TO:	**PIRSA FISHERIES AND AQUACULTURE (PROF. GAVIN BEGG – EXECUTIVE DIRECTOR)**
FROM:	**SARDI AQUATIC AND LIVESTOCK SCIENCES (DR TROY ROGERS)**
SUBJECT:	**SCIENTIFIC ADVICE TO SUPPORT DEVELOPMENT OF THE SNAPPER REBUILDING PLAN**
DATE:	**21 JULY 2025**

KEY POINTS

- PIRSA Fisheries and Aquaculture requested scientific advice to inform development of the Snapper Rebuilding Plan for the Spencer Gulf / West Coast (SG/WC) and Gulf St Vincent (GSV) stocks.
- This Advice Note provides scientific advice to inform potential management options including the appropriate timing of a seasonal spawning closure and potential locations of spatial closures in Spencer Gulf and Gulf St Vincent.
- A potential performance indicator and reference point for recruitment is proposed that involves the interpretation of regional population age structures.
- The most appropriate periodicity of integrated stock assessments for the SG/WC and GSV stocks is every three years to monitor fishable biomass and recruitment during the Snapper Rebuilding Plan.

BACKGROUND

There are three recognised stocks of Snapper throughout the coastal waters of South Australia (SA): the Spencer Gulf / West Coast (SG/WC) stock, the Gulf St Vincent (GSV) stock, and the Western Victoria Stock that extends into the South-East Region of SA (Fowler et al., 2017; Bertram et al., 2023). The SG/WC and GSV stocks experienced significant declines in fishable biomass during the 2010s that related to extended periods of poor juvenile recruitment and the concurrent exploitation of the remaining population (Fowler, 2023). The declines in biomass and stock status for the SG/WC and GSV stocks prompted a suite of management actions from 2012 that culminated in the complete closure of the two stocks to commercial and recreational fishing on 1 November 2019. The most recent stock assessment was delivered in November 2022 which indicated that the closures had arrested the decline in biomass for the two stocks, but there was not yet sufficient evidence of recovery (Drew et al., 2022). Consequently, the fishery closures were extended to 30 June 2026.

The Snapper Rebuilding Plan is being developed by PIRSA Fisheries and Aquaculture to support the recovery of the SG/WC and GSV Snapper stocks. The Rebuilding Plan will outline the key objectives to support stock recovery including performance indicators to monitor recovery against predefined reference points and key management arrangements to achieve the rebuilding objectives.

This Advice Note provides scientific advice to inform the development of the Snapper Rebuilding Plan including:

- A potential approach to integrate recruitment information as an additional performance indicator.
- The most appropriate timing for a potential closure to protect Snapper during the spawning period.
- Potential locations for spatial fishing closures to protect aggregations of Snapper in Spencer Gulf and Gulf St Vincent.
- Proposed frequency of integrated stock assessments to monitor recovery of the SG/WC and GSV stocks during the Rebuilding Plan.
- Proposed scientific monitoring to assess the proposed performance indicators of the Rebuilding Plan and collect the data necessary for stock assessment.

RESULTS / DISCUSSION

Potential performance indicator for recruitment

The population dynamics and fishery productivity of Snapper in SA are fundamentally driven by high inter-annual variation in recruitment, i.e., the number of age-0 juveniles that are added to the population each year (Fowler and Jennings, 2003; Fowler et al., 2017; Fowler, 2023). Even though spawning occurs each year, in most years the proportion of eggs that survive to become juveniles is extremely low. The recovery of the SG/WC and GSV stocks is dependent on the recruitment of juveniles to each population and the subsequent accumulation of biomass.

The variation in juvenile recruitment between years is manifested in the age structure of the population as distinct strong and weak year classes (McGlennon et al., 2000; Fowler and McGlennon, 2011; Fowler, 2023). Annual length and age structures for Snapper in SA have been developed since 2000 and are considered at the regional population scale (Fowler 2023), i.e., the West Coast of Eyre Peninsula (WC), northern Spencer Gulf (NSG), southern Spencer Gulf (SSG), northern Gulf St Vincent (NGSV), southern Gulf St Vincent (SGSV), and the South-East (SE) Region.

The interpretation of recruitment variability from age structure data is challenging because an age structure reflects the proportional contributions of individual year classes to the catch sampled, rather than the abundance of those year classes in the population. However, confidence in the interpretation of age structure data can be increased when:

- Sampling is considered representative of the population and sample sizes are adequate (i.e., greater than 200 fish per region per year);
- There are consistent trends in the proportional contributions of individual year classes among age structures developed in successive years; and
- Age structure data are considered in conjunction with biomass estimates (e.g., relative biomass (B/Best0), estimate of spawning biomass).

