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Assessment of dolphin interactions, effectiveness of Code of Practice and fishing behaviour in the South Australian Sardine Fishery: 2019-20



R. J. Kirkwood, S. D. Goldsworthy and T. M. Ward

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SARDI Aquatics Sciences
PO Box 120 Henley Beach SA 5022

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Report to PIRSA Fisheries and Aquaculture



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Jason Earl, Craig Noell and Steve Shanks (PIRSA) reviewed a draft of the report. The report was approved for release by Dr Stephen Mayfield.

EXECUTIVE SUMMARY

Interactions between the South Australian Sardine Fishery (SASF) and Short-beaked Common Dolphins (*Delphinus delphis*) during purse-seining have been assessed annually since 2004-05.

This report documents the interactions in 2019-20, details patterns of observer coverage in the fishery, compares observed and reported rates of dolphin encirclement and mortality, and fishing behaviour, and assesses the effectiveness of the Code of Practice (CoP) in mitigating dolphin interactions.

The observer coverage target for the 2019-20 financial year was 20% (up from 10% in 2018-19). However, COVID-19 restrictions required the observer program to cease on 19 March 2020, resulting in just 8% (84 of 1051 net-sets) of total fishing effort being observed. Up until 19 March, observer coverage was 21% (84 of 404 net-sets). Coverage was distributed well across the months it operated and across vessels.

A total of 122 dolphin encirclement events were recorded (8 observed) involving a total of 455 dolphins (36 observed). Overall encirclement event rates were similar with and without an observer (9.5 and 11.8 [12.8 up to 19 March, 11.3 after 19 March] events per 100 net-sets, respectively).

Four dolphin mortality events were recorded, each involving a single dolphin. The dolphin mortality rate with and without an observer, was 1.2 and 0.3 dolphins per 100 net-sets, respectively; indicating a reporting rate discrepancy of 4.

Sardine CPUE by net-set and night in 2019-20 were lower when an observer was present, in part due to the higher percentage of zero net-sets recorded.

As in previous years, during 2019-20 fishers applied the CoP effectively when observers were present and observed rates of dolphin mortality were low. However, in the absence of observers, reported rates of dolphin mortalities were lower and fishing behaviour was different, providing uncertainty about how the CoP was applied. Electronic monitoring systems, such as those used in Commonwealth fisheries managed by the Australian Fisheries Management Authority (AFMA), may be suitable for evaluating application of the CoP and fishing behaviour in the absence of observers.

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

1. INTRODUCTION

1.1. Background

The South Australian Sardine Fishery (SASF) is Australia's largest fishery in terms of tonnage landed. It is a purse-seine net fishery that targets Australian Sardines (*Sardinops sagax*) in waters off South Australia (SA). A key feature of the fishery is that all net-sets (shots) are at night, when the sardines surface school. Fishing seasons run from November to July with peak catches in April, but are reported per financial year (July to June). Landings 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.

Short-beaked 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 all off-shore waters, but are most common in southern waters (Ross 2006). Genetic 'sub-population' structure is evident in south-eastern Australian waters with those east of Bass Strait being distinct from those to the west (Bilgmann *et al.* 2008, 2014a; Möller *et al.* 2012). There is also some mixing of sub-populations through long range movement of some groups (Bilgmann *et al.* 2014a). Abundance data for SA come from 2005 to 2008 boat-based surveys in Gulf St Vincent (densities estimate 0.5 per km², Filby *et al.* 2010), 2011 winter and summer aerial-surveys in Spencer Gulf, Gulf St Vincent and Investigator Strait (20,700 in winter and 14,500 in summer, Möller *et al.* 2012 – dolphin densities not provided), and a 2013 winter aerial-survey in shelf waters west of Eyre Peninsula (21,000 dolphins at 0.7 per km², Bilgmann *et al.* 2014b). All estimates have broad confidence intervals.

Interactions between common dolphins and the SASF occur when dolphins feeding on schools of sardines or attracted to fishing operations are encircled or become entangled in the purse-seine nets. This results in catch loss to the fishers as they try to release the dolphins, and injury or death to the dolphins (Hamer *et al.* 2008). Dolphin mortalities are generally caused by stress, drowning or crushing following entanglement in the net. An initial observer program undertaken by the South Australian Research and Development Institute (SARDI), between November 2004 and June 2005, estimated 1728 dolphins were encircled and 377 died in 2004-05 (Hamer *et al.* 2008). In response, the fishery was closed for two months while a Code of Practice (CoP) to reduce interactions with dolphins was developed. An independent observer program was established in 2006 to monitor the fishery and efficacy of the CoP (Ward *et al.* 2010).

The CoP is continuously reviewed by a Wildlife Interaction Working Group (WIWG) that includes members from the South Australian Sardine Industry Association (SASIA), the Department of Primary Industries and Regions South Australia (PIRSA), and South Australia's Department of Environment and Water (DEW). Refinements to the CoP aim to minimise dolphin interactions and improve outcomes for both fishers and dolphins (Ward *et al.* 2018). The CoP includes clear operational procedures to mitigate interactions with common dolphins (Figure 1).

The operational procedures per net-set are:

Avoidance procedures:

- 1) Active searching for dolphins prior to setting the net;
- 2) Immediate reporting of dolphins sighted to skipper; and
- 3) Delaying and potentially relocating fishing activity if dolphins are sighted;

Release procedures:

- 4) Active searching for dolphins after setting the net (during pursing and hauling);
- 5) Active searching after lights are switched on and during pumping;
- 6) Immediate action to release encircled dolphins; and
- 7) Abort fishing if dolphins cannot be released.

All interactions, including sightings that delay or require the relocation of net-sets, encirclement and releases, and mortalities are to be reported on Wildlife Interaction Forms (WIFs), and submitted to SARDI.

Further stipulations in the CoP are for skippers to communicate to each-other the location of dolphins in real time, and to share experiences that help mitigate adverse dolphin interactions. The current release procedure in the CoP is to first open the front of the net to form a large escape opening. If this is not successful, the set is aborted by releasing the end of the net (SASIA 2015).

