# Technical information supporting the 2023 Coorong, Lower Lakes and Murray Mouth diadromous fish recruitment environmental trend and condition report card

Department for Environment and Water
August, 2023

DEW Technical note 2023/33

Government of South Australia
Department for Environment and Water

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August 2023

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*Preferred way to cite this publication*

Department for Environment and Water (2023). *Technical information supporting the 2023 Coorong, Lower Lakes and Murray Mouth diadromous fish recruitment environmental trend and condition report card*, DEW Technical report 2023/33, Government of South Australia, Department for Environment and Water, Adelaide.

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# Acknowledgement of Country

We acknowledge and respect the Traditional Custodians whose ancestral lands we live and work upon and we pay our respects to their Elders past and present. We acknowledge and respect their deep spiritual connection and the relationship that Aboriginal and Torres Strait Islanders people have to Country. We also pay our respects to the cultural authority of Aboriginal and Torres Strait Islander people and their nations in South Australia, as well as those across Australia.

# Acknowledgements

This document was prepared by Gareth Oerman (DEW). Rebecca Quin (DEW) provided principal oversight throughout and technical review of this report. We greatly appreciate the data provided by the South Australian Research Development Institute (South Australian Research and Development Institute, SARDI) and the technical oversight by Chris Bice (SARDI). Improvements were made to this report and associated report card based on reviews by Adrienne Rumbelow and Luke Vial.

The data used in this report were funded by The Living Murray's Lower Lakes, Coorong and Murray Mouth condition monitoring program. The Living Murray is a joint initiative funded by the New South Wales, Victorian, South Australian and Commonwealth governments.

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# Summary

The 2023 release of South Australia's environmental trend and condition report cards summarises our understanding of the current condition of the South Australian environment, and how it is changing over time.

This document describes the indicators, information sources, analysis methods and results used to develop this report and the associated 2023 Coorong, Lower Lakes and Murray Mouth (CLLMM) diadromous fish recruitment report card. The reliability of information sources used in the report card is also described.

The CLLMM diadromous fish recruitment report card sits within the report card Biodiversity theme and Inland waters sub-theme. Report cards are published by the Department for Environment and Water and can be accessed at www.environment.sa.gov.au.

# 1 Introduction

## 1.1 Environmental trend and condition reporting in SA

The Minister for Climate, Environment and Water under the *Landscape South Australia Act 2019* is required to 'monitor, evaluate and audit the state and condition of the State's natural resources, coasts and seas; and to report on the state and condition of the State's natural resources, coasts and seas' (9(1(a-b)). Environmental trend and condition report cards are produced as the primary means for the Minister to undertake this reporting. Trend and condition report cards are also a key input into the State of the Environment Report for South Australia, which must be prepared under the *Environment Protection Act 1993*. This Act states that the State of the Environment Report must:

- include an assessment of the condition of the major environmental resources of South Australia (112(3(a))), and
- include a specific assessment of the state of the River Murray, especially taking into account the Objectives for a Healthy River Murray under the *River Murray Act 2003* (112(3(ab))), and
- identify significant trends in environmental quality based on an analysis of indicators of environmental quality (112(3(b))).

## 1.2 Purpose and benefits of SA's trend and condition report cards

South Australia's environmental trend and condition report cards focus on the state's priority environmental assets and the pressures that impact on these assets. The report cards present information on trend, condition, and information reliability in a succinct visual summary.

The full suite of report cards captures patterns in trend and condition, generally at a state scale, and gives insight to changes in a particular asset over time. They also highlight gaps in our knowledge on priority assets that prevent us from assessing trend and condition and might impede our ability to make evidence-based decisions.

Although both trend and condition are considered important, the report cards give particular emphasis to trend. Trend shows how the environment has responded to past drivers, decisions, and actions, and is what we seek to influence through future decisions and actions.

The benefits of trend and condition report cards include to:

- provide insight into our environment by tracking its change over time
- interpret complex information in a simple and accessible format
- provide a transparent and open evidence base for decision-making
- provide consistent messages on the trend and condition of the environment in South Australia
- highlight critical knowledge gaps in our understanding of South Australia's environment
- support alignment of environmental reporting, ensuring we 'do once, use many times'.

Environmental trend and condition report cards are designed to align with and inform state of the environment reporting at both the South Australian and national level. The format, design and accessibly of the report cards has been reviewed and improved with each release.

## 1.3 Coorong, Lower Lakes and Murray Mouth diadromous fish recruitment

Diadromous fish migrate between freshwater and marine environments to complete their lifecycle (McDowall 1997; Verhelst et al. 2021). The dependence of diadromous fishes on multiple aquatic environments over very large spatial scales means that they are particularly vulnerable to habitat loss and fragmentation (Verhelst et al. 2021). Anthropogenic impacts including climate change, pollution, introduction of invasive species and overfishing also threatened populations of diadromous fishes (Lin et al. 2017). The loss and fragmentation of habitat in association with anthropogenic impacts has resulted in diadromous fishes being amongst the most threatened vertebrate species in the world (Angermeier 1995; Jonsson et al. 1999). In Australia, several diadromous fish species have declined in distribution and abundance since European settlement (Miles et al. 2014).

