

Marine Ecosystems

Assessment of dolphin interactions, effectiveness of Code of Practice and fishing behaviour in the South Australian Sardine Fishery: 2021-22



Roger Kirkwood and Simon Goldsworthy

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PO Box 120 Henley Beach SA 5022**

November 2022

Report to PIRSA Fisheries and Aquaculture



**Government
of South Australia**
Department of Primary
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SOUTH AUSTRALIAN
RESEARCH AND
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EXECUTIVE SUMMARY

Interactions between the South Australian Sardine Fishery (SASF) and common dolphins during purse-seining have been assessed annually since 2004-05. This report documents the interactions in 2021-22; details patterns of observer coverage; compares observed and fisher reported rates of dolphin interactions and fishing behaviour; and assesses the effectiveness of the Code of Practice (CoP) at mitigating dolphin interactions.

In 2021-22, there were 988 net-sets with most activity in March to May (70% of net-sets) and most sets in Spencer Gulf (65%). Observers covered 11.3% of net-sets, in line with the 10% target. Coverage was distributed well across net-sets by month, vessels, and the Spencer Gulf (13% observed) and Outer (16%) fishing zones, but was low in Gulf St Vincent (4%).

In 2021-22, 109 dolphin encirclement events involving 396 dolphins and three dolphin mortality events involving five dolphins were recorded. Observed encirclement rates were comparable with rates when observers were not onboard, but the observed mortality rate of 3.6 dolphins per 100 net-sets was 36 times the unobserved rate (0.1 dolphins per 100 net-sets).

Fishing behaviour was different in the presence of an observer (more net-sets per night, more net-sets with zero sardine catch, and less tonnage caught per net-set). Individual vessel catch was between 23 and 66% lower if an observer was present.

Over the last 15+ years, consistent discrepancies in the observed and unobserved dolphin mortality rates and fishing behaviour suggests a significant observer effect, i.e., fishers fish differently when an observer is present. Although fishers apply the CoP effectively when observers are present, it is unclear how well the CoP is applied in the absence of observers.

To reduce uncertainty in dolphin mortality levels and to improve confidence that the fishery is taking adequate steps to minimise and mitigate interactions with dolphins, the use of alternative observing systems such as electronic monitoring could be considered.

Keywords: Purse-seine fishery, Observer, Logbook, *Sardinops sagax*, *Delphinus delphis*.

1. INTRODUCTION

1.1. Background

South Australian Sardine Fishery

The South Australian Sardine Fishery (SASF) is Australia's largest fishery in terms of tonnage landed. It is a purse-seine fishery that targets Australian sardines (*Sardinops sagax*) in waters off South Australia (SA), mostly in Spencer Gulf. A key feature of the fishery is that all net-sets (shots) are at night, when sardines school near the surface. Fishing seasons run from November to July, but are reported per financial year (July to June). Landings of sardines increased from 145 tonnes in 1991-92, to 12,156 tonnes in 2001-02, and peaked at 56,952 tonnes in 2004-05 (PIRSA 2014). Since then, catches have ranged from 20,000-40,000 tonnes per financial year (Grammer et al. 2021).

Common dolphins in South Australia

Common dolphins (*Delphinus delphis*) are widely distributed in tropical and temperate waters of the Atlantic, Pacific and Indian Oceans (Perrin 2017). In Australia, they occur in large gulfs and offshore waters, and are most abundant in southern Australia (Ross 2006). Genetic structuring is evident in south-eastern Australia with dolphins east of Bass Strait being distinct from those to the west (Bilgmann et al. 2008, 2014). There is some mixing of 'sub-populations', however, through long range movement of some groups (Bilgmann et al. 2014). Density estimates of common dolphins in South Australian waters have ranged between 0.5 – 0.7 per km² (Filby et al. 2010, Parra et al. 2021, Bilgmann et al. 2017, SARDI unpublished 2021 data). Total abundance estimates in 2011 across Spencer Gulf, Gulf St Vincent Gulf and associated shelf waters were, in summer/autumn, 21,733 (CV = 0.25; 95% CI = 13,809–34,203) and, in winter/spring, 26,504 (CV = 0.19; 95% CI = 19,488–36,046) (Parra et al. 2021).

Interactions

Interactions between common dolphins and the SASF occur when dolphins feeding on schools of sardines are approached by fishing vessels or are attracted to fishing activity due to the feeding opportunities it presents. Dolphins can be encircled or entangled in the nets, at times resulting in their injury or death (Hamer et al. 2008).

Data on dolphin interactions have been recorded in logbooks since January 1999. Up to 2003-04, about six encirclement events were recorded per year and a single dolphin mortality was recorded in April 2002 (Hamer et al. 2007).

During a South Australian Research and Development Institute (SARDI) observer program in 2004-05, an estimated 1,728 dolphins were encircled and 377 died (Hamer et al. 2008). This resulted in a 2-month closure of the fishery between fishing seasons while a Code of Practice (CoP) to minimise dolphin interactions was developed. In 2005-06, the CoP was implemented along with an observer program (which is reviewed periodically by a working group comprising members of South Australian Sardine Industry Association (SASIA), the SA Department of Primary Industries and Regions (PIRSA), and the SA Department for Environment and Water (DEW): Ward et al. 2018). In 2006-07, the observer program identified on-going high rates of dolphin interactions, and significantly lower rates (potential under-reporting) when observers were absent (Hamer and Ward 2007). The finding stimulated an increase in observer coverage from 10 to 30% for the next three fishing seasons to try to normalise data with and without observers (the achieved coverage was 20-25%). Normalisation was not achieved, however, in 2011-12, SASIA introduced 'real-time' reporting, by which fishers immediately notified the industry association executive officer and reported to other vessels when they had significant dolphin interactions (mortalities or multiple encirclements). Encirclement rates with and without observers present were normalised after this, but higher mortality rates continued to be recorded in the presence of observers.

Annual assessments of dolphin interactions, effectiveness of the CoP and fishing behaviour in the SASF have been undertaken since 2006-07 (Hamer et al. 2008, 2009; Ward et al. 2010, 2011, 2012, 2013, 2015a, b; Mackay and Goldsworthy 2016, 2017; Goldsworthy 2018; Goldsworthy et al. 2019; Kirkwood et al. 2020; and Kirkwood and Goldsworthy 2021). Higher mortality rates in the presence of observers and apparent differences in fisher behaviour with, versus without, observers have been reported in most years. In 2018-19, there was an unusually high level of mortalities recorded by observers and a larger than usual (>100 times) discrepancy between observed and unobserved rates of mortality (Goldsworthy et al. 2019). In response, a target of 20% observer coverage was set for 2019-20. Due to COVID-19 protocols restricting observer access to vessels, only 8% observer coverage was achieved, however, discrepancies returned to previously reported levels and in 2020-21, observer coverage returned to 10%.

In summary, dolphin encirclement rates with and without an observer have been similar since 'real-time' reporting was implemented in 2011-12, but in the absence of an observer, reported

mortality rates have usually been about 10 times lower. Differences in fishing behaviour when observers are absent (fewer net sets per night, fewer net sets with zero catch and more sardines caught per net-set) have also been recorded in most years, providing uncertainty about how well the observed data for the fishery reflects the unobserved data, and how well the CoP is applied in the absence of an observer.

1.2. Objectives

Assessment of the observer program, dolphin interaction rates, and compliance with the CoP are analysed by SARDI and reported annually (Hamer and Ward 2007; Hamer et al. 2008, 2009; Ward et al. 2010, 2011, 2012, 2013, 2015a, b; Mackay and Goldsworthy 2016, 2017, Goldsworthy 2018, Goldsworthy et al. 2019, Kirkwood et al. 2020, Kirkwood and Goldsworthy 2021).

Key objectives of this assessment are to collate and present 2021-22 data against data from previous years and:

- 1) Examine patterns of observer coverage against target levels,
- 2) Assess dolphin interaction rates (the frequency of delays in fishing due to dolphin presence, dolphin encirclements and mortalities),
- 3) Assess the effectiveness of the CoP at mitigating interactions, and
- 4) Assess dolphin interaction rates and fishing patterns with and without observers present.

2. METHODS

Three data sets for the 2021-22 financial year were collated, entered into spreadsheets, cross-checked for accuracy, then incorporated into a long-term data records for the fishery, including:

- 1) South Australian Sardine Fishery Research Logbook data (recorded by the commercial fisher) – logbook number, vessel, date, location, time of net-sets, and estimated catch.
- 2) SASF Observer Datasheets (recorded by an independent observer) – logbook number, date, net-set, weather conditions, timing, adherence to CoP, dolphin encirclement details (stage observed/released, release method, nature of interaction and dolphin condition), other wildlife (e.g., dolphins outside the net) and comments. Observer coverage was measured in ‘nights of fishing’ before 2012, and ‘net-sets’ thereafter.
- 3) Wildlife Interaction Forms (WIFs) (recorded by the commercial fisher) – logbook number, date, net-set, location, species (number, nature of interaction, status and fate), actions to release (if required), comments.