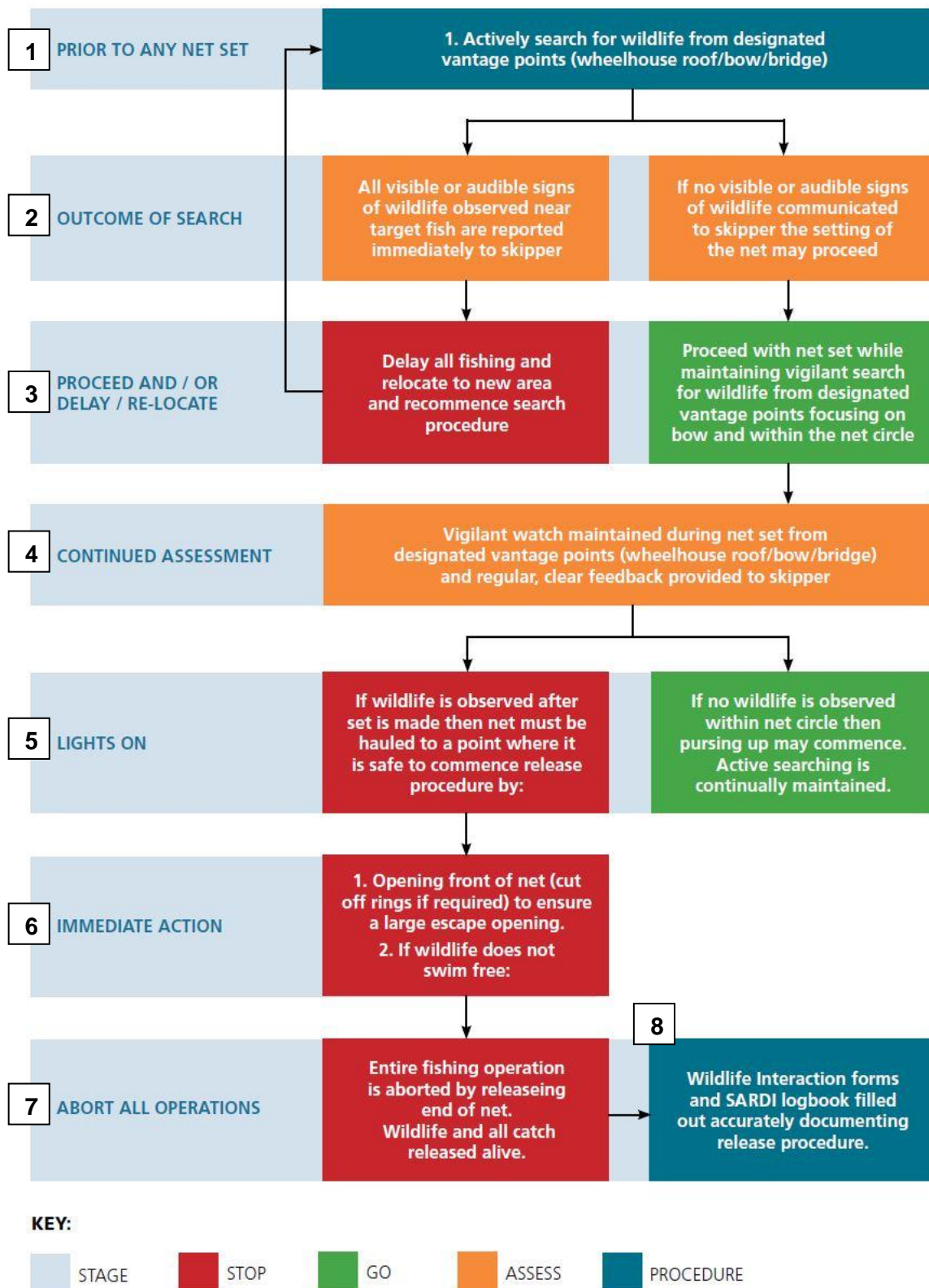


Figure 1. Operational procedures to mitigate interactions with common dolphins in the South Australian Sardine Fishery (SASF) industry Code of Practice (CoP) (SASIA 2015).

The independent observer-based program collects information on dolphin interactions and mortality events, adherence to the CoP, dolphin release methods, and other wildlife observations. Results are analysed by SARDI and reported to the WIWG annually (Ward *et al.* 2010, 2011, 2012, 2013, 2015a,b, 2018; Mackay and Goldsworthy 2016, 2017, Goldsworthy 2018, Goldsworthy *et al.* 2019). In its first year, the program reported an 87% reduction in dolphin encirclement rates and a 97% reduction in mortality rates (Hamer *et al.* 2008). While interactions generally remain low compared with the pre-CoP data, there are consistent discrepancies between data recorded by observers and when observers are not on-board. For example, dolphin mortality rates appear to be higher when an observer is on-board, suggesting an under-reporting of mortalities in the absence of an observer.

Observer coverage has aimed at 10% of fishing effort (effort measured in 'nights of fishing' before 2012, and 'net-sets' thereafter), except in 2007-08, 2008-09 and 2009-10, when a 30% target was set (and 21-24% coverage achieved) in response to high rates of encirclement and mortality in 2006-07 (Ward *et al.* 2010). Again, this year (2019-20), in response to high interaction rates and low apparent reporting in 2018-19, the targeted observer-coverage was increased, to 20%.

In addition to the observer coverage, fishers in the SASF report interactions with Threatened, Endangered and Protected Species (TEPS) using the WIFs. The WIFs enable South Australia to meet its obligations under the federal *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), to report interactions with TEPS.

1.2. Objectives

This report provides an assessment of interactions between Common Dolphins and the SASF during purse-seine operations in 2019-20. It also integrates observer and fishery data collected between 2007-08 and 2019-20.

The key objectives were to:

- 1) Examine the patterns of observer coverage;
- 2) Compare rates of encirclement and mortality recorded by observers and in WIFs when an observer was not present;
- 3) Compare the number of encirclements and mortalities estimated to have occurred each year using observer data with the numbers recorded in WIFs;
- 4) Assess the effectiveness of the CoP in mitigating interactions; and
- 5) Compare fishing patterns with and without an observer.

2. METHODS

2.1. Data collection

Sources of data for this report include:

- 1) *South Australian Sardine Fishery Research Logbook* data (recorded by the commercial fisher) – logbook number, vessel, date, location and time of net-sets, estimated catch.
- 2) *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.
- 3) *SASF TEPS Observer Datasheets* (recorded by an independent observer) – logbook number, date, net-set, weather conditions, timing, adherence to CoP, dolphin encirclement details (stage observed/ release commenced, release method, nature of interaction, dolphin condition), other wildlife observations (including dolphins outside the net), comments.
- 4) Previous data for the SASF (held by SARDI Aquatic Sciences).

Fishery logbook data are generic across all South Australian fisheries and record information required for fisheries management. The data are recorded daily while at sea by the skipper of the vessel, and supplied routinely to PIRSA.

WIFs were introduced to the SASF in 2017. Their primary purpose was to ensure all wildlife interactions were recorded, whether or not an observer was on-board. Information recorded in WIFs are a subset of the information recorded by observers, and allow for comparison with observer data. They record interactions that otherwise may be under-recorded, and improve assessments of the application of the industry CoP.

Since July 2006, an independent observer program has been operated continuously by Protec Marine Pty Ltd and Seatec Marine Services Pty Ltd. Observers generally go with a vessel for single trips (typically these are over-night but may be up to 4-nights). They monitor activity during purse-seine net-sets from a high and unobstructed vantage point, and search for dolphins in the illuminated area surrounding the vessel immediately prior to the net-set. Once the net is set, the observer searches for dolphins within the net and outside for the duration of the fishing operation (pursing, hauling and pumping).

Specific data recorded that allow an assessment of the application of the CoP include:

- 1) If initial search procedures are followed;
- 2) If delays in setting or relocations occur;
- 3) If dolphins are observed prior to setting; and
- 4) The steps taken if an encirclement occurs.

Information recorded if a dolphin encirclement event occurs include:

- 1) The number of dolphins involved;
- 2) The stage of fishing when dolphin(s) were first observed;
- 3) How individual dolphins were caught;
- 4) The release method used;
- 5) The success of the release method; and
- 6) Injuries and mortalities.

Observer effort aimed to be distributed evenly among vessels, across months and by management zones. The harvest strategy for the SASF defines two spatial management zones, the Gulf Zone and the Outside Zone (PIRSA 2014). Previous assessments have not identified differences between zones, so they are not considered independently in this report. Observer coverage for 2019-20 was examined relative to month (temporal effort) and vessel (randomly assigned unique numbers to ensure data confidentiality). As mentioned in the introduction, in 2019-20, the targeted observer-coverage was 20% of net-sets.