If the above criteria are met, a potential reference point for recent recruitment to the population is one strong year class in the first eight years of the regional age structure. A strong year class is defined as being ≥20% of the overall age structure for age structures developed in two consecutive years.

When applied retrospectively in the two examples, there were regional differences in the timing and frequency of when the potential reference point was reached. For NSG, the reference point was reached in five consecutive annual age structures developed in the early 2000s by the 1997 year class, and then was not reached by any year class in the age structures developed between 2005 and 2020 (Figure 1). For SGSV, the reference point was first reached in the age structures developed in 2008 and 2009 by the 2001 year class, then in the age structures developed in 2010 and 2011 by the 2006 year class, and again in the age structures age structures for 2014 and 2015 by both the 2007 and 2009 year classes (Figure 2). For both examples, the year classes that reached the reference point were later recognised as moderate to strong recruitment events (Drew et al., 2022; Fowler 2023).

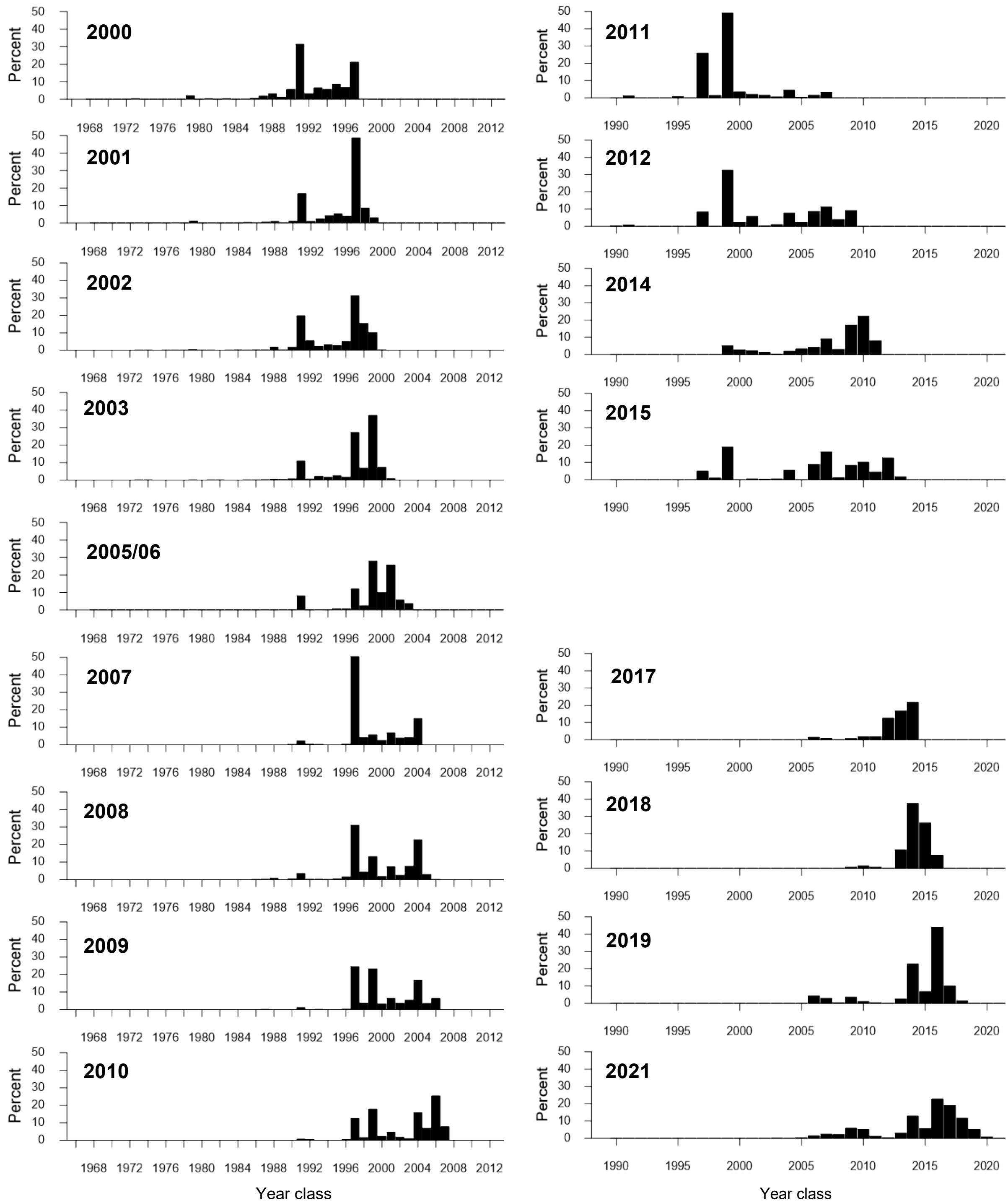

Figure 1. Estimated annual age structures for Snapper sampled from northern Spencer Gulf (NSG) between 2000 and 2021. Extracted from Fowler (2023).

