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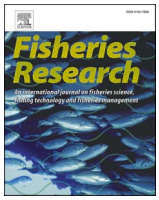

Full length article

Perceptions and beliefs of recreational anglers about Murray Cod (*Maccullochella peelii*) fishing in Victoria, Australia: A path to enhancing education and outreach

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ABSTRACT

Murray Cod (*Maccullochella peelii*) is an iconic freshwater fish species in Australia with high cultural importance. Following declines, management and conservation efforts have helped Murray Cod populations recover to such an extent that the species now supports a vibrant recreational fishery. With high participation rates, the Victorian Fisheries Authority initiated the Care for Cod campaign in 2017 to increase awareness of best practices that can ensure fish are released in the best condition possible. With emerging concerns about potential threats to Murray Cod populations and greater promotion of recreational angling by governmental and non-governmental bodies, the objective of our survey of over 3500 Murray Cod anglers was to assess perceptions related to handling practices and other factors that could influence the sustainability of the recreational fishery. Over 90% of respondents believed handling practices are important to the welfare of released Murray Cod and the Care for Cod Campaign was found to have assisted anglers to engage in better handling practices. Most respondents reported being satisfied with Murray Cod fishing in Victoria, and angler ratings have increased over time from the 1970s to 2020 – consistent with the perceived recovery of Murray Cod populations. Respondents were concerned with threats from hypoxic 'blackwater' events and invasive carp, and valued fish stocking and regulations as the most important fishery management interventions. Our results can help inform the evolution of the Care for Cod Campaign and how other similar campaigns may want to target recreational anglers to maximize the potential and effectiveness of education and outreach campaigns.

1. Introduction

Murray Cod (*Maccullochella peelii*) is an iconic large-bodied native freshwater fish species found throughout the Murray-Darling Basin in southeastern Australia. The species is long-lived, recorded to 48 years of age, and grows to be one of the largest solely freshwater fish in the world reaching 113 kg and 1.8 m in length (Anderson et al., 1992; Rowland, 2005). Due to its size and stature, Murray Cod has a deep culturally important connection to indigenous Australians (Anderson et al., 1992; Lintermans and Phillips, 2005; Rowland, 2005) and has also been the focus of harvest for subsistence, commercial, and recreational fisheries (Rowland, 2020). With time, overharvest and other impacts such as the regulation of river flows, habitat degradation, and invasive species, caused significant declines in Murray Cod populations compared to pre-European time (Cadwallader and Gooley, 1984; Lintermans and Phillips, 2005; Rowland, 2020), triggering them to be legislatively listed

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as Vulnerable, Threatened, and Endangered under state and national legislation from 1988 onwards (Lintermans, 2023).

From the 1990's onwards, major changes in management practices are believed to have contributed to a noticeable increase in Murray Cod abundance in many systems, including the cessation of commercial fishing, introduction of recreational fishing gear restrictions (e.g., removal of drum nets and set lines), seasonal closures to protect breeding fish (Rowland, 2005, 2020), large-scale hatchery production and stocking (Rowland, 2013; Hunt Jones, 2018), habitat restoration and improved water flows (Nicol et al., 2004; Lyon et al., 2019; Tonkin et al., 2022), and changes in angler behavior, such as more Murray Cod being caught and voluntarily released (Douglas et al., 2010). At a national level, Murray cod is no longer considered to meet the criteria of being a nationally listed species (Lintermans, 2023, Lintermans et al. 2024) and the species IUCN Red List assessment has been downgraded to 'Least Concern' (Gilligan et al., 2019). At a state jurisdictional level, increases in abundance of Murray cod have been observed in Victoria (Bell at al. 2024; Ingram et al., 2024) and NSW (Crook et al., 2023; Lintermans, 2023). The biological stock status of Murray cod and other targeted fish species in Australia are assessed periodically and reported through the Status of Australian Fish Stocks Reports (Roelofs et al., 2024). Whilst the stock status of Murray cod is variable depending on the jurisdiction, since 2020, Murray cod has been considered to have a stock status of 'recovering' in the state of Victoria (Qifeng et al., 2023). This classification is based on evidence of increasing catch-per-unit-effort trends and presence of mature fish in six of seven indicator rivers since 2014 (Qifeng et al., 2023; Bell et al., 2024; Ingram et al., 2024). Stock recovery has been attributed to strong natural recruitment, effective current fishing regulations and substantial stocking of hatchery-reared Murray cod during the past two decades.

With their recovery, the popularity of Murray Cod as a target for recreational anglers increased throughout its native range and beyond (Barwick et al., 2014; Rowland, 2020; Crook et al., 2023; Qifeng et al., 2023; Lintermans, 2023; Bell et al., 2024; Ingram et al., 2024). In 2011, recreational fishing in the Murray-Darling Basin was found to contribute $1.3 billion (AUD) to the economy, support an estimated 10,950 jobs, and involve over 430,000 recreational fishers (Ernst and Young, 2011). Given that Murray Cod are frequently regarded as Australia's highest profile freshwater fish species with an iconic status throughout the Murray-Darling Basin (Fulton, 2011; Rowland, 2020; Qifeng et al., 2023), it is reasonable to assume much of the economic value of fishing in the Murray-Darling Basin can be attributed to Murray Cod. Furthermore, since 2011, the popularity of and deep cultural connection to Murray Cod fishing has only grown, concurrent with the increase in recreational fishing participation in Australia (Moore et al., 2021) and the resurgence in abundance of the Murray Cod in waterways within and outside of the Murray-Darling Basin (Rowland, 2020; Crook et al., 2023; Ingram et al., 2024). Hundreds of thousands of recreational anglers engage with Murray Cod annually through targeted and casual fishing for the species, as well as participating in Murray Cod focused events and platforms, such as the annual public conference: 'Murray Codference', Murray Cod angling competitions, Murray Cod tackle industry tradeshows, and Murray Cod social media groups (Hunt et al., 2016; Douglas et al., 2017, 2018; Ho et al., 2019). The 10th World Recreational Fishing Conference featured Murray Cod fishing as a key focus of presentations and an indigenous painting of a Murray Cod made up the conference logo (Westaway, 2023) and cover of the Conference Special Journal Issue: *Innovation in recreational fisheries research, community participation and management* (Fisheries Management and Ecology 2025). Collectively, the high cultural and economic importance of the Murray Cod recreational fishery means there is a strong expectation that the fishery is well understood and sustainably managed.

As the abundance and popularity of Murray Cod fishing continued to grow during the 2000's, quantitative assessments and consultation with stakeholders and rightsholders about whether recreational fishing regulations are suitable were conducted (Allen et al., 2009; Fulton, 2011; Gwinn et al., 2013; Hunt et al., 2014) and resulted in the introduction of a 55–75 cm slot-limit for Murray Cod across most of the Murray-Darling Basin in December 2014. Given that the introduction of the slot-limit was expected to increase the number of large Murray Cod caught and released, the Victorian Fisheries Authority (VFA) and recreational fishing partners (particularly the Victorian Murray Cod Recreational Fishing Reference Group) introduced the Care for Cod campaign in 2017 to encourage best practice for the capture and handling of Murray Cod (Forster, 2017). The Care for Cod campaign aimed to improve catch-and-release (C&R) practice through a four-point plan, developed through the best available science, aquatic veterinarians, and practical advice from leading Murray Cod anglers. The campaign was communicated through social media, videos, presentations, and the distribution of stickers and flyers at fishing tackle stores. Overall, it was the intent of the Care for Cod campaign to begin changing social norms related to how Murray Cod were captured, handled, and released, and create a stronger angler movement for greater awareness of the status and management of this target species (Forster, 2017).

After five years of implementation of the Care for Cod campaign, we used an online survey targeted at Murray Cod anglers to: 1) assess perceptions related to the C&R practices for Murray Cod; 2) assess perceptions of emerging threats and contemporary management measures to Murray Cod populations and the broader recreational fishery; and 3) collect insights on the perceptions, behaviors, and demographics of Murray Cod fishers (including perceived state of the Murray Cod fishery over time and currently), the motivations, focus, and catch and harvest levels of Murray Cod fishers. As with similar surveys of other recreational fisheries, we expected that there would be a disconnect between the actions anglers report and their perceptions of the impacts of such actions (e.g., see Dinkelacker et al., 2025).

Over the last decade, new threats to the recovery of Murray Cod have emerged including fish kills associated with hypoxic 'blackwater' events (Leigh and Zampatti, 2013; Koehn, 2021), water management and extraction (Stuart and Sharpe, 2022), rapid increases in range and abundance of exotic species such as carp, *Cyprinus carpio* (Fanson et al., 2024, Schilling et al., 2024), and climate impacts including greater frequency and intensity of droughts and bushfires (Qifeng et al., 2023). We anticipated that although respondents may be aware of many of these threats, there could be a disconnect between the root causes of the potential disturbance, such as the linkage between blackwater events and extreme weather conditions driven by climate change. Recreational fishing technology and communication changes are also occurring, such as the rise of live imaging sonar and the rapid exchange of information on social media, however the effects of these developments on Murray Cod populations remain unstudied (Cooke et al., 2025). While some studies have compared and examined the efficacy of management techniques for sustaining and recovering Murray Cod fisheries, such as stocking and harvest regulations (Rogers et al., 2010; Thiem et al., 2016), an understanding of how anglers are perceiving contemporary management measures and environmental threats and the adoption of best practices for C&R could help inform education and outreach strategies to influence social norms and regulation compliance, including shape the evolution of the Care for Cod campaign.

2. Methods

2.1. Sampling frame and distribution

The target population for our survey included recreational anglers aged 18 years and older who were active in the Murray Cod fishery (i.e., angled for Murray Cod in the last year). Survey recruitment and distribution occurred from 8 December 2022 – 31 January 2023. Participants were recruited via snowball sampling (Baltar and Brunet 2012; Leighton et al., 2021), a method proven effective for engaging anglers in prior studies (Casselberry et al., 2022; Griffin et al., 2023, Dinkelacker et al., 2025). This approach is appropriate and advantageous to access, and

deeply understand niche groups and phenomena (e.g., Murray Cod anglers, emergence of a restoration 'bright spot' among Murray-Darling Basin anglers; Howarth et al., 2024). We disseminated the survey through various fishing magazines and social media platforms, including Twitter, Instagram, and Facebook. The survey was also directly emailed via VFA to over 230,000 Victoria recreational anglers with one or three year fishing licenses. Participants were not compensated for their participation, though a weekly incentive raffle survey was also included as an option in the survey, where one participant was randomly selected to receive a $250 fishing tackle voucher. The survey was administered using the Qualtrics platform and duplicate, incomplete, or potential responses originating from bots were filtered out manually and via Qualtrics. All methodologies were approved by the Antioch University New England Institutional Review Board, ensuring adherence to ethical standards and participant privacy.

2.2. Survey instrument

The survey questionnaire included a series of closed- and open-ended questions investigating a range of topics, including those related to (1) general angler characteristics and attitudes, (2) perceptions of and engagement with handling practices, (3) awareness of and engagement with the Care for Cod campaign, (4) angling behavior and attitudes towards management/impacts, and (5) demographic information, including angling focus. All survey questions are provided in Supplemental Materials. Throughout the survey, anglers were allowed to skip questions of their choice and still advance through the entirety of the survey. At the start of the survey, anglers responded to a series of questions that gauged their angling frequency, where they angle from (i.e., bank or boat), motivations for angling Murray Cod, the gear they use to fish (i.e., bait, lures, fly), landing and harvesting rates, livescope usage, how satisfied they are with the Murray Cod fishing (1 = extremely dissatisfied; 5 = extremely satisfied) and how they rate Murray Cod fishing over time (1 = very poor; 5 = very good).

Following this section, anglers were asked to indicate their perceived importance of handling practices (1 = not at all important, 5 = extremely important), how different aspects of the angling event impact the fate of angled and released fish (e.g., 'extent of fight time'; 1 = not at all, 7 = a great deal; 8 = unsure), and perceived challenges of specific handling practices (1 = not at all challenging, 5 = extremely challenging; 6 = unsure). Anglers were also asked to report all the practices they currently use when capturing and handling Murray Cod. Six of these practices, which represent key empirically-validated and universally accepted best handling and release practices identified in fisheries research across various species (e.g., Brownscombe et al., 2017), were combined to form a cumulative index for each respondent. These included, "minimize fight time", "wet your hands when handling fish", "Only hold fish in or over the water (and not over land or boats)", "don't remove fish from water", "release fish as quickly as possible", and "when handling, support the body (including the belly), and keep fish held horizontally". One item then assessed anglers' perceptions about the need for fish handling practices to be improved by anglers ('indifferent', 'yes', 'no').

Respondents were then asked to indicate whether or not they were aware of the Care for Cod campaign. Those who reported being aware of the Care for Cod campaign then answered specific questions about the campaign, including how the campaign influenced their handling practices when fishing for Murray Cod, whether or not they have communicated with other anglers about the campaign, and where they received information about it. Following this section, anglers provided information about the extent to which different factors impact the status and sustainable future of Murray Cod (e.g., 'climate change', 1 = not at all; 7 = a great deal) as well as the importance of fishery management interventions are to improving the Murray Cod fishery (e.g., 'fish stocking', 1 = not at all important, 5 = extremely important).

Respondents also provided demographic information relative to their self-reported gender and age. Finally, anglers were asked to indicate their angling focus as either 'committed' (e.g., fishing is the center of your life, your social life revolves around fishing; you use high-quality species-specific tackle and always target a particular species), 'advanced' (e.g., fishing is your most important leisure activity; your circle of friends include many anglers; you prefer high quality tackle and usually target a particular species), 'active' (e.g., fishing is one of many activities you enjoy; you occasionally go fishing with a few friends; you prefer common tackle and often target a particular species), 'casual' (e.g., fishing is not your most important leisure activity; social life rarely involves fishing; you prefer common tackle and target whatever is biting) (Beardmore et al., 2013).

Throughout the survey, participants also responded to open-ended questions about angler motivations, handling practices, threats to Murray Cod, and Murray Cod management and conservation. To better understand respondent thought processes (e.g., beliefs about how to manage and conserve Murray Cod), and to capture items that were overlooked in survey design (e.g., handling practices not included in pre-existing response options), these responses were analyzed by inductive thematic coding as in Thomas (2006). This process divides raw textual data (e.g., typed responses to open-ended survey questions) into different codes (i.e., thematically grouped text segments) representing broad themes, as well as key insights (e.g., highly explanatory and/or revealing responses) in social survey data. We identify and describe these broad themes, which correspond to codes with many segments. Representative and illustrative quotes are provided to give additional context to these themes, and to the results of our quantitative analyses. Such methods were used to emphasize 'bright spots' that are points of hope related to conservation and how these sentiments can be used to side-step despair and apathy when it comes to empowering stakeholders to recognize the complexity of policy and management decisions (Bennett et al., 2016; Jeanson et al., 2021; Cinner, 2025; Embke et al., 2025; Hoesen and Lemieux, 2025).

2.3. Data preparation and analysis

A rigorous data cleaning protocol was administered to ensure valid participant responses through the detection and removal of bots. Additionally, prior to analysis, respondents were removed from the sample for failure to meet basic screening questions (i.e., did not fish recreationally for Murray Cod in the last year) or who completed less than 50% of the survey. This completion threshold eliminated respondents who had not progressed sufficiently through items of the survey addressing the Care for Cod campaign. In order to maintain a focus on anglers' perceptions of the Murray Cod fishery and anglers' current engagement with handling practices, we primarily report descriptive, topline results across the diverse set of survey items included in the survey. Additionally, some exploratory inferential analyses are provided in the main text and supplemental materials, which specifically examine anglers' awareness and impact of the Care for Cod campaign. For each relevant open-ended question, a working list of primary codes was created during data preparation, and a working code book with secondary and tertiary codes was created during the first full read of all responses. Results from these analyses give context to results from quantitative analyses and shed light on complex processes (e.g., Murray Cod handling practices) underlying general trends (e.g., Murray Cod species and fishery restoration).

All analyses were conducted in R version 4.3.0 (R Core Team, 2023). Figures were visualized using *ggplot2* (Wickham, 2016), *HH* (Heiberger, 2024), *and likert* (Bryer and Speerschneider, 2016) packages in R. Likert-style data were treated either as nominal categorical or ordinal, depending on the structure of the response categories. For instance, items including the response category 'unsure' were treated as nominal categorical variables. Where appropriate, the Mann-Whitney test, a non-parametric test, was used to compare two independent groups on an ordinal outcome. For comparing more than two independent groups on

an ordinal outcome variable, the Kruskal-Wallis test was used, followed by the Dunn test to examine post-hoc comparisons. Epsilon Squared (ε^2) was used to assess the effect size of the Kruskal-Wallis test, where values around 0.01 indicate a small effect, values around 0.06 represent a medium effect, and values around 0.14 indicate a large effect (King et al., 2018). Welch's *t*-test was used to compare two independent groups on a continuous outcome, while ANOVA was used to compare more than two groups on a continuous outcome.

Binomial logistic regressions were used to better understand which factors influenced anglers' awareness of the campaign and sharing information about it. Model fit was assessed by the Hosmer-Lemeshow test (Fagerland and Hosmer, 2017) using the *ResourceSelection* package in R (Lele et al., 2023). The null hypothesis of the Hosmer-Lemeshow test suggests that the model fits the data, with a recommended p-value cutoff of 0.1 (Fagerland and Hosmer, 2017). Where necessary, chi-squared tests were conducted to examine the relationship between categorical variables. Cramer's V was used to assess the effect size of the chi-squared test (Cohen, 1988). Cramer's V ranges from 0 to 1, where values between 0.1 and 0.3 indicate a small effect, values between 0.3 and 0.5 suggest a medium effect, and values above 0.5 represent a large effect size (Cohen, 1988). Additionally, standardized residuals and the critical value approach were used to detect where differences emerged in the chi-squared tests. Standardized residuals measure how many standardized deviations the observed count differs from the expected count under the assumption of independence. The alpha for the critical value was set at 0.05, accounting for a two-tailed test, and was adjusted to account for multiple comparisons specific to each test. Cells whose absolute value of the standardized residual exceeds the critical value are considered significant (Agresti, 2007).

3. Results

Following data cleaning to detect and remove bots, our survey distribution efforts resulted in 5935 respondents who agreed to participate in the study. Prior to analysis, 2429 participants were removed from the sample for failure to meet basic screening questions (i.e., did not fish recreationally for Murray Cod in the last year) or who completed less than 50% of the survey. This completion threshold eliminated respondents who had not progressed sufficiently through items of the survey addressing the Care for Cod campaign. As a result, a total of 3506 participants remained in the sample.

3.1. Sample demographics and angling behavior information

The majority of respondents were male (85.0%), between the ages of 35 and 44 (26.1%; Table 1). Approximately 40% of respondents identified as 'active' anglers and roughly similar numbers of anglers reported angling from the boat and the bank (Table 1).

The reported median number of Murray Cod landed per year was 7 (M = 40.87, SD = 597.32, n = 3087). After accounting for outliers using interquartile range (IQR), measures of central tendency and spread for Murray Cod landed per year decreased (M = 9.63, SD = 9.69, median = 6, n = 2753). Of the Murray Cod caught in the 55–75 cm harvestable slot, the median keep rate (percentage) for the table or to eat was 0 (M = 16.33, SD = 27.71, n = 3120), however the mean and standard deviation decreased after accounting for outliers using IQR (M = 4.79, SD = 9.77, median = 0, n = 2579). Overall, the vast majority of anglers agreed with slot limits (e.g., min/max) for Murray Cod (82.7%, n = 2665) compared to those who were 'indifferent' (11.4%, n = 367) and those indicating disagreement (5.9%, n = 189). Frequency of documenting Murray Cod post-catch (i.e., taking photographs) varied across anglers with 18.8% (n = 605) indicating 'occasionally', followed by 'frequently' (17.3%, n = 557), 'all the time' (17.1%, n = 551), 'rarely' (13.3%, n = 428), 'once in a while' (12.1%, n = 390), 'very often' (11.6%, n = 374), and 'never' (9.8%, n = 316).

Livescope usage varied across respondents, with the majority (51.1%, n = 1643) indicating that they do not use it because they are 'not interested in using it.' Fewer anglers reported 'I have never used it, but would if I had the opportunity' (28.1%, n = 904), followed by 'I will not use it because I don't agree with it' (9.0%, n = 290), 'I use it sometimes' (7.7%, n = 248), 'I use it often' (2.8%, n = 89), and 'I always use it' (1.3%, n = 41). Regarding the perceived efficacy of livescope (e.g., 'active target sonar' or 'forward facing sonar') in supporting greater Murray Cod catch rates, most anglers (45.1%, n = 1453) reported being 'unsure', followed by those indicating 'yes' (34.5%, n = 1112), 'indifferent' (13.0%, n = 417) and 'no' (7.4%, n = 238). Self-reported annual landing rates of Murray Cod (adjusted for outliers) varied across Livescope usage. Anglers who reported that they 'I use it often' had the highest mean annual catch rate (M = 14.55; SD = 12.26), followed by those who indicated that 'I always use it' (M=13.00; SD = 11.61), 'I will not use it as I don't agree with it' (M = 11.61; SD = 10.48), 'I use it sometimes' (M = 11.16; SD = 10.62), 'I have never used it, but would if I have the opportunity' (M = 10.13; SD = 9.86), and 'No, because I'm not interested in using it' (M = 8.61, SD = 9.02).

Table 1
Demographic and angling behavior information for Murray Cod anglers that responded to the survey.

	n	%		*n*	%
Gender (n = 3146)			**Angling frequency past 12 months** (n = 3506)		
Male	2673	85	Once	678	19.3
Female	455	14.5	2–5 times	1436	41.0
Prefer not to say	18	0.6	6–10 times	540	15.4
Age (n = 3151)			More than 10 times	852	24.3
18–24	234	7.4	**Angling frequency pre-covid** (n = 3414)		
25–34	678	21.5	I didn't fish for Murray Cod	373	10.9
35–44	822	26.1	Once	302	8.8
45–54	754	23.9	2–5 times	1041	30.5
55–64	523	16.6	6–10 times	628	18.4
65–74	119	3.8	More than 10 times	1070	31.3
75 or older	7	0.2	**Gear type** (n = 3502)		
Prefer not to say	14	0.4	Lures	1587	45.3
Fishing Focus (n = 3135)			Bait	1875	53.5
Committed	367	11.7	Fly	40	1.1
Advanced	969	30.9	**Angling Location** (n = 3502)		
Active	1266	40.4	Bank	1826	52.1
Casual	533	17.0	Boat	1676	47.9
Information Sourcing for Murray Cod			**Motivation for Angling**		
Facebook	1282		For competition	415	
Fishing club/org.	493		For sport	1421	
Fishing magazines	1094		To be with friends and family	2146	
Other social media	785		Fishing club activity	285	
Other sources	289		To be outdoors	2533	
Television shows	1082		To relax	2377	
Word of mouth	1850		For food	679	
YouTube	1451		Other	170	

3.2. Perceptions of Murray cod fishery

Anglers' perceptions of the overall state of Murray Cod fishing were favorable. The majority of anglers reported being either 'somewhat satisfied' (45.8%, n = 1600) or 'extremely satisfied' (23.6%, n = 824) with Murray Cod fishing in Victoria, with fewer anglers expressing 'neither satisfied or dissatisfied' (19.6%, n = 694), 'somewhat dissatisfied' (8.4%, n = 292) and 'extremely dissatisfied' (2.7%, n = 95). Anglers' ratings of Murray Cod fishing also appear to be increasingly positive over time (Fig. 1). Blackwater was perceived as having the most impact on the status and sustainable future of Murray Cod fishing, followed by carp (Fig. 2). Fish stocking and appropriate fishing regulations were perceived as the most important management interventions on

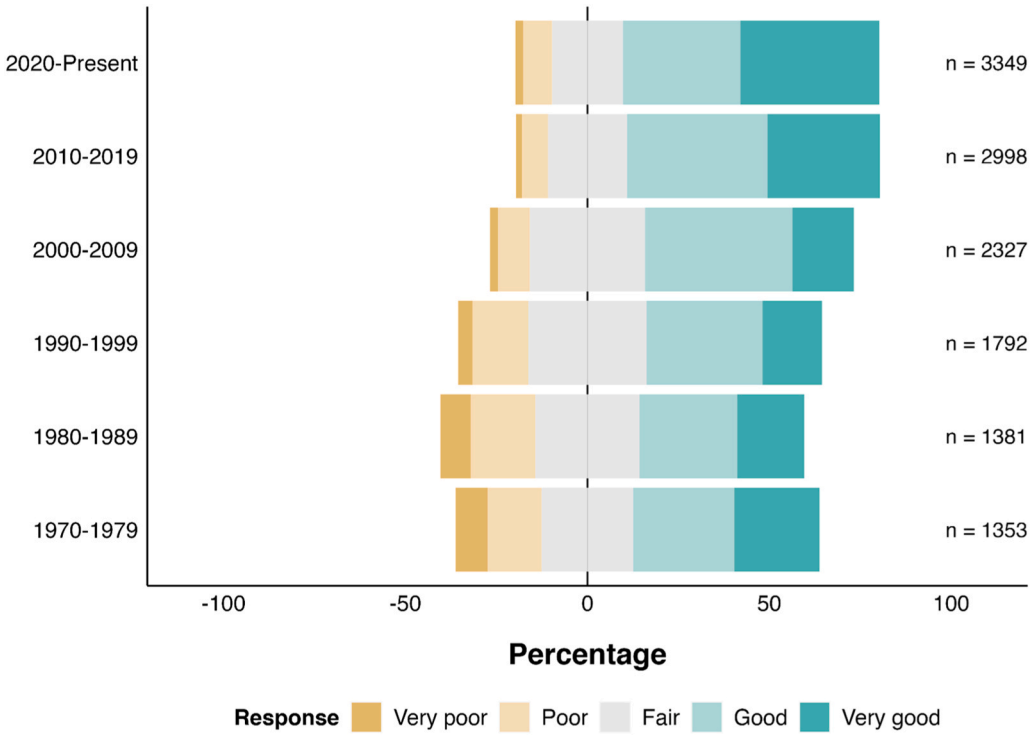

Fig. 1. Anglers' rating of Murray Cod fishing over ten year increments from 1970 - Present. The figure is centered at the middle response category 'fair' for better visual comparison of response distributions across items. Total n for each item appears on the far right. 'Not applicable' responses are not included, thus differences in total number of responses per item.

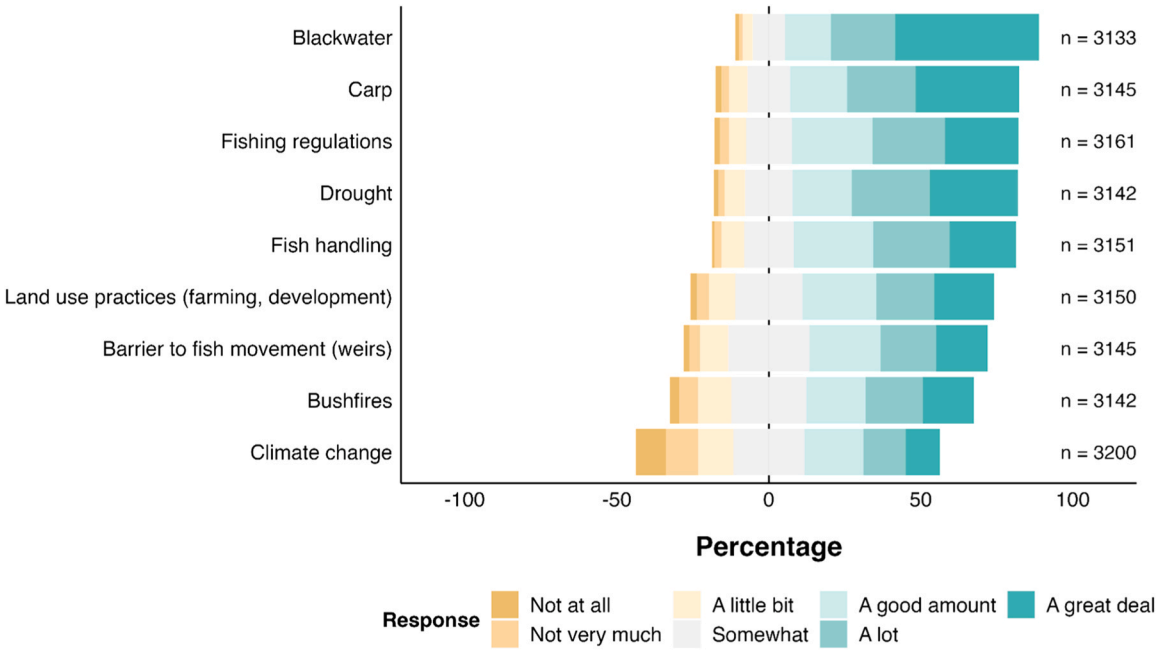

Fig. 2. Perceived impacts of various factors on the status and sustainable future of Murray Cod. The figure is centered at the middle response category 'somewhat' for better visual comparison of response distributions across items.

improving the Murray Cod fishery (Fig. 3).

Our analysis of open-ended statements related to fisheries management revealed strong support for VFA: supportive (37 segments), solutions- and/or future-focused (40 segments), and positive sentiments (38 segments) outnumbered unsupportive and/or critical (13 segments), problems- and/or past-focused (19 segments), and negative and/or concerned sentiments (27 segments). Statements about high-quality fishing opportunities, Care for Cod, natural habitat and reproduction, and native species appreciation (see below) are testaments to this. Respondents who offered suggestions or made statements related to fisheries management focused more on mitigating human impacts on Cod and Cod habitat than stocking and population monitoring (32 segments). There were few suggestions related to stocking (10 segments), and some respondents who did mention stocking referred specifically to

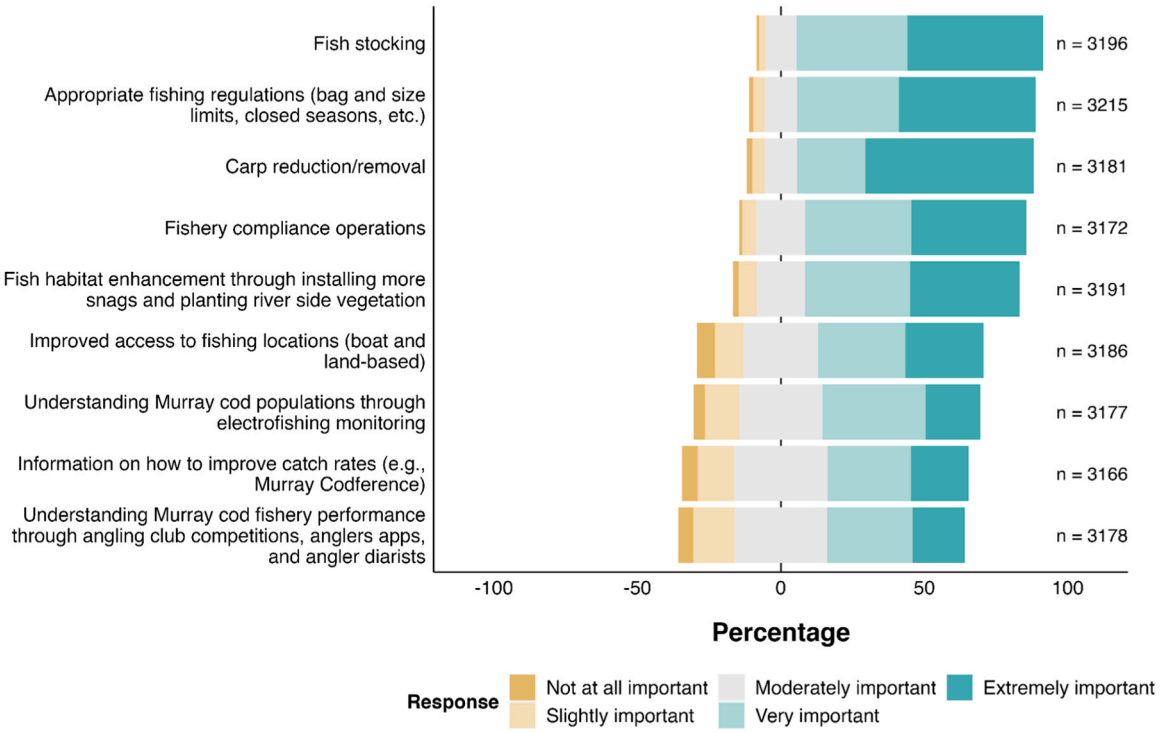

Fig. 3. Perceived importance of various management interventions and strategies on improving the Murray Cod fishery. The figure is centered at the middle response category 'moderately important' for better visual comparison of response distributions across items.

re-stocking areas within the natural, historical range of Murray Cod. Managing non-native species (13 segments) and applied research (6 segments) were mentioned infrequently.

Respondents to our survey also expressed appreciation for habitat management and restoration as means to more robust fish populations and fisheries (95 segments). In particular, managing freshwater use was viewed as a major opportunity to improve Cod populations and fishing (51 segments). Land use management was also discussed somewhat frequently (21 segments), and Cod anglers seemed partial to watershed- and/or landscape-level approaches. For instance, one angler (Male, 35–44, Advanced) offered a suggestion to "Improve water quality by ensuring [that] CMAs [Catchment Management Authority] properly manage flows to replicate a natural system. Tougher regulations on pollution entering waterways" while another angler (Male, 35–44, Committed) mentioned "Stopping cattle grazing from ruining riparian zones… have minor floods throughout winter instead of just an environmental flow to allow the manure, pesticides, and organic matter to wash off [of] the floodplains to prevent pollution and possible hypoxic events when we have a serious, devastating flood…"

References to habitat protection and regulation (e.g., monitoring industrial activities, penalizing polluters) were relatively few (11 segments), but quite critical of industry and government (e.g., "Get wake boats out of the river. The damage to the environment from unnecessarily large waves is ridiculous."; Male, 55–64, Active). Meanwhile, another respondent (Male, 45–54, Advanced) noted the need to "Have the waterways managed better—blackwater events have killed more fish than any poor handling techniques. Blackwater events in the seventies, through to the early nineties, did not [cause] fish kills in my area. And don't feed me the rubbish that it's a natural thing!"

Most written responses to questions about or related to fishery management involved 'people management' (301 segments)—a discussion topic that was dominated by references to education and/or outreach (185 segments). This emphasis on managing fishery users may be exaggerated due to our interest in Care for Cod, which was reflected in our survey. However, Murray Cod anglers still seem to view education and/or outreach as one of two major opportunities—possibly *the* major opportunity—to improve Murray Cod populations and fishing. Regulation and/or enforcement (94 segments) was viewed as a second, major opportunity for this. Survey responses involving education and/or outreach tended toward fostering better handling, and more effective C&R (e.g., youth education, taking key messages *to* anglers), while statements about regulation and/or enforcement fell into roughly two categories: enforcement of existing rules (i.e., crackdown on poaching) and special regulations (e.g., gear restrictions, protected areas). Representative quotes paint a picture of all this:

> "… education at schools, other sporting groups, and at the time of purchasing your fishing license." (Male, 55–64, Advanced)

> "More signage at Cod [fishing] location boat ramps and road entrances." (Male, 45–54, Active)

> "Stronger enforcement. I would like to see the Fisheries [Authority] in the field more [often] enforcing the law." (Male, 35–44, Committed)

> "Designated 'no fishing' areas for breeding." (Male, 45–54, Active)

> "Double paternoster rigs should be banned for freshwater fishing." (Male, 55–64, Committed)

On their own, statements like these are not indicative of the frequency of various beliefs in the angling population. Instead, our results provide a cross-section of Murray Cod angler desires for improved management of their preferred species—desires which tended toward human impacts on habitat and fish. An illustrative quote captures the general attitude of anglers toward 'people management' as a means for Murray Cod conservation:

> "I think it's important that people are made aware of the best practices. The Cod
>
> population is healthy in my area. I have even caught them in Lake Hume [while] fishing for perch. I think the reason their population is healthy is due to conservation. There are still a lot of anglers that

don't have enough respect for the environment. Maybe some harsher penalties for those who ignore the rules." (Male, 45–54, Advanced)

3.3. Perceptions of Murray Cod handling

Respondents emphasized the importance of employing proper handling practices to ensure the welfare of released Murray Cod during a C&R angling event, with 63.4% (n = 2177) indicating that it was 'extremely important', 29.9% selecting 'very important' (n = 1028) and fewer respondents indicating 'moderately important' (5.2%, n = 178), 'slightly important' (1.3%, n = 45) and 'not at all important' (0.1%, n = 5). The majority of respondents also reported that fish handling practices for Murray Cod generally need to be improved by anglers (62.9%, n = 2201), with fewer being indifferent (24.7%, n = 863) and even less suggesting no improvements are necessary (12.5%, n = 436). Perceived impacts of how different aspects of the angling event influenced the fate of fish varied (Fig. 4), with physical injury perceived as having the most impact. Furthermore, anglers reported limited perceived challenges in performing specific best practices when handling and releasing Murray Cod (Fig. 5). Deep hooking events generally appear to be rare, with the majority of anglers reporting 'rarely' (51.0%, n = 1785) deeply hooking Murray Cod. Fewer anglers responded that they experience a deep hooking event 'occasionally' (32.4%, n = 1135), 'never' (10.7%, n = 375), often (5.2%, n = 182) or 'all the time' (0.7%, n = 23).

Many responses to the open-ended 'Other' option (on the question about handling practices) overlap with pre-existing response options. When given the opportunity, respondents gave even greater emphasis to supporting the full body of fish (23 segments), avoiding and/or minimizing contact with dry surfaces (19 segments, keeping fish in water (19 segments), minimizing handling time (6 segments), using barbless and/or release-friendly hooks (e.g., circle hooks; 6 segments), and minimizing fight time and/or using appropriate gear (1 reference). Some responses to the same 'Other' option did not overlap with pre-existing options, and might warrant more discussion/consideration: helping and/or waiting for fish to revive (26 segments); avoiding use of lip grips, gill grabs, other tools/practices (15 segments); wetting brag mats and/or bump boards before measuring Cod (14 segments); avoiding and/or minimizing photography (13 segments); avoiding acute heat exposure (e.g., contact with hot surfaces; 10 segments), and using lip grip tools and/or handling gloves (9 segments) were raised somewhat frequently. In discussing their handling practices, one respondent (Male, 55–64, Advanced) noted, "As [more] anglers get excited over Cod, could there be more research [on] or development [of] Cod-friendly brag mats that have minimal or no impact on the fish? I do see mats that are rough or coarse material that I do feel impact the fish." Another angler (Male, 25–34, Committee) expressed interest in the need for better understanding how best to release a Murray Cod that "has been pulled from depth and suffered [some] degree of barotrauma [and] does not want to release back down to the depths. How to use a release weight on a stressed fish as this can happen to anyone no matter how experienced the angler is." Responses to the open-ended 'Other' option on the question about C&R impacts suggest that improper handling and/or lack of support, contact with dry and/or hot surfaces, improper release or 'revival' methods, lip grip tools, handling and/or photography time, and extreme weather and/or air temperature are of particular concern to anglers. Here, respondents had the opportunity to list a handling practice and offer a scaled response regarding its perceived impact (1 = Not at all, 5 = A great deal).

A lot: Improper holding and/or lack of support (8 segments), contact with dry surfaces (4 segments), extreme weather and/or air temperature (3 segments), using lip grip tools (3 segments), improper release or 'revival' method (3 segments), handling and/or photography time (1 reference)

A good amount: Improper holding and/or lack of support (4 segments), contact with dry and/or hot surfaces (4 segments), improper release or 'revival' method (4 segments), handling and/or photography time (1 reference)

A great deal: Improper holding and/or lack of support (11 segments), contact with dry and/or hot surfaces (6 segments), improper release

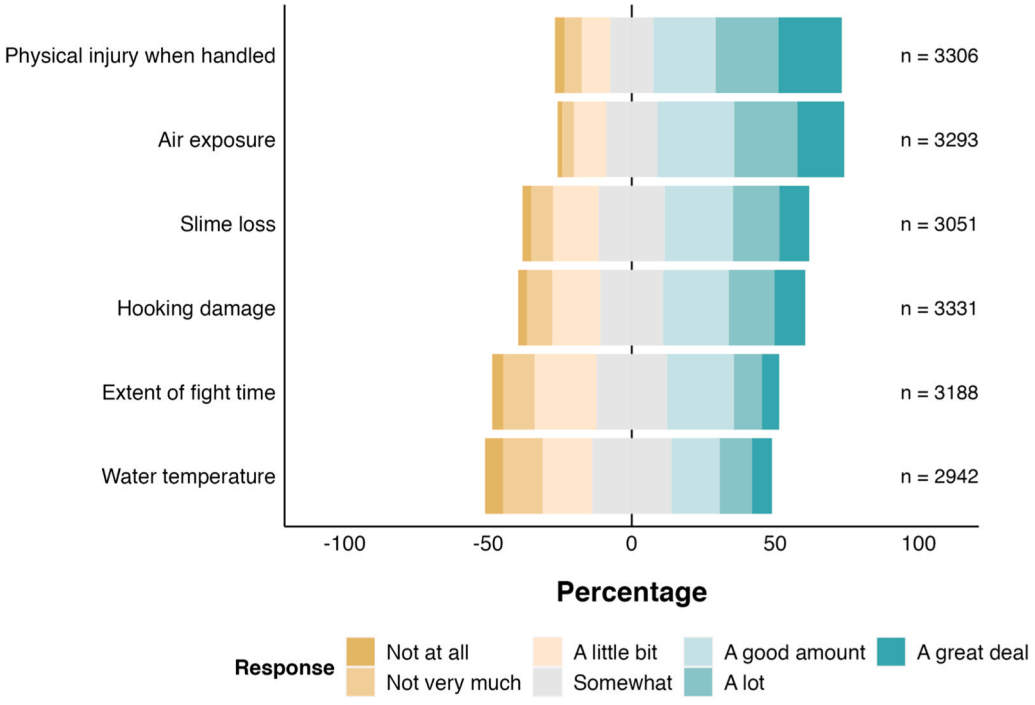

Fig. 4. Perceived impact of various factors on the fate of angled and released Murray Cod. The figure is centered at the middle response category 'somewhat' for better visual comparison of response distributions across items. Total n for each item appears on the far right.

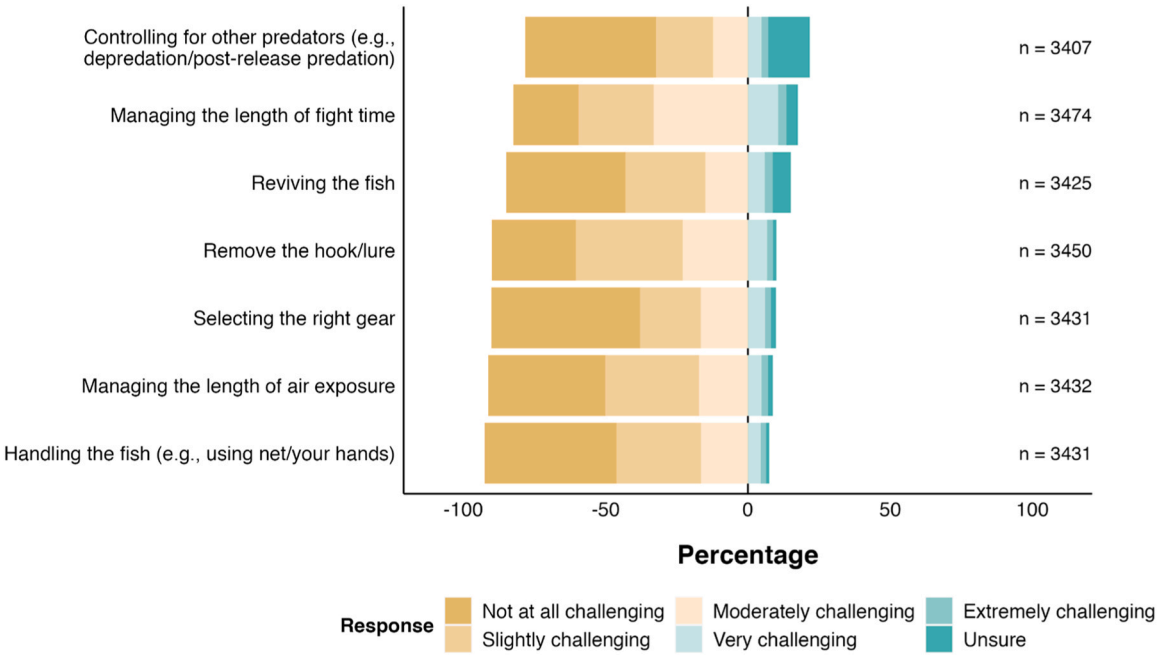

Fig. 5. Perceived challenges for implementing various catch-and-release practices when angling and releasing Murray Cod. The figure is centered at the middle of the six response categories for better visual comparison of response distributions across items.

or 'revival' method (5 segments), handling and/or photography time (3 segments), using lip grip tools (3 segments)

3.4. Potential for improvements to handling practices

In addition to reporting their perceptions of C&R handling practices, anglers reported whether or not they currently engage in various handling practices (Fig. 6), with 'release fish as quickly as possible' the most practiced action. Responses to these items were aggregated to create an overall index indicating the total number of practices they currently engage in (min = 0, max = 6, M = 3.27, SD = 1.54). Of the respondents who indicated that they wear gloves for holding fish, the majority (54.2%; n = 439) indicated that they, 'only wear a glove on my hand that is holding the mouth/lip of the fish', while 42.8% (n = 347) reported that they wear gloves on both hands and 3.0% (n = 24) reported not wearing gloves.

3.5. Angler awareness of the Care for Cod Campaign

Approximately equal numbers of respondents reported being aware of the Care for Cod campaign (49.2%, n = 1719) compared to not being aware (50.8%, n = 1777). Of the anglers who were aware of the campaign, the majority expressed that the 'campaign influenced me in some aspects' (31.2%, n = 539), whereas 30.9% (n = 533) noted that they were 'aware of [the] campaign, but already doing as recommended' and 21.0% (n = 362) indicated that the 'campaign influenced all

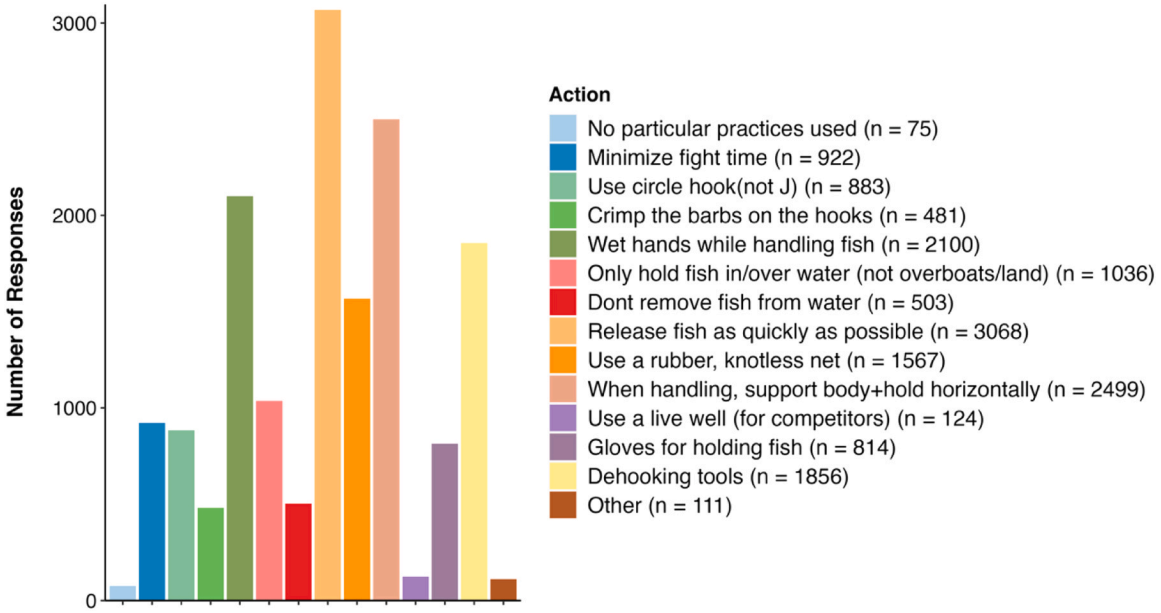

Fig. 6. Count data for the anglers engaging specific handling practices for Murray Cod.

practices.' Fewer respondents indicated that they were 'aware of campaign, but need more information' (9.6%, n = 166) or that the 'campaign has not influenced me' (7.2%, n = 125). Anglers mostly received information about the campaign via social media (n = 1049), followed by 'other anglers and/or guides' (n = 556), the VFA website (n = 548), promotional materials (n = 402), print media (n = 223) and videos (n = 223). When asked if they had shared information about the Care for Cod campaign with others, 82.2% (n = 1416) of anglers responded 'yes', while 17.8% (n = 307) said either 'no' or 'not sure'.