2.2. Data integration

The three 2019-20 data sets (logbook, WIFs and observer) were collated, entered onto *Excel* spreadsheets and independently cross-checked for accuracy. Data sets were then linked, by logbook number, vessel (name and license), date and net-set, and further cross-checked. The 'cleaned' 2019-20 data were then incorporated into the long-term data set for the SASF.

In this report, data from 2007-08 onwards are presented. Prior to 2007-08, data were not collected on individual net-sets. Information on operational interactions between the SASF and dolphins between 2004-05 and 2007-08 are available in Ward *et al.* (2015b, 2018).

2.3. Dolphin interaction rates

Operational interactions between the SASF and common dolphins recorded by observers and reported in the WIFs were analysed using encirclement events, the number of dolphins encircled, mortality events and the number of dolphins that died. For each dolphin in an encirclement event, the initially observed condition and condition on release (alive, injured or dead) was recorded. In instances when a dolphin's condition was not definitive, e.g. it was cut free or fell out of the net and was not observed resurfacing, it was assumed to have died.

The total number of encirclement and mortality events, and dolphins encircled or died, in the SASF in 2019-20 were estimated from those in observed net-sets multiplied by the total fishing effort (net-sets).

2.4. Code of Practice assessment

The assessment of the effectiveness of the CoP at mitigating interactions with dolphins was based on:

- 1) Observed fishing behaviour - searches for dolphins, delays to net-sets when dolphins were sighted, and release of dolphins following encirclement and/or entanglement;
- 2) Comparisons of observed and unobserved rates of interactions.

2.5. Fishing Behaviour

In addition to assessments of dolphin interactions and effectiveness of the CoP, fishing behaviour with and without an observer on-board was assessed based on estimated catch per unit effort (CPUE, effort being net-sets and nights).

3. RESULTS

3.1. Observer coverage

Of 108 observer data sheets submitted during the 2019-20 financial year, four recorded no searching for sardines (e.g. steaming, or towing), and 17 recorded searching but no net-sets, due to fish being 'not located' and/or 'not schooling' (15), or seas being too rough (2). This left 87 situations when a fish school was located and setting the net was considered possible. On 64 (74%) of these occasions, no dolphins were sighted and the net was set, while on 23 (26%) occasions, dolphins were sighted prior to the net-set, resulting in one or more delays and, often, relocations. On 20 of the 23 delay/relocations, net-sets were ultimately made and on three occasions there was no net-set. Hence, a total of 84 net-sets were witnessed by observers (64 + 20).

During 2019-20, there were 1051 purse-seine net-sets, the highest number since 2011-12 (Table 1). The observer coverage of 8% (84), however, represented the lowest level of coverage since 2011-12 and the second lowest level since the independent-observer program began, less than half the 20% planned for the year. The low coverage resulted because observers were not allowed to go onto vessels after 19 March 2020, in accordance with State Government and industry actions to reduce the spread of the Covid-19 virus.

In 2019-20, 92% of fishing effort occurred between January and June (Figure 2a). Although observers covered just 8% of net-sets for the year, they had covered 20% up to 19 March (including 3% in November, 21% in December, 25% in January, 21% in February, and 31% to 19 March). From 19 March to end of June, 62% of net-sets for the year occurred with no observer coverage.

Twelve vessels were active in the SASF in 2019-20 (Figure 2b). Effort in terms of number of net-sets by individual vessels accounted for 5-14% of fleet fishing effort. Observer coverage per vessel ranged from 1-13% of net-sets, all below the 20% originally targeted for the year (Figure 2b). Up to 19 March, observers had covered 1-17 net-sets per vessel (17-75%, average 25%).

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 2007-08 and 2019-20.

Financial year	Fishing effort (net-sets)					Encirclement events (no. dolphins)						Mortality events (no. dolphins)					
	Logbook total	With observer	Without observer	% observed	% target	Total		With obs.		Without obs.		Total		With obs.		Without obs.	
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)
Average	950	124	826			78	(242)	13	(46)	65	(196)	4	(5)	2	(3)	2	(2)

Target observer coverage for 2019-20 was not achieved due to Covid-19 restrictions on observer access to vessels.

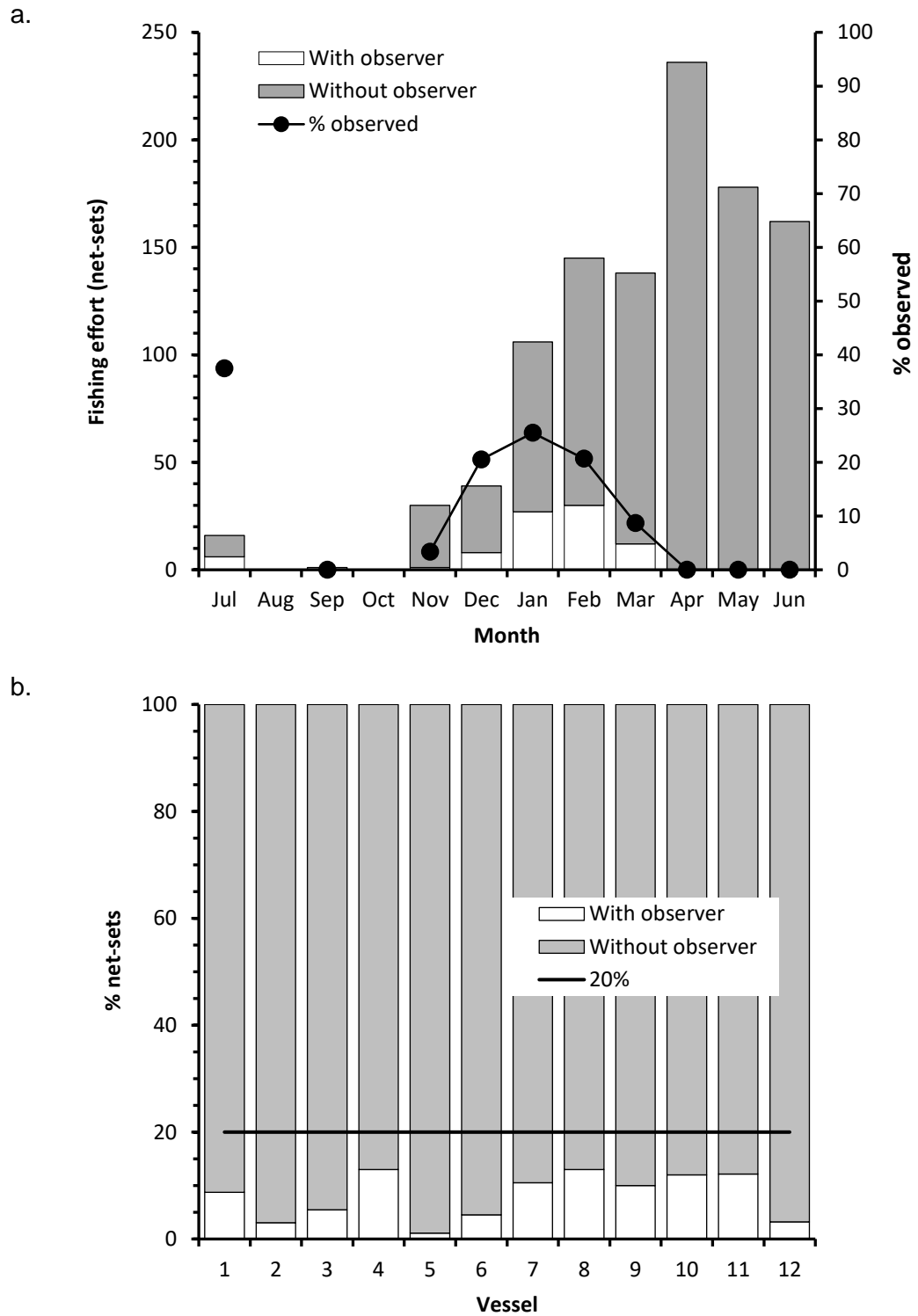


Figure 2. Observer coverage relative to fishing effort (net-sets) **a)** by month and **b)** by vessel (identifying numbers assigned randomly), for the 2019-20 financial year. The 20% target level (black line in b) was not achieved due to Covid-19 restrictions from 19 March 2020.