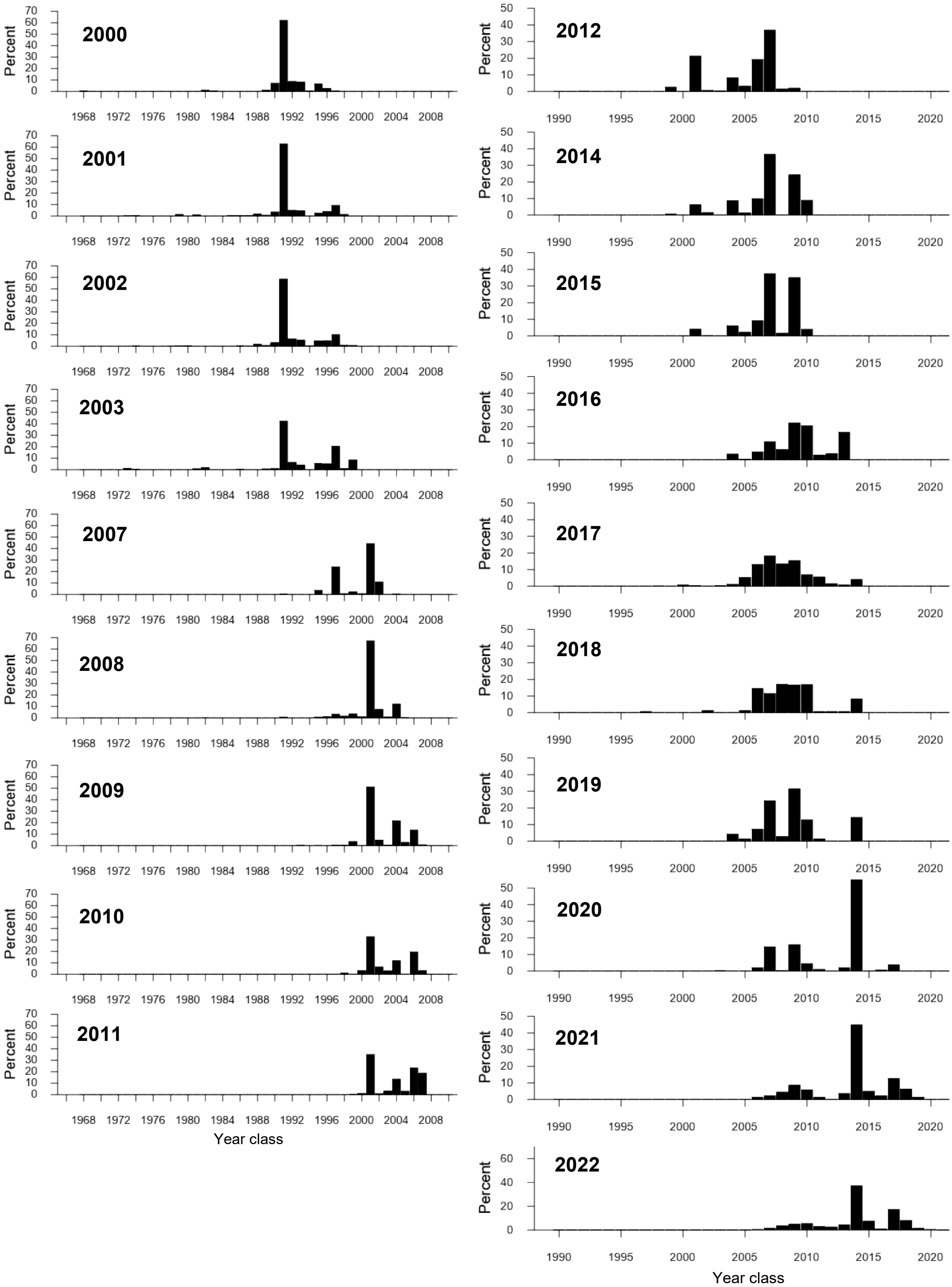

Figure 2. Estimated annual age structures for Snapper sampled from southern Gulf St Vincent (SGSV) between 2000 and 2022. Extracted from Fowler (2023).