The vast majority of responses to the open-ended question about the Care for Cod Campaign question and/or references to Care for Cod, generally, involved the need for greater exposure and/or improved communications (n = 225). Many of these responses involved alternative modes of advertisement and/or channels of communication which, at least according to respondents, will intercept wide-ranging anglers (e.g., all ages, degrees of avidity) who may not actively search for or discover the campaign on their own. Social media exposure, use of license database info, youth and/or educational programs, and on-location signage were major talking points among respondents to this query (e.g., "Signs that show a clear picture of how to hold Cod and some handling practices, placed at boat ramps, weirs, entrances to national parks and state forests where fishing for Cod is common."; Male, 25–24, Advanced).

3.6. Impact of the Care for Cod Campaign

A binomial logistic regression was conducted to examine which anglers were more or less likely to be aware of the campaign based on several underlying demographic and angling attributes (i.e., focus, frequency, gender, age, gear type, angling location). The regression model (Hosmer-Lemshow test p = 0.700) revealed significant effects for angling focus, including 'committed' ($p < 0.001$) and 'advanced' ($p < 0.001$) anglers as well as gear type, specifically bait-based anglers, when compared to the respective reference levels for each categorical predictor (i.e., 'casual', 'lures'). Odds ratios indicated that the odds of being aware of the campaign were 5.313 times higher for 'committed' anglers and 2.077 times higher for 'advanced' anglers compared to 'casual' anglers. Furthermore, anglers who predominantly use bait were 0.690 times less likely to be aware of the campaign than anglers' who use lures. The complete output table of the binomial logistic regression model, as well as individual chi-squared goodness of fit tests examining the relationship between each predictor and the response variable (i.e., awareness of Care for Cod campaign), can be found in the Supplemental Materials.

Respondents who were aware of the campaign did not differ in terms of how important proper fish handling practices were for ensuring that released fish survive the C&R process compared to anglers unaware of the campaign (Mann Whitney *U* test: n = 3425, U = 1499441, p = 0.169). When evaluating the six-item cumulative index of best handling practices, a Welch's *t*-test revealed that participants who were aware of the campaign (M = 3.23, SD = 1.60) did not report engaging in significantly more or less handling and angling practices than those who were unaware of the campaign (M = 3.32, SD = 1.48; t (3451.8) = -1.87, p = 0.06). A significant relationship emerged between perceived need of improving handling practices and awareness of the Care for Cod campaign, $\chi 2$ (2, N = 3491) = 74.32, $p < 0.001$; Cramer's v = 0.146, 95% CI [0.125, 0.167]. An evaluation of standardized residuals revealed that the probability of perceiving that handling practices need to improve among anglers was higher for anglers who were aware of the campaign (0.6894) compared to those who were unaware (0.5701). Anglers who were unaware of the campaign had a higher probability (0.3076) of being indifferent about improving practices compared to those who were aware (0.1836). Similar probabilities for anglers aware (0.1270) and unaware (0.1222) were observed when suggesting no change was needed.

A one-way ANOVA revealed a significant effect of perceived impact of the Care for Cod campaign on the number of handling practices anglers currently engage in, F(4,1720) = 29.34, p = < 0.001 (See Fig. 7). Post-hoc Tukey HSD tests, with adjusted p values, revealed that anglers' who felt that the 'campaign influenced all practices' reported in engaging in significantly more practices than anglers who felt the 'campaign has not influenced me' ($p < 0.001$) and anglers who were 'aware of campaign, but need more information' ($p < 0.001$). Additionally, anglers who reported the 'campaign has not influenced me' engaged in significantly less handling practices compared to anglers who noted that 'campaign has influenced me in some aspects' ($p < 0.001$), 'aware of campaign, but already doing as recommended' ($p < 0.001$), and 'aware of campaign, but need more information' (p = 0.009). Anglers who were 'aware of the campaign but need more information' engaged in significantly less practices than anglers who reported that the 'campaign has influenced me in some aspects' ($p < 0.001$) and anglers who were 'aware of campaign, but already doing as recommended' (p = 0.015).

A Kruskal-Wallis test was used to assess the relationship between self-reported impact of the Care for Cod campaign and perceived importance of proper handling practices H (4) = 127.41, $p < 0.001$, $\varepsilon^2 = 0.074$ (Fig. 8). Post-hoc Dunn test revealed several differences between pairs of groups. Anglers who reported 'campaign influenced all aspects' perceived handling practices as significantly more important than anglers who were 'aware of campaign but need more information' ($p < 0.001$), 'campaign influenced me in some aspects' (p = 0.001), and 'campaign has not influenced me' ($p < 0.001$). Anglers who reported 'campaign has not influenced me' perceived handling practices as less important than those who reported 'campaign has influenced me in some aspects' ($p < 0.001$), 'aware of campaign, but need more information' (p = 0.019), and 'aware of campaign, but already doing as recommended' ($p < 0.001$). Additionally, anglers in the group 'aware of campaign, but already doing as recommended' reported greater importance of handling practices than anglers who indicated, 'campaign has influenced me in some aspects' ($p < 0.001$) and 'aware of campaign but need more information' ($p < 0.001$).

Responses to the question, "To what extent do you think each of the following factors impacts the fate of angled and released Murray Cod?' varied slightly between respondents aware and not aware of the care for Cod campaign. Detailed results of individual chi-squared tests and subsequent analyses of standardized residuals can be found in the Supplemental Materials. A binomial logistic regression was conducted to examine which anglers were more or less likely to communicate about the Care for Cod campaign based on several underlying demographic and angling attributes (i.e., angling focus, angling location, age, gear type, angling frequency, gender and perceived need of improving handling practices). The regression model (Hosmer-Lemeshow test p = 0.463 revealed significant effects for angling focus (i.e., committed, advanced), age (i.e., 25–34, 35–44, 45–54, 55–64) and angling frequency (i.e., more than 10 times per year) compared to the respective reference groups (i.e., casual, 18–24, once per year). Odds ratios indicated that the odds of sharing information about the campaign were 2.97 times higher for 'committed' anglers ($p < .001$) and 2.08 times higher for 'advanced' anglers (p = 0.001) compared to 'casual' anglers. Furthermore, anglers aged 55–64 were 2.586 times more likely (p = 0.001) to communicate about the Care for Cod campaign compared to anglers aged 18–24. Anglers aged 35–44 were 2.54 times more likely to communicate (p = 0.001), followed by anglers aged 25–34 (Odds ratio = 2.056, p = 0.008) and anglers aged 45–54 (Odds ratio: 1.959; p = 0.013). Anglers who fish more than 10 times per year were 1.98 times more likely (p = 0.005) to share information about the campaign than anglers who fish once per year. The complete output table of the binomial logistic regression model, as well as individual chi-squared goodness of fit tests examining the relationship between each predictor and the response variable (i.e., sharing information about the campaign), can be found in the Supplemental materials.

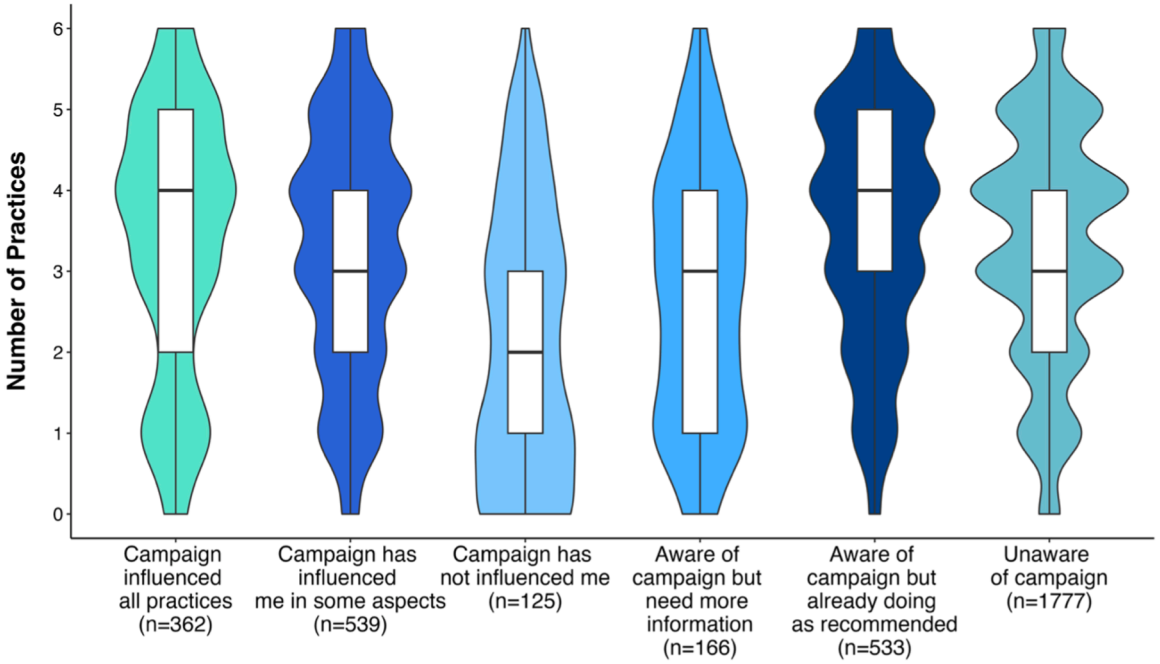

Fig. 7. Violin plot of the effects of perceived impact of the care for Cod campaign on number of handling practices currently engaged in by anglers, using the six-item cumulative index, including "minimize fight time", "wet your hands when handling fish", "only hold fish in or over the water (and not over land or boats)", "don't remove fish from water", "release fish as quickly as possible", and "when handling, support the body (including the belly), and keep fish held horizontally." Respondents who reported being unaware of the Care for Cod campaign are included for reference. Violin plots depict a boxplot within a rotated kernel density plot (Hintze and Nelson, 1998).

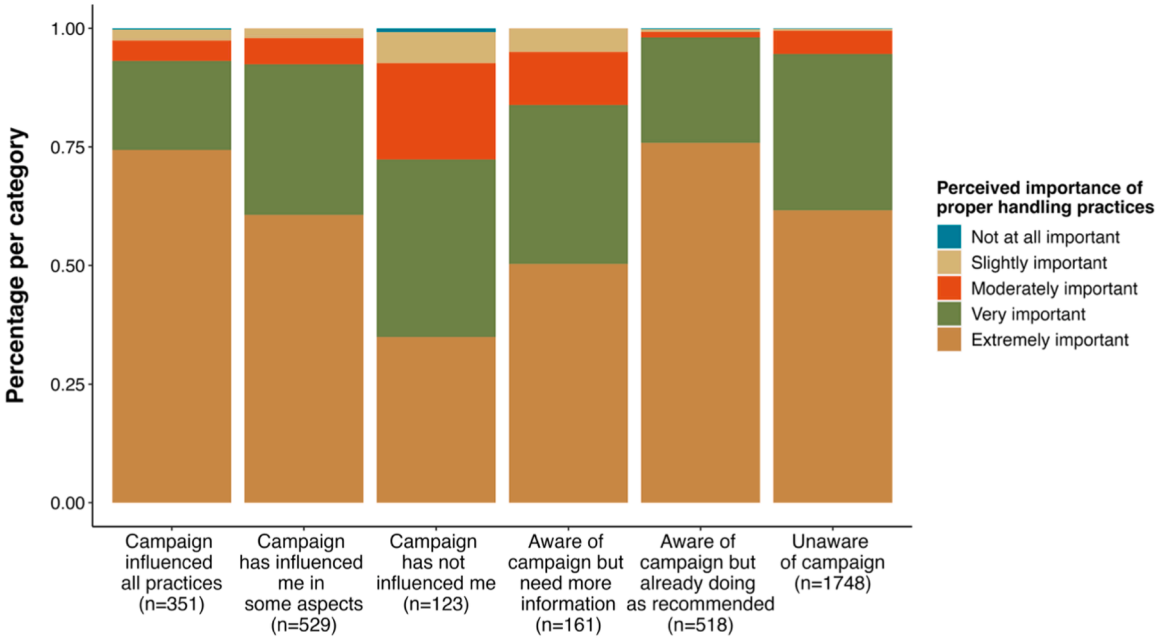

Fig. 8. Mosaic plot depicting distribution frequencies between perceived importance of proper handling practices and self-reported impact of the Care for Cod campaign; respondents indicating they were unaware of the Care for Cod campaign are included for reference.

3.7. Murray Cod population and fishery 'bright spots'

In addition to improvements in fishing quality, fish handling practices, and enthusiastic support for Murray Cod management and conservation, there are noteworthy 'bright spots' related to the Murray Cod angling experience, native species recovery, and even the relatedness of fishery health to human wellbeing:

"Fishing, for me, also generally involves a weekend away, so it's essentially a holiday." (Male, 25–34, Advanced)

"The environment that they occupy—the beauty of the fish and the ecosystem they require." (Male, 35–44, Advanced)

"To fish with my six-year-old son who is passionate about [this] particular fish." (Female, 25–34, Advanced)

> "Just being on [or] in the water, by myself, fishing for Cod is amazing for my mental health. I am lucky enough to be able to Squ

> walk out my back door and be in the gin clear water of the upper Ovens [River] fishing for Cod. Not many things are better. Upstream wading for trout, downstream paddling for Cod. I am blessed." (Male, 45–54, Advanced)

Most responses to the open-ended 'Other' option on the angling motives question involve non-catch-related (55 segments), as opposed to catch-related motives (36 segments): motivations related to general recreation and/or lifestyle (19 segments), experience of and/or immersion in nature (13 segments), mental health and/or general well-being (11 segments), and time with family and/or friends (9 segments) made up the bulk of these. The combined appreciation for native species, natural reproduction, pristine habitat, and watershed- and/or landscape-level management, as well as enthusiastic support for management, ready adoption of handling practices, and holistic (i.e., catch- and non-catch-related) enjoyment of fishing by Murray Cod anglers in our survey (see above and below) highlight bright spots amidst negative sentiments. Some additional, illustrative quotes help to paint this picture are:

> "Overall, the Murray Cod fishery has improved greatly [in] the last 10 years. Habitats, stocking, and better information on handling and release have greatly improved the sustainable Cod fishery." (Male, 45–54, Active)

> "… I just hope everyone treats them with [the] respect that they deserve." (Female, 25–34, Advanced)

4. Discussion

Understanding the perceptions anglers have about the status of recreational fisheries and contemporary management measures can help shape education and outreach strategies that influence social norms and compliance of regulations (Bova et al., 2017; Nguyen et al., 2013). Our survey of Murray Cod anglers, including their knowledge of the Care for Cod campaign, revealed sentiments that were aligned with the existing management measures (e.g., stocking, slot limit), while it also identified limitations between angler engagement and filling knowledge gaps. Specific to the Care for Cod campaign, our survey showed that those aware of the campaign felt that they benefited from the information it shares, however the fact that over half of the respondents were unaware of the campaign suggests that there is more work to be done specific to outreach efforts.

Angler satisfaction can be a driving and dominant force when it comes to acceptance of management measures and related compliance with regulations (Birdsong et al., 2021). Angler ratings of Murray Cod fishing appear to be increasingly positive over time from the 1970's until 2020-present, which is consistent with the recovery of stocks and the fishery in Victoria (Rowland, 2020; Qifeng et al., 2023; Bell et al., 2024; Ingram et al., 2024). The combination of over 15 million Murray Cod being stocked between 2012 and 2022 and the introduction of the 55–75 cm slot-limit for Murray Cod (implemented in 2014) is widely believed to have contributed to the continued recovery of the Murray Cod fishery (Hunt et al., 2016; Douglas et al., 2018). Indeed, respondents in our survey identified fish stocking and appropriate fishing regulations, including the slot limit, as important management interventions that are improving the Murray Cod fishery. Open-ended statement analysis revealed 'bright spots' for current management and a positive trajectory for habitat management, while also revealed sentiments of hope related to how improved education, outreach, and enforcement would be appreciated and accepted by Murray Cod anglers. The connection between improving angler satisfaction and the acceptance of conservation and management efforts should not be taken for granted, especially as new potential threats emerge (Beardmore et al., 2015; Birdsong et al., 2021; Casselberry et al., 2022).

Contemporary threats to recreational fisheries and how anglers perceive such threats are both fundamental for the development of effective stakeholder engagement campaigns (Danylchuk et al., 2018; Pita et al., 2025). For instance, respondents in our survey highlighted that blackwater events and invasive carp were viewed as the most pressing concerns. These perceptions likely reflect recent experiences, including large-scale blackwater events in 2011, 2016, and 2018 (Koehn, 2021) and again during when our survey was being administered in 2022/23. Similarly, widespread flooding in 2022 was followed by a rapid increase in carp numbers, reinforcing long-standing concerns about their ecological impacts. Carp have expanded greatly since the mid-1970s (Fanson et al., 2024; Schilling et al., 2024), prompting interest in control measures. Although Murray Cod populations have generally increased over the past two decades, potentially suppressing carp in localized areas (Rowland, 2005), carp remain a persistent threat to native fish communities, including to Murray Cod. Angler support for recent management proposals for the introduction of carp-specific biocontrol strategies, including viral agents, to mitigate their impact (Kopf et al., 2019) will greatly depend on the alignment between real and perceived threats. This is also the case for the emerging use of live sonar that could both be perceived as an opportunity for some recreational anglers while a threat to others (Cooke et al., 2025). The adoption of a new technology or technique for increasing angler success comes with the potential conflict among stakeholders that are opposed to its use as well as the implications that live sonar may have for management and related education and outreach (Cooke et al., 2021). Our survey revealed potential emerging tensions within the Murray Cod recreational fishery, strongly suggesting that the use of live sonar needs to be more actively addressed via engagement and outreach efforts before potential conflicts create cascading effects relating to regulatory compliance and stakeholder tensions (Cooke et al., 2025). None of the above topics were addressed in earlier surveys of Murray Cod anglers (Brown, 2011), highlighting a need to create mechanisms where anglers could share their perceptions and beliefs on a regular basis so that results can feed into education and outreach campaigns as part of adaptive management (Robinson et al., 2025).

Whether mandated or voluntary, C&R can be an effective management tool for recreational fisheries, however anglers need to be aware of science-based best practices and be willing to actively use behaviors that minimize the effects of capture and handling (Brownscombe et al., 2017). Our survey showed that the reported harvest rate for Murray Cod was low (an average of 4.79% were retained for harvest within the 55–75 cm slot limit), and compared to past surveys (Henry and Lyle 2000; Brown, 2011), C&R for Murray Cod has increased considerably over the past several decades (though see potential limitations below on potential survey recruitment biases). C&R and related best practices can certainly contribute to increased resiliency of fish populations of target species but only if adoption rates contribute to reduced mortality and sublethal effects post-release (Cooke et al., 2025; Dinkelacker et al., 2025). Respondents in our survey expressed an elevated understanding of the importance of employing proper handling practices to ensure the welfare of angled and released Murray Cod, while also conveying a high adoption rate of certain handling practices, such as releasing the fish as quickly as possible, supporting the body and holding horizontally, and using wet hands when handling fish. Respondents also viewed physical injury and the duration of air exposure as the most impactful aspects of the angling event influencing the fate of angled and released Murray Cod.

Although there is a growing body of C&R science that can broadly inform best practices (Brownscombe et al., 2017), species-specific responses to capture and handling can help make additional incremental changes to angler behaviour that increase fish survival and minimize sublethal effects (Cooke and Suski, 2005). As encounter and released rates potentially increase for target fish species, additional species-specific studies focused on the response to capture and handling

will be essential for reducing impacts and keeping education and outreach campaigns as contemporary as possible (Cooke and Suski, 2005, Cooke et al., 2025). Given that over 95% of Murray Cod are released following capture, even low mortality rate could translate into substantial cumulative losses, making C&R-associated mortality a potentially significant driver of fishing-induced mortality in some systems (Douglas et al., 2010). However, to date, there have only been two studies that have specifically assessed post-release mortality in Murray Cod (Douglas et al., 2010; Hall et al., 2012), limiting the potential to hone best practices and increase the effectiveness of C&R. Indeed, this may be especially important to examine since the use of live sonar in the Murray Cod fishery is increasing and is predominantly used by C&R-oriented anglers that target larger individuals in the population. The results of such science could feed into targeted education and outreach that focuses on more specialized segments of the Murray Cod angling community (Golden et al., 2019), increasing the overall positive outcomes of improved angler behaviour on individual fish and their populations (Cooke et al., 2025; Dinkelacker et al., 2025).

Understanding disconnects between angler awareness, social norms, and the use of science-based best practices for C&R can provide useful guideposts for outreach priorities (Danylchuk et al., 2018; Dinkelacker et al., 2025). For instance, although the Care for Cod campaign emphasizes minimizing air exposure and improving handling, the results from our survey showed that there was no difference in reported handling practices between anglers who were aware of the campaign and those who were not. Such outcomes could be the result of bias in our survey and it only reaching more conservation-minded anglers who were already inclined to use recommended handling techniques, or strong established social norms or peer influence may already be driving increases the broader adoption of best practices for handling Murray Cod. Despite a high level of self-reported engagement in current practices and elevated understanding of the impact of aspects of the angling among survey respondents, over 60% of respondents believed fish handling practices for Murray Cod generally need to be improved by anglers. Our results also revealed that respondents did not feel that actions to minimize handling effects were difficult to do, however they also did not prioritize them in comparison to other perceived threats. These results suggest that there may be a discrepancy between real and perceived norms within the angling community, but our study design does not allow us to discern from the survey whether and to what extent social misperceptions may exist (and relative to what specific practices). Since best practices for C&R angling are voluntarily practiced, peer-to-peer communication offers an important channel through which to spread social norms (Guckian et al., 2018). Fostering best practices as the social norm within the Murray Cod angling community is paramount, and anglers who were exposed to the Care for Cod Campaign reported sharing the campaign with others. Word of mouth was also indicated as the primary channel through which anglers reported receiving information about Murray Cod, and thus leveraging interpersonal communication among anglers may offer a potentially powerful pathway in supporting the widespread adoption of best practices.

5. Limitations

Non-probabilistic social surveys can provide insight on various aspects of recreational fishing (e.g., perceptions of recreational anglers targeting Murray Cod), but researchers and end-users must consider the limitations of non-probabilistic surveys when interpreting and using results. Above all else, non-probabilistic surveys have uncertain (and therefore limited) generalizability (Schillewaert et al., 1998; Brick, 2014; Cornesse et al., 2020). Because non-probability sampling does not provide each member of the target population with a known probability of selection, the demographic, behavioral, and other characteristics of respondents may differ from those of the broader angling population. Snowball sampling via social media, online portals, and angler social networks, as well as reaching out directly to fishing license holders could have biased our results toward individuals who are more engaged with the fishery or more connected to fisheries management (Johnston et al., 2010). Our sampling methods may have also biased our results toward more avid Murray cod anglers who are more likely to complete and distribute surveys related to the Murray cod fishery (Fisher, 1996; Ditton et al., 1992; Hutt and Bettoli, 2007). This means that our results may not be used to answer high-stakes questions or inform high-stakes decisions related to the Murray cod fishery. However, the perspectives of very avid and engaged recreational fishers can be very valuable (Hunt et al., 2010; Mcclellan Press et al., 2016; Lennox et al., 2022), and many important questions in the human dimensions of fisheries involve lower-stakes decisions and niche (as opposed to general) groups and phenomena (Howarth et al., 2024). Surveys like ours can inform these decisions, provide insight on these niche groups and phenomena, and provide various starting points for researchers and practitioners (e.g., preliminary answers to more general questions). In short, the validity and utility of non-probabilistic surveys depend on how results are used (see Fig. 1 in Howarth et al., 2024), and readers of this paper should use our results to better understand niche groups and phenomena, generate new research questions, inform low-stakes decisions, and preliminarily answer more general questions about the Murray cod fishery.

Despite their limitations, non-probabilistic surveys remain widely used in the human dimensions of recreational fisheries, particularly when the objective is to explore perceptions, identify emerging issues, or access a subpopulation with no sampling frame for various other reasons (Howarth et al., 2024). Even where researchers have access to a license database and data from a full-scale, probabilistic survey of recreational fishers in a jurisdiction, subgroups of recreational fishers (e.g., Murray cod anglers in Victoria) may still be undefined and impossible to sample with 'textbook' probabilistic methods. In these cases, non-probabilistic surveys can be implemented relatively quickly, reach geographically dispersed angling communities, and collect attitudinal information at lower costs than probability-based surveys that solely rely on license registries or extensive field sampling (Howarth et al., 2024). This approach may not generate high-confidence estimates and other population inferences, but it does provide working answers to some general questions (e.g., what portion of Murray cod anglers are aware of best practices for fish handling?) and more definitive answers to others (e.g., do any anglers use 'lip grip' tools to handle Murray cod?). Some of these answers are immediately actionable, and others tell researchers and practitioners what may be worth looking further into. A non-probabilistic approach such as the one we adopted can also provide exploratory insights that identify stakeholder priorities and inform the design of subsequent probability-based monitoring programs or targeted management engagement (Johnston et al., 2010; Fedler and Ditton, 1994). Despite their limitations, there is still much to glean from non-probabilistic surveys of recreational fishers—particularly in complex recreational fisheries with undefined, hard-to-reach, and yet socially and ecologically significant subgroups of fishers (e.g., Murray cod anglers in Victoria).

6. Conclusion

Our study provides important insights of perceived threats and status of Murray Cod, the understanding and use of best practices for C&R by anglers, and the reach of the Care for Cod campaign. Most respondents perceived that Murray Cod populations and fishing opportunities have improved in recent years, likely influenced by visible outcomes of long-term stocking programs and installment of a slot limit. While blackwater events and carp occurrence were perceived as greater threats to the fishery, long-term stressors such as climate change were viewed as less concerning. Respondents demonstrated strong baseline knowledge and widespread adoption of best practice C&R techniques, particularly identifying the importance of minimizing air exposure and physical injury. Reenforcing and amplifying this recognition via an evolution of

the Care for Cod campaign could alone lead to reduced post-release and greater resiliency of Murray Cod stocks. Nevertheless, if the Care for Cod campaign is to continue as a major angler engagement tool to foster conservation of Murray Cod, our results also highlighted a need for additional efforts to make the campaign more visible and accessible to anglers. Including a renewed emphasis on best handling practices as well as other conservation and management tools via the Care for Cod campaign could contribute to the further recovery of Murray Cod stocks and a broader awareness of emerging threats.

CRediT authorship contribution statement

Andrew Howarth: Writing – review & editing, Methodology, Formal analysis, Data curation. **Guckian Meaghan L:** Writing – review & editing, Writing – original draft, Visualization, Supervision, Methodology, Investigation, Formal analysis, Conceptualization. **Sascha Clark Danylchuk:** Writing – review & editing, Project administration, Methodology, Investigation, Conceptualization. **Cooke Steven J:** Writing – review & editing, Methodology, Investigation, Conceptualization. **Danylchuk Andy J:** Writing – review & editing, Writing – original draft, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization. **Taylor Hunt:** Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Funding acquisition, Data curation, Conceptualization. **Griffin Lucas P:** Writing – review & editing, Project administration, Methodology, Investigation, Formal analysis, Conceptualization.

Ethics Approval Statement

All methodologies were approved by the Antioch University New England Institutional Review Board, ensuring adherence to ethical standards and participant privacy.

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Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Andy J. Danylchuk reports travel was provided by Victorian Fisheries Authority. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.fishres.2026.107722.

Data availability

Data will be made available on request.

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