3.2. Dolphin interaction rates

Encirclement

Logbook data for 2019-20 revealed a total of 455 dolphins encircled in 122 dolphin encirclement events (Table 1). This represented the highest number of encirclements and encirclement events for any year within the current data set (2007-08 to 2019-20). Logbook data recorded four mortality events with a single dolphin mortality in each event (Table 1). These levels approximated the long-term recorded averages of four events and five mortalities per year, and represent a reduction from 2018-19, when 15 dolphin mortalities were recorded, 14 being when observers were on-board. In 2019-20, observers sighted eight encirclement events (involving 36 dolphins) including one mortality event (one dolphin).

Encirclement event rates were slightly lower (9.5 events per 100 net-sets) for net-sets with observers than those without (up to 19 March, 12.8 events per 100 net-sets, after 19 March, 11.3, overall, 11.8) in the 2019-20 financial year (Figure 3a). The reported number of dolphins encircled per 100 net-sets with and without observers were the same (both 43 dolphins per 100 net-sets; Figure 3b). There was minimal discrepancy in encirclement event (0.8) and dolphin encirclement rates (1.0 – note that a value of 1.0 indicates nil discrepancy). Although there has been a high level of congruence between the encirclement event rates reported with and without an observer, since 2012-13, the reported number of dolphins encircled (dolphin encirclement rates) has generally been higher when an observer is present (Figure 3a-d).

Mortality

Given all the mortality events involved single dolphins, the mortality event and dolphin mortality rates were the same for the 2019-20 financial year. Reported rates were higher for net-sets with observers (1.2 events/dolphin mortalities per 100 net-sets) than those without (0.3 events/dolphin mortalities per 100 net-sets; Figures 4a and b), providing a reporting rate discrepancy of 4x for both mortality events and dolphin mortality rates (Figure 4c and d). These rates are lower than the long term averages (8x and 16x, respectively), and markedly reduced from the high discrepancy rates recorded in 2018-19 (28x and 99x, respectively; Figures 4c and d).

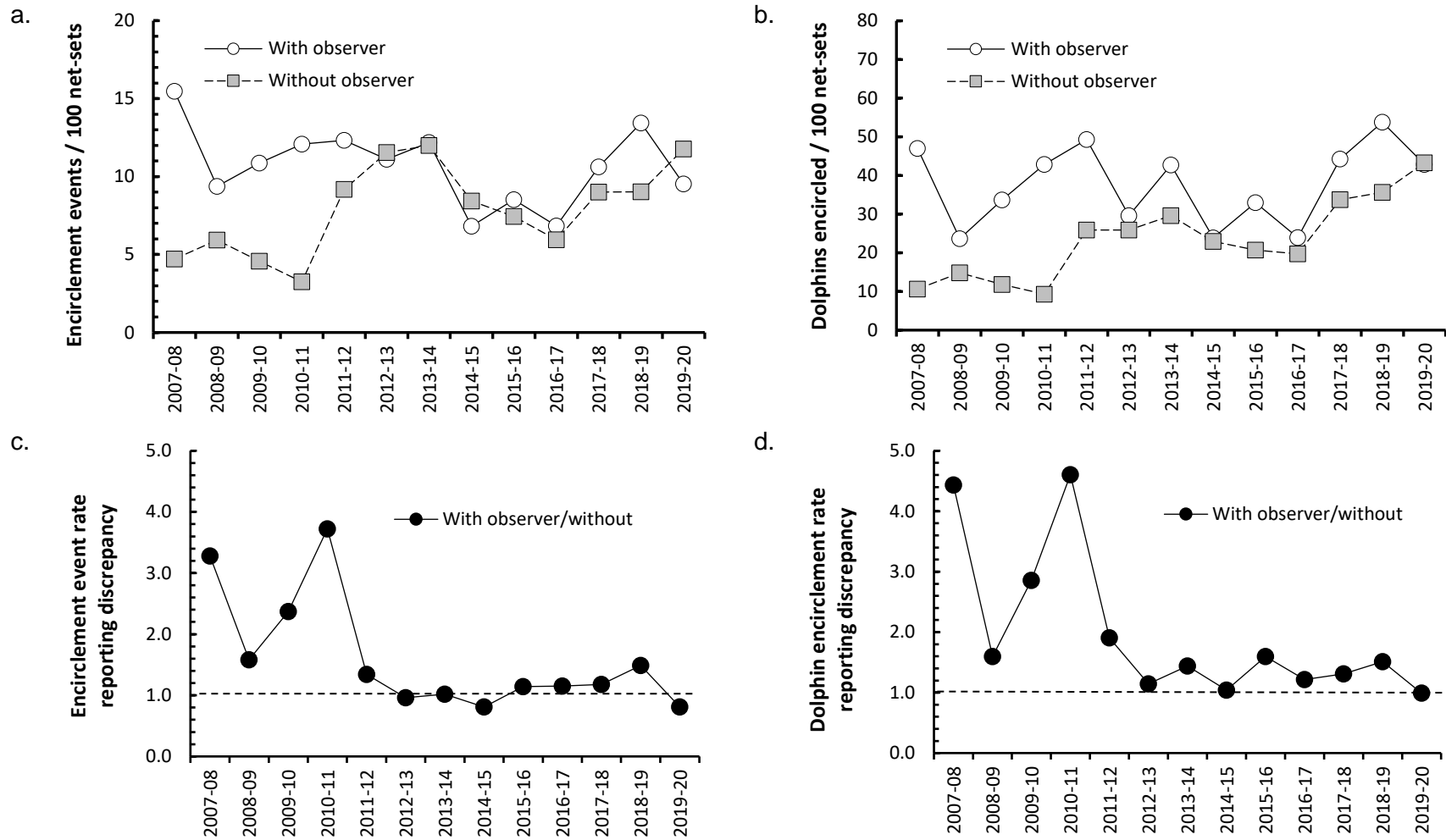


Figure 3. Comparison of **a)** encirclement events and **b)** dolphin encirclement rates, with and without an observer, by financial year in the SASF, and reporting rate discrepancies (with observer/without observer) for **c)** encirclement events and **d)** dolphin encirclement rates. In the discrepancy graphs, the dashed line indicates no reporting discrepancy (i.e. a value of 1.0).