The Coorong, Lower Lakes and Murray Mouth (CLLMM) is unique within the Murray–Darling Basin as it is the sole interface between freshwater, estuarine and marine environments. Therefore, connectivity between these regions and their habitats is critical to the life histories and migrations of diadromous fishes (Lintermans 2007; Bice et al. 2018a). Freshwater flows through open barrage gates and fishways are critical for diadromous fishes in the CLLMM as they enable bi-directional movement past the Murray barrages (Bice et al. 2018a; Bice et al. 2021). Five diadromous species inhabit the CLLMM, comprised of the pouched lamprey (*Geotria australis*), short-headed lamprey (*Mordacia mordax*), short-finned eel (*Anguilla australis*), congolli (*Pseudaphritis urvillii*) and common galaxias (*Galaxias maculatus*) (Bice et al. 2018b). This report card focuses on the recruitment of the two most abundant species, the congolli and common galaxias.

The life history of the congolli is represented in Figure 1.1, and shows differences in the migrations and habitat use between sexes. Adult females are fully catadromous, meaning they migrate from freshwater habitats to marine habitats to spawn (Bice et al. 2021). In winter, adult females migrate downstream from the River Murray and Lower Lakes to spawn in the Southern Ocean over winter/spring (Bice et al. 2018a). Adult males primarily reside in the estuarine environments (e.g. Coorong) (Cheshire et al. 2013) and are presumed to migrate to the Southern Ocean to spawn. Larval and juvenile development also occurs in the Southern Ocean, with juveniles then migrating upstream to freshwater habitats in spring/summer (Bice et al. 2021). It is possible that the environment of upstream migration determines the sex of juveniles, with individuals that enter freshwater developing as females and individuals that remain in marine and estuarine environments developing as males (Crook et al. 2010).

The life history of common galaxias is represented in Figure 1.2. Common galaxias are semi-catadromous, meaning they migrate from freshwater to estuarine habitats rather than marine habitats to spawn (Bice et al. 2021). Sexual maturity is reached at one year of age, and adults of both sexes migrate downstream from the River Murray and Lower Lakes to spawn in the Coorong estuary in winter/spring (Bice et al. 2021). Freshwater flows disperse larvae to the Southern Ocean, where they develop into juveniles (Bice et al. 2021). Juveniles then migrate upstream in spring/summer to freshwater habitats of the Lower Lakes and tributaries of the eastern Mount Lofty Ranges (Bice et al. 2018b), where they mature into adult fish (Bice et al. 2021).