Potential timing of a temporal spawning closure

Snapper demonstrates seasonality in its reproductive biology, where maturation and spawning is restricted to a consistent time of the year that is entrained with the physical environment. Throughout its temperate and sub-tropical distribution around Australia, there is latitudinal variation in the timing of Snapper reproduction that primarily occurs when water temperatures are within the range of 17 to 23°C (Sheaves, 2006; Wakefield, 2006; Saunders et al., 2012; Pecl et al., 2014; Fowler, 2023).

For Snapper in SA, the analysis of reproductive biology is based on data collected from 2000 to 2025 (see Chapter 3 of Fowler (2023) for methodology and a comprehensive analysis of data prior to 2022). These data were primarily collected from commercial catches accessed through the market sampling program, and more recently through the biological sampling program following the implementation of the fishery closures for the SG/WC and GSV stocks.

Each fish was processed for biological information following a standard protocol. First, it was measured for caudal fork length and weighed (total weight), then the gonads were removed, sex determined and weighed, and the otoliths removed. The gonads were classified to a stage of development based on their macroscopic characteristics including size, colour, and visibility of oocytes (Appendix 1). For each fish, the gonosomatic index (GSI) was calculated as:

$$\mathrm{GSI}\ (\%) = \left(\frac{\text{gonad weight}}{\text{total weight} - \text{gonad weight}}\right) \times 100$$

Monthly estimates of GSI and macroscopic gonad stages were considered for each sex at the regional population scale (i.e., WC, NSG, SSG, NGSV, and SGSV).

For males, gonad development was evident from October in all regions. In general, mean GSI increased during October and November, and reached a peak in December, with 75–95% of males classified as stage 3 (i.e., 'running') (Figure 3). For the WC, NSG, and NGSV, mean GSI decreased in January and February, and most fish had returned to stage 2 (i.e., 'resting/developing') in March. For SSG and SGSV, mean GSI remained high in January, and decreased in February and March, with reproductive activity concluded by April.

For females, gonad development was evident from October in all regions, although there were regional differences in the timing of reproductive activity. For the WC, NSG, and NGSV, mean GSI increased during October and November, and reached a peak in December (Figure 3). Females classified as stage 4 (i.e., 'hydrated') were actively spawning and were observed from November to February. For SSG and SGSV, mean GSI peaked in December and January, with stage 4 females observed from December to March (Figure 3). For all regions, reproductive activity had concluded by April. Differences in the timing of spawning between the northern and southern regions of the gulfs correspond to differences in regional water temperature regimes and coincide with water temperatures in the range of 18.5 to 22.5°C (Fowler, 2023).

Based on these data, the most appropriate timing of a seasonal spawning closure for the SG/WC and GSV stocks is from 1 October to 31 March. This would provide protection for Snapper throughout the reproductive period (i.e., pre-spawning aggregation, active spawning, and dispersion after spawning has concluded) and optimise the opportunity for successful spawning and recruitment.