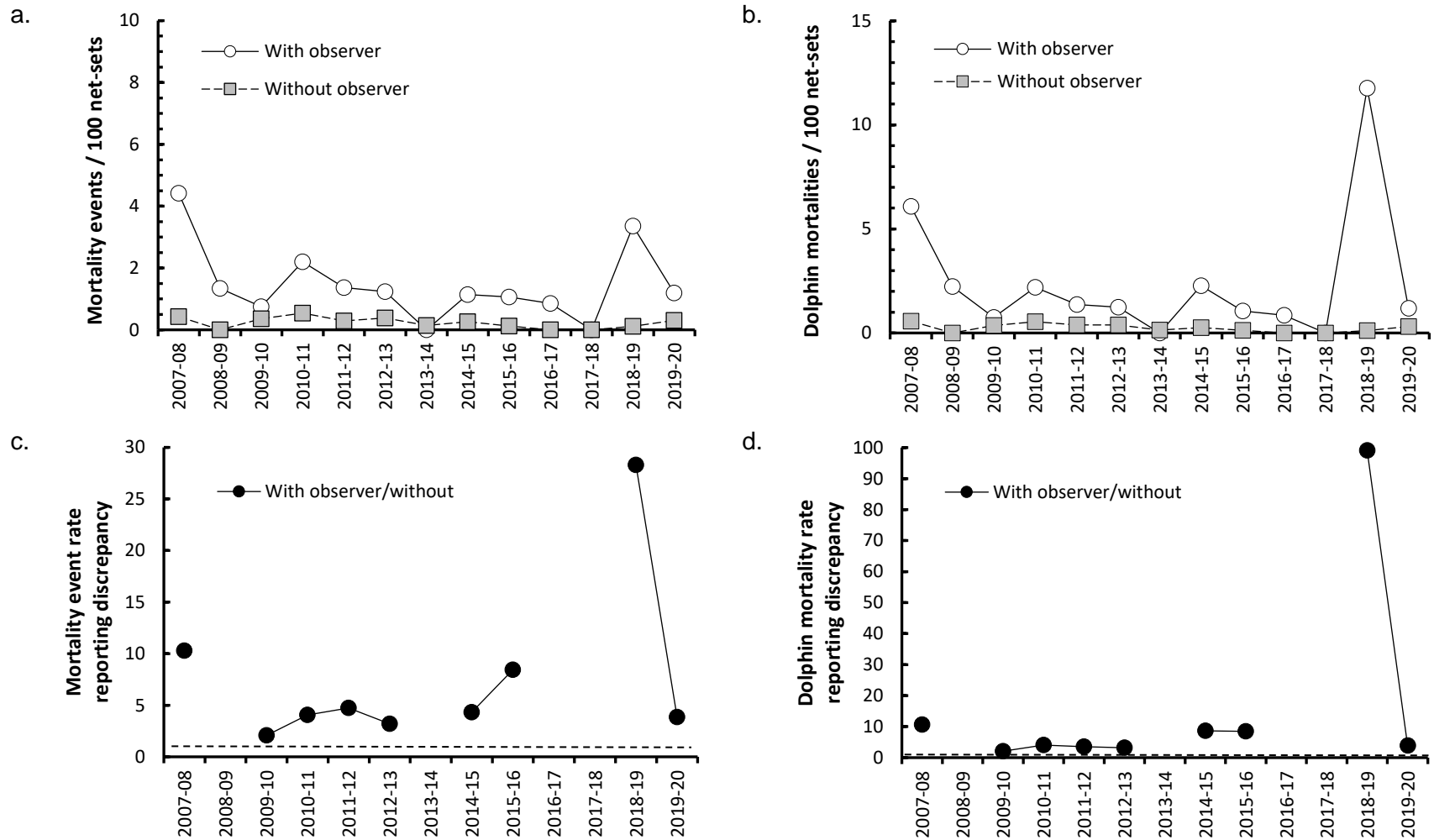


Figure 4. Comparisons of **a)** mortality events and **b)** dolphin mortality rates, with and without an observer, by financial year in the SASF, and reporting rate discrepancies (with observer/without observer) for **c)** mortality events and **d)** dolphin mortalities. In the discrepancy graphs, the dashed line indicates no reporting discrepancy (i.e. a value of 1.0), missing values represent years when the ‘with’ and/or the ‘without’ observer rates were zero.

Estimated number of interactions and mortalities

The estimated number of encirclement events and dolphin encirclements for 2019-20, based on observed rates multiplied by the total fishing effort, was 100 and 450, respectively. This compares with totals of 122 and 455 reported in logbooks, respectively (Figure 5a and b). In the long-term, the annual numbers of encirclement events and dolphins encircled estimated from observer data have been significantly higher than those recorded in logbooks (paired t-test, events $t = 2.58$, $df = 12$, $p = 0.02$; dolphins $t = 4.24$, $df = 12$, $p = 0.001$).

The estimated number of mortality events and dolphin mortalities for 2019-20, based on observed rates multiplied by the total fishing effort was 13. This compares to a total of 4 reported in logbooks (Figure 5c and d). Significantly higher mortality estimates from observer data have occurred consistently since 2007-08 (paired t-test, events $t = 3.99$, $df = 12$, $p = 0.001$; mortalities, $t = 2.39$, $df = 12$, $p = 0.03$).