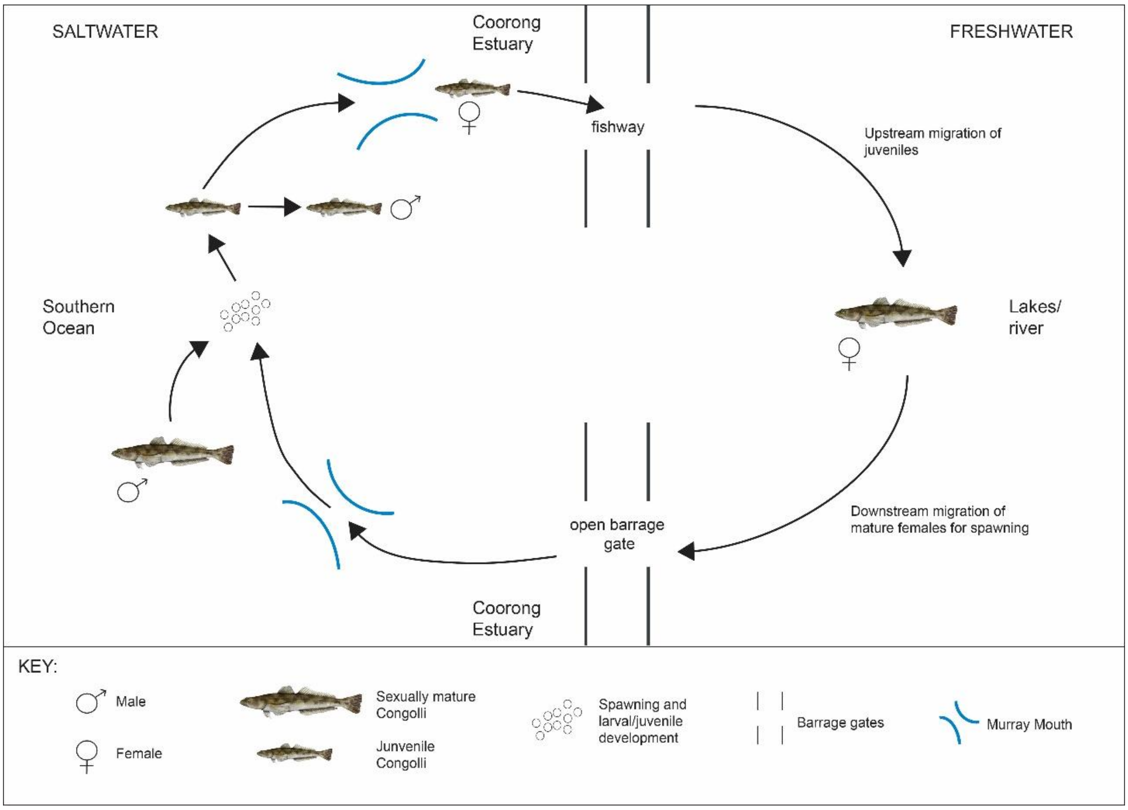



**Figure 1.1. Life history of congolli in the Coorong, Lower Lakes and Murray Mouth region.**

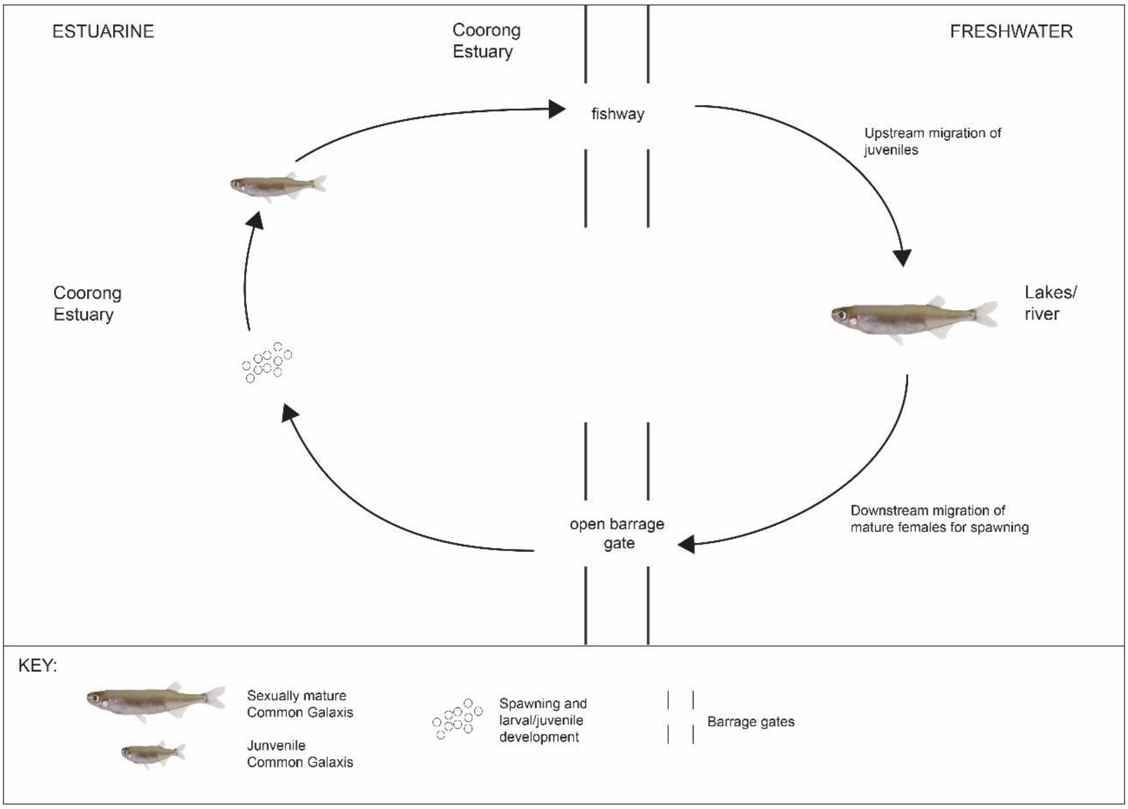



**Figure 1.2. Life history of common galaxias in the Coorong, Lower Lakes and Murray Mouth region.**

# 2 Methods

## 2.1 Indicator

The indicator used for the Coorong, Lower Lakes and Murray Mouth diadromous fish recruitment report card is the annual rate of upstream migrating young-of-the-year (YOY) congolli and common galaxias.

Ecological targets for congolli and common galaxias as described in the updated SA River Murray Long Term Watering Plan (DEW 2020a) are presented in Table 2.1. The ecological targets for diadromous fish in the CLLMM were established in the 'Diadromous fish' chapter (Bice and Zampatti 2017) of the *LLCMM Icon Site Condition Monitoring Plan* (DEWNR 2017).

**Table 2.1. Ecological targets for diadromous fish species: congolli and common galaxias.**

| Species | Ecological target |
|---|---|
| Congolli | 1. Annual detection of upstream migrating YOY congolli is ≥ that of defined 'Recruitment Index' value (44.5 $YOY.hr^{-1}$) |
| Common galaxias | 2. Annual detection of upstream migrating YOY common galaxias is ≥ that of defined 'Recruitment Index' value (6.1 $YOY.hr^{-1}$) |

## 2.2 Data sources

Data were sourced from the Coorong and Lower Lakes fish assemblage structure, movement and recruitment monitoring program conducted by the South Australian Research and Development Institute (SARDI) (Aquatic Sciences) and jointly funded by the South Australian and Australian governments as part of *The Living Murray* initiative.

## 2.3 Data collection

The methodology for diadromous fish monitoring followed that of Bice and Zampatti (2017) as described in the *LLCMM Icon Site Condition Monitoring Plan* (DEWNR 2017), and summarised below.