In this report, summaries are provided of data sourced from logbooks by financial year since 1998-99, observer programs since 2004-05 and WIFs since 2017-18. Where appropriate, data are summarised as means \pm SE.

In 2021-22, the observer program was operated by Seatec, Port Lincoln. Observer effort aimed for an even distribution across net-sets by month, vessels, and fishing areas. Three spatially discrete fishing areas were in place in 2021-22: Spencer Gulf, Gulf St Vincent and an Outside Zone (mainly west of Eyre Peninsula or east of Kangaroo Island (PIRSA 2020). Observers boarded a vessel mostly for single trips (usually one, but up to four nights). Prior to and during fishing operations (setting, pursing, hauling and pumping), observers monitored fishing activity from a high and unobstructed vantage point.

Data collected by observers included:

- 1) Data to assess application of the CoP, such as:
 - a. If search procedures were followed.
 - b. If delays in setting occurred when dolphins were sighted.
 - c. The steps taken if an encirclement occurred.
- 2) Information on dolphin interactions, such as:
 - a. The number of dolphins.
 - b. The stage of fishing that dolphin(s) were first observed.

- c. The number of individual dolphins caught.
- d. The release method.
- e. The success of the release method, and
- f. The release fate of dolphins (injuries and mortalities).

Wildlife Interaction Forms (WIFs) were introduced to meet state government obligations under the federal *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). All interactions with Threatened, Endangered and Protected Species (TEPS), including all marine mammals and Great White Sharks, are to be recorded on WIFs, and submitted to PIRSA. Reportable interactions with common dolphins include:

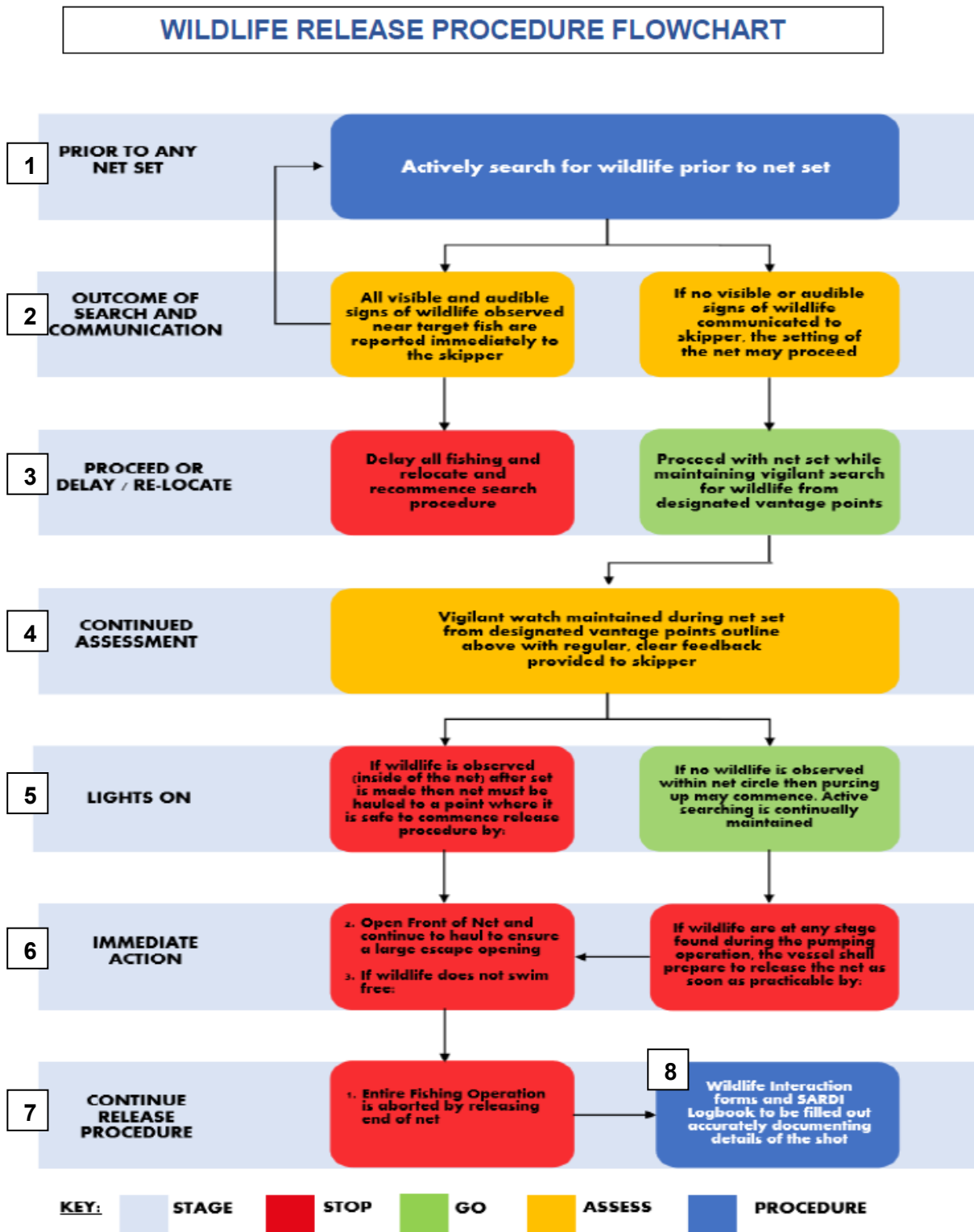
- 1) Dolphin sightings that delay net-sets,
- 2) Encirclements and mortalities.

Assessments of dolphin encirclement and mortality rates were based on observer records and WIFs. The assessment of the effectiveness of the CoP at mitigating dolphin interactions was based on observer records. An assessment of the effectiveness of the CoP when observers were not present was evaluated by comparing rates of dolphin interaction (observer records and WIFs) and fisher behaviour (logbook data – net sets per night, net-sets with zero catch, and mean catch of sardines per net-set) to those recorded in the observer program.

Code of Practice

Operational procedures outlined in the CoP include (see Figure 1):

- 1) Avoidance procedures:
 - a. Active searching for dolphins prior to setting the net.
 - b. Delaying and potentially relocating fishing operations if dolphins are sighted.
- 2) Release procedures:
 - a. Active searching for dolphins during pursing, hauling and pumping.
 - b. Taking immediate action to release encircled dolphins.



** This procedure is a requirement of the Code of Practice and must be displayed at all times in the wheelhouse and galley

Figure 1. Operational procedures to mitigate interactions with common dolphins in the South Australian Sardine Fishery (SASF) industry Code of Practice (CoP) (SASIA 2021).

3. RESULTS

3.1. Fishing effort

Logbooks recorded a total of 988 net sets for which catch was landed in the 2021-22 financial year (**Table 1**). Peak fishing effort was during March to May, with 70% of the annual net-sets in these months. Nets were set in Spencer Gulf (65%), Outside Zone (24%: 15% west of Eyre Peninsula, 9% south and east of Kangaroo Island) and in Gulf St Vincent (10%).

3.2. Observer coverage

Of 131 observer data sheets submitted during the 2021-22 financial year, 10 recorded no fishing (steaming or engine breakdown) and seven recorded searching but no net-sets due to bad weather (2), mechanical failure (1), or fish being 'not located, not schooling or too small' (4). This left 114 events when a fish school was located and setting the net was considered possible. On 96 (84%) occasions, no dolphins were sighted, and the net was set. On 18 occasions dolphins were sighted and net-setting was delayed. Twice, no set was made due to the on-going presence of dolphins (in one case fish were also not schooling). On the other 16 of 18 occasions when dolphins were sighted, net-sets were ultimately made – on one of these occasions, dolphins were encircled. Hence, a total of 112 (96 + 16) net-sets were witnessed by observers, 11.3% of the 988 nets set for the year (Table 1).

Observers recorded 11 encirclement events involving 36 dolphins. As noted above, one of these (involving two dolphins) followed a delay/relocation due to dolphin sightings.

Observer coverage was spread evenly across months and vessels (Figure 2). Coverage per vessel ranged from 10 to 15% of net-sets. A 12th vessel conducted just two net sets in the year, both in July 2021. Coverage by zone was 75 of 644 net-sets in Spencer Gulf (12%), 4 of 102 net-sets in Gulf St Vincent (4%) and of 33 of 242 net-sets in the Outside zone (14%). Within Spencer Gulf, there were differences between where net-sets were most frequent without (south-west gulf) observers onboard versus with observers (central gulf) (Figure 3). However, this difference was not apparent in the distribution of all unobserved and observed net-sets since 2005-06 (SARDI, unpublished data).

Table 1. Summary of fishing effort (net-sets), observer coverage, and dolphin encirclement and mortalities events recorded in the South Australian Sardine Fishery (SASF), by financial year between 1998-99 and 2021-22.

Financial year	Fishing effort (net-sets)					Encirclement events (no. dolphins)					Mortality events (no. dolphins)		
	Logbook total	With observer	W/out ob.	% observed	% target	Total	With obs.		W/out obs.	Total	With obs.		W/out obs.
1998-99	256		256			6	(13)		6 (13)	0	(0)		0 (0)
1999-00	411		411			0	(0)		0 (0)	0	(0)		0 (0)
2000-01	434		434			2	(9)		2 (9)	0	(0)		0 (0)
2001-02	639		639			12	(23)		12 (23)	1	(1)		1 (1)
2002-03	788		788			8	(17)		8 (17)	0	(0)		0 (0)
2003-04	960		960			7	(10)		7 (10)	0	(0)		0 (0)
2004-05	1248	49	1199	3.9	5	24	(128)		18 (87)	20 (41)	12 (19)	11 (19)	1 (1)
2005-06	1006	86	920	8.5	10	36	(70)		9 (20)	27 (50)	5 (6)	1 (1)	4 (5)
2006-07	954	82	872	8.6	10	47	(120)		14 (60)	33 (60)	5 (10)	4 (7)	1 (3)
2007-08	880	181	699	20.6	30	61	(159)		28 (85)	33 (74)	10 (15)	8 (11)	2 (4)
2008-09	932	224	708	24.0	30	63	(158)		21 (53)	42 (105)	3 (5)	3 (5)	0 (0)
2009-10	1097	267	830	24.3	30	67	(188)		29 (90)	38 (98)	5 (5)	2 (2)	3 (3)
2010-11	1015	91	924	9.0	10	41	(125)		11 (39)	30 (86)	7 (7)	2 (2)	5 (5)
2011-12	1108	73	1035	6.6	10	104	(304)		9 (36)	95 (268)	4 (5)	1 (1)	3 (4)
2012-13	861	81	780	9.4	10	99	(226)		9 (24)	90 (202)	4 (4)	1 (1)	3 (3)
2013-14	774	82	692	10.6	10	93	(240)		10 (35)	83 (205)	1 (1)	0 (0)	1 (1)
2014-15	847	88	759	10.4	10	70	(195)		6 (21)	64 (174)	3 (4)	1 (2)	2 (2)
2015-16	887	94	793	10.6	10	67	(195)		8 (31)	59 (164)	2 (2)	1 (1)	1 (1)
2016-17	975	117	858	12.0	10	59	(197)		8 (28)	51 (169)	1 (1)	1 (1)	0 (0)
2017-18	957	113	844	11.8	10	88	(335)		12 (50)	76 (285)	0 (0)	0 (0)	0 (0)
2018-19	961	119	842	12.4	10	92	(371)		16 (68)	76 (303)	5 (15)	4 (14)	1 (1)
2019-20	1051	84	967	8.0	20	122	(455)		8 (36)	114 (419)	4 (4)	1 (1)	3 (3)
2020-21	843	92	751	10.9	10	132	(424)		19 (66)	113 (358)	5 (5)	3 (3)	2 (2)
2021-22	988	112	876	11.3	10	109	(396)		11 (36)	98 (360)	3 (5)	2 (4)	1 (1)

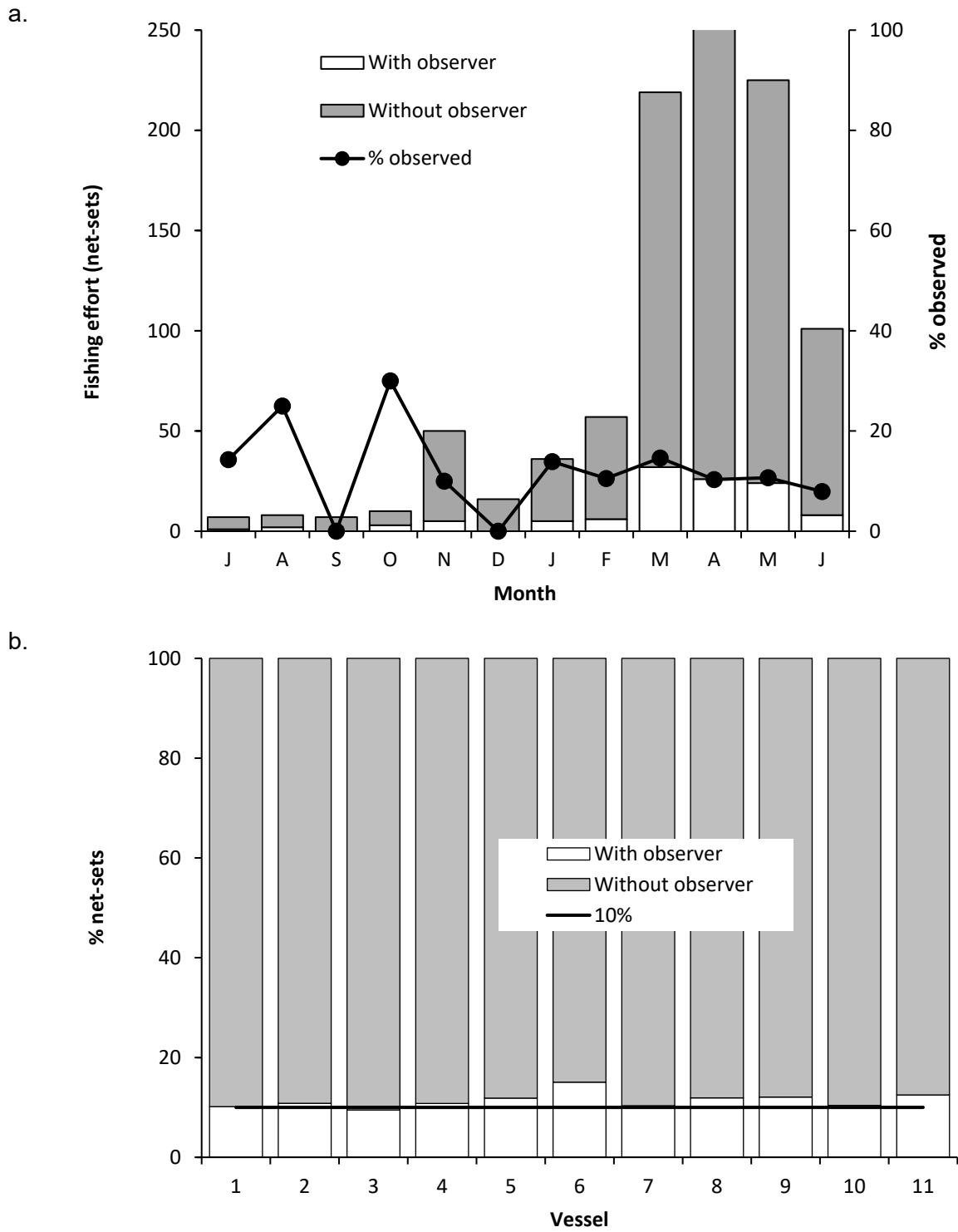


Figure 2. Observer coverage in 2021-22 by **a)** month & **b)** vessel (numbers assigned randomly).