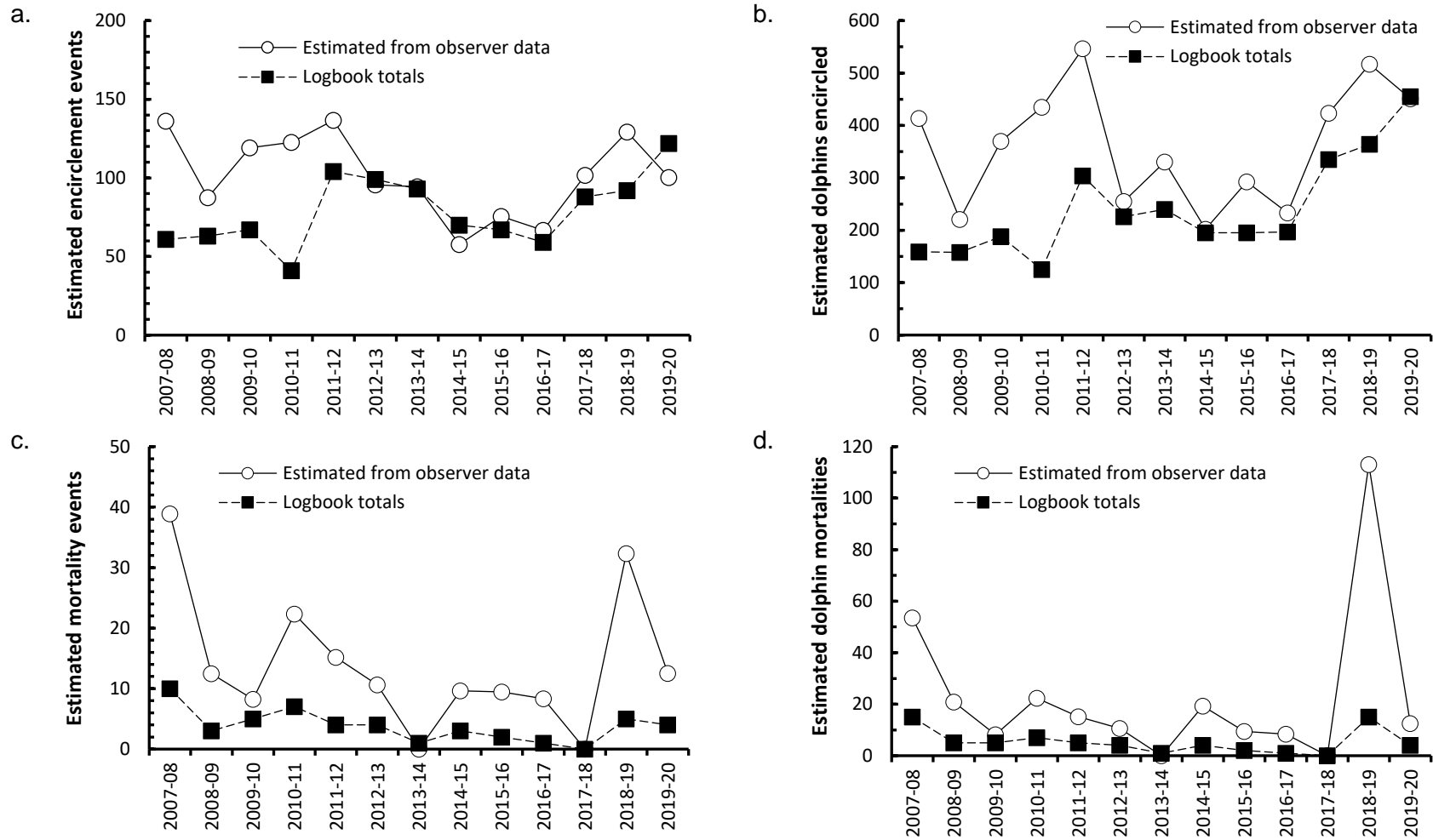


Figure 5. Comparisons between estimates based on observer data and logbook totals (including observed sets) of **a)** the number of encirclement events, **b)** the number of dolphins encircled, **c)** the number of mortality events and **d)** the number of dolphin mortalities, by financial year since 2007-08.

3.3. Code of Practice assessment

The CoP assessment for 2019-20 was based on comparisons between data submitted by observers (SASF TEPS Observer Datasheets, n = 108) and fishers (WIFs, n = 181, 161 without an observer). A summary of the CoP assessment is provided in Appendix 1.

Avoidance procedures

1) Active searching prior to net setting

A search for dolphins was recorded as having been undertaken prior to net-setting in all set approaches covered by observers (100%), and all net-sets without observers that were reported in WIFs (161).

2) Search outcome

Of the 87 net-set approaches viewed by observers, 76 (87%) did not result in dolphin encirclement events (Table 2). This was in line with success rates in previous years (average since 2005-06 = 91%).

When dolphins were not sighted prior to net-sets, there was a small (6-7%) chance that dolphins would be encircled, the same chance whether or not an observer was on-board. When dolphins were sighted and the net was set following delays/ relocations, however, resultant net-sets were less likely to encircle dolphins if an observer was on-board (20%) than if one was not (54%).

Observers reported that on 74% (64 of 87) of first approaches to set a net, dolphins were not sighted and sets were not delayed. WIFs indicated that when observers were not present, 89% (863 of 967) of first approaches were not delayed by dolphin sightings. However, this result should be viewed cautiously as not all delays may be recorded (see section below on 'WIF completed and submitted to SARDI').

3) Delay or delay & relocate fishing activity

Dolphins were sighted on 23 observed searches, including 20 that resulted in net-sets (Table 2). On the other three occasions, the presence of dolphins in the planned fishing area influenced the skipper to not set the net at all, but to steam to another area – twice this decision was also influenced by fish patches being small. On all occasions when dolphins were sighted, the skipper delayed setting the net, or delayed and relocated. Note that all relocations involve delays, but not all delays include relocations.

Table 2. The number of net-set approaches viewed by observers and the percentage that were “successful” (net-set and no dolphins encircled); the number of sets delayed/relocated due to sighting a dolphin, the percentage of dolphin instigated delay/relocations, and the percentage of “successful” delay/relocations (net-set and no dolphins encircled).

Financial year	Net-set approaches	“Successful” (%)	Dolphin instigated delay/relocations	%	Delay/relocate “successful” (%)
2005-06	89	90	6	6	100
2006-07	82	85	7	8	71
2007-08	189	91	34	15	71
2008-09	233	93	31	12	87
2009-10	265	93	34	11	79
2010-11	91	89	2	2	50
2011-12	73	88	1	1	100
2012-13	84	91	4	5	50
2013-14	81	94	15	16	67
2014-15	93	93	13	12	85
2015-16	95	91	5	5	92
2016-17	116	93	17	13	88
2017-18	113	93	11	9	55
2018-19	119	93	24	17	83
2019-20	87	87	23	26	80

On the 20 occasions a net was set following dolphin sightings, 12 involved a single delay, four involved two delays, one involved three delays, two involved four delays and one involved six delays. On 17 of the 20 occasions, the fisher chose to also relocate, while on three occasions, all re-set attempts were at the same location.

Unobserved WIFs indicated dolphins were sighted on 104 occasions prior to net-setting. A delay or delay and relocation was recorded in 103 instances (99% compliance). These involved nine delays and sets at the same location, and 94 delay and relocations. Nets were set following single delay/relocations 66% of the time ($n = 68$), with a maximum of eight delay/relocations before a net was set.

4) Actively searching for dolphins after setting the net

Observers noted that active searching for dolphins continued after the net was set in all but one of the 84 net-sets observed (99% searched). WIFs recorded active searching after the net was set in all but 12 of 161 ‘un-observed’ net-sets (93% searched).

Observers reported common dolphins outside the net following 55 of 84 net-sets (65%), including six of the eight sets involving dolphin encirclements (Figure 6). This rate was above average but within the range recorded in previous years (2007-08 – 2018-19; average = 47%, range 21-74%). The number of dolphins seen outside the net averaged 22 (range 4-90).

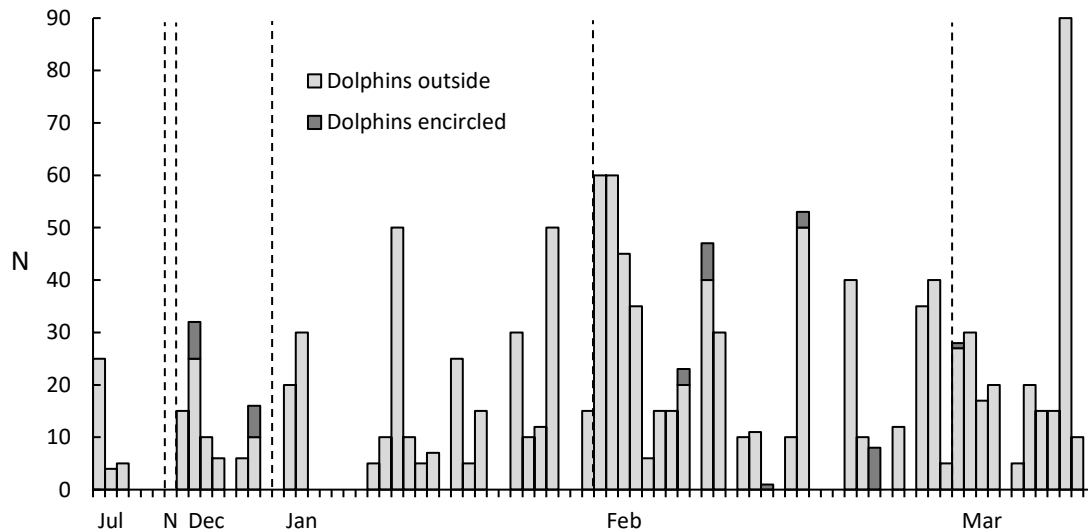


Figure 6. Dolphin encirclements and dolphins seen outside the net after setting during the 2019-20 financial year. X-axis indicates order of net-sets observed (n = 84) delineated by month.