Fish are sampled at up to six sites across the River Murray barrages, including fishways on the Tauwitchere and Goolwa barrages, sites adjacent to these barrages, and at Hunters Creek causeway fishway. The entrances to the vertical slot fishways are sampled using cage traps designed to fit in to the first cell of each fishway, while the site adjacent the Tauwitchere rock ramp and adjacent Goolwa Barrage are sampled with a large double-winged fyke net.

A week of fish sampling (four weeks in total) is conducted for each month from October to January. Vertical slot fishways are sampled overnight typically three times per sampling week and the sites adjacent the Tauwitchere rock ramp and adjacent Goolwa Barrage are sampled once overnight per sampling week. All trapped congolli and common galaxias are identified, counted and during each trapping event a random subsample of up to 50 individuals are measured to the nearest millimetre (total length, TL) to represent the size structure of the population.

## 2.4 Data analysis

### 2.4.1 Recruitment index calculation

The recruitment index calculations are detailed in Bice and Zampatti (2017) and summarised below.

An annual recruitment index is determined for congolli and common galaxias by calculating the overall site abundance of upstream migrating YOY (i.e. fish.hr$^{-1}$) during the sampling period (Table 2.2) and comparing that against a predetermined reference value. Reference values were calculated by using monitoring data from 2006–07, 2010–11, 2011–12 and 2013–14, which comprised years of variable barrage outflow. Monitoring data from 2007–08, 2008–09 and 2009–10 were not used to set reference values as there was no barrage outflow across these years.

**Table 2.2. Sampling period and young-of-the-year size thresholds for congolli and common galaxias.**

| Species | Sampling period | Young-of-the-year (YOY) size |
|---|---|---|
| Congolli | November to January | <60 mm TL |
| Common galaxias | October to December | <40 mm TL |

Annual recruitment indices were calculated for congolli using Equation 1 and for common galaxias using Equation 2.

**Equation 1** $RI = (S_1(mean((r*A_{Nov}) )+(r*A_{Dec})+(r*A_{Jan})) + S_2(mean((r*A_{Nov})+(r*A_{Dec})+(r*A_{Jan}))\ldots\ldots S_n)$

where $S$ = site, $A$ = abundance (fish hour$^{-1}$) and $r$ = the percentage of the sampled population comprised of YOY (i.e. <60 mm TL).

The recruitment index value was calculated with the above equation using monitoring data from the years 2006–07, 2010–11, 2011–12 and 2013–14. A final reference value was calculated using the equation below:

$RI_{final}$= mean ($RI_{2006–07}$+ $RI_{2010–11}$+$RI_{2012–13}$+$RI_{2013–14}$) ± half confidence interval.

$RI_{final}$= 44.26 ± 21.78 YOY.hr$^{-1}$.

**Equation 2** $RI = (S_1(mean((r*A_{Oct}) )+(r*A_{Nov})+(r*A_{Dec})) + S_2(mean((r*A_{Oct})+(r*A_{Nov})+(r*A_{Dec}))\ldots\ldots S_n)$

where $S$ = site, $A$ = abundance (fish hour$^{-1}$) and $r$ = the percentage of the sampled population comprised of YOY (i.e. <40 mm TL).

The recruitment index value was calculated with the above equation using monitoring data from the years 2006–07, 2010–11, 2011–12 and 2013–14. A final reference value was calculated using the equation below:

$RI_{final}$= mean ($RI_{2006–07}$+ $RI_{2010–11}$+$RI_{2012–13}$+$RI_{2013–14}$) ± half confidence interval.

$RI_{final}$= 6.12 ± 3.00 YOY.hr$^{-1}$.

## 2.5 Methods to assign trend, condition and reliablity

### 2.5.1 Trend

A Bayesian modelling approach was used to assess trend in the data collected for diadromous fish recruitment. This modelling approach was used as it provides more information surrounding the results and allows for a more detailed assessment of trend based on variability inherent in the data. Bayesian models provide an estimate of the likelihood of the trend in the time series data assessed.

Trend analysis was undertaken in R Studio (R version 4.2.1, R Core Team 2022) using a Bayesian generalised linear model (using the stan-glm function in the rstanarm package, Goodrich et al. [2020], 4000 runs) with a gamma family. Models aimed to determine the likelihood of trend (either positive or negative) in the rate of upstream migrating YOY (i.e. fish.$hr^{-1}$) of diadromous fish through the Murray barrages. The model included an interaction effect between time step (years since commencement of monitoring program) and species, to allow species to have different slopes as well as intercepts. As such, the likelihood of trend could be determined for both congolli and common galaxias recruitment indices. Slope (trend) was estimated from the posterior distribution resulting from the Bayesian analysis. Trend direction was assessed using calculated probability (as per McBride 2019). A graduated scale was used to describe outcomes. Outcomes from the trend assessment were aligned with the categories used for report cards (Table 2.3).