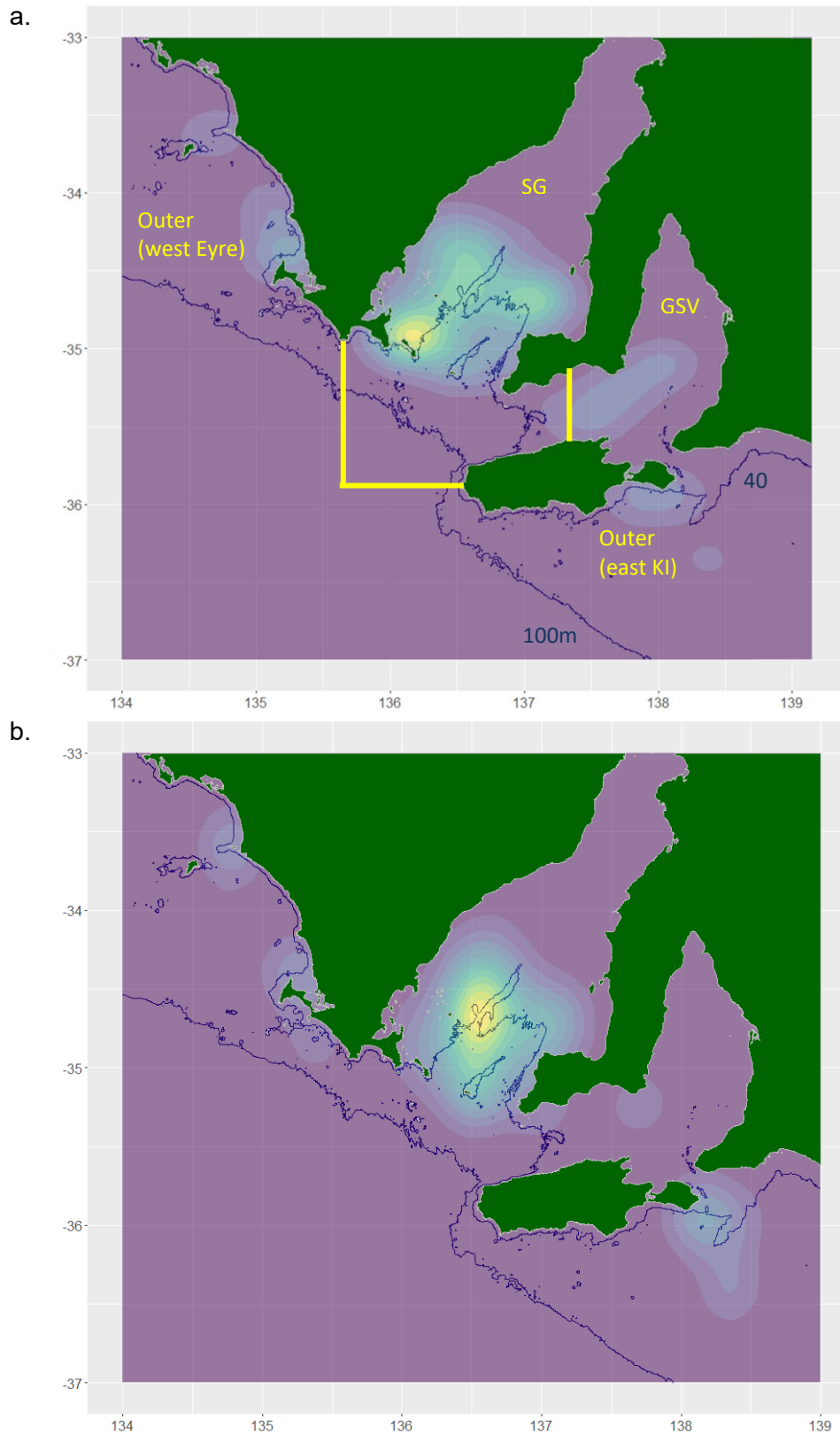


Figure 3. Kernel density plots indicating the distribution of **a)** net-sets without observers ($n = 876$) with fishing zones indicated and **b)** net-sets with observers ($n = 112$), in 2021-22.

3.3. Wildlife interaction forms (WIFs)

Wildlife Interaction Forms (WIFs) were submitted by fishers for 150 TEPS interactions, 18 with an observer, 132 without. Of those without an observer, 126 reported interactions (representing 14% of the 876 net sets without observers present) were with common dolphins. Dolphin encirclements accounted for 98 WIFs (involving 360 dolphins, one entanglement outside the net is included here; Table 1), 54 when no delay/relocation had been needed, 43 following delay/ relocations due to prior dolphin sightings and one WIF sighting dolphins outside the net during pumping. Delay/relocations with no encirclement were reported in 28 WIFs. Net-sets were possible following 26 of these, but on two occasions, continued dolphin presence prevented any shot being made.

Seven WIFs reported interactions with TEPS other than common dolphins: one an encirclement of a southern right whale *Eubalaena australis* (released unharmed), two interactions with Australian sea lions *Neophoca cinerea* (both jumped over the cork line before pumping began), and four great white shark *Carcharodon carcharias* interactions (one died, three were released alive). One of the great white sharks was encircled with six common dolphins, all were released alive.

The 18 WIFs submitted when observers were present were compared with observer data:

- 1) on 14 occasions (six delay only, nine encirclements) the data recorded were identical,
- 2) on two occasions, a delay/relocation prior to setting was reported by the fisher but not by the observer,
- 3) on one occasion, both the WIF and Observer data indicated four consecutive delay/relocations, after which the fisher reported that no set was possible due to the presence of dolphins, whereas the observer reported the shot was made (20 t caught).
- 4) on one occasion there was a mortality event: the fisher (WIF) recorded six dolphins in the net, one became entangled and died, the other five were released; whereas the observer reported 6-8 or more dolphins encircled (taken as eight in the database), five became entangled, three of which died, with the remaining five dolphins released alive.

Fishers submitted WIFs on all nine occasions when observers reported encirclements, but a WIF was not submitted on one occasion when an observer reported a juvenile dolphin became entangled under the net and was able to free itself. WIFs were submitted on seven of 17 occasions (41%) when observers reported delays due to dolphin sightings that did not result in encirclements.

3.4. Dolphin interaction rates

Encirclements

Of 114 observed net-set approaches in 2021-22, 103 (90%, 86 without a delay/relocation and 17 following at least one delay/relocation) did not result in dolphin encirclements. This is in line with the average since 2005-06 ($90 \pm 3.5\%$, $n = 16$ years). On 10 occasions when there was no prior dolphin sighting and once following a delay/relocation, dolphins were encircled (Table 2).

Of 876 unobserved net-sets reported in WIFs, 778 (89%) did not result in a dolphin encirclement and 98 (11%) did.

Estimated encirclements per 100 net-sets were 10 events with 32 dolphins, based on observer data, and 11 events with 41 dolphins, based on WIF data when no observer was present (Figure 4). The discrepancies between rates with and without an observer were 0.9 for events and 0.8 for dolphins encircled (Figure 4). Since 2011-12, when real time reporting commenced, the mean discrepancies between encirclement rates with and without an observer have averaged 1.1 for events and 1.4 for the number of dolphins.

The estimated total numbers of encirclement events and dolphins encircled in 2021-22 were 97 and 318, respectively, from observer data, and 111 and 406, respectively, from WIF data (Figure 5).

Mortalities

In 2021-22, three dolphin mortality events (two with an observer present) were recorded and comprised five mortalities (Table 3). Two events were single dolphins, one entangled on the outside of a purse-seine net (observer present) and one not sighted until at the end of pumping (no observer present). The third (observer onboard) involved the encirclement of eight dolphins, five became entangled and three died. Thus, the observed rates of mortality events and dolphin mortalities (1.3 events and 3.6 dolphins per 100 net-sets) was >10 times and >30 times higher, respectively, than the unobserved rates (0.1 events and 0.1 dolphins per 100 net-sets; Figure 6).

The estimated total mortality events and number of dolphin mortalities based on the observed rate in 2021-22 was 18 and 35, respectively. Based on the unobserved rates, there was one mortality event involving one dolphin (Figure 7).

Table 2. The number of net-set approaches viewed by observers, the number and % delayed/relocated (D/R) due to sighting a dolphin, D/R 'success' rate (% D/Rs with no dolphins encircled/entangled), and Net-set 'success' (% net-set approaches with no dolphins encircled/entangled).

Financial year	Observed net-set approaches	Dolphin instigated delay/relocate (D/R)	%	D/R "Success" % D/Rs with no dolphins encircled/entangled	Net-set "Success" % Net-set with no dolphins encircled/entangled
2005-06	89	6	6	100	90
2006-07	82	7	8	71	85
2007-08	189	34	15	71	91
2008-09	233	31	12	87	93
2009-10	265	34	11	79	93
2010-11	91	2	2	50	89
2011-12	73	1	1	100	88
2012-13	84	4	5	50	91
2013-14	81	15	16	67	94
2014-15	93	13	12	85	93
2015-16	95	5	5	92	91
2016-17	116	17	13	88	93
2017-18	113	11	9	55	93
2018-19	119	24	17	83	93
2019-20	87	23	26	80	87
2020-21	94	21	22	90	80
2021-22	114	18	16	94	90

Table 3. Details of dolphin mortality events in 2021-22.

Date	Time	Observer present	After delay	Stage observed	Dolphins encircled	Mortalities	Entangled	Comment
21-Feb	0:51	yes	no	hauling	8	3	yes	*
14-Apr	21:40	no	yes	hauling	1	1	no	in bag with fish
25-Apr	3:52	yes	no	hauling	0	1	yes	entangled outside

*Observer data are presented here. WIF had 5 encircled and 1 mortality (entangled on outside).

Since 2007-08, observed rates of dolphin mortality have been higher than those reported in logbooks/WIFs when observers were not present, in all but two years, 2013-14 and 2017-18 – in both years no mortalities were recorded by observers.

Since 2010-11, an average of 96 net-sets have been observed each year and observers recorded 1.4 mortality events (2.5 dolphin mortalities) per 100 net-sets. The low frequency of observed mortality events and low annual observer coverage (10% in most years) hampers interpretations of trends from year to year. To investigate change over time, observations were summed over 5-year intervals and plotted using a running mean (Figure 8, data in Appendix 1). Accordingly, it was apparent that up to 2017-18, with and without observers, mortality rates were declining. In 2018-19, an unusually high mortality rate was recorded by observers: four events and 14 dolphin mortalities, which was comparable to the combined total of the previous 10 years (Goldsworthy et al. 2019). Inclusion of the 2018-19 data would therefore mask other trends, so for the purposes of the 5-yearly averages, the year was treated as an outlier and not included. Even excluding this year, however, between 2019-20 and 2021-22 rates of dolphin mortality have increased.

The on-going discrepancy between observed and unobserved dolphin mortality rates is evident in the 5-year running mean of net sets per dolphin mortality (Figure 8). Between 2005-06 and 2013-14, in observed data, there were less than 100 net-sets per dolphin mortality, whereas in logbook/WIF data when observers were not present, there were >200 net-sets per dolphin mortality. Thereafter, while observed rates remained around 100 net-sets per mortality, unobserved rates rose to 987 net-sets per mortality in 2017-18, before reducing to 573 net-sets per mortality in 2021-22.

Mortality events by vessel were investigated since 2017-18, when WIFs were introduced (i.e., the last five seasons). Of 12 vessels that operated in the fishery, four recorded mortality events when observers were not present (one to four events per vessel, all single dolphins), four recorded mortalities only when observers were present (one to four events per vessel, one to six mortalities per event), and four have not recorded any mortality events.

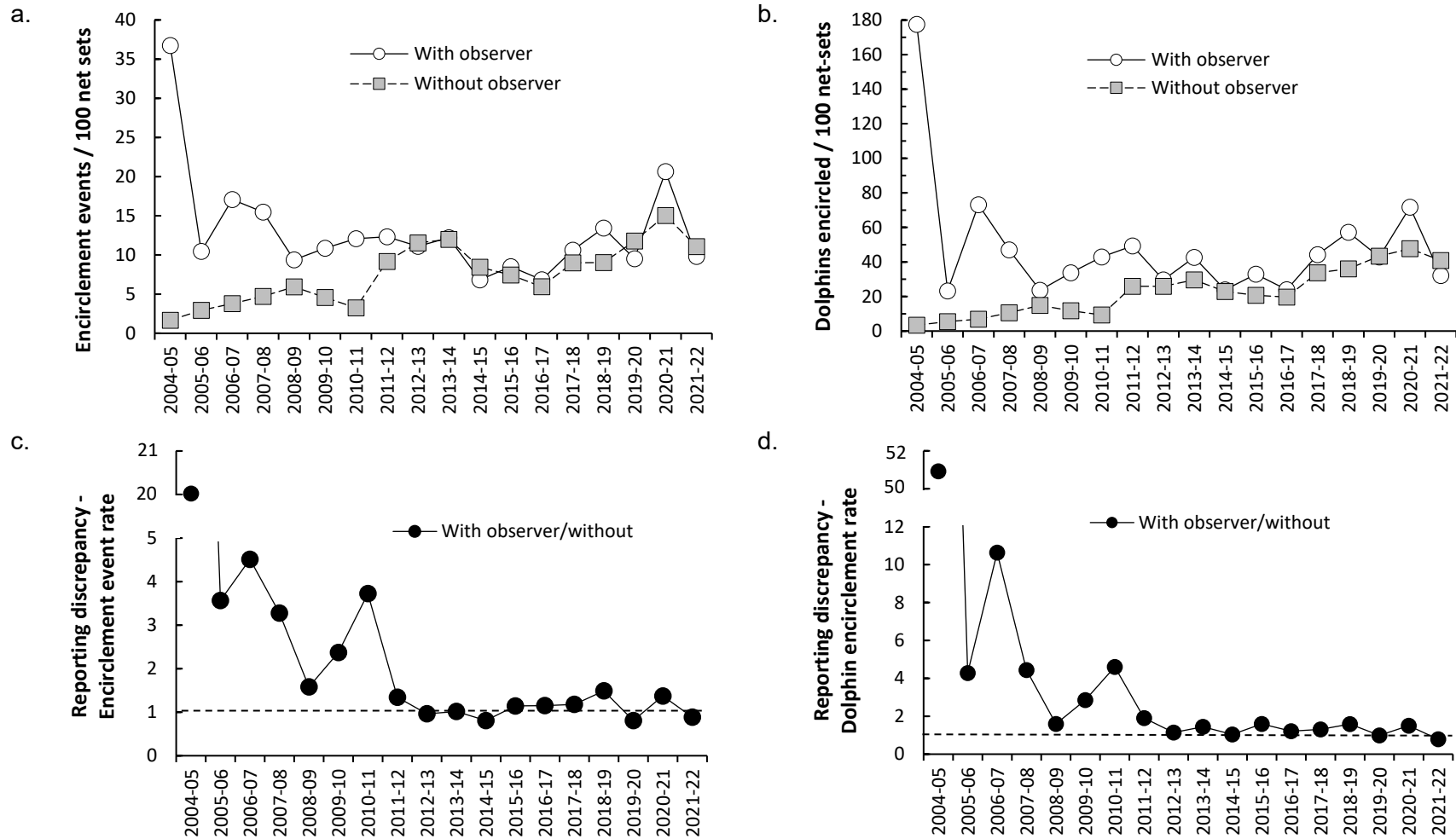


Figure 4. Dolphin encirclements per 100 net-sets since 2004-05 – **a)** encirclement events and **b)** dolphins encircled, comparing rates with and without an observer, and reporting rate discrepancies (with observer/without observer) for **c)** encirclement events and **d)** dolphins encircled. In the discrepancy graphs, the dashed line at one indicates no reporting discrepancy. Note y-axis scales break to include high discrepancies in 2004-05.

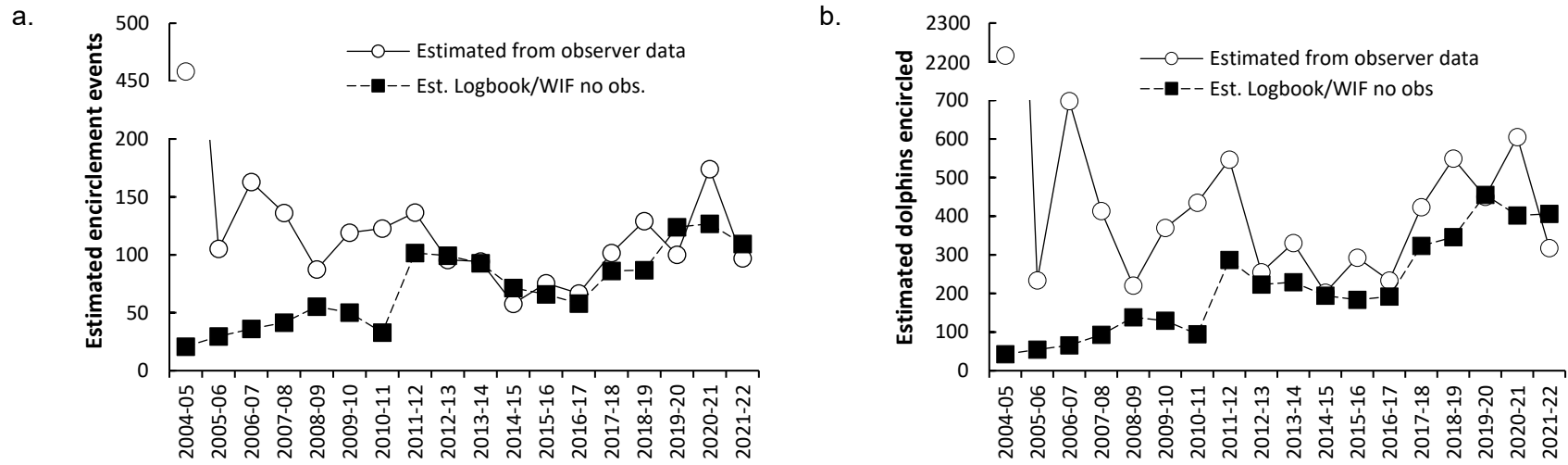


Figure 5. Estimated dolphin encirclements per year since 2004-05 – **a)** events and **b)** dolphins encircled, comparing observer data with data when observers were not present, recorded in logbooks (before 2017-18) and by Wildlife Interaction Forms (since 2017-18).

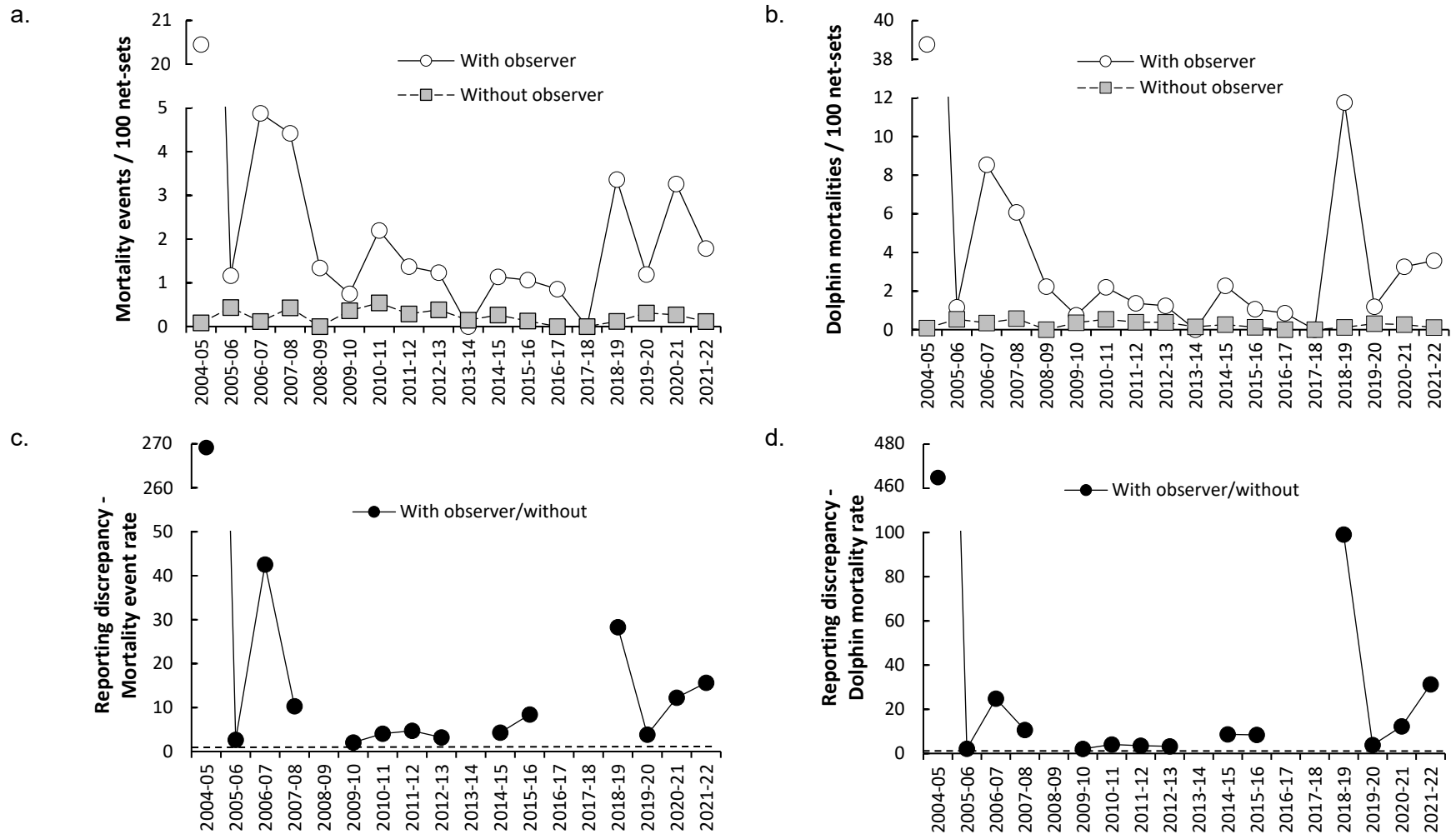


Figure 6. Dolphin mortalities per 100 net-sets since 2004-05 – **a)** mortality events and **b)** dolphin mortalities, comparing rates with and without an observer, and reporting rate discrepancies (with observer/without observer) for **c)** mortality events and **d)** dolphin mortalities. In the discrepancy graphs, the dashed line at one indicates no reporting discrepancy. Note y-axis scales break to include high discrepancies in 2004-05.

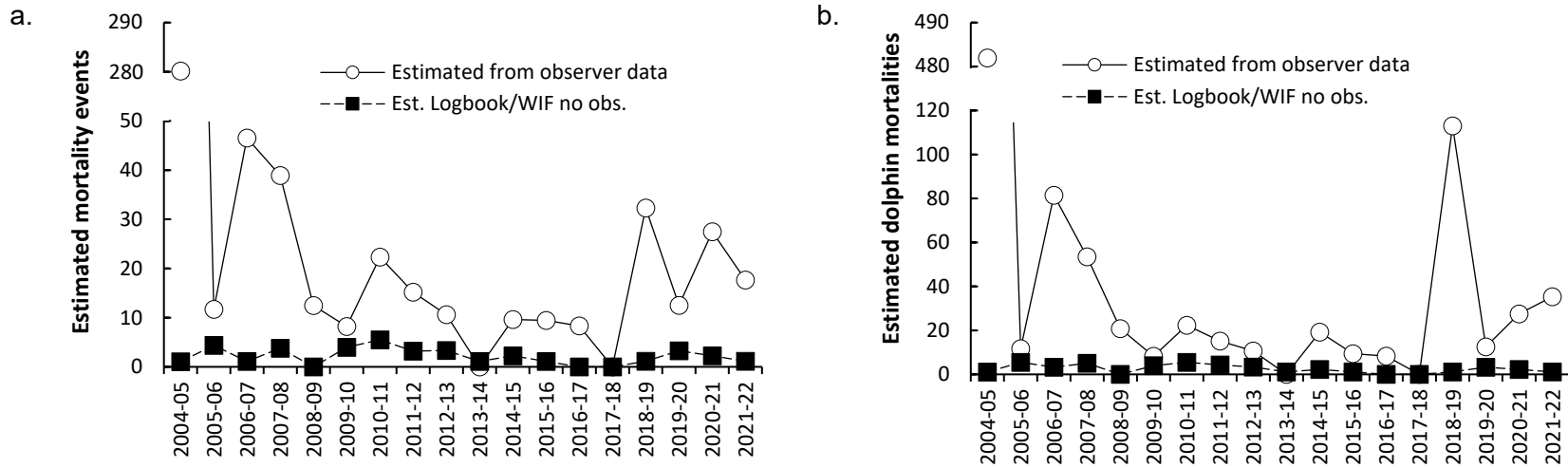


Figure 7. Estimated dolphin mortalities per year since 2004-05 – **a)** events and **b)** dolphin mortalities, comparing observer data with data when observers were not present, recorded in logbooks (before 2017-18) and by Wildlife Interaction Forms (since 2017-18).

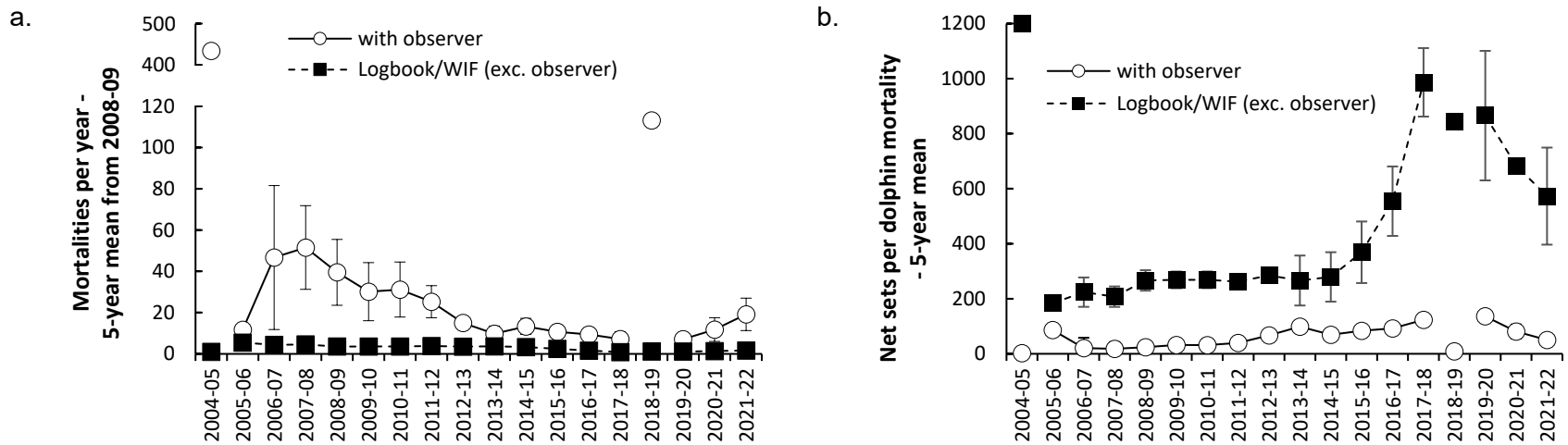


Figure 8. 5-year running mean estimates of dolphin mortalities per year since 2004-05 – **a)** mortalities and **b)** net-sets per mortality, comparing observer data with logbook/WIF data when observers were not onboard (data in Appendix 1). 2018-19 is considered an outlier for this analysis and is not included in the 5-year means.

3.5. Code of Practice assessment

The CoP was deemed to have been followed when observers were present (Appendix 2):

- 1) A search for dolphins prior to net-setting was always conducted,
- 2) Crew always immediately and clearly communicated dolphin sightings to the skipper,
- 3) If dolphins were sighted prior to setting the net, the set was always delayed/ relocated,
- 4) If dolphins were sighted encircled or entangled, the response to release them was always immediate (acknowledging that a delay of minutes could be needed to complete a procedure before the front of the net could be released), and
- 5) Release procedures were always in accordance with the CoP i.e., crew released the front of the net and aborted the set.

WIFs submitted when observers were not onboard document comparable rates of dolphin encirclement to observer reports, but fewer dolphin entanglements, injuries, and mortalities.

A comparison between observer reports and WIFs submitted when observers were onboard demonstrated there was good adherence to the CoP in all steps, except that WIFs were not routinely submitted for delay/relocations when there was no subsequent encirclement/ entanglement. No WIF was submitted on 10 of 17 occasions when an observer recorded a delay/relocation due to a dolphin sighting and dolphins were not encircled/entangled.

3.6. Fishing behaviour

In 2021-22, when an observer was present there were on average:

- 1) More net-sets per night (1.9 with an observer, 1.5 without; Table 4, Figure 9a).
- 2) More net-sets with zero sardine catch (23% with an observer, 13% without; Figure 9b).
- 3) Less tonnage caught per net-set (26 t with an observer, 46 t without; Figure 9c).
- 4) Excluding net-sets with zero catch, still less tonnage of sardines caught per net-set (34 t with an observer, 53 t without; Table 4, Figure 9d). By individual vessel, the mean sardine catch was between 23 and 66% lower if an observer was present.