Encirclements

Despite the high levels of searching for dolphins and the consistently applied delay/relocations if dolphins were sighted, 122 encirclement events were recorded in 1051 logged net-sets (12%). WIF data of encirclement events and dolphin numbers recorded in the presence of observers were identical to the data recorded by the observers.

Amongst the eight encirclements witnessed by observers, four followed no pre-sighting of dolphins and four followed delays caused by dolphin sightings. The success rate of achieving no encirclement when a net was set after delay/relocating until no dolphins were sighted was 80% (i.e. 20 net-sets after delays of which 16 did not encircle dolphins, Table 2). This success rate was in line with previous years (average since 2005-06 = 77%).

WIFs recorded in the absence of observers documented 114 encirclement events, 58 (51%) were in net-sets after no prior dolphin sighting/ delay, seven (6%) followed a delay and net-set at the

same location, and 49 (43%) followed dolphin sightings, a delay and relocation. To delay and relocate had a better success rate (47% no encirclement) than to delay and not relocate (22% no encirclement). Overall, no encirclement occurred on 46 of the 102 delay/relocations, suggesting a success rate of 45%.

Release procedures

1) Immediate mitigation action to release encircled dolphins

Observers noted that dolphins were first observed four times during pursing (50%) and four times during hauling (50%). They recorded that action to release encircled dolphins was immediate in all encirclements. Immediate action meant the fisher prepared for the release: this could not be instantaneous as opening the front of the net or aborting the set required the net to be in a certain configuration, otherwise it could alter shape and entangle the dolphins or roll up on itself. The time between encirclement and commencement of release averaged 25 min (n = 8, range 2-60 min).

WIFs (without observer) did not always record the stages when dolphins were sighted or released. When they did, sighting occurred 13% of times during setting, 14% during pursing and 73% during hauling. The time to commencement of release was recorded 88% of the time, and averaged 13 min (n = 91, range 0-50 min). This shorter time compared with times recorded by observers likely relates to there being many zero values entered by fishers, indicating they immediately started setting up the net for the actual release actions – which commenced shortly after.

2) Aborting all fishing if dolphins cannot be released

Observers recorded the primary release procedure to be opening the front of the net (seven of eight encirclements). On one occasion the net was aborted prior to opening the front. All releases were successful, however, one dolphin death was recorded (entangled in outside of the net, see mortalities below).

WIFs (without observer) reported the first-choice release methods were opening the front of the net (65%) or aborting the net-set (33%). Once, a dolphin entangled in the float-line was manually handled out of the net by crew in the skiff and several times dolphins were cut from the net. Herding with the skiff was once conducted as a secondary action.

Mortalities

Observers noted interactions with 36 dolphins, of which 35 had been encircled and all of these were released apparently un-injured. One dolphin mortality was observed on 5 December at 2:40 am. During the release of six free-swimming dolphins, a seventh was sighted entangled and dead in the net. Although not definite, the observer and crew felt that the dolphin had become entangled on the outside of the net. The net-set in which the dolphin died had followed four delay/relocations.

WIFs (without observers) recorded the release of 415 uninjured dolphins and one injured dolphin. The injured dolphin was observed entangled in the net, it released itself and was observed to swim away freely. Three dolphin mortalities were recorded. On 1 April at 0:20 am during hauling, a dead juvenile dolphin was observed outside the net below the power-block. It was the only dolphin sighted during the net-set. Potentially, it had become entangled in the net and fallen out as the net was being hauled up to the block. On 16 May at 2:30 am, a dolphin mortality was recorded but with no further details. On 16 May at 3:55 am following pumping, the rest of the net was brought on-board and a previously unseen dead dolphin went through the power-block.

WIF completed and submitted to SARDI

On all eight observed encirclements, corresponding WIFs were completed and submitted (100% compliance). The extent to which WIFs were completed and submitted where no observers were present is not assessable. Of 19 observed delay/relocations that did not result in encirclements, just 12 (63%) WIFs were submitted, consistent with an under-reporting of interactions that caused delay/relocations.

3.4. Fishing behaviour

In 2019-20, the average number of net-sets per night was the same (1.6) with and without an observer present (Figure 7a). However, the percentage of net-sets with zero catch was higher when an observer was present (24%) than without an observer (15%): the discrepancy between these data was 8.5%, in-line with the long-term average in discrepancy of 8% (Figure 7b).

CPUE_{net-set} and CPUE_{night} was significantly lower for net-sets with an observer present, which has occurred in most years (Table 3, Figure 8a, 9). Lower catch rates recorded when an observer was present was influenced, in part, by the higher percentage of net-sets having zero catch recorded when an observer was present (Table 3). However, a significant difference still remained following

exclusion of zero-catch net-sets (2019-20 catches, two-sample t-test assuming unequal variance, $t = 2.41$, $df = 75$, $p = 0.02$; Figure 8b).

Table 3. T-tests comparing the difference with and without an observer, of sardine CPUE_{net-set} and of net-sets per night, between 2007-08 and 2019-20. P-values <0.05 (in bold) indicate significant difference.

Financial year	CPUE (per net-set)			Net-sets per night		
	t	df	p	t	df	p
2007-08	0.19	256.76	0.846	-1.84	258.86	0.067
2008-09	5.15	474.21	<0.001	-3.32	299.57	<0.01
2009-10	2.40	443.70	<0.05	-3.14	391.45	<0.01
2010-11	1.18	112.15	0.248	1.95	125.70	0.053
2011-12	-0.13	77.80	0.894	2.34	87.26	<0.05
2012-13	2.40	101.50	<0.05	-3.51	91.32	<0.001
2013-14	2.85	109.68	<0.001	-2.93	90.36	<0.05
2014-15	4.25	117.46	<0.001	-1.93	103.70	0.056
2015-16	2.00	124.27	<0.05	-1.12	118.99	0.266
2016-17	2.72	143.19	<0.05	-1.45	147.20	0.153
2017-18	5.00	162.38	<0.001	-2.62	62.71	<0.05
2018-19	2.28	164.04	<0.01	0.06	97.04	0.954
2019-20	3.15	102.00	<0.01	0.03	62.00	0.976

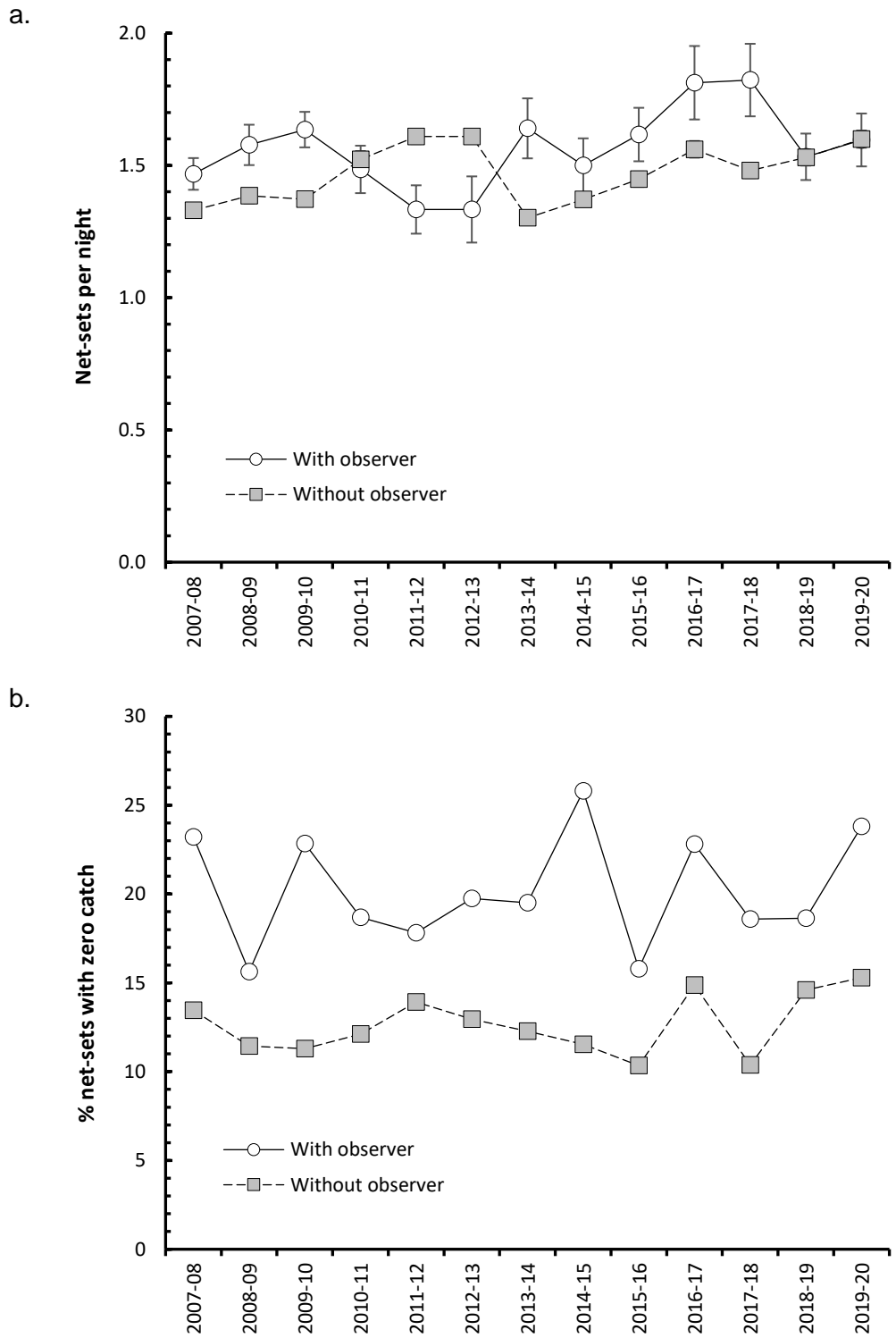


Figure 7. Comparison of net-sets with and without an observer, by financial year: **a)** average per night (error bars in = \pm SE), and **b)** percentage with zero catches.

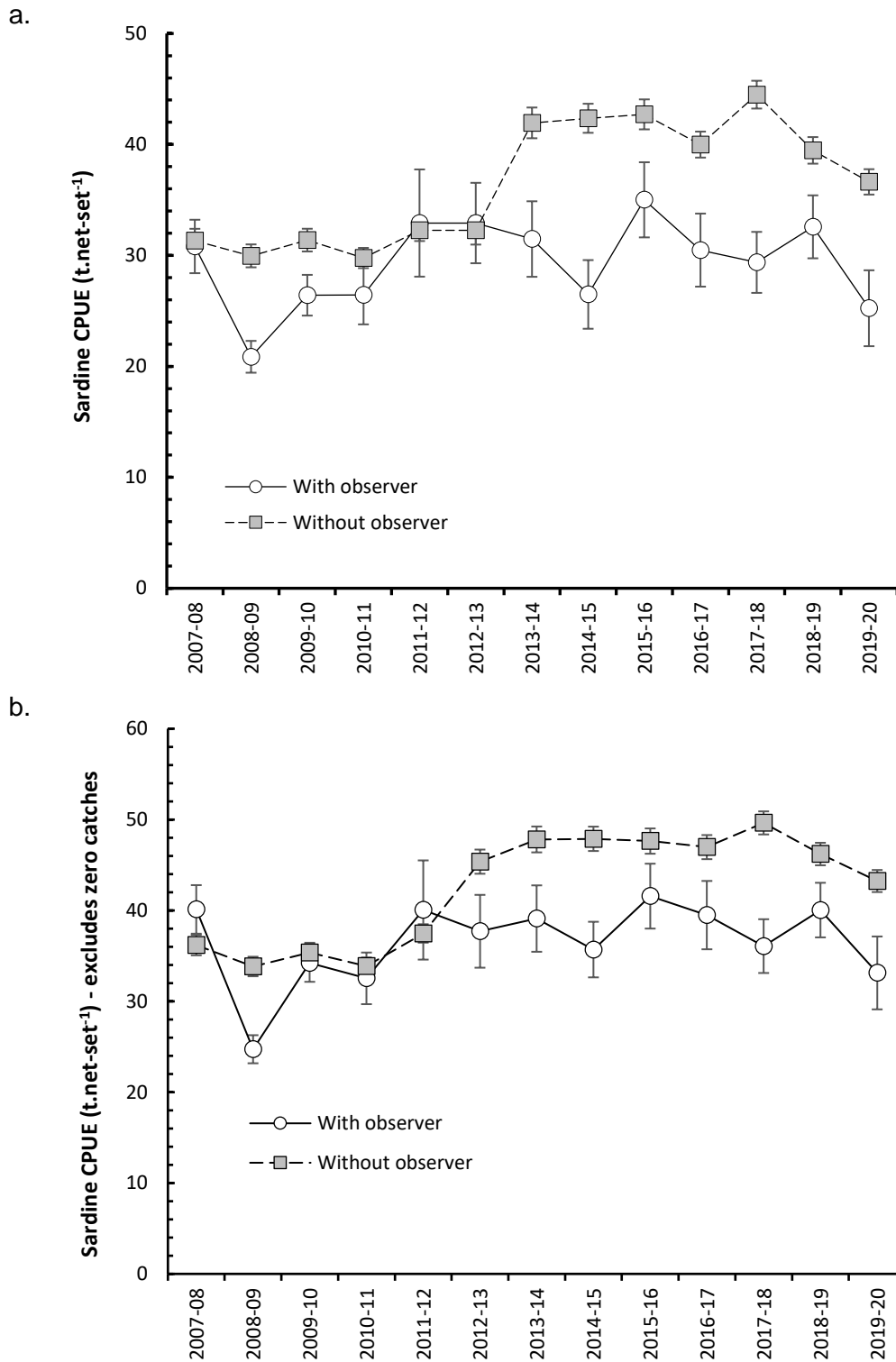


Figure 8. