	Objectives.....	28
9.3	Species.....	29
9.4	Assessment method	29
9.5	Previous strategies	30
9.6	Performance Indicators.....	30
9.7	Spatial management.....	33
9.8	Decision rules	34
9.9	Meta-rules.....	37
9.10	Decision-making process.....	37
9.11	Examples.....	38
9.12	Review.....	39
10	Stock assessment and research.....	39
10.1	Research services	39
10.2	Data collection and analysis.....	39
10.3	Strategic research plan	40
11	Compliance and monitoring	40
12	Resources required to implement plan	41
13	Review of plan.....	42
14	References	43
15	Appendices.....	47
15.1	Performance reports	47

1 Fishery to which this plan applies

This plan applies to the class of commercial fishing activities involving the taking of Australian Sardines and Australian Anchovy in South Australian waters using the purse seine method (using a sardine net) pursuant to a Sardine Fishery licence. This class of fishing activity is part of the formally constituted Fisheries Management (Sardine Fishery) Regulations 2021 (hereafter referred to as the Sardine Fishery Regulations). This plan describes the management framework for the fishery.

2 Consistency with other management plans

This management plan has been developed to be consistent with other management plans where applicable.

This management plan has also been developed so that it can be integrated with any Aboriginal traditional fishing management plans that are made in the future that apply to the waters of this fishery. No Indigenous land use agreements (ILUA) and therefore no Aboriginal traditional fishing management plans had been made at the time of writing this management plan.

3 Term of plan

This management plan applies from xxx 2023 for a period of ten years. A comprehensive review of this management plan will be undertaken as soon as practicable after the fifth anniversary of the commencement of this plan under section 46(2) of *the Fisheries Management Act 2007* (hereafter referred to as the Act) to determine whether it should be amended, replaced or reinstated without amendment (see Section 13).

4 Description of the fishery

The Sardine fishery is primarily based on the capture of Australian Sardine (*Sardinops sagax*) using a sardine net. The take of Australian Anchovy (*Engraulis australis*), Maray (*Etrumeus teres*), Blue Sprat (*Spratelloides robustus*) and Sandy Sprat (*Hyperlophus vittatus*) are also permitted in the area of the Fishery. Access to the sardine fishery is provided through a licence for the Sardine Fishery with a sardine net endorsement.



Figure 1: The area of waters of the sardine fishery

The area of the Sardine fishery includes all the waters adjacent to the state of South Australia to the edge of the 200-nautical-mile Australian Fishing Zone (Figure 1), with the exception of closed areas. The legislative instrument defining the area of jurisdiction for the Sardine fishery is the 1996 Offshore Constitutional Settlement arrangements for scalefish species between South Australia and the Commonwealth of Australia.

The fishery is managed through an individual transferrable quota (ITQ) system with a total allowable commercial catch (TACC) set for each 12-month period. In 2010, spatial management zones were implemented to encourage development of the fishery outside of Spencer Gulf and Gulf St Vincent. In 2013, the zones were amended to address concerns regarding declines in size and age composition of sardines caught in southern Spencer Gulf.

The fishery has complementary input controls including limited entry and gear restrictions.

Sardines are primarily used as feed for Southern Bluefin Tuna, which are farmed by the aquaculture industry near Port Lincoln, South Australia. Small amounts are also sold for human consumption and as recreational fishing bait.

4.1 Historical overview

In February 1991 the (then) Department of Fisheries provided 20 Marine Scale Fishery (MSF) licence holders with net endorsements access to take Sardines using a small-mesh purse seine net thus establishing a fishery for Australian Sardines (then called 'pilchards') (Mackie 1995). Catches initially were low, as few licence holders took up Sardine fishing on a full-time basis and the fishery was unable to supply the newly established Tuna farms with required supply of Sardines. The access entitlement was subsequently reviewed and, as a result seven MSF licence holders and seven fishers previously nominated by the Australian Tuna Boat Owners Association (ATBOA) were granted access to fishing activity in 1993 administered by Ministerial exemptions.

In 1996, access was also granted to licence holders with a Commonwealth Southern Bluefin Tuna Permit to take the genera/species *Emmelichthyes*, *Trachurus*, *Sardinops*, *Clupea*, *Scomber australasicus* and *Engraulis* for chum bait purposes whilst targeting Southern Bluefin Tuna. These management arrangements were legislated pursuant to the 1996 Offshore Constitutional Settlement arrangements for scalefish species between South Australia and the Commonwealth.

In 2000, a Pilchard Fishery Independent Advisory Allocation Panel advised the then Minister, that the 14 Ministerial exemption holders should maintain their access to the Sardine resource in waters adjacent to South Australia; seven by virtue of holding a commercial licence in the MSF and seven as nominees of the ATBOA.

Mass Sardine mortality events in 1995 and 1998 resulted in the Sardine Fishery being closed for a short period during each event. These events have been attributed to a Herpes-like virus of unknown origin (Ward et al. 2001b) and killed approximately 70 per cent of the spawning biomass (SpB) in South Australian waters (Ward et al. 2001b). Difficulties in reliably estimating Sardine age have impeded the assessment of the fishery's capacity to recover from these events (Ward et al. 2012), but the fact that recoveries have occurred relatively quickly demonstrates the fishery's robustness.

Explicit spatial management arrangements were adopted in the 2014 Harvest Strategy (PIRSA 2014) to protect stocks of Sardines in southern Spencer Gulf from depletion of target-sized fish and adverse impacts on the ecosystem. That Harvest Strategy defined two zones in the Sardine fishery – the Gulfs Zone (GZ) and the Outside Zone (OZ). In 2020 a trial of a refinement to the spatial management arrangements for the Sardine fishery was implemented providing for 6,000 t of OZ quota entitlements to be harvested from Gulf St Vincent (GSV). The benefits of establishing a GSV Zone was to reduce fishing costs and improve product quality compared to fishing in the OZ.

In 2021, the Sardine Fishery was formally constituted under the Sardine regulations, separating the fishery from the MSF. At this time, new fishing licences were issued to each of the 14 MSF licence holders who held a MSF licence with a Sardine net

endorsement. Table 1 provides a summary of the major milestones in the development of the sardine fishery.

Table 1: A chronology of major management milestones in the sardine fishery

Date	Event
1991	20 MSF licence holders access to take Sardines using a small-mesh purse seine net a sardine fishery using purse seine nets.
1992	Access entitlements reviewed due to low catches and limited commitment to the fishery.
1993	Seven MSF licence holders and seven fishers nominated by the ATBOA granted access to sardines.
1995	The first management plan was implemented for the Sardine fishery.
1995	The first daily egg production method (DEPM) survey was completed
1995	Mass mortality event occurred attributed to the Herpes-like virus of unknown origin.
1996	Access granted to Commonwealth Southern Bluefin Tuna statutory fishing right holders to take Sardines and anchovies to use as chum bait whilst targeting Southern Bluefin Tuna.
1998	Mass mortality event occurred attributed to the Herpes-like virus of unknown origin.
2000	An independent advisory panel provided advice in regard to future access of the resource. Fourteen fishers retained access to the sardine fishery (seven MSF licence and seven nominated by the ATBOA).
2004	The first ecological study was completed for the fishery.
2005	Second management plan implemented
2005	Sardine fishery closed due to evidence of increased Common Dolphin mortalities in sardine nets. The fishery was reopened two months later upon the introduction of a Code of Practice to reduce encirclements and mortalities and Independent Observer Program was implemented
2007	A revised Harvest Strategy was implemented through an addendum to the 2005 management plan.
2010	Spatial management zones introduced to explore the feasibility of sardine fishing outside the gulfs.
2012	The TACC increased mid-season by 2000 t to address an unanticipated shortfall of feed for SBT.
2013	The 2013 TACC reduced by 2000t in response to the additional quota provided in 2012.
2013	Spatial management measures were implemented in the fishery in response to a decline in size and age of sardines caught in southern Spencer Gulf in the previous seasons.
2014	2014 management plan implemented as Part B of the MSF management plan
2020	Trial of refined spatial management arrangements with establishment of a GSV Zone
2020	Additional quota issued to mitigate impact of COVID-19
2021	Carry over of uncaught quota from 2020 as COVID-19 assistance measure 2021 TACC set taking into account additional quota provided in 2020. Separation of the fishery from MSF through new regulations.

4.2 Threatened, endangered and protected (TEPS) species

In November 2004 an independent monitoring program was initiated to monitor interactions of the Sardine Fishery with threatened, endangered and protected species (TEPS) to address recommendations under the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999*. This monitoring program indicated the fishery was having interactions with Common Dolphins (*Delphinus delphis*) and an independent observer program was implemented, initially at a level of 10% of fishing nights, increased to 30% in 2007 (Hamer et al. 2009).

In response to the interactions, industry implemented a Code of Practice (CoP) to mitigate interactions with Common Dolphins by introducing an avoidance and delay approach. This CoP raised awareness within the industry and saw a reduction in the interaction rates with common dolphins (Hamer et al. 2009). In 2008 the CoP was reviewed and refinements were made, including requirements that operators delay the commencement of fishing prior to setting the net and dropping the front of the net if they noticed a dolphin enclosed in the net. This, together with improved implementation of the CoP, saw an increase in the effectiveness of the Sardine industry to mitigate against interactions (Hamer et al. 2009).

In 2010 the required level of observer coverage returned to 10% following reduced number of dolphin interactions, and in 2013 observer coverage changed from being based on nights fished to the number of net sets, in order to improve the effectiveness and transparency of the program.

A project was undertaken during 2010 to analyse the effectiveness of the CoP to mitigate interactions with Dolphins and found it to be highly effective and successful (Ward et al. 2010b). The report also highlighted the statistical difference between observer data and logbook data in the 2006-07 financial year (Ward et al. 2010b). This difference decreased in 2009-10 (Ward et al. 2010b). A reduction in encirclements was also reported and attributed to the industry's avoidance procedures and the reduction in mortalities to industry's reaction times and the success of the adopted release procedures Ward et al. (2010b). Despite the effectiveness of the CoP in reducing Common Dolphin interactions, the discrepancy between the observed interaction rates and logbook interaction rates remained a focus of managers and stakeholders (Ward et al. 2010b).

In 2011, SASIA started collecting real-time information on interactions to help improve transparency resulting in a marked reduction in the discrepancy between interaction rates. In the two years from 2018-2020 the highest level of mortality was reported since the inception of the industry CoP and corresponding independent observer program, where a total of 15 dolphin mortalities in 4 individual events occurred.