**Table 2.3. Alignment of trend outcomes based upon their likelihood of an increase or decrease (modified from Mastrandrea et al. 2010) with categories used for report cards.**

| Outcome | Likelihood of outcome | Report card |
|---|---|---|
| Virtually certain increase | >+99 to +100% | Getting better |
| Extremely likely increase | >+95 to +99% | |
| Very likely increase | >+90 to +95% | |
| Likely increase | >+66 to +90% | |
| About as likely as not | -66 to +66% | Stable |
| Likely decrease | <-66 to -90% | Getting worse |
| Very likely decrease | <-90 to -95% | |
| Extremely likely decrease | <-95 to -99% | |
| Virtually certain decrease | <-99 to -100% | |

### 2.5.2 Condition

The condition of the congolli and common galaxias populations in the CLLMM was assessed based on the recruitment index values of each species in the last year of the assessment period (2021–22) using the methodology developed in DEW (2020b). The matrix used in the conversion of recruitment index values to a condition rating is provided in Table 2.4. The condition of the fish species in poorest condition was used to represent condition of diadromous fish for the report card.

**Table 2.4. Criteria used to define recruitment index (RI) value ranges that align with condition classes used for report cards.**

| Criteria | RI value range | | Condition rating |
|---|---|---|---|
| | congolli | common galaxias | |
| >100% greater than the RI reference value | ≥88.53 | ≥12.25 | Very good |
| >RI reference value + half confidence interval to 100% greater than RI reference value | 66.05-88.52 | 9.13-12.24 | Good |
| RI reference value ± half confidence interval | 22.48-66.04 | 3.12-9.12 | Fair |
| < RI reference value – half confidence interval | ≤22.47 | <3.11 | Poor |

### 2.5.3 Reliability

The reliability of data to assess trend and condition of diadromous fish (based on recruitment) were scored based upon the method devised by Battisti et al. (2014) with modifications to improve its applicability to the report card process. This scoring system assesses answers to questions relating to the method used for data collection, representativeness and repetition. A scoring system as shown in Table 2.5 was used to determine a final score for data reliability that ranges between 0 and 12. Final scores are then converted into an information reliability rating that ranges between poor and excellent using the matrix in Table 2.6.

**Table 2.5. Scoring system for the reliability of data used to assess and analyse trend and condition for diadromous fish.**

| Methods | Question | Scoring system | | |
|---|---|---|---|---|
| | | Yes | Partially | No |
| Methods used | Are the methods used appropriate to gather the information required for evaluation? | 2 | 1 | 0 |
| Standard methods | Has the same method been used over the sampling program? | 2 | 1 | 0 |
| **Representativeness** | | | | |
| Space | Has sampling been conducted across the spatial extent of the Murray estuary with equal effort? | 2 | 1 | 0 |
| Time | Has the duration of sampling been sufficient to represent change over the assessment period? | 2 | 1 | 0 |
| **Repetition** | | | | |
| Space | Has sampling been conducted at the same sites over the assessment period? | 2 | 1 | 0 |
| Time | Has the frequency of sampling been sufficient to represent change over the assessment period? | 2 | 1 | 0 |

**Table 2.6. Conversion of the final score (0–12) for data reliability into an information reliability rating that ranges from poor to excellent for report cards.**

| Final score | Information reliability |
|---|---|
| 12 | Excellent |
| 11 | Very good |
| 10 | Good |
| 9 | Fair |
| ≤8 | Poor |

## 2.6 Data transparency

Data transparency for this report card is represented in Appendix A.

# 3 Results

Recruitment indices for both diadromous fish species showed similar patterns in variability, and were typically low from 2006–07 to 2011–12 and were moderate to high from 2013–14 to 2021–22 (Figure 3.1). Congolli did not meet their Long Term Watering Plan (LTWP) target during the peak of the Millennium Drought (2006–07 to 2009–10), while common galaxias only met their LTWP target in 2006–07. Since the Millennium Drought, both diadromous species have had greater success meeting their LTWP targets, with congolli exceeding their LTWP target in all years except 2011–12, while common galaxias have met their LTWP target in all years except 2016–17 and 2021–22. However, results in 2016–17 should be treated with caution as upstream migration for common galaxias peaked in January rather than between October and December, which is more typical for the species (Bice et al. 2017). As recruitment index values for common galaxias are calculated for the period of October to December (typical peak migration period), the recruitment index value for 2016–17 missed the peak period of upstream migration. If the January migration of common galaxias was included in the recruitment index calculation for 2016–17, the LTWP target would have been met (Bice et al. 2017).

The recruitment index for congolli was very low in 2006–07, with 18.2 YOY migrating upstream per hour (Figure 3.1). There was almost no attempted upstream migration of YOY between 2007–08 and 2009–10, with recruitment index values varying from 0.07–0.14. The recruitment index increased in 2010–11 and 2011–12 to 7.6 and 16.3, respectively. No monitoring was conducted in 2012–13, however, the recruitment index continued to increase in 2013–14 to 183.1 and in 2014–15 to 395.4. Recruitment index values declined to 177.2 in 2015–16 and have since remained relatively stable (46.4 to 190.4).

The recruitment index for common galaxias was moderate in 2006–07, with 11.7 YOY migrating upstream per hour (Figure 3.1). There was no attempted upstream migration of YOY in 2007–08 and 2008–09, with recruitment index values below 0.1. The recruitment index remained low from 2009–10 to 2011–12, however, increased over this period from 3.5 to 6.6. No monitoring was conducted in 2012–13. Recruitment index values were relatively high from 2013–14 to 2015–16, ranging from 11.6 to 29.4. In 2016–17, there was a great reduction in recruitment index to 2.2, although this result would have been significantly greater had January migration data been included in the recruitment index calculation. From 2017–18 to 2020–21 the recruitment index increased from 7.5 to 16.1. In 2021–22, the recruitment index was greatly reduced to 4.5.

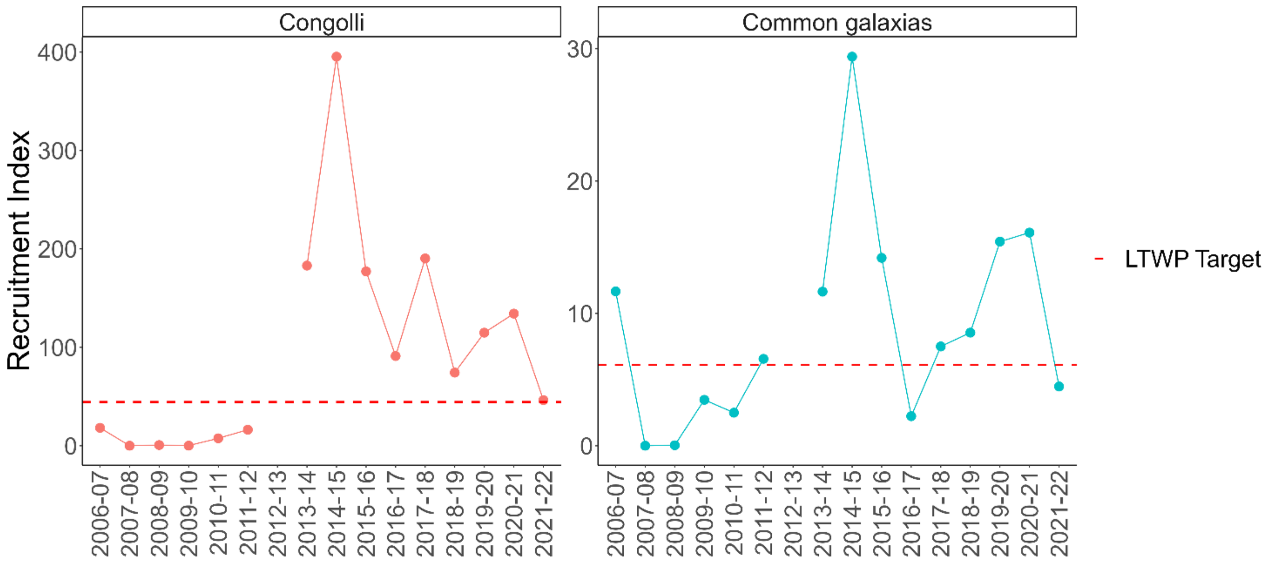



**Figure 3.1. Annual recruitment index (number of upstream migrating YOY.hour$^{-1}$) for congolli and common galaxias from 2006–07 to 2021–22 (no monitoring was conducted in 2012–13). The Long Term Watering Plan (LTWP) Target is shown as a horizontal dashed red line.**

## 3.1 Trend

Recruitment index values of congolli and common galaxias from 2006–07 to 2021–22 were extremely likely (97%) and likely (80%) to be **getting better**, respectively (Figure 3.2).

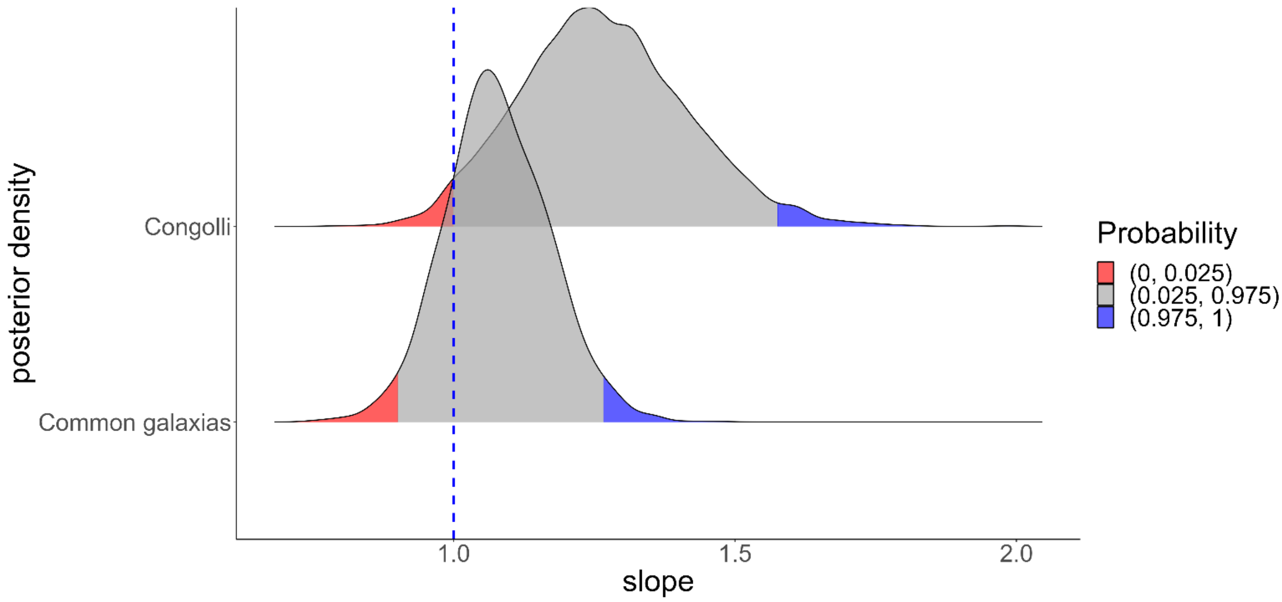



**Figure 3.2. Estimated values for the slope generated from Bayesian modelling for recruitment index values for congolli and common galaxias from 2006–07 to 2021–22. Posterior slope values >1 infer a positive trend (getting better) and values <1 infer a negative trend (getting worse).**

## 3.2 Condition

The recruitment index values of congolli and common galaxias in 2021–22 were 46.42 and 4.48 YOY migrating upstream per hour, respectively. Therefore, based on the criteria in Table 2.4, the population condition of congolli and common galaxias were both classed as fair. Overall, the condition of diadromous fish recruitment in the CLLMM is considered to be **fair**.

## 3.3 Reliability

The overall reliability rating for this report card is **good**, based on Table 3.1, which also provides justification for the scoring of diadromous fish data reliability.

**Table 3.1. Reliability of diadromous fish recruitment index data to assess trend and condition for CLLMM diadromous fish (congolli and common galaxias). The methods used in data collection as well as the representativeness and repetition of data were scored based upon the answers provided to questions related to each facet of data collection. Answers to questions regarding the methods, representativeness and repetition of data collected were scored 2 points – Yes, 1 point – Partially and 0 points 0 – No.**

| Methods | Question | Answer and justification | Score |
|---|---|---|---|
| Methods used | Are the methods used appropriate to gather the information required for evaluation? | **Yes.** Methods were peer reviewed as part of the *Condition Monitoring Plan* (DEWNR 2017). | **2** |
| Standard methods | Has the same method been used over the sampling program? | **Partially.** The same method has been used at individual sampling sites over the monitoring program, however, there are differences in method between sites due to differences in the size and type of barrage fishways. | **1** |
| **Representativeness** | | | |
| Space | Has sampling been conducted across the spatial extent of the Murray estuary with equal effort? | **Yes.** Sampling sites are well spread across the Murray barrages. | **2** |
| Time | Has the duration of sampling been sufficient to represent change over the assessment period? | **Yes.** Sampling has been conducted from 2006–07 to 2021–22, and therefore includes a range of hydrological conditions. | **2** |
| **Repetition** | | | |
| Space | Has sampling been conducted at the same sites over the assessment period? | **Partially.** There has been an increase in the geographical spread of sites over the monitoring program associated with the construction of new fishways. | **1** |
| Time | Has the frequency of sampling been sufficient to represent change over the assessment period? | **Yes.** Sampling was conducted on an annual basis (except for the absence of sampling in 2012–13) and over a time period (October to January) that the majority of congolli and common galaxias YOY migrate upstream. | **2** |
| **Final score** | | | **10** |
| **Information reliability** | | | **Good** |

# 4 Discussion

## 4.1 Trend

Diadromous fish recruitment in the CLLMM was determined to be **getting better** over the duration of the assessment period (2006–07 to 2021–22). The key driving factor behind improved recruitment of congolli and common galaxias appears to be greater hydrological connectivity between freshwater, estuarine and marine environments (Bice et al. 2021). Both diadromous fish species require open barrage gates in winter for the downstream migration of reproductively mature fish to spawn, and open fishways for the upstream migration of juveniles to the Lower Lakes and tributaries of the eastern Mount Lofty Ranges (Bice et al. 2018a) where they mature (Bice et al. 2021).

The lack of freshwater inflows and loss of connectivity due to closure of the barrages and fishways during the peak of the Millennium Drought (2007–2010) resulted in negligible recruitment of diadromous fish and a depletion of the population of reproductively mature adults (Bice et al. 2021). This prompted emergency measures to facilitate downstream spawning migrations of congolli through the Goolwa Barrage navigation lock in July 2010 to help safeguard the population (Zampatti et al. 2012).

Extensive flooding across the Murray–Darling Basin reinstated freshwater flows from the barrages in late 2010, restoring system connectivity and opening barrage gates and fishways (Bice et al. 2021). The delivery of water to maintain open barrage gates in winter and operable fishways in summer improved diadromous fish recruitment, however, the abundance of juveniles were likely limited by the low population of reproductively mature adults until 2014–15 (Bice et al. 2021). From 2014–15 to 2020–21, the abundance of juvenile congolli and common galaxias were strongly associated with the percentage of days when at least one barrage gate was open in winter for downstream migration (referred to as open days). However, this association between diadromous fish recruitment and open days in winter did not occur in 2021–22, and reasons for this remain a knowledge gap (Chris Bice, Pers. Comms. 21 August, 2022) (see Section 4.2).

## 4.2 Condition

The population condition of both congolli and common galaxias were classed as **fair** in 2021–22. The 2021–22 water year (July 1–June 30) was characterised by high flow conditions (estimated barrage flow of 6,185 GL). This high flow event was expected to result in recruitment indices for congolli and common galaxias within categories of good or very good given the connectivity between freshwater, estuarine and marine habitats. In 2021–22, the relationship between open days and recruitment indices for congolli and common galaxias was not correlated like all other sampling years since 2014–15. The reasons for the lower than expected recruitment indices for congolli and common galaxias remain a knowledge gap, however, it may have been influenced by (Chris Bice, pers. comms. 21 August, 2022):

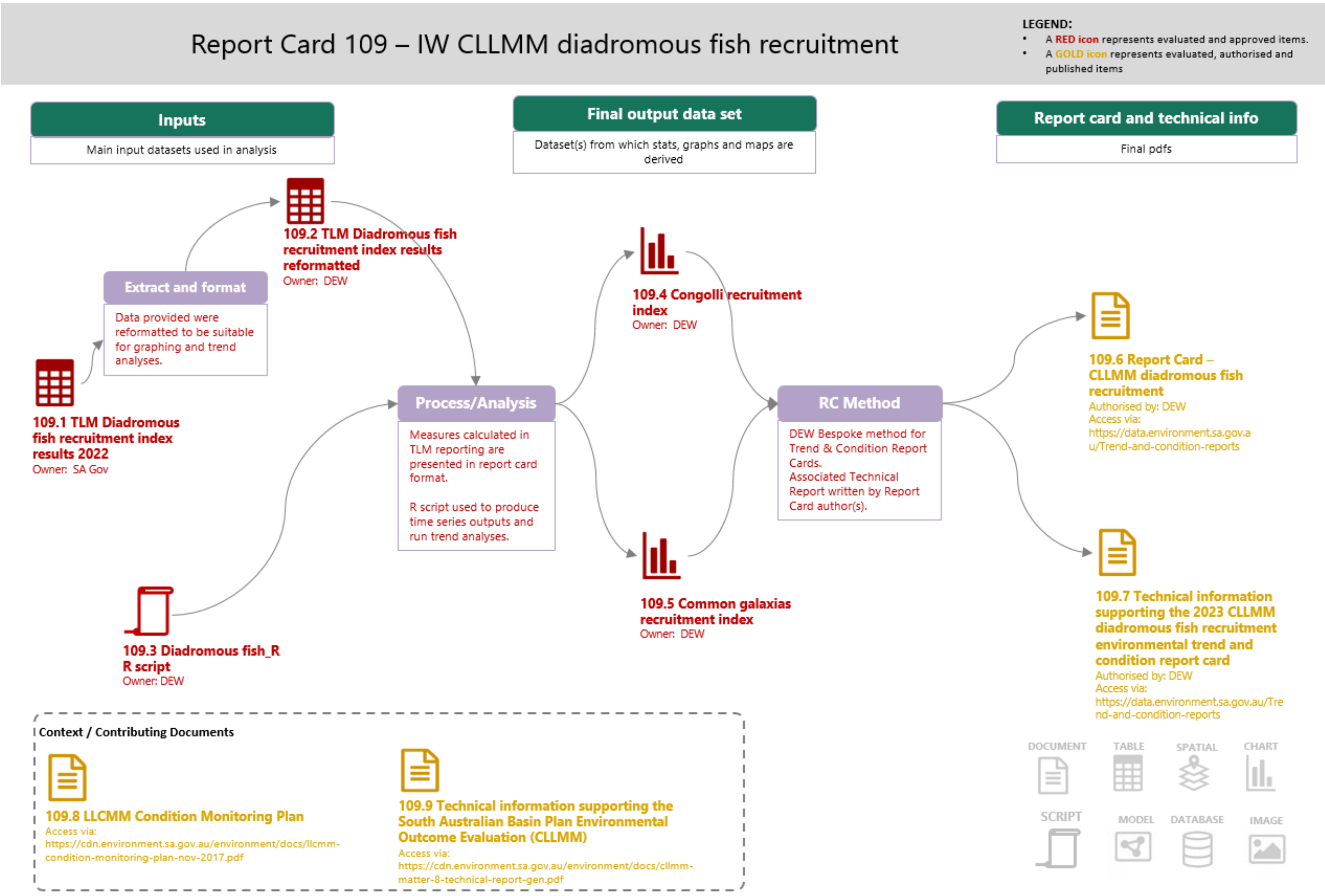
- YOY bypassing fishways when migrating upstream due to more instances of similar water levels between the Lower Lakes and Murray estuary, and
- the timing of fish sampling at the Murray barrages. The change in timing may have influenced the congolli recruitment index as the vertical slot fishway that traditionally has higher captures was not accessible in January and instead was surveyed in February, which may have missed the month of peak upstream migration.

# 5 Conclusion

Diadromous fish in the CLLMM were determined to be in **fair condition** and **getting better**. Recruitment of diadromous fishes is getting better due to improved system connectivity between freshwater, estuarine and marine habitats. Critical to the recruitment of diadromous fish is the delivery of water for the environment to maintain open barrage gates in winter and operable fishways with attractant flow in spring and summer. This enables congolli and common galaxias to migrate downstream and upstream, and complete their lifecycles.

# 6 Appendices

## A. Managing environmental knowledge chart for Coorong, Lower Lakes and Murray Mouth (CLLMM) diadromous fish recruitment



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