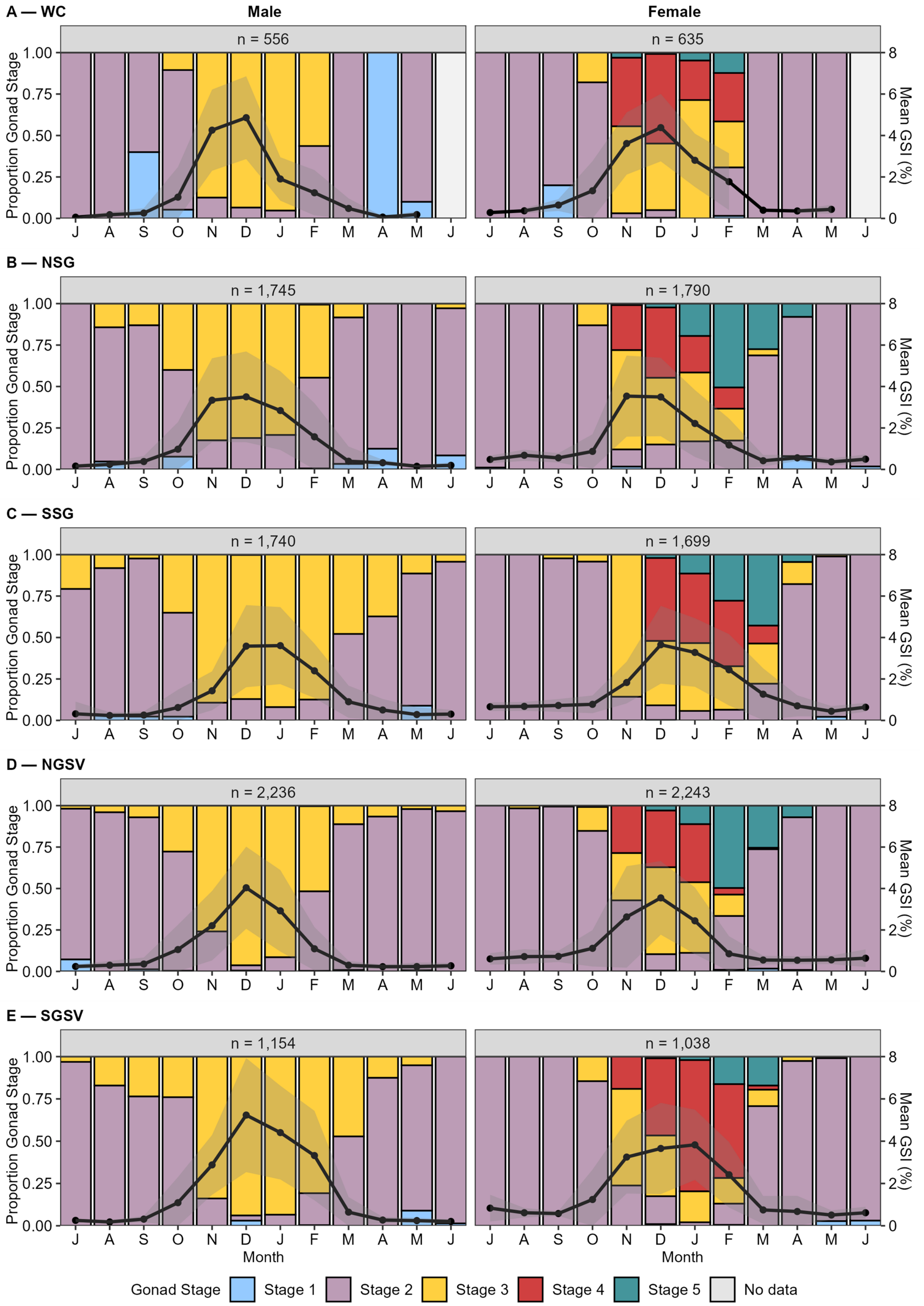

Figure 3. Monthly summary of macroscopic stages of gonads (stacked columns) and mean monthly gonosomatic index (GSI; line ± SD) for Snapper sampled between 2000 and 2025. Data were separated by sex (male – left, female – right) and regional population (A – West Coast (WC); B – northern Spencer Gulf (NSG); C – southern Spencer Gulf (SSG); D – northern Gulf St Vincent (NGSV); E – southern Gulf St Vincent (SGSV)). Gonad stages are defined in Appendix 1.

Potential locations of spatial closures

Snapper is a schooling species that has the capacity to form large aggregations, which can result in the localised concentration of fish that is predictable in time and space (Wakefield, 2006; 2010). This aggregating behaviour is an evolutionary trait that provides protection from predators and optimises the potential for successful reproduction (Rhodes and Sadovy, 2002). Aggregations of Snapper are particularly common prior to and during the spawning period (McGlennon 2003, Saunders 2009), which renders them susceptible to exploitation by fishers.

In SA's gulfs, recognised aggregation sites for Snapper are typically characterised by high relief structures including large banks, natural hard substrates (e.g., limestone ledges, rock piles), and artificial structures (e.g., shipwrecks). It is also acknowledged that aggregations of Snapper move throughout the gulfs and can occur across a diversity of habitats. The spatial and temporal aspects of aggregation sites were informed by various data sources including fishery statistics, biological samples, egg distributions, and anecdotal information from fishers.

For Spencer Gulf, recognised aggregation sites for Snapper include:

- the shipwreck of the *Illusion*, a 13 m wooden trawler that sunk in 1981.
- the shipwreck of the *Santa Anna*, a 14 m wooden trawler that sunk in 1976.
- the shipwreck of the *Estelle Star*, a 24 m wooden trawler that sunk in 1978.
- an area of mixed natural and artificial structure referred to as '*Jurassic Park*'.

These four sites are in the northern and central regions of Spencer Gulf (Figure 4). In addition to historically supporting large aggregations of adult Snapper, these areas have also produced moderate to high abundances of Snapper eggs in episodic plankton surveys from the mid-1990s (McGlennon, 2003) to 2021 (Drew et al., 2022). The areas surrounding the *Illusion*, *Santa Anna*, *Estelle Star*, and *Jurassic Park* were seasonal spatial spawning closures for Snapper from 2013 to 2019 (Fowler and McGarvey, 2014). These four sites are considered the most appropriate locations for potential spatial closures for Snapper in Spencer Gulf.