Table 4. Comparisons with and without an observer in the mean number of sardine net-sets per night, mean sardine catch in tonnes per net-set (excluding sets with no catch) and the percentage difference in the means (% with/without observer) by financial year between 2007-08 and 2021-22. Mann-Whitney U-tests compare the rates with and without an observer, in bold indicates a significant difference.

Financial year	Average net-sets per night					Average catch per net-set (t) – excludes zero catch sets				
	With observer	Without observer	% Difference	Mann-Whitney U-test		With observer	Without observer	% Difference	Mann-Whitney U-test	
				U	<i>p</i>				U	<i>p</i>
2007-08	1.5	1.3	110	29397	0.02	40	36	111	39258	0.22
2008-09	1.6	1.4	114	33320	0.07	25	34	73	73617	<0.01
2009-10	1.6	1.4	119	45626	<0.01	34	35	97	79560	0.30
2010-11	1.5	1.5	98	20971	0.78	33	34	96	30174	0.95
2011-12	1.3	1.6	83	22667	<0.01	40	38	107	26215	0.80
2012-13	1.8	1.4	128	9842	<0.01	38	45	83	25101	0.07
2013-14	1.6	1.3	126	10404	<0.01	39	48	82	22896	0.06
2014-15	1.5	1.4	109	16923	0.49	38	48	75	28205	<0.01
2015-16	1.6	1.4	112	15014	0.09	42	48	87	31036	0.18
2016-17	1.8	1.6	116	16206	0.16	40	47	84	38119	0.01
2017-18	1.8	1.5	123	14682	0.01	36	50	73	43353	<0.01
2018-19	1.5	1.5	100	21568	0.79	40	46	87	38277	0.09
2019-20	1.6	1.6	100	15427	0.81	33	43	77	32371	<0.01
2020-21	1.6	1.4	109	14714	0.47	40	52	76	26445	0.01
2021-22	1.9	1.5	129	11314	<0.01	34	53	65	43590	<0.01

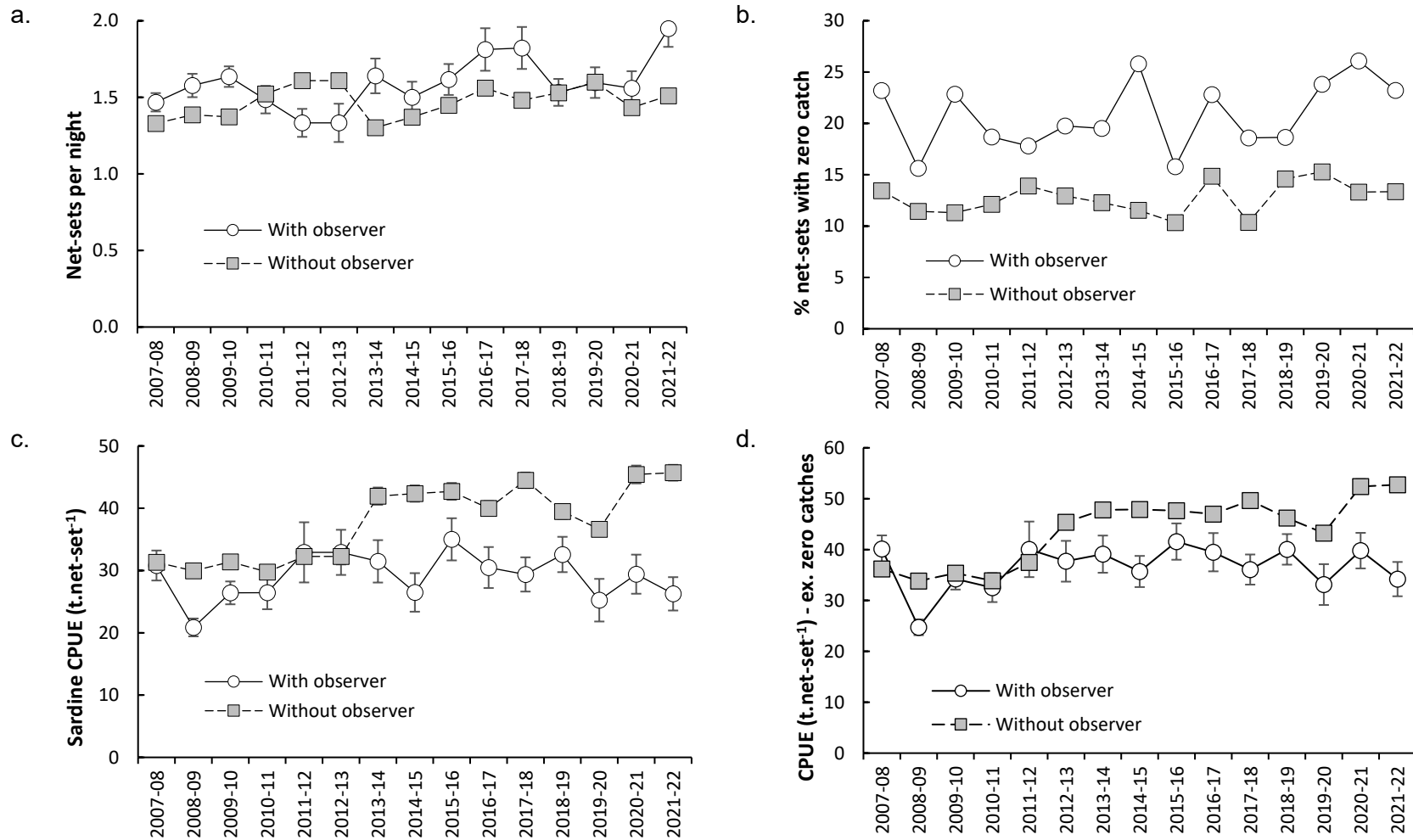


Figure 9. Fisher behaviour with and without an observer: comparison by financial year of **a)** net-sets per night, **b)** percentage net-sets with zero catch, and sardine CPUE (tonnes per net-set) by financial year **c)** including zero-catch net-sets, and **d)** excluding zero-catch net-sets.

4. DISCUSSION

4.1. Observer coverage

The targeted observer coverage of 10% of net-sets for the 2020-21 financial year was achieved. Coverage was well distributed across months and vessels. There was good coverage of net-sets in Spencer Gulf (12%) and the Outside zone (14%), but low coverage in Gulf St Vincent (4% of net-sets). When observers board a vessel, they will not know where fishing is going to take place, so the low coverage by them in Gulf St Vincent is unlikely to be related to the how observers distribute effort. Potential reasons for the low coverage in Gulf St Vincent Gulf are unknown. Future effort should attempt to increase coverage in this area.

Within Spencer Gulf, observers were most frequently onboard for net-sets in the central gulf, whereas net-sets when observers were not on board were most frequent in the south-east of the Gulf. The pattern was not apparent in an investigation of the distribution of observed and unobserved net-sets since 2005-06 (SARDI, unpublished data).

4.2. Dolphin interactions

The 109 encirclement events and 396 dolphins encircled in 2021-22 were comparable to totals recorded in recent years and suggest there is a dolphin encirclement event approximately every 10 net-sets. The three mortality events and five dolphin mortalities were also comparable to totals recorded in recent years and suggest a dolphin mortality rate of one to two every 100 net-sets.

An aerial survey in 2011 estimated approximately 22,000 common dolphins were present in summer/autumn in Spencer Gulf, Gulf St Vincent and the Investigator Strait (Parra et al. 2021). Using 'Potential Biological Removal' (PBR) analysis, and assuming a conservative maximum population growth rate of $R_{max} = 0.02$ and a recovery factor of $F_r = 0.5$ for a species of unknown conservation status, Parra et al. (2021, 2022) estimated that the loss of between 95 to 120 dolphins per year through human interactions could have an impact on the population's sustainability. Observer data indicate this level of bycatch has only been exceeded by the SASF in two years, 2004-05 (>400; Hamer et al. 2008) and 2018-19 (113; Goldsworthy et al. 2020). Based on PBR assumptions and the average annual mortality rate since 2005-06, from observer records, of 26 ± 7 dolphins per year, the SASF is currently unlikely to be having a population-level impact on common dolphin survival in South Australia.

There are several caveats to this conclusion. Firstly, the rates do not include dolphin mortalities resulting from injury or stress that may be caused by encirclement, entanglement or separation. These are difficult to assess, particularly as the fishery occurs at night. Secondly, observed rates of mortality are unlikely to reflect overall rates. This is discussed in the following section – Code of Practice Assessment. Thirdly, the estimate of dolphin abundance was based on surveys in 2011. Dolphin abundance in the Gulfs may change seasonally and over time (Parra et al., 2021), and a better idea of total numbers will be derived from future surveys. Data currently being collected as part of an FRDC Project (2019-063 – *Assessment of the sustainability of common dolphin interactions with the South Australian Sardine Fishery*) will further assist interpretation of the potential biological consequences of dolphin interactions in the SASF. This research includes a survey of common dolphin abundance and distribution in Spencer Gulf in 2021, and a population model based on demographic for the species in South Australia, based on age structure of stranded/ dead dolphins collected and stored in the South Australian Museum.

4.3. Code of Practice assessment

In 2021-22, observers reported that in their presence, fishers routinely followed the CoP by checking for dolphins prior to setting the net and throughout fishing operations, delaying and possibly relocating if dolphins were sighted prior to net-sets, immediately reacting to abort net-sets if dolphins were sighted encircled or entangled, and released dolphins by aborting the set and opening the front of the net.

One shortcoming was that WIFs were not routinely submitted when there were delay/relocations due to the presence of dolphins. In 2021-22, WIFs were submitted for 41% of observed delay/relocations (when there was no encirclement). Previously, WIFs were submitted on 5% of occasions in 2017-18, 42% in 2018-19, 63% in 2019-21, and 91% in 2020-21, indicating a trend for increased observance of this component of the CoP. The drop in reporting of delay/relocations in 2021-22 meant WIFs could not be relied on to record the frequency of delay/relocations in the absence of an observer.

Assessment of the application and success of the CoP when observers were absent was based on WIF and logbook records, compared to those of observers. Although encirclement rates reported by observers and by fishers (when observers were absent) have been similar since 2011-12, fisher reported mortality rates (when observers were absent) have been generally lower than observed rates in most years since 2004-5. In 2021-22, two mortality events occurred in 114

observed net sets and one in 876 unobserved net-sets. Therefore, recorded mortality events were >10 times more frequent when an observer was present.

The last ten seasons of fishing data were examined to provide an overview of the degree of discrepancy in dolphin mortality reporting rates. These analyses indicated 27 dolphin mortalities in 982 observed net sets (i.e., 2.7 dolphin mortalities per 100 net-sets) compared to 14 dolphin mortalities in 8,162 net-sets recorded by fishers with no observer (i.e., 0.17 dolphins per 100 net-sets). Thus, dolphin mortalities are recorded 16-times more frequently when an observer is present.

The 'observer effect', whereby observed bycatch rates are higher than those reported with no observer, has been recognised in many world-fisheries and is a reason that observer rates are used in preference to unobserved rates to estimate fishery impacts (e.g., Johnson et al. 1999, Burns and Kerr 2008). Observer programs also aid the overall establishment of open fishing practices and adherence to CoPs. The accuracy of observer data at estimating bycatch, however, is predicated on fisher behaviour being consistent, irrespective of observer presence (Luck et al. 2020, Zollett et al. 2015). If fishing behaviour changes in the presence of observers, bycatch rates recorded by observers may not accurately represent the broader fishery. There is now consistent data over the last 15+ fishing seasons indicating there is a strong observer effect in the SASF, evident in discrepancies in both reported dolphin mortality rates and fishing behaviour.

Acknowledging that observer data are not representative of the broader fishery has implications on how the observer data are used and interpreted, i.e., there are limitations to their application to estimate dolphin bycatch and the sustainability of interactions on dolphin populations, and on how effectively the CoP is applied when an observer is not present.

5. MANAGEMENT CONSIDERATIONS

Over the last 15+ years, on-going discrepancies in the observed and unobserved dolphin interaction rates and fishing behaviour suggest that there is a significant observer effect in the fishery. Results indicate that observer data may not be representative of the broader fishery.

Although fishers apply the CoP effectively when observers are present, in the absence of observers, reported rates of dolphin mortalities are lower (0.1 vs. 3.6 dolphins per 100 net-sets in 2021-22) and fishing behaviour is different (fewer net-sets per night, few net-sets with zero catch and higher catch rates – even if zero-catch net-sets are excluded).

Due to uncertainty in the representativeness of observer data, it is not possible to accurately quantify bycatch rates in the fishery and the sustainability of interactions on dolphin populations can only be evaluated with low confidence. It is also not possible to evaluate the effectiveness of CoP in reducing dolphin interactions when an observer is not present.

To reduce uncertainty in dolphin mortality levels in the absence of observers and improve confidence that the fishery is taking adequate steps to minimise and mitigate interactions with dolphins, the use of alternate observing systems such as electronic monitoring could be considered.

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APPENDIX 1

Estimates of dolphin mortalities in the SASF based on data collected with and without observers onboard: mortalities per 100 net-sets, per year, and the mean over 5-years. The 5-year means exclude 2004-05 and 2018-19, as exceptionally high observer rates in those years would mask trends across following years (n = number of years averaged).

Year	Mortalities per 100 net-sets		Annual mortality estimate		5-year mean estimate				
	with	without	with	without	n	with	SE	without	SE
2004-05	38.8	0.1	483.9	1.0					
2005-06	1.2	0.5	11.7	5.5	1	11.7		5.5	
2006-07	8.5	0.3	81.4	3.3	2	46.7	34.9	4.4	1.1
2007-08	6.1	0.6	53.5	5.0	3	51.5	20.3	4.6	0.7
2008-09	2.2	0.0	20.8	0.0	4	35.8	16.0	3.5	1.2
2009-10	0.7	0.4	8.2	4.0	5	26.0	14.1	4.6	1.0
2010-11	2.2	0.5	22.3	5.5	5	25.7	13.3	3.6	1.0
2011-12	1.4	0.4	15.2	4.3	5	25.3	7.8	3.8	1.0
2012-13	1.2	0.4	10.6	3.3	5	15.0	2.8	3.5	0.9
2013-14	0.0	0.1	0.0	1.1	5	9.8	3.7	3.7	0.7
2014-15	2.3	0.3	19.3	2.2	5	13.3	3.9	3.3	0.8
2015-16	1.1	0.1	9.4	1.1	5	10.7	3.2	2.4	0.6
2016-17	0.9	0.0	8.3	0.0	5	9.4	3.1	1.6	0.6
2017-18	0.0	0.0	0.0	0.0	5	7.2	3.6	0.9	0.4
2018-19	11.8	0.1	113.1	1.1					
2019-20	1.2	0.3	12.5	3.3	4	7.1	2.7	1.1	0.8
2020-21	3.3	0.3	27.5	2.2	4	11.8	5.7	1.4	0.8
2021-22	3.6	0.1	35.3	1.1	4	19.2	7.9	1.7	0.7

APPENDIX 2

Dolphin interactions Code of Practice (CoP): Assessment of procedures with and without observers in the SASF for the 2021-22 financial year.

1. Active searching prior to net setting

CoP followed (%)	
With observer (OBS)	100

CoP : Success – Observers reported active searches for dolphins always conducted prior to net-sets.

2. Search outcome

CoP : Success. – Observers reported crew always communicated sightings of dolphins.

3. Dolphins sighted - Delay and/or relocate fishing activity

	Events	(%)	Dolphins not sighted – net-set	
			No encirclement (%)	Encirclement (%)
With observer				
Dolphins sighted	18	(16)	17 (94)	1 (6)
Not sighted	96	(84)	86 (90)	10 (10)
TOTAL	114	(112 sets)	103 (90)	11 (10)
Without observer (Sightings not always reported)				
TOTAL	877	(875 sets)	779 (89)	98 (11)

*CoP : Success – Observers reported delays (relocations) always took place when dolphins were sighted.
(Encirclement frequency similar with and without an observer)*

4. Active search for dolphins after setting

CoP followed (%)	
With observer (OBS)	100

CoP : Success – Observers reported active searches for dolphins always conducted after net-sets.

5. Lights on

6. Immediate action once dolphin/s observed in net-set

	Yes	No	CoP followed (%)
With observer	9	1	90

CoP : Success – Observers reported immediate action was usually taken once dolphins were observed encircled or entangled. Once an observer recorded there was a delay of 15 min. until the commencement of release procedures.

7. Dolphin encircled – Continue release procedure

Primary action (%)		Secondary action	
<u>With observer</u>			
Open net/ abort	10 (91)		
Dolphin freed itself	1 (9)		
<u>Without observer</u>			
Open net/ abort	95 (97)	Herd with skiff	3
Dolphin freed itself	1 (1)		
Cut from net	1 (1)		
(not recorded)	1 (1)		
<u>Position in net</u>	N (%)	<u>Condition on release</u>	N (%)
<u>With observer</u>			
Free in net	28 (76)	Uninjured	32 (86)
Entangled	9 (24)	Injured	1 (3)
		Dead	4 (11)
<u>Without observer</u>			
Free in net	357 (99)	Uninjured	357 (99)
Entangled	2 (1)	Injured	1 (<1)
		Dead	1 (<1)

CoP : Success – The front of the net was opened and net-sets were aborted if dolphins were encircled.

However – With observer, dolphins more likely to be recorded as entangled, and mortalities are recorded more frequently.

8. Completed WIF submitted to SARDI (assessed with observer only)

	Yes	No	CoP followed (%)
Delay/relocate no encircle	7	10	40
Encirclement/entanglement	10	1*	90
TOTAL	17	11	61

** No WIF submitted for observed encirclement of white pointer/ entanglement of dolphin on outside*

CoP : Unclear - WIFs routinely document encirclements but not delay/relocations.