As a result, the following actions were undertaken:

- The level of observer coverage for the 2020 calendar year was increased to 20% of net sets
- SASIA in collaboration with PIRSA undertook a review of the industry CoP
- The SASIA CoP was modified to incorporate training and education requirements for crew aboard vessels in the fishery

Industry have continuously been proactive in implementing any measures considered appropriate to help reduce the discrepancy between the two rates and to reduce the level of interactions with dolphins. SASIA has established a TEPS working group that holds quarterly meetings to monitor interactions and the effectiveness of the CoP.

Annual reports of TEPS interactions and effectiveness of the COP are published by SARDI on https://www.pir.sa.gov.au/research/publications/research_reports, the only purse seine fishery globally to conduct such reporting.

4.3 Ecosystem and habitat

The Great Australian Bight contains a broad continental shelf (up to 200 km wide) that is the location of the world's only northern boundary current upwelling ecosystem (Goldsworthy et al. 2011). The area where the continental shelf waters and the southern Spencer Gulf meet forms a complex oceanographic system (Goldsworthy et al. 2011). At the mouth of the gulf, thermal and salinity fronts limit the exchange between cool, low-salinity water (outside the gulf) and the warmer, higher salinity water (inside the gulf). The system is not greatly understood but is thought to play an important ecological role in the region (Goldsworthy et al. 2011).

This region supports coastal upwelling in summer and autumn, as well as numerous currents along the continental shelf – providing a complex interaction of oceanographic processes. These processes support a high level of planktonic production during upwelling periods and a diverse range of marine species with high conservation significance and substantial economic value to local ecological communities (Goldsworthy et al. 2011). These conditions are suitable for the spawning, survival and growth of a diverse small pelagic fish comprising of six families– Clupeidae, Engraulidae, Scombridae, Carangidae, Emmelichthyidae and Scomberesocidae (Goldsworthy et al. 2011). From these six families there are 10 key species found in South Australia – Australian Sardine (*S.sagax*), Australian Anchovy (*E. australis*), Maray (*Etrumeus teres*), Sandy Sprat (*Hyperlophus vittatus*), Blue Sprat (*Spratelloides robustus*), mackerels (*Trachurus declivis* and *T. novaezelandiae*), Blue Mackerel (*Scomber australasicus*), Redbait (*Emmelichthys nitidus*) and King Gar (*Scomberesox saurus*). Of these small pelagic fish the family Clupeidae is dominant, with five species occurring in the region (Goldsworthy et al. 2011).

4.4 Biology of key species

Sardines occur in cool, temperate to subtropical waters along with species of Anchovy, and in South Australia are the dominant clupeid, occurring from the southern parts of both gulfs to past the continental shelf (Ward et al. 2001b) and supporting the largest component of the Australian population (Ward et al. 2012).

Australian Anchovies are also abundant in South Australian waters and occur mostly in the northern part of the gulfs when Sardine biomass is high, but with the capacity to increase abundance and expand distribution into shelf waters when Sardine abundance is reduced (Ward et al. 2012).

Sardines are serial spawners and release numerous batches of pelagic eggs. The eggs are released throughout the spawning season, between January to April with approximately 10,000 to 30,000 eggs spawned per female each week (Ward et al. 2012). After fertilisation, Sardine eggs take two days to hatch, followed by a relatively long larval phase of one to two months. In South Australia, larvae are abundant at the mouth of the gulfs and along the shelf waters, coinciding with the upwelling periods (Ward et al. 2012).

4.4.1 Role in the ecosystem

Sardines are an important food source for many predatory fishes, Squid, seabirds and marine mammals (e.g. Pikitch et al. 2012). However, the reliance of predators on Sardine and other small pelagic fishes varies among ecosystems and species (e.g. Smith et al. 2011; Hilborne et al. 2017). The trophic role of Sardines is particularly important in 'wasp-wasted' ecosystems, such as those found in the productive California, Humboldt and Benguela Current systems where one or two species usually dominate the pelagic fish biomass (e.g. Cury et al. 2000). In contrast, several studies have shown that Australia's less productive pelagic ecosystems support a wide range of small to medium sized planktivores and that few predators are highly dependent on a single prey species (Bulman et al. 2011; Smith et al. 2015). In South Australian waters, marine predators feed opportunistically on a wide range of prey species and none have been shown to be primarily dependent on Sardine as a food source (Goldsworthy et al. 2013).

4.5 Biological status of Australian Sardines

The performance indicator (PI) for the Sardine Fishery is primarily the estimate of SpB obtained from undertaking a DEPM survey, which was first completed in 1995.

Grammer et al. (2021), reported the SpB of the Australian Sardine was in a relatively strong position with estimates of SpB (from surveys in 2019 and 2020) well above the limit reference point of 75,000 t. Further, the 2021 assessment stated the model outputs suggest the SpB has been relatively stable at approximately 270,000 t (range: 170,000 t to 370,000 t over the last decade. Stock status of the Sardine fishery is reported regularly in SARDI research reports available at:

https://www.pir.sa.gov.au/research/publications/research_reports

4.6 Economic characteristics

The economic and social objectives of the fishery are reported within an annual economic report which currently includes economic and social indicators for the South Australian Sardine Fishery. The Gross Value of Production (GVP) in 2019/20 was estimated at \$A27.0m, provided \$A34.5m to Gross State Product (GSP) and 186 full time equivalent jobs. Economic reports for the Sardine Fishery are available at: <https://www.bdo.com.au>.

Economics of the Sardine fishery can be difficult to interpret as many of the companies that operate in the fishery are vertically integrated (where a business owns multiple stages of production). In this case, a company that holds a Sardine fishery licence may

also own and operate a processing facility, other fishery access rights such as the Commonwealth's Southern Bluefin Tuna Fishery or Spencer Gulf Prawn, aquaculture leases to ranch tuna (the main market for Sardines) or a slipway to maintain vessels.

5 Ecologically sustainable risk assessment

The Act currently requires that the following ecological impacts be identified and assessed as the first step in developing a management plan:

- Current known impacts of the fishery on the ecosystem.
- Potential impacts of the fishery on the ecosystem.
- Ecological factors that could have an impact on the performance of the fishery.

The ecological impacts associated with the Sardine fishery have been identified and assessed through a review of the ecologically sustainable development (ESD) risk assessment for the Sardine fishery conducted in 2021, using the *National Ecologically Sustainable Development Reporting Framework for Australian Fisheries* (Fletcher et al. 2002) to guide the assessment.

The ecological, economic and social factors that affect the management of the Sardine fishery were prioritised by stakeholders using risk ratings from negligible to extreme. A report describing the outcomes of the assessment are available through PIRSA (in prep). A performance report for the risks rated Moderate or above are provided at Appendix 1.

6 Goals and Objectives

The objects of the *Fisheries Management Act 2007* are to protect, manage, use and develop the aquatic resources of the State in a manner that is consistent with ESD. The Act also requires that management plans must be consistent with the Act's objects. The Act identifies a number of biological, social and economic factors that must be balanced in pursuing ESD; however, the principle of avoiding over-exploitation of resources and ensuring that those resources are not endangered is specified as the primary consideration.

The four key goals for the Sardine fishery are set out below and are linked to the operational objectives for the fishery. PIs and reference points for each objective are provided to allow for assessment of the management plan in meeting the identified goals.

Goal 1: Maintain harvest of Sardines at ecologically sustainable levels

This goal relates to the sustainability of the target stock. The operational objective of this management plan in relation to sustainability is:

- South Australian Sardine stocks are maintained at a sustainable stock status.

This objective aims to ensure that Sardine resources are harvested within sustainable limits as defined by the target reference point included in the Harvest Strategy at Section 9

The main strategies for ensuring the sustainability of the resource include spatially discrete TACCs, limited entry, gear restrictions, and the Harvest Strategy for the fishery.

Goal 2: Optimum utilisation and equitable distribution

This goal relates to the economic and social benefits derived from the fishery. Optimising the use of the fishery focuses on allowing for economic efficiency of the fishing operations. The objective of this management plan in relation to optimum utilisation is:

- An economically efficient fleet without compromising sustainability objectives.

The strategies to achieve this goal are focused on a Harvest Strategy that allows for flexible fishing operations within sustainable limits.

With regard to equitable distribution, this fishery is exclusively a commercial fishery by virtue of the limiting management arrangements. The objectives in this plan ensure access of the resource is in line with requirements under the Act. The operational objective related to resource access is:

- To provide access to the resource as per the PIRSA Allocation Policy: Allocation of Access to Fisheries Resources Between Fishing Sectors (PIRSA 2011) (hereafter referred to as the Allocation Policy).

Goal 3: Protect and conserve aquatic resources, habitats and ecosystems

This goal relates to the management of the fishery using an EBFM approach.

To achieve this goal, this management plan's objectives are that:

- Fishery impacts on by-catch and by-product species are sustainable.
- Fishery impacts on TEPS are sustainable.
- Fishery impacts on benthic habitat and associated species communities are sustainable.

Management strategies to achieve this goal include controls on fishing effort, spatial management of the fishery, and promoting activities that reduce impacts of fishing activity.

Goal 4: Cost effective and consultative co-management of the fishery

The overall objectives of this goal are to ensure that stakeholders and government fisheries administration have involvement and share responsibility through consultative and, where possible, collaborative co-management¹ in the decision-making processes for developing and implementing management arrangements, and to ensure that management arrangements are complied with. The cost-effectiveness of these arrangements also needs to be considered in the development process as the management costs are recovered from fishers in accordance with the government's cost-recovery policy for fisheries (PIRSA 2013b).

The operational objectives of this management plan in relation to co-management, planning and cost-recovery are:

- Industry participation in management through co-operative arrangements.
- Management arrangements support cohesion between the fishing industry and wider community.
- Maximising stewardship of fisheries resources.
- Costs of management of the fishery are funded by relevant stakeholders.

¹Consultative and collaborative co-management are two prescribed co-management levels in the *Policy for the Co-Management of Fisheries in South Australia*.

Table 2: Goals, objectives, strategies for the management of the sardine fishery.

Goal 1: Maintain ecologically sustainable sardine biomass.					
Objective	Strategy	Addressing risk	Performance indicator	Description	Reference Point
1a Maintain sardine stocks above the target reference point by managing total catch across the fishery and preventing the depletion of large Sardines in Gulf Zones	<p>1a(i) Set a TACC for Sardine annually using framework set out in the Harvest Strategy</p> <p>1a(ii) Maintain entry and gear restrictions</p> <p>1a(iii) Monitor average size of harvested sardines during season</p>	Australian Sardines - fishery impacts on the target species – effectiveness of management of Australian Sardines	<p>Spawning biomass from Sardine survey (or stock assessment if assessment is not completed)</p> <p>Mean size of Sardines</p>	<p>Spawning biomass estimates of sardines is the primary indicator of stock abundance in the sardine fishery</p> <p>Mean size of Sardines is the indicator to monitor whether depletion of target size sardines is occurring in the gulfs system</p>	<p>Trigger reference point – spawning stock biomass >150,000 t</p> <p>Limit reference point – spawning stock biomass > 75,000 t</p> <p>Reference point – mean size of harvested sardines > 135 mm for Spencer Gulf and the Gulf of St Vincent</p>
1b Ensure sufficient data is collected to undertake a stock assessment	<p>1b(i) Collect fishery dependent data through commercial logbooks and CDRs</p> <p>1b(ii) Maintain independent monitoring program to collect biological samples of sardines for the development of size frequencies and age determination</p> <p>1b(iii) Undertake a fishery independent DEPM survey and stock assessment</p> <p>1b(iv) Review and update the strategic research and monitoring priorities regularly</p> <p>1b(v) Work with industry, where necessary, to develop an</p>	Australian Sardines - fishery impacts on the target species – research and development	<p>Numbers of logbooks and CDRs provided</p> <p>Stock assessment and/or a daily egg production method survey is completed</p> <p>Annual stock assessment or fishery assessment report published</p>	<p>All commercial fisheries provide spatial and temporal catch and effort data</p> <p>The appropriate population model assessment is used to determine the stock status</p>	<p>Licence holders provide logbook records for each fishing trip</p> <p>CDRs are provided for each off-load of harvested sardines</p> <p>Stock assessment survey completed to meet criteria for exploitation level set in the Harvest Strategy (i.e. annually or bi-annually)</p> <p>DEPM surveys completed to meet criteria for exploitation level set in the Harvest Strategy (i.e. annually or bi-annually)</p>

	industry led real-time size monitoring program				Annual stock assessment or fishery assessment report published
1c Limit and monitor Australian Anchovy catches	<p>1c(i) Set a TACC for anchovy annually within sustainable limits</p> <p>1c(ii) Maintain entry and gear restrictions</p> <p>1c(iii) Monitor catch levels of harvested anchovy during season</p> <p>1c(iv) Adopt a precautionary principle to make decisions when robust information is lacking</p>	Australian Anchovy – fishery impacts on the target species – effectiveness of management	Catch levels of anchovy	Monitor catches of Australian Anchovy against the TACC as an indicator that has been set for the species	

Goal 2: Optimum utilisation and equitable distribution.					
Objective	Strategy	Addressing risk	Performance indicator	Description	Reference Point
2a Maximise value of the fishery to the community within ecologically sustainable limits	<p>2a(i) Undertake economic review on a regular basis</p> <p>2a(ii) Develop arrangements to improve the operational efficiency of the fishing fleet, while maximising flexibility (e.g., new fishing grounds if appropriate)</p> <p>2a(iii) Develop arrangements that allow for value-adding strategies, where possible</p> <p>2a(iv) Ensure fisheries information is available in a timely and publicly accessible manner</p> <p>2a(v) Develop options for the permanent transfer of quota within the fishery</p>	<p>Market – profit</p> <p>Market – employment</p> <p>Market – asset value</p> <p>Economic – market forces/demand</p>	<p>Gross value of production (GVP)</p> <p>Gross operating surplus (GOS)</p> <p>Number of FTEs directly and indirectly employed</p> <p>Licence value</p> <p>PIRSA Website information on the sardine fishery is the most up-to-date available</p>	<p>GVP is the total catch valued at the landed beach price</p> <p>GOS provides an index of capacity of operator to remain in the fishery in the short to medium term</p> <p>Licence value is the estimated market value of the licence</p> <p>Information includes; management plan, stock assessment, status report, TEPS interaction reports and economics report</p>	<p>GVP monitored regularly</p> <p>GOS monitored regularly</p> <p>Licence value monitored regularly</p> <p>Economic indicators report conducted regularly</p> <p>Information on the PIRSA website is reviewed regularly</p>
2b An economically efficient fleet	<p>2b(i) Consider economic and financial impacts when implementing management arrangements</p> <p>2b(ii) Undertake economic review on a regular basis</p> <p>2b(iii) Where appropriate, and if possible, influence other processes that impact on infrastructure development</p>	<p>Market – profit</p> <p>Market – employment</p> <p>Market – asset value</p> <p>Infrastructure and access to unload facilities</p>	<p>Gross value of production</p> <p>Gross operating surplus</p> <p>Licence value</p> <p>Economic indicators assessed in economic indicators report</p>		

2c Ensure sufficient economic information is used to make informed management decisions	2c(i) Undertake economic surveys to assess the economic performance of the fishery	Research and data collection	Economic indicators assessed in economic indicators report	The economic indicators report provides detailed regional information on the economics of the fishery	The economic indicators report is published regularly
2d Allocate access to the fishery resources and manage shares to optimise utilisation and equitable distribution	2d(i) Allocate access to sardine and anchovy resource and commercial, recreational and Aboriginal traditional fishing sectors, in accordance with the Act. 2d(ii) Monitor mortality levels from other sources.	Legal framework – Allocation/Offshore Constitutional Settlement	Review of allocation between sectors undertaken periodically or when necessary Total catch in the sardine fishery Total by-catch of Australian Sardines by other fisheries (e.g., Commonwealth Small Pelagic Fishery)		Allocation reviewed when appropriate

Goal 3: Protect and conserve aquatic resources, habitats and ecosystems.

Objective	Strategy	Addressing risk	Performance indicator	Description	Reference point
<p>3a Fishery impacts on by-catch species are monitored and arrangements used to limit fishery impact on the ecosystem</p>	<p>3a(i) Maintain Part 13 and 13A accreditation under the Environmental Protection and Biodiversity Conservation Act 1999</p> <p>3a(ii) Maintain input arrangements that control effort and gear</p> <p>3a(iii) Monitor catches of by-catch species</p> <p>3a(iv) Develop arrangements where necessary to minimise the fishery impacts on the ecosystem</p> <p>3a(v) Where appropriate, and if possible, influence other processes that impact on the application of the EPA (Environment Protection Authority) <i>Water Quality Policy</i></p> <p>3a(vi) Ensure fisheries information is available in a timely and publicly accessible manner</p>	<p>By-product and non-retained species</p> <p>Ecosystem effects</p> <p>Impacts on trophic structure</p> <p>Water quality – refrigerated seawater discharge</p>	<p>Develop base line information of by-catch rates</p> <p>PIRSA Website information on the sardine fishery is the most up-to-date available</p>	<p>Use the independent monitoring program to monitor net sets for by-catch</p> <p>Information on the website includes; management plan, stock assessment, status report, TEPS interaction reports and economics report</p>	<p>Information on the PIRSA website is reviewed regularly</p>
<p>3b Fishery impacts on TEPS are sustainable</p>	<p>3b(i) Consider fishery TEPS interaction information for setting the annual level of observer coverage</p>	<p>Non-retained –TEPS</p> <p>Ecosystem effects</p>	<p>Monitor whether the observer coverage is appropriately representative of commercial operations</p>	<p>Ratio of TEPS interactions reported in wildlife interaction logbooks compared to observer-reported interactions</p>	

	<p>3b(ii) Maintain a representative independent monitoring program to collect information and monitor TEPS interactions</p> <p>3b(iii) Investigate, develop and improve arrangements, where possible, that assist avoidance of TEPS interactions</p> <p>3b(iv) Monitor TEPS interactions through wildlife interaction logbooks</p> <p>3b(v) Maintain TEPS working group</p> <p>3b(vi) Ensure fisheries information is available in a timely and publicly accessible manner</p>	Impacts on trophic structure	<p>Level of independent monitoring compared to target level</p> <p>The number of common dolphin mortalities each year</p> <p>Up-to-date industry TEPS CoP provided to skippers at the start of each season or induction of new skipper</p> <p>PIRSA Website information on the sardine fishery is the most up-to-date available</p>	<p>Number of reported Dolphin interactions</p> <p>Information includes; management plan, stock assessment, status report and economics report</p>	<p>Increasing trends in independently monitored mortality rates over three year period²</p> <p>Adherence with industry CoP and regulations</p> <p>Maintain meetings to monitor and discuss TEPS interactions</p> <p>Monitor level of actual observer coverage compared to target level.</p> <p>TEPS interaction reports made publicly available</p> <p>Management survey of the information on the website is undertaken each year</p>
3c Limit the fishery impacts on the trophic structure by maintaining stocks above the target reference point and preventing the depletion of large Sardines in Gulf Zones	<p>3c(i) Adopt a precautionary principle to make decisions when robust information is lacking</p> <p>3c(ii) Maintain a representative independent monitoring program to collect information and monitor TEPS interactions</p>	Impacts on trophic structure	Website information on the sardine fishery is the most up-to-date available	Information includes; management plan, stock assessment, status report and economics report	Management survey of the information on the website is undertaken each year

² Any significant (>20%) increase in interaction and mortality rates between years will be investigated.

3d Manage diseases to minimise the impact on the resources	3d(i) Where appropriate, and if possible, influence and improve processes between agencies responsible for biosecurity and natural resource management	Ecological impacts – biological			
--	--	---------------------------------	--	--	--

Goal 4: Cost effective and consultative co-management of the fishery.

Objective	Strategy	Addressing risk	Performance indicator	Description	Reference Point
4a Provide cost-effective and efficient management of the fishery, in line with government's cost recovery policy	<p>4a(i) Develop management arrangements that are effective at achieving management objectives and optimising cost effectiveness</p> <p>4a(ii) Determine the real cost of management, compliance tasks, research and compliance for the fishery on an annual basis</p> <p>4a(iii) Recover licence fees from commercial licence holders, sufficient to cover the attributed costs of fisheries management, research and compliance of the commercial fishery in accordance with the government's cost recovery policy</p> <p>4a(iv) monitor and, if possible, develop a longer-term cost recovery agreement</p>	<p>Profit</p> <p>Asset value</p> <p>Primary species – effectiveness of management</p>	Key economic indicators: licence fees as a percentage of gross value of production, gross operating surplus, licence value	The economic indicators report	Available economic information is monitored and reported

	<p>4a(v) Review the management framework in line with the results from the rules review project</p> <p>4a(vi) Monitor licence fees as a percentage of GVP</p>				
<p>4b Support industry body to participate and function within the co-management framework of the fishery</p>	<p>4b(i) Promote stakeholder input and industry ownership of the fishery, through consultative co-management processes and communication strategies</p> <p>4b(ii) where possible work to develop collaborative co-management arrangements</p> <p>4b(iii) Ensure fisheries information is available in a timely manner and is publicly accessible</p> <p>4b(iv) Attend industry quarterly meetings and promote stakeholder attendance</p>	<p>Primary species – effectiveness of management</p>	<p>Stakeholders participate in meetings as required</p> <p>PIRSA Website information on the Sardine fishery is the most up-to-date available</p>	<p>Quarterly research and management committee and TEPS working group meetings</p> <p>Information includes; management plan, stock assessment, status report, TEPS interaction reports and economics report</p>	<p>All relevant stakeholders are represented at quarterly meetings</p> <p>Information on the PIRSA website is reviewed regularly</p>
<p>4c Effective compliance program for the fishery</p>	<p>4c(i) Undertake annual compliance risk assessment and address those risks</p> <p>4c(ii) Review existing reporting and monitoring arrangements</p> <p>4c(iii) Develop and implement management arrangements that are clear and uncomplicated to promote voluntary</p>	<p>Primary species – management effectiveness</p>	<p>Quota use reported throughout the season</p> <p>Where necessary, Fisheries Officers to participate in industry meetings</p> <p>Number of prosecutions related to the sardine fishery</p>	<p>Quota use is monitored by PIRSA through CDR form returns</p> <p>Where necessary, fisheries officers participate in quarterly meetings</p>	<p>Quota use reported throughout the season</p> <p>Where necessary, fisheries officers to participate in industry meetings</p> <p>Number of prosecutions over three years does not increase significantly</p>

	<p>compliance and assist with successful enforcement</p> <p>4c(iv) Where possible, develop and implement licensing, compliance and monitoring arrangements that are consistent with other fisheries to reduce administrative costs</p> <p>4c(v) Encourage the community and industry to report fisheries offences to 'Fishwatch'.</p> <p>4c(vi) Develop formal relationships between industry and fisheries officers to improve effective compliance</p>		<p>Compliance risk assessment undertaken</p>		<p>Compliance risk assessment undertaken annually</p>
--	--	--	--	--	---

7 Co-management arrangements

Co-management is an arrangement whereby responsibilities and obligations for sustainable fisheries management are negotiated, shared and delegated at appropriate levels between government, the commercial fishing industry, recreational fishers, Aboriginal traditional fishers, and other key stakeholders such as conservation groups (Neville 2008). Co-management is recognised as comprising various levels – starting from centralised government regulation with no industry input at one end to more autonomous management by industry groups and key stakeholders at the other, where government plays more of an audit role. It is designed to achieve efficient regulatory practice (among many other things) and is by no means a way of industry or other key stakeholders avoiding regulatory scrutiny and influence.

PIRSA has adopted a *Policy for the Co-Management of Fisheries in South Australia* (PIRSA 2013b) (hereafter referred to as the Policy for the Co-management of Fisheries) to inform discussion with the wider commercial fishing industry and other stakeholder groups as to how best to promote and implement co-management arrangements. The policy proposes that implementation of a preferred co-management model should be through a phased approach that allows industry and key stakeholders to build their capacity over time and a government audit process to measure performance and success.

SASIA has been recognised by PIRSA as the peak representative industry body for the commercial Sardine Fishery. Consultative co-management arrangements have been established in the Sardine Fishery, where PIRSA administers fisheries legislation and makes decisions on fisheries management through consultative processes with fishers and other key stakeholders. Fisheries management decisions are discussed and debated through SASIA.

SASIA holds regular meetings with PIRSA Fisheries and Aquaculture and SARDI Aquatic Sciences to discuss research and management issues in the fishery. SASIA has established the TEPS Working Group to provide advice on management of the industry's COP and the Independent Observer Program. Membership of the working group includes Sardine fishery licence holders, PIRSA, SARDI and the Department for Environment and Water.

Opportunities to improve the co-management arrangements for the sardine fishery will continue to be pursued in accordance with the principles provided in the Policy for the Co-management of Fisheries.

8 Allocation of access between sectors

8.1 Current allocated shares of the resource

The Act provides that a management plan must specify the share of the fishery to be allocated to each fishing sector under the plan (43(2)(h)).

The Act also provides that, in determining the share of aquatic resources to be allocated to a particular fishing sector under the first management plan for an existing fishery, the share of aquatic resources to which that fishing sector had access at the time the Minister requested preparation of the plan (based on the most recent information available to the Minister) must be taken into account (43(3)).

The Minister formally requested preparation of the first management plan under the Act being the 2014 management plan on 17 June 2010 taking into account the share of the sardine fishery that the commercial fishing sector had access to on that date. Allocations for the recreational and Aboriginal traditional fishing sectors must be determined at the same time.

Sardine and Anchovy Total Allowable Commercial Catch (TACC) are allocated 100% to the commercial sector, reflecting the shares of the resource between the three sectors at the time the Minister requested the preparation of the 2014 plan. The most recent recreational fishing survey at that time, being the 2007/08 survey (Jones 2009) reported the recreational sector does not take sardines or anchovies.

The Offshore Constitutional Settlement agreement between South Australia and the Commonwealth of Australia sets out that Sardines are managed by South Australia. Any allocation discussed in this management plan refers to South Australian fishing sectors only.

There is little documented information on the take of Sardines or Anchovy by the Aboriginal traditional fishing sector and there have been no claims relating to Sardines and Anchovies in the Native Title claims that relate to South Australia.

It should be noted that this allocation of resource shares does not prohibit the recreational or Aboriginal traditional take of these species. In the future, if either of the non-commercial sectors increases their take of Australian Sardine or Australian Anchovy, the allocation of shares may be reviewed, as set out in Section 8.4.

The shares allocated to each sector in relation to the Sardine Fishery are set out in Table 3.

Table 3: Shares of sardine fishery allocated to each fishing sector

Species	Commercial %	Recreational %	Aboriginal traditional %
Australian Sardines	100.0	0.0	0.0
Australian Anchovy	100.0	0.0	0.0

8.2 Information for adjusting allocations of access in future

Catch data used to allocate shares has been collected through commercial logbooks submitted in accordance with the regulations. Recreational data is set out in the report of the Recreational Fishing Survey 2007-08 (Jones 2009).

Access to South Australia's fisheries resources by Aboriginal communities under the Act may be provided through Aboriginal traditional fishing management plans. These plans may be developed when an ILUA, agreed to resolve a Native Title claim, is in place in relation to a Native Title claim area. The State is currently engaged in ILUA negotiations with Native Title claimants and other stakeholder groups, including the fishing industry. The agreements arising from these negotiation processes may inform the way that access to fisheries resources by Aboriginal communities is defined and implemented. Currently, Aboriginal traditional fishing under the Act only relates to fishing agreed through the ILUA process. Aboriginal people are also recreational fishers outside of these arrangements.

8.3 Allocation triggers

An important component of the allocation of shares is monitoring to identify a change in the relative value of those shares over time. The value of shares can be measured in a variety of ways, including catch and effort, economic value and social values. Measuring the social values of a fishery is an evolving area of natural resource management and there are no clearly identifiable indicators of social value that can be readily incorporated into an assessment of share value at this point in time. For these reasons, catch will be used as the indicator to measure changes in the value of shares (catch has been used to determine the first shares in this management plan). Catch estimates are available annually for all commercial fisheries. Estimates of recreational catches will be available at a minimum of once every five years from recreational fishing surveys.

Due to Sardines being 100% allocated to the commercial sector, there are no allocation triggers described in this management plan. Allocation triggers are usually set at a level commensurate with the initial allocation, allowing for variability in catches. Where a sector has been allocated over 91%, no trigger limit has been set as any shares greater than this amount are considered to be within normal fluctuation ranges.

8.4 Review of allocations of access in future

Allocation of access to Australian Sardine and Australian Anchovy stocks may be reviewed in accordance with PIRSA's Allocation Policy under the following scenarios and may be considered during a review of allocations;

- A review of the management plan, which will reassess the appropriateness of shares and may trigger an adjustment.
- One or more sectors exceed their allocation of Australian Sardine or Australian Anchovy.

- A major change in the management of a species and/or a sector that results in a shift of allocations to a sector(s).

The declaration of a Marine Protected Area that would result in a reallocation of shares may be given effect through the *Marine Parks Act 2007* and policies applying under that Act. The *Marine Parks Act 2007* requires the Government to pay fair and reasonable compensation to commercial fishers whose statutory rights are affected by marine park zoning.

8.4.1 Initial assessment

An initial assessment of allocations may be conducted by PIRSA in consultation with the relevant sectors of the fishery. Once the need for a review has been recognised, an assessment committee will be established. The committee may be required to assess the need for a second-stage assessment based on consideration of the following questions:

- Whether there has been a shift in the access value of the fishery or there is new information available that suggests a reallocation of shares would bring additional social and economic benefits to the State.
- A trigger limit³ has been breached, and whether that breach can be readily explained and justified.
- Whether the potential change in shares is significant and considered long-term as a minor shift/anomaly may not require a full review.

A written report will be prepared by the committee to PIRSA, with a recommendation to proceed to a full evaluation or not. PIRSA will determine whether to move to a full evaluation or may refer a recommendation to the Minister.

8.4.2 Full assessment

As with the initial assessment, a full assessment of allocation may be conducted by PIRSA in consultation with relevant stakeholders. An evaluation panel may be established with membership including independent experts as required.

The evaluation panel must evaluate how the value of one or more sectors is changing and the likely trends in the future. In the context of these changes, all options being considered should be evaluated against the option of maintaining the status quo and the potential flow-on effects with regard to:

- contribution to gross state product
- contribution to employment
- access to fresh seafood for consumers
- maintenance, growth and wellbeing of regional communities

³Trigger limits are not described in this management plan as the resources are 100% allocated to a sector. Recreational triggers will be described within their respective management plans.

- health impacts
- sport and recreation opportunities
- consistency with tourism policies
- other criteria relevant to the fishery

8.4.3 Assessment outcomes

Following the full assessment, the Allocation Policy provides that the review panel may recommend to the Minister one of two actions, to:

1. Manage each sector within the existing allocated shares
2. Proceed to adjust shares

8.4.4 Managing within existing shares

If shares are to be maintained it may be necessary, depending on the circumstances, to alter the catch of one or more sectors to maintain the existing shares between all sectors. To determine the appropriate mechanism to re-establish initial allocations, the existing co-management arrangements will be used to develop a preferred option. Adjusting commercial shares may be achieved through quota units for Sardines and a variety of controls such as seasonal and temporal closures, gear restrictions, and or catch limits. Recreational adjustments are likely to be made through alterations to existing bag and boat limits, seasonal closures and size limits.

8.4.5 Adjusting allocations of shares

Any future adjustments to the shares will be consistent with the requirements of the Fisheries Management Act 2007. Adjustment may, in the first instance, be implemented through a voluntary process and through direct negotiations between the relevant sectors. Where possible, market mechanisms will be used to adjust shares. Where there are no or limited market mechanisms available, adjustments to shares will be made in a similar manner used to manage shares within existing allocations.

If a voluntary adjustment scheme is not able to be implemented in the fishery, a second voluntary option/step may be considered, including an incentive-based scheme for share adjustment.

A process of compulsory acquisition may occur (through regulations) if necessary. Any compulsory acquisition of entitlements would include compensation to the commercial sector in accordance with the provisions of the Allocation Policy. Adjustments are to be finalised within two years.

9 Harvest Strategy

9.1 Introduction

This harvest strategy includes a set of decision rules that provide for fixed exploitation rates to allow for removal of a fixed fraction of the stock during a set period (normally annually).

Consistent with the *National Guidelines to Develop Fishery Harvest Strategies* (Sloan et al. 2014), the Sardine Harvest Strategy is defined as a framework that sets out the management actions necessary, using fixed exploitation rates and maintaining biomass above agreed levels, to control the exploitation of Sardines in order to achieve the ecological, economic and social objectives of the Sardine fishery.

9.2 Objectives

The Sardine Harvest Strategy aims to achieve the following objectives, to:

- Maintain the Sardine spawning biomass at a sustainable stock status, as defined in section 9.6.
- Optimise economic returns within these sustainability imperatives.
- Provide greater certainty and stability for industry stakeholders.
- Establish a simple and practical guide for fishery managers, researchers and industry stakeholders.
- Ensure cost-effectiveness of management.

The Sardine Harvest Strategy is designed to support the ecologically sustainable management of the Sardine fishing industry. The framework allows for harvesting of Sardines at ecologically sustainable levels through TACCs that are set based on catching a conservative percentage (exploitation rate) of the estimated SpB. The exploitation rate can vary depending on the level of monitoring and the assessment that is undertaken (see the decision rules at section 9.8). As with the Commonwealth Small Pelagic Fishery⁴, the three-tiered approach of the Sardine Harvest Strategy aims to achieve a balance between risk associated with various levels of exploitation (TACCs) with the information provided by the monitoring and assessment program. It is recognised that the costs for monitoring and assessment increase as the level of exploitation moves up from Tier 3 to Tier 1.

Key design principles of the Sardine Harvest Strategy include:

- Exploitation limits that do not exceed 33%, which recent ecosystem and population modelling assessment of Australian Sardine Fishery suggests is a

⁴ https://www.afma.gov.au/sites/default/files/uploads/2017/04/SPF-Harvest-Strategy_April-2017_FINAL.pdf

conservative approach that takes into account the ecological importance of Sardines (Smith et al. 2015).

- Stock status is explicitly linked with SpB estimates.

9.3 Species

The Sardine Harvest Strategy only applies to the primary target species, Australian Sardine (*S. sagax*). Although the Australian Anchovy (*E. australis*) is also targeted in the sardine fishery, the level of exploitation is considered to be set at a precautionary catch level. Should expansion of Anchovy fishing operations occur in the future, there is the potential to develop a Harvest Strategy for Anchovy fishing that is conceptually similar to the Sardine Harvest Strategy, with appropriate levels of research.

9.4 Assessment method

The primary biological PI for the Sardine Harvest Strategy is calculation of the SpB using the daily egg production method (DEPM) (Lasker 1985). The DEPM is recognised internationally as a practical and cost-effective method for estimating the SpB of small pelagic fishes (Stratoudakis et al. 2006, Ward et al. 2011a, Ward et al. 2021). Using the most recent SpB value, the recommended TACC for the Sardine Fishery is determined as a proportion of the SpB (exploitation rate) within sustainable limits.

Although SpB estimates derived from the DEPM are considered accurate, they can be relatively imprecise, mainly due to uncertainties associated with estimation of total daily egg production (Fletcher et al. 1996, McGarvey and Kinloch 2001, Ward et al. 2001a, Gaughan et al. 2004, Stratoudakis et al. 2006). Imprecision of the DEPM was partly addressed in the previous Harvest Strategy by establishing a conservative TACC in conjunction with the tiered framework.

The DEPM applied to Sardine off South Australia was reviewed by Ward et al. (2021). The outcomes of this review were adopted to improve the precision of SpB estimates since the 2020 DEPM survey.

Supporting the DEPM assessment is a Sardine fishery stock assessment, which synthesises updated information relevant to the Sardine fishery, assesses the status of the stock, and comments on the management arrangements from a biological perspective. An age-structured population model is also used to inform the status of the stock by producing SpB estimates, but uncertainty regarding natural mortality rates, recruitment variability and biases in the age samples mean the DEPM survey is preferred (Ward et al. 2005) as the primary indicator. In 2019, an integrated stock assessment model, 'SardEst', was developed specifically for the Sardine Fishery (Ward et al. 2019). In years when there is no DEPM survey completed, the 'SardEst' model is used to inform the status of the stock.

9.5 Previous strategies

There are three previous harvest strategies for the Sardine Fishery. The first harvest strategy contained in the 2005 management plan for the fishery (Shanks 2005), the second harvest strategy implemented in 2007 as an addendum to the 2005 management plan and the third included in the 2014 management plan (PIRSA 2014).

The first harvest strategy maintained the harvest of Sardines within exploitation rate limits of 10 per cent to 17.5 per cent. The actual TACC recommendation was dependent on the magnitude of the SpB (where stepwise increases in exploitation rate were possible with increasing SpB) and the proportion of 2- and 3-year-old age classes in the population (>40% indicated high levels of egg production, thus allowing the TACC to be recommended at a slightly higher exploitation rate than if the proportion was ≤40%).

The second harvest strategy established that a precautionary baseline TACC of 30,000 t be maintained, while the latest SpB estimate remained between 150,000 and 300,000 t, corresponding to exploitation rates of 20 per cent and 10 per cent respectively. The basis for this addendum to the first harvest strategy was to provide industry with greater certainty and stability, and thereby allow fishing operations and the supply of Sardines (mainly as feed for the Southern Bluefin Tuna aquaculture sector) to be planned with confidence.

The third Harvest Strategy, adopted the same approach as the second in maintaining a baseline TACC within a target range of SpB estimates. However, built upon the previous harvest strategy with the introduction of two new features of a tiered framework and rules for spatial management of the catch.

This fourth Harvest Strategy for the Sardine Fishery provides for:

- Increased exploitation rates at each of the three tiers to reflect the higher certainty in SpB estimates provided through the refined DEPM surveys;
- Increased Target Reference Point to 200,000 t
- TACC levels based on linear relationship with SpB above the upper trigger reference point (UTrRP)
- Spatial management for three fishing zones, Spencer Gulf Zone (SGZ), Gulf St Vincent Zone (GSVZ) and Outside Zone (OZ). In the term of this management plan legislative amendments will be sought to formalise the amended spatial management zones.

9.6 Performance Indicators

9.6.1 Primary Performance indicator and reference points

SpB is the primary biological Performance Indicator (PI) for the Sardine Fishery derived from either the most recent DEPM survey or outputs from the integrated stock

assessment model, 'SardEst' as described in Grammer et al (2021). The reference points are described in Table 4.

Table 4: Reference Points for Spawning Biomass (SpB)

Reference Point	SpB
Limit	75,000 t
Trigger	150,000 t
Target	200,000 t

The Limit Reference Point of 75,000 t has been selected because historically the stock has been shown to be stable above this level and quickly recovered from below this biomass level following two mortality events that reduced biomass to 68,175 t in 1999 (Ward et al. 2012). Secondly in consideration of ecosystem impacts, impacts would be relatively minor on ecologically dependant species (such as marine mammals and seabirds) at this level (Goldsworthy et al. 2013). The Trigger Reference Point is set at twice the level of the LRP.

Ecosystem and population modelling assessment of Australian Sardine Fisheries suggest that 33% exploitation rate is a conservative level that takes into account the ecological importance of Sardines (Smith et al. 2015). This harvest strategy has a maximum exploitation rate of 27.5% and is precautionary when compared to the national standard.

Other data and performance measures may be used to assess the fishery but do not trigger explicit decisions under the harvest strategy. Information includes (but is not limited to):

- Spawning area
- Length frequency distributions of Sardine from fishing zones
- Distribution and abundance of Sardine eggs collected during surveys

9.6.2 Stock Status

The classification of stock status is explicitly linked to reference points adopted from SpB as described in Table 5.

Table 5: Stock status for the Sardine Fishery

SpB	Stock Status
$\geq 150,000$ t	Sustainable
<150,000 t to $\geq 75,000$ t	<p>Sustainable or depleting</p> <p>When primary performance indicators are below the Trigger Reference Point, stock status will be interpreted in consideration of the trajectory of the performance indicators (primary and other if available) identified for the fishery. If a majority of performance indicators are declining, the fishery will be classified as depleting, or where a majority of performance indicators are stable or increasing the fishery will be classified as Sustainable.</p>
<75,000	<p>Depleted or depleting</p> <p>When primary performance indicators are below the Limit Reference Point, stock status will be interpreted in consideration of the trajectory of the performance indicators (primary and other if available) identified for the fishery. If a majority of performance indicators are declining or stable the fishery will be classified as depleted, or where a majority of performance indicators are increasing the fishery will be classified as recovering.</p>

The stock status used in the harvest strategy as based on the terminology in the national reporting framework for stock classification described in Pidcocke et al. (2021) (www.fish.gov.au) is summarised in Table 6.

Table 6: Descriptions of stock status categories from Pidcocke et al. (2021)

Stock status category	Description
Sustainable	Biomass (or proxy) is at a level sufficient to ensure that, on average, future levels of recruitment are adequate (recruitment is not impaired) and for which fishing mortality (or proxy) is adequately controlled to avoid the stock becoming recruitment impaired (overfishing is not occurring).
Depleting	Biomass (or proxy) is not yet depleted and recruitment is not yet impaired, but fishing mortality (or proxy) is too high (overfishing is occurring) and moving the stock in the direction of becoming recruitment impaired.
Recovering	Biomass (or proxy) is depleted and recruitment is impaired, but management measures are in place to promote stock recovery, and recovery is occurring.

Depleted

Biomass (or proxy) has been reduced through catch and/or non-fishing effects, such that recruitment is impaired. Current management is not adequate to recover the stock, or adequate management measures have been put in place but have not yet resulted in measurable improvements

9.7 Spatial management

Explicit spatial management arrangements were adopted in the 2014 Harvest Strategy (PIRSA 2014) to protect stocks of Sardines in southern Spencer Gulf from depletion of target-sized fish and adverse impacts on the ecosystem. That Harvest Strategy defined two zones in the Sardine Fishery – the Gulfs Zone (GZ) and the Outside Zone (OZ) (see Figure 2).

The harvest strategy in this management plan describes the general area of the three zones as follows:

- **Spencer Gulf Zone (SGZ)** encompasses waters adjacent to South Australia, east of the meridian of longitude 135°37'30"E (extending south from near Cape Carnot, Eyre Peninsula) and north of latitude 35°52'00"S (extending to Kangaroo Island, in the vicinity of Vennachar Point) Then west of the meridian of longitude 137°10'E.
- **Gulf St Vincent Zone (GSVZ)** encompasses waters adjacent to South Australia, east of the meridian of longitude 137°10'E and north of latitude 35°52'00"S (extending to Kangaroo Island, in the vicinity of Vennachar Point). Then north of a line between Penneshaw, Kangaroo Island and Cape Jervis, Fleurieu Peninsula. At the time of developing this management plan, a northern boundary for the GSV zone was managed through licence condition.
- **Outside Zone (OZ)** covers the waters adjacent to South Australia, excluding the SGZ and GSVZ.

Under this spatial management framework, no more than 30,000 t of Sardines will be taken from the SGZ in any single quota period (fishing season) to protect stocks of Sardines in southern Spencer Gulf from depletion of target-sized fish and adverse impacts on the ecosystem. Furthermore, where there is evidence of reductions in the mean size of fish taken from the SGZ, the maximum catch will be reduced to 27,000 or 24,000 t depending on the mean size of fish taken in that zone in the previous quota period as described in section 9.8.3. The biological data considered in setting these levels of catch at size is described in the 2014 Management Plan (PIRSA 2014).

In the GSVZ, no more than more than 6,000 t of sardines will be taken in any single quota period (fishing season), with that level being reduced to 4,000 or 2,000 t depending on the mean size of fish taken in that zone in the previous quota period as described in section 9.8.3. As this is the first harvest strategy setting a limit on Sardine harvest in the GSVZ, the levels of catch are considered to be conservative and based on levels set for the fishery during the trial of the GSVZ between 2020-2021.

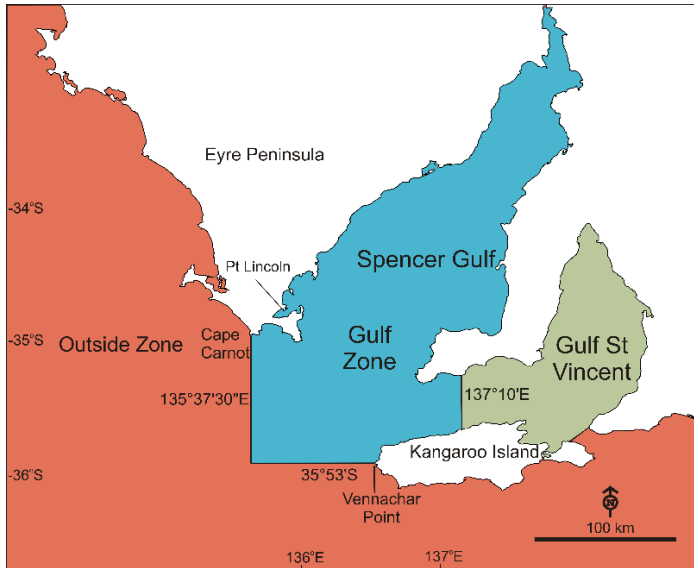


Figure 2: The three spatial management zones for the Sardine Harvest Strategy. Abbreviations: OZ,

9.8 Decision rules

9.8.1 Harvest Strategy Tiers

Under this harvest strategy, the monitoring requirements for each tier level are as follows:

- Tier 3: biennial stock assessment and biennial DEPM survey (alternating each year) OR biennial DEPM survey and biennial stock assessment or ecosystem assessment (that is, a stock assessment will be undertaken every four years with an ecosystem assessment conducted every four years alternating with stock assessment survey).
- Tier 2: biennial stock assessment and an annual DEPM survey with an ecosystem assessment conducted every four years.
- Tier 1: annual stock assessment and annual DEPM survey with an ecosystem assessment conducted every four years alternating with stock assessment survey to replace the stock assessment survey or DEPM survey in that year.

For the purpose of the first implementation of this Harvest Strategy, the Sardine Fishery is currently considered to be at Tier 3.

9.8.2 TACC decision rules

Once the SpB estimate has been calculated the corresponding harvest decision rules that guide the appropriate levels of exploitation (and therefore the TACC) across the three tiers can be considered as provided in Figure 3: The relationship between spawning biomass, stock status and level of exploitation (or TACC) of the Sardine Harvest Strategy for each tier

and represented in Figure 3.

Figure 3: The relationship between spawning biomass, stock status and level of exploitation (or TACC) of the Sardine Harvest Strategy for each tier

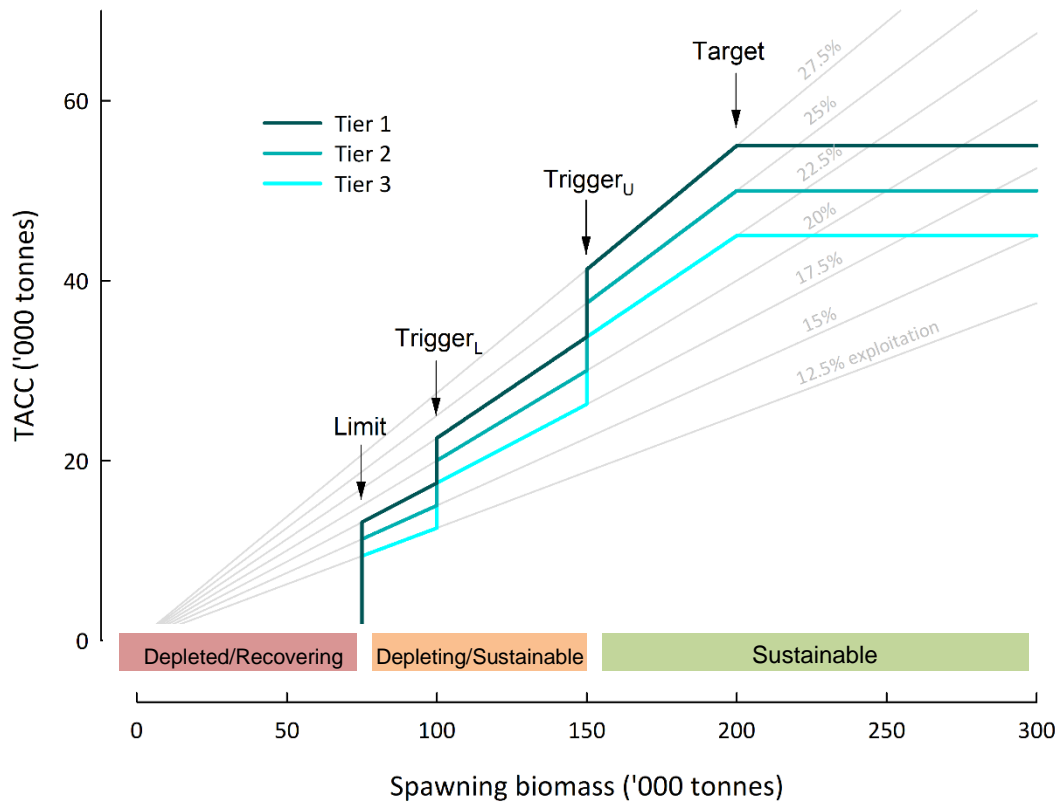


Table 7: Decision table for the Sardine Harvest Strategy to guide levels of exploitation and TACC.

Reference Range	SpB (t)	% B ⁰	Tier 1		Tier 2		Tier 3	
			TACC (t)	Max ER	TACC (t)	Max ER	TACC (t)	Max ER
Upper Target	≥200,000	>67%	55,000	27.5%	50,000	25%	45,000	22.5%
Lower Target	<200,000to	50-	41,250-	27.5%	37,500-	25%	33,750-	22.5%
	≥150,000	67%	55,000		50,000		45,000	
Upper Trigger	<150,000to	33-	22,500-	22.5%	20,000-	20%	17,500-	17.5%
	≥100,000	50%	33,750		30,000		26,250	
Lower Trigger	<100,000	25-	13,125-	17.5%	11,250-	15%	9,375 –	12.5%
	to ≥75,000	33%	17,500		15,000		12,500	
Limit	<75,000	<25%	0	0	0	0	0	0

9.8.3 Spatial management decision rules

Once the TACC has been determined using the harvest decision rules, the maximum catch from the SGZ and GSVZ will be determined on the basis of the mean size of the catch in each zone reported by SARDI for the period up to 30 June in the most recent year available. These decision rules have been implemented to prevent the depletion of target size fish and maximise catches of optimal-sized Sardines from the SGZ and GSVZ.

Samples of the commercial catch are collected by independent observers present on approximately 10% of fishing trips in the Sardine Fishery. Samples are sent to SARDI Aquatic Sciences for processing. Fish are measured (mm FL) and catch weighted mean size of sardines (MSS) per zone are reported to industry.

Mean sizes and total catch limits are set out in the catch limit decision (Table 8, but in the calculation of mean sizes, certain data requirements must be met (as agreed to by the SASIA Research and Management Committee).

Table 8: Spatial management decision rules to guide the maximum catch allowed from the SGZ and GSVZ.

Mean size of sardines (MSS)	Maximum catch limits	
	SGZ	GSVZ
>142 mm	30,000 t	6,000 t
>135 mm to ≤ 142 mm	27,000 t	4,000 t
≤ 135 mm	24,000 t	2,000 t

If the most recent SpB is below the TrRP (150,000 t), the SASIA Research and Management Committee will assess the most recent information regarding Sardine egg distribution and size of fish to make a recommendation about the allocation of catch in the SGZ and GSVZ.

If SpB estimate of >250,000 t, a reduction in allocation to the relevant zone would not be required in the first year that MSS was ≥ 135 mm but <142 mm in either SGZ or GSVZ. This rule does not apply if the MSS in a fishing zone fell below 135mm.

9.9 Meta-rules

The following meta-rules apply for the Sardine Harvest Strategy:

- 1 Where a recommended increase in TACC requires moving up to a higher tier, a stepwise increase can only occur one tier at a time; i.e., stepping up from Tier 3 to Tier 2 and from Tier 2 to Tier 1 is permitted, but not from Tier 3 to Tier 1. There are no restrictions when moving down to a lower tier.
- 2 Where a recommendation to move up a tier level has occurred under this Harvest Strategy, the TACC recommendation can be based on that corresponding tier level.
- 3 In moving from Tier 3 to Tier 2, the industry commits to a minimum of three DEPM surveys over three years to closely monitor any changes in SpB after changing the maximum exploitation rate. Stock assessments will be undertaken biennially at this tier level.
- 4 In moving from Tier 2 to Tier 1, the industry must commit to a minimum of three stock assessments in three years; and during this time DEPM surveys will be undertaken annually.
- 5 If there is clear scientific evidence that the primary biological PI (estimate of SpB) used in the harvest decision rule (Section 9.6.1) is underestimated in any one year (due to logistical problems with the completion of the survey, the lack of sampled survey stations, problems with the analysis of survey samples or environmental anomalies), the minimum SpB for each exploitation level (and TACC) may be up to 10% lower. This rule may only be invoked when there is suitable scientific justification and there is support from industry, scientists and management..

9.10 Decision-making process

The most recent SpB estimate (and other biological information) will be provided by SARDI to SASIA's Research and Management Committee at a TACC meeting scheduled to occur around October each year.

The Research and Management Committee will consider the presented information and apply the available information to the Sardine Harvest Strategy decision rules set out at the TACC meeting.

The Research and Management Committee will provide a recommendation to PIRSA on TACC levels for the Sardine Fishery, and allocations of that TACC for harvest within the SGZ and GSVZ. This recommendation should be provided to PIRSA as soon as practicable after the TACC meeting.

Recommendations provided to PIRSA that are inconsistent with the decision rules outlined in this Harvest Strategy should be clearly justified including all information considered in making that recommendation.

Upon receiving the Research and Management Committee's recommendation and advice, the Minister or his/her delegate will consider this advice before making a formal TACC determination. Licence holders and the Executive Officer of SASIA will be notified of the TACC determination as soon as possible before the start of the quota period commencing 1 January.

9.11 Examples

Example 1 (Tier 3)

A SpB estimate was available from DEPM survey conducted in 2020 and a stock status survey was published in 2021. The fishery is considered to be monitored at the Tier 3 level (biennial stock assessment and biennial DEPM survey (alternating each year)).

If the Sardine SpB was determined at 189,000 t, the fishery status would be 'Sustainable'. Under these circumstances, the TACC would be calculated using a maximum exploitation rate of 22.5% under Tier 2 and can be set at up to 45,000 t.

If the mean size of Sardines was calculated at 146 mm in both zones, the maximum catch that could be taken from the SGZ would be 30,000 t and 6,000 t in the GSVZ. The remaining TACC would be allocated to harvest in the Outside Zone.

Example 2 (Tier 2)

A SpB estimate was available from DEPM survey conducted in 2020 and in 2021, and a stock status survey was published in 2021. The fishery is considered to be monitored at the Tier 2 level (biennial stock assessment and annual DEPM survey).

If the Sardine SpB was determined at 96,000 t, the fishery status would be classified as depleting or sustainable depending on PIs either declining or increasing. Under these circumstances, the TACC would be calculated using a maximum exploitation rate of 15% under Tier 2 and a TACC set between 11,250 t and 15,000 t.

If the mean size of Sardines was calculated at 137 mm in both zones, the maximum catch that could be taken from the SGZ would be 27,000 t and 4,000 t in GSVZ. The remainder of the TACC to be taken from the OZ.

Example 3 (Meta Rule 3)

If a SpB estimate was available from DEPM surveys conducted in 2020 and a stock status survey was published in 2019 and 2021, the fishery would be considered to be monitored at the Tier 3 level (biennial stock assessments and DEPM surveys).

If the sardine SpB was determined at 153,000 t, a TACC could be calculated using a maximum exploitation rate of 25% at the Tier 2 between 37,500 t and 50,000 t under Meta Rule 3 with industry committing to annual DEPM surveys for not less than three years and biennial stock assessments.

9.12 Review

Following implementation of this Harvest Strategy, PIRSA Fisheries and Aquaculture in partnership with SASIA's Research and Management Committee will monitor its performance annually. Should new information become available, a review of the harvest strategy may be considered under section 49(1) of the Act. A comprehensive review of the harvest strategy will be undertaken as soon as practicable after the fifth anniversary of the commencement of this management plan under section 49(2) of the Act.

10 Stock assessment and research

10.1 Research services

PIRSA Fisheries and Aquaculture contracts research services for each fishery. SARDI Aquatic Sciences is currently the primary research provider for core research for the Sardine Fishery. Costs of the annual research program for the fishery are recovered through licence fees.

External funding sources, such as the Fisheries Research and Development Corporation (FRDC), and universities also provide funding for specific research projects. The fishery contributes to the FRDC through an annual levy base, also collected through licence fees.

10.2 Data collection and analysis

To achieve the research and monitoring needs for the fishery, a variety of data are collected and analysed. These come from two main sources – fishery independent data and fishery dependent data.

10.2.1 Fishery independent data

Fishery independent data are collected through two processes – DEPM surveys and the Independent Observer Program.

The DEPM survey is the main data source for the stock assessment and has been used to estimate the SpB of Sardines in South Australia since 1995. The central tenet of the DEPM is that SpB can be calculated by dividing the mean number of pelagic eggs produced per day throughout the spawning area (that is, total daily egg production) by the mean number of eggs produced per unit mass of adult fish (Ward et al. 2009). Currently the survey is conducted biennially however the Harvest Strategy allows for the survey to be conducted annually, which could increase the available TACC depending on stock assessment results.

The observer program was implemented in November 2004 to monitor TEPS interactions. Initially run by SARDI Aquatic Sciences, the program was taken over by independent contractors in 2006.

10.2.2 Fishery dependent data

Fishery dependent data consists of commercial catch and effort logbooks data, wildlife interaction logbook data, and industry biological sampling.

Fishers are required to complete fishery logbooks that document the date, location and timing of each net-set, the weight of each catch, and details of interactions with TEPS. Since 2007, fishers have also been required to complete wildlife interaction forms, which are validated, stored and collated by SARDI Aquatic Sciences (as seen in Tsolos and Boyle 2013).

In late October 2011, SASIA initiated a data collection and monitoring program to collect and collate real-time TEPS interaction information, and (in January 2012) to collect Sardine size data in order to improve the transparency of industry reporting. This data is in addition to information collected through logbooks and the observer program. It is being used to reduce any discrepancies between data sets by providing ongoing and timely feedback of the industry's performance, while highlighting areas for improvement. SASIA is also looking to understand spatial and temporal Sardine movements through the collation of size information.

10.2.3 Reporting

SARDI Aquatic Sciences has assessed the status of the stock of Australian Sardine off South Australia since 1998 and has provided scientific advice to PIRSA Fisheries and Aquaculture to assist with the management of the fishery. This involves biennial SpB and stock assessment reports in alternate years. These reports summarise information about the fishery, assess the status of the stock, and provide comments on future management and research needs (Ward et al. 2012). All SARDI reports are available on the SARDI publications webpage.

10.3 Strategic research plan

In addition to the core stock assessment work that informs periodic decision-making in the fishery, additional research projects are also undertaken to meet longer-term fishery objectives or to underpin the development of research strategies.

These research priorities are reviewed and updated annually by the SASIA Research and Management Committee.

11 Compliance and monitoring

PIRSA Fisheries and Aquaculture runs a compliance program that has dual objectives:

1. To maximise voluntary compliance with fisheries rules.⁵

⁵ Rules include regulations, licence conditions, closure notices or any other enforceable instrument under the Fisheries Management Act 2007.

2. To create effective deterrence to breaching fisheries rules.

These objectives are consistent with the *National Fisheries Compliance Policy*.⁶

PIRSA maximises voluntary compliance by ensuring that fishers are aware of the rules that apply to their fishing activities, that they understand the rules and the purpose of those rules, and that they operate in a culture of compliance.

PIRSA creates effective deterrence through the presence of fisheries officers and the visibility of compliance operations, as well as through detection and prosecution of illegal activity⁷.

12 Resources required to implement plan

South Australia's fisheries resources are managed in accordance with the *Fisheries Management Act 2007* established to protect, manage and develop the aquatic resources of the State in a manner that is consistent with ecologically sustainable development. Management should occur in an efficient and cost-effective manner via transparent methods.

The recovery of costs associated with the management of the commercial fisheries as required by the *Fisheries Management Act 2007* has been intended to ensure specific industry sectors fund the government products and services required as a direct result of their commercial activities derived from access to the State's community-owned aquatic resources. The cost for the provision of these services is recovered by PIRSA Fisheries and Aquaculture through the administration of annual fees applied to regulated licences, or fee for service work applied on a per-transaction basis if required.

The fundamental principle applied to cost recovery of management costs is that the main beneficiaries of the services (commercial licence holders) are required to bear the cost of delivering the services required to manage their activities.

In determining the level of cost recovered from industry, PIRSA is guided by relevant cost recovery policies and reviews.

⁶ The Australian Fisheries National Compliance Strategy 2010-15 was developed by the National Fisheries Compliance Committee and outlines the objectives that Australian fisheries agencies will pursue to achieve an optimal level of compliance and to create effective deterrence to illegal fishing activity.

⁷ Prosecution may include the issuing of a formal caution or an expiation notice, in addition to prosecution through the courts.

13 Review of plan

A review of this management plan may be conducted at any time by the Minister. A review of this management plan will be conducted as soon as practicable after the fifth anniversary of its commencement as set out in Section 49 of the Act.

Section 49 of the Act prescribes the process of reviewing a management plan. Amendments to this management plan may also be considered under section 46 of the Act.

DRAFT

14 References

- Australian Fisheries Management Authority. 2009, *Small Pelagic Fishery Harvest Strategy*. Australian Fisheries Management Authority.
- Dimmlich, WF, Breed, WG, Geddes, M and Ward, TM. 2004, 'Relative importance of gulf and shelf waters for spawning and recruitment of Australian anchovy, *Engraulis australis*, in South Australia', *Fisheries Oceanography*, 13 (5), pp.310-323.
- Dimmlich, WF, Ward, TM and Breed, WG 2009, 'Spawning dynamics and biomass estimates of an anchovy *Engraulis australis* population in contrasting gulf and shelf environments', *Journal of Fish Biology*, 75, pp.1560-1576.
- Cury, P., Bakun, A., Crawford, R., Jarre, A., Quiñones, R., Shannon, L., Verheye, H. 2000. Small pelagics in upwelling systems: patterns of interaction and structural changes in "wasp-waist" ecosystems, *ICES Journal of Marine Science*, Volume 57, Issue 3, pp 603–618 <https://doi.org/10.1006/jmsc.2000.0712>
- Econsearch 2012, *Economic Indicators for the South Australian Sardine Fishery 2010/11: report prepared for Primary Industries and Regions South Australia*, Econsearch Pty. Ltd., June.
- Fletcher, WJ, Lo, NCH, Hayes, EA, Tregonning, RJ and Blight, SJ 1996, 'Use of the daily egg production method to estimate the stock size of Western Australian sardines (*Sardinops sagax*)', *Marine and Freshwater Research*, 47, pp. 819-825.
- Fletcher, WJ, Chesson, J, Fisher, M, Sainsbury, KJ, Hundloe, T, Smith, ADM and Whitworth, B 2002, *National ESD reporting framework for Australian fisheries: the 'how to' guide for wild capture fisheries*, FRDC Project 2000/145, Fisheries Research and Development Corporation, Canberra.
- Gaughan, DJ, Leary, TI, Mitchell, RW and Wright, IW 2004, 'A sudden collapse in distribution of Pacific sardine (*Sardinops sagax*) off south-western Australia enables an objective re-assessment of biomass estimates', *Fishery Bulletin*, 102, pp. 617-633.
- Goldsworthy, SD, Page, B, Rogers, P and Ward, T 2011, *Establishing ecosystem-based management for the South Australian Sardine Fishery: developing ecological performance indicators and reference points to assess the need for ecological allocations: final report to the Fisheries Research and Development Corporation*, SARDI publication no. F2010/000863-1, SARDI Research Report Series no. 529, South Australian Research and Development Institution (Aquatic Sciences), Adelaide.
- Goldsworthy, SD, Page, B, Rogers, PJ, Bulman, C, Wiebkin, A, McLeay, LJ, Einoder, L, Baylis, AMM, Braley, M, Caines, R, Daly, K, Huveneers, C, Peters, K, Lowther, AD and Ward, TM 2013, 'Trophodynamics of the eastern Great Australian Bight ecosystem: ecological change associated with the growth of Australia's largest fishery', *Ecological Modelling*, 255, pp. 38-57.
- Hamer, DJ, Ivey, A and Ward, TM 2009, *Operational interactions of the South Australian Sardine Fishery with the Common Dolphin: November 2004 to March 2009*,

SARDI Aquatic Sciences publication no. F2007/001098-2, SARDI Report Series no. 354, South Australian Research and Development Institute (Aquatic Sciences), Adelaide.

Izzo, C, Gillanders, BM and Ward, TM 2012, *Movement patterns and stock structure of Australian sardine (Sardinops sagax) off South Australia and the East Coast: implications for future stock assessment and management*, SARDI publication no. F2011/000487-1, SARDI Research Report Series no. 611, FRDC Project no. 2009/021, final report to the Fisheries Research and Development Corporation, South Australian Research and Development Institute (Aquatic Sciences), Adelaide.

Jones, K 2009, *South Australian Recreational Fishing Survey*, South Australian Fisheries Management Series paper no. 54, Primary Industries and Regions South Australia (Fisheries and Aquaculture), Adelaide.

Lasker, R (ed.) 1985, *An egg production method for estimating spawning biomass of pelagic fish: application to northern anchovy, Engraulis mordax*, NOAA Technical Report NMFS, 36, US Department of Commerce (National Oceanic and Atmospheric Administration), USA.

Lo, NCH, Hunter, JR and Charter, R 2001, 'Use of a continuous underway fish egg sampler for ichthyoplankton surveys: application to the estimation of daily egg production of Pacific sardine (*Sardinops sagax*) off California', *Fishery Bulletin*, 99, pp. 554-571.

Mackie, DW 1995, *A management plan for the experimental pilchard fishery*, South Australian Fisheries Management Series paper no. 13.

McGarvey, Rand Kinloch, MA 2001, 'An analysis of the sensitivity of stock biomass estimates derived from the daily egg production method (DEPM) to uncertainty in egg mortality rates', *Fisheries Research*, 49, pp. 303-307.

Neville, P 2008, *Co-management: managing Australia's fisheries through partnership and delegation: report of the Fisheries Research and Development Corporation's National Working Group on the Fisheries Co-management Initiative Project no. 2006/068*.

PIRSA 2011, *Allocation policy: allocation of access to fisheries resources between fishing sectors*, Primary Industries and Regions South Australia (Fisheries and Aquaculture), Adelaide.

PIRSA 2013a, *Management plan for the South Australian Commercial Marine Scalefish Fishery*, South Australian Fisheries Management Series, Primary Industries and Regions South Australia (Fisheries and Aquaculture), Adelaide.

PIRSA 2013b, *Policy for the co-management of fisheries in South Australia*, Primary Industries and Regions South Australia (Fisheries and Aquaculture), Adelaide.

PIRSA 2013c, *Primary Industries and Regions South Australia cost-recovery policy*, Primary Industries and Regions South Australia (Fisheries and Aquaculture), Adelaide.

PIRSA in prep., *ESD risk assessment of South Australia's Sardine Fishery*, Primary Industries and Regions South Australia (Fisheries and Aquaculture), Adelaide.

Shanks, S 2005, *Management Plan for the South Australian Pilchard Fishery*, South Australian Government paper no. 47, South Australian Fisheries Management Series, Primary Industries and Regions South Australia (Fisheries and Aquaculture), Adelaide.

Sloan, SR, Smith, ADM, Gardner, C, Crosthwaite, K, Triantafillos, L, Jeffries, B and Kimber, N 2014, *National Guidelines to Develop Fishery Harvest Strategies*, Fisheries Research and Development Corporation Report Project 2010/061.

Smith, AD, Brown, CJ, Bulman, CM, Fulton, EA, Johnson, P, Kaplan, IC, Lozano-Montes, H, Mackinson, S, Marzloff, M, Shannon, LJ, Shin, YJ and Tam, J 2011, 'Impacts of fishing low-trophic level species on marine ecosystems', *Science*, 333, pp.1147-1150.

Smith, AD, Ward, TM, Hurtado, F, Flaer, N, Fulton, E and Punt, AE. (2015) Review and update of harvest strategy settings for the Commonwealth Small Pelagic Fishery - Single species and ecosystem considerations. Hobart. Final Report of FRDC Project No. 2013/028

Stratoudakis, Y, Bernal, M, Ganias, K and Uriate, A 2006, 'The daily egg production method: recent advances, current applications and future challenges', *Fish and Fisheries*, 7, pp. 35-57.

Tsolos, A and Boyle, M 2013, *Interactions with threatened, endangered or protected species in South Australian managed fisheries – 2009/10, 2010/11, and 2011/12: report to PIRSA Fisheries and Aquaculture*, SARDI publication no. F2009/000544-3, SARDI Research Report Series no. 682, South Australian Research and Development Institute (Aquatic Sciences), Adelaide.

Ward, TM, Hoedt, F, McLeay, LJ, Dimmlich, WF, Jackson, G, Rogers, PJ and Jones, K 2001a, 'Have recent mass mortalities of the sardine *Sardinops sagax* facilitated an expansion in the distribution and abundance of the anchovy *Engraulis australis* in South Australia?', *Marine Ecology Progress series* 220, pp. 241-251.

Ward, TM, Hoedt, FE, McLeay, LJ, Dimmlich, WF, Kinloch, MW, Jackson, G, McGarvey, R, Rogers, PJ, and Jones, K 2001b, 'Effects of the 1995 and 1998 mass mortalities on the spawning biomass of *Sardinops sagax* in South Australia', *Journal of Marine Science*, 58(4), pp. 830-841.

Ward, TM, Rogers, PA, Stephenson, P, Schmarr, DW, Strong, N and McLeay, LJ 2005, *Implementation of an age structured stock assessment model for sardine (*Sardinops sagax*) in South Australia: report to the Fisheries Research and Development Corporation*, Project 2000/125, South Australian Research and Development Institute (Aquatic Sciences), Adelaide.

Ward, TM, Rogers, PA, McLeay, LJ and McGarvey, R 2009, 'Evaluating the use of the daily egg production method for stock assessment of blue mackerel, *Scomber australasicus*', *Journal of Marine and Freshwater Research*, 60, pp.112-128.

Ward, TM, Burch, P and Ivey, AR 2010a, *South Australian Sardine (Sardinops sagax) Fishery: stock assessment report 2010*, SARDI publication no. F2007/000765-3, SARDI Research Report Series no.496, South Australian Research and Development Institute (Aquatic Sciences), Adelaide.

Ward, TM, Ivey, AR, Hamer, DJ and Burch, P 2010b, *Effectiveness of an industry code of practice in mitigating the operational interactions of the South Australian Sardine Fishery with the short-beaked common dolphin (Delphinus delphinus)*, SARDI publication no. F2010/000726-1, SARDI Research Report Series no. 493, South Australian Research and Development Institute (Aquatic Sciences), Adelaide.

Ward, TM, Burch, P, McLeay, LJ and Ivey, AR 2011a, 'Use of the daily egg production method for stock assessment of sardine, *Sardinops sagax*: lessons learnt over a decade of application off southern Australia', *Reviews in Fisheries Science*, 19, pp. 1-20.

Ward, TM, Ivey, AR and Burch, P 2011b, *Spawning biomass of sardine, Sardinops sagax, in waters off South Australia in 2011*, SARDI Aquatic Sciences publication no. F2007/000566-4, SARDI Research Report Series no. 584, South Australian Research and Development Institute (Aquatic Sciences), Adelaide.

Ward, TM, Burch, P and Ivey, AR 2012, *South Australian Sardine (Sardinops sagax) Fishery: stock assessment report 2012*, SARDI publication no. F2007/000765-4, SARDI Research Report Series no.667, South Australian Research and Development Institute (Aquatic Sciences), Adelaide.

15 Appendices

15.1 Performance reports

Table 9: Performance Report for High and Moderate Risks from the 2021 review of the ESD Risk Assessment for the Sardine Fishery (PIRSA in prep)

Component	Risk/Issue	Description	Risk/Importance	Objective	Strategies
Retained species	Australian Sardines	The risk of maintaining the biomass at a sustainable level	Moderate	Maintain biomass at sustainable stock status	Manage fishery under harvest strategy. Maintain DEPM surveys
External Factors	Biological – Disease	The risk of external factors of mortality event of sardines impacting on the performance of the fishery	Moderate	Maintain biomass at sustainable stock status	Maintain communications with Aquatic Health/Biosecurity SA Licence holders to communicate any fish kills detected



**Government
of South Australia**

Department of Primary
Industries and Regions