For Gulf St Vincent, recognised aggregation sites for Snapper include:

- the shipwreck of the *Zanoni*, a 42 m composite sailing vessel that sunk in 1867 offshore from Ardrossan (Figure 4). The wreck of the *Zanoni* is protected under the *Historic Shipwreck Act 1981* and is within a sanctuary zone of the Upper Gulf St Vincent Marine Park (DEW, 2022).
- the shipwreck of the *Ulonga*, a 34 m wooden sailing vessel that sunk in 1976 offshore from Rapid Head (Figure 4).
- Tapley Shoal, an area of large limestone ledges and banks approximately 15 km offshore from Edithburgh (Figure 4).

Tapley Shoal was the site of a seasonal spatial spawning closure for Snapper in 2018/19 (Fowler et al., 2019) and moderate to high densities of Snapper eggs were consistently sampled throughout the area in four plankton surveys between 2014 and 2022 (Drew et al., 2022). The most appropriate locations of potential spatial closures for Snapper in Gulf St Vincent are Tapley Shoal and the shipwreck of the *Ulonga*.

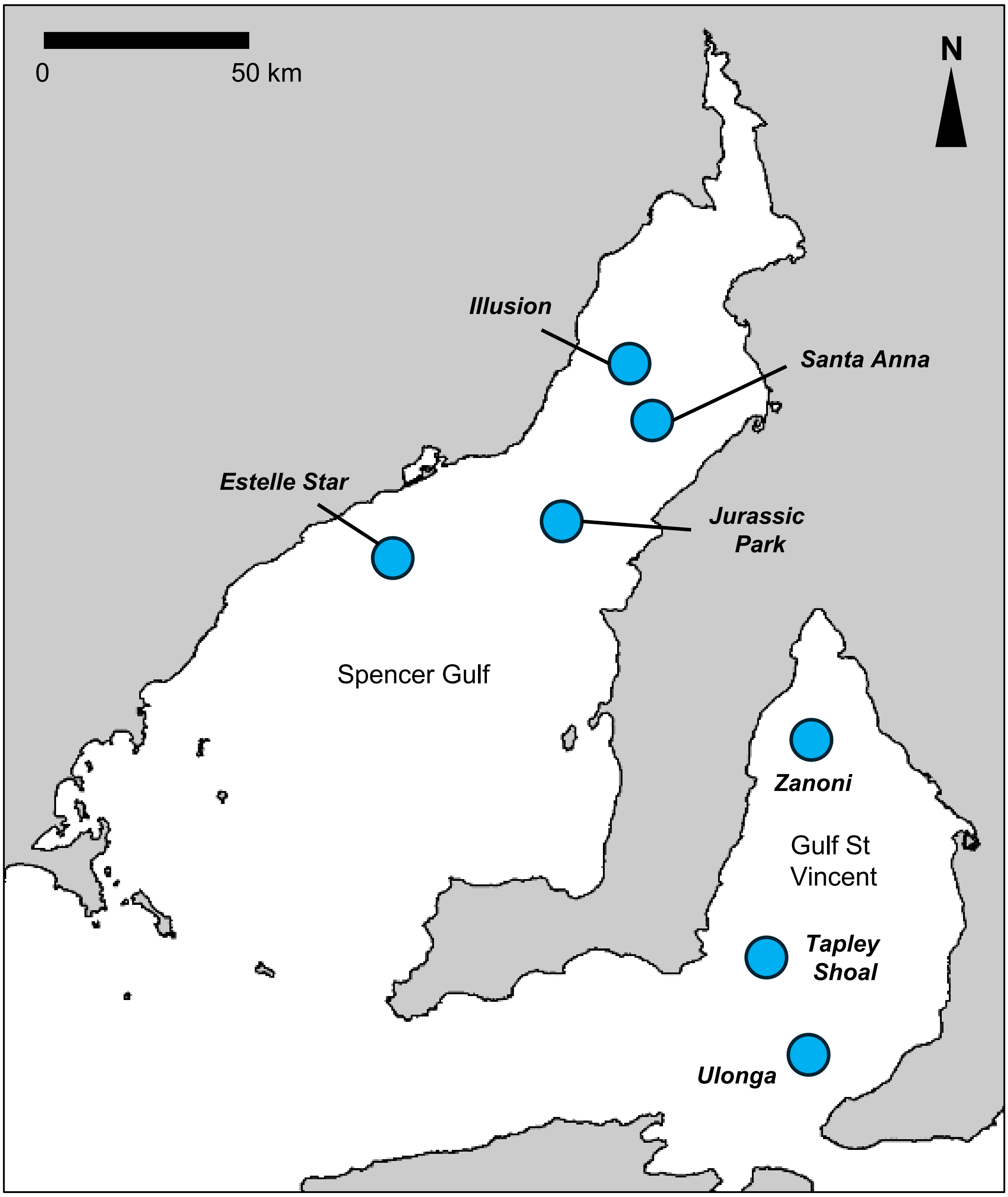

Figure 4. Potential locations of spatial closures to protect aggregations of Snapper in Spencer Gulf and Gulf St Vincent.

Proposed scientific monitoring and frequency of stock assessments

Monitoring the demographics of a population through time provides data and information on population response to ecological processes and exploitation. Such population demographics include the length and age of individuals through time, trends in juvenile recruitment, and estimates of biomass.

Previous monitoring and stock assessment

Stock assessments for Snapper in SA have been completed every 2–3 years since the late 1990s. Early stock assessments considered trends in fishery statistics from the commercial Marine Scalefish Fishery (MSF) and length and age structures developed for the main region of the fishery (i.e., northern Spencer Gulf; NSG). Over time, the assessments became increasingly comprehensive as the time series of fishery statistics extended and annual length and age structures were developed for each regional population (since 2000). Additional data sources were incorporated including the relative abundance of age 0+ juveniles in NSG (2000 to 2010), outputs from the fishery assessment model (since 2003), evaluation against prescribed performance indicators (since 2007), and estimates of spawning biomass using the daily egg production method (DEPM; since 2018). These data were considered in a weight-of-evidence approach to assign stock status following the National Fishery Status Reporting Framework (Piddocke et al., 2021).

Scientific monitoring to inform stock assessment of Snapper populations in SA over the past 30 years has relied on several key data sources:

- Fishery statistics – trends in catch, effort, and catch rates as a relative index of abundance, with these data primarily obtained from the commercial MSF;
- Biological sampling – develop regional length and age structures to retrospectively monitor recruitment variability. Primarily from commercial catches accessed through the market sampling program initiated in 2000;
- Estimates of biomass – since 2018/19, estimates of spawning biomass for Spencer Gulf and Gulf St Vincent using the DEPM; and
- Recruitment surveys – relative abundance of age-0 juveniles in key nursery areas to monitor inter-annual trends in recruitment variability.

Proposed scientific monitoring

Scientific monitoring and data collection are required to assess the recovery of the SG/WC and GSV stocks against the performance indicators that will be identified in the Snapper Rebuilding Plan. The potential performance indicators include fishable biomass, fishing mortality, and recruitment. The proposed scientific monitoring program involves the continuation of data collection for the key data sources described above, i.e., biological sampling, estimates of biomass, recruitment surveys, and fishery statistics (Table 1).

Biological sampling is an essential component of the monitoring program. The regional length and age structures developed from > 30,000 fish processed over the past 25 years have provided the fundamental understanding of population dynamics and scientific monitoring for Snapper in SA (Fowler 2023). The primary outputs are the time series of population age structures that are used to interpret recruitment variability and are a key input into the fishery model. Representative samples are required annually for each regional population, i.e., WC, NSG, SSG, NGSV, and SGSV. The appropriate method to collect biological samples is dependent on the management arrangements for the stock, i.e., samples can primarily be accessed from commercial catches when the fishery is open, but if the fishery is closed, samples must be accessed by targeted sampling under an exemption.

Periodic fishery-independent estimates of biomass are essential to undertake integrated stock assessments for the SG/WC and GSV stocks. Estimates of spawning biomass in Spencer Gulf and Gulf St Vincent using the DEPM have been integrated into stock assessments for the SG/WC and GSV stocks since 2018/19 (Fowler et al., 2019). Alternative methods to estimate biomass are currently being assessed in Research Theme 2 – Estimates of Biomass of the Snapper Science Program (FRDC Project No. 2023-091). The alternative methods are hydroacoustic surveys and close-kin mark-recapture (CKMR). A key output of Research Theme 2 is a series of recommendations regarding appropriate methods to estimate biomass for Snapper to inform stock status.

The recovery of the SG/WC and GSV stocks is dependent on episodic recruitment events and the subsequent accumulation of biomass (Drew et al., 2022). Surveys to monitor relative trends in age 0+ juvenile abundance for the key nursery areas of NSG and NGSV have been completed annually since 2022 through two FRDC-funded projects. In addition, age 1+ juveniles have been monitored annually since 2023 through routine fishery-independent surveys for the Spencer Gulf and Gulf St Vincent prawn fisheries. The continuation of these two independent time series of relative juvenile abundance is essential to detect episodic recruitment events that underpin stock recovery.

In addition, if a stock is open to fishing, fishery statistics for each sector will be analysed to assess fishing mortality against prescribed reference points, including estimates of discard mortality for each sector. Standardised handline (HL) CPUE for the commercial sector may also provide a relative index of abundance that could be incorporated into a fishery model.

Table 1. Summary of the primary data sources and outputs proposed for scientific monitoring in the Snapper Rebuilding Plan, and the respective performance indicator assessed. Each data source is analysed independently and then integrated into a fishery model. CPUE – catch per unit effort.

Data source	Output	Performance indicator
Fishery statistics	Catch, effort, and CPUE Relative index of abundance	Fishing mortality
Biological sampling	Regional length and age structures Retrospectively interpret recruitment	Recruitment
Estimate of biomass	Estimate of biomass (spawning or absolute) Relative index of abundance	Fishable biomass
Recruitment surveys	Relative abundance of juvenile Snapper Relative index of recent recruitment	Recruitment
Integrated fishery model	Annual time series of biological performance indicators, i.e., fishable biomass, recruitment, harvest fraction, and egg production.	Fishable biomass Fishing mortality Recruitment

Proposed frequency of stock assessments

An integrated stock assessment involves multiple data sources (e.g., fishery statistics, length and age structures, estimate of biomass, recruitment indices) that are considered independently, and then integrated into a fishery model to produce a time series of biological performance indicators (e.g., fishable biomass, recruitment, harvest fraction, and egg production). Using fishable biomass as an indicator would be consistent with the approach under the new harvest strategy framework for the MSF (PIRSA 2024), aligning directly with the framework's focus on estimating fishing mortality (F) and stock status relative to unfished biomass (depletion, B/B0). This approach would enable robust, transparent decision-making in setting catch limits and managing stock rebuilding consistent with the objectives of the harvest strategy.

An integrated stock assessment is required to assess each stock against the potential performance indicators of fishable biomass, fishing mortality, and recruitment. Adequate biological sampling and an estimate of biomass are the minimum data inputs required to apply the fishery model. An integrated assessment would also include analysis of fishery statistics if the fishery were open. During the Snapper Rebuilding Plan, the most appropriate frequency of integrated stock assessments for each stock is every three years (Table 2). One approach could be to assess the SG/WC and GSV stocks in different years.

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Table 2. Proposed schedule of scientific monitoring for the Spencer Gulf / West Coast and Gulf St Vincent stocks to evaluate the proposed performance indicators and inform stock assessment during the Snapper Rebuilding Plan. Blue symbols (●) identify monitoring and assessment that could be delivered if the fishery is open.

	Delivered / Committed							Proposed												
	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27	2027/28	2028/29	2029/30	2030/31	2031/32	2032/33	2033/34	2034/35	2035/36	2036/37	2037/38	2038/39
Fishery statistics																				
Commercial catch and effort	●							●	●	●	●	●	●	●	●	●	●	●	●	●
Charter catch and effort	●							●	●	●	●	●	●	●	●	●	●	●	●	●
Recreational catch and effort								●	●	●	●	●	●	●	●	●	●	●	●	●
Scientific monitoring																				
Biological sampling	●	●	●	●	●	●		●	●	●	●	●	●	●	●	●	●	●	●	●
Estimate of biomass	●		●			●			●			●			●			●		
Recruitment surveys			●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Assessment																				
Stock assessment (integrated)	●	●		●			●			●			●			●			●	
Fishery statistics	●	●							●	●	●	●	●	●	●	●	●	●	●	●

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APPENDIX 1 – Development stages of Snapper gonads

Table A1. Summary of macroscopic stages of gonad development for Snapper. From Saunders et al. (2012) and Fowler (2023).

Stage		Macroscopic description
Male		
Stage 1	Immature	Sexes almost indistinguishable. Testes narrow threads, colour variable but usually cream.
Stage 2	Developing / resting	Testes small to medium, white in colour, no milt visible when gonad cut.
Stage 3	Running	Testes large, creamy white, milt easily visible when gonad cut.
Female		
Stage 1	Immature	Sexes almost indistinguishable. Ovaries narrow threads, colour variable.
Stage 2	Developing / resting	Ovaries small, opaque, light yellow to pink in colour, individual oocytes not discernible.
Stage 3	Developed	Ovaries medium to large, yellow to orange in colour, individual oocytes easily discernible but not translucent.
Stage 4	Gravid / hydrated	Ovaries large, yellow to orange in colour. Large translucent oocytes visible amongst smaller opaque ones. Oocytes may be ovulated, i.e., located in the oviduct.
Stage 5	Spent / regressing	Ovaries flaccid, small to medium in size, generally dark red, particularly at the posterior end, with some remnant oocytes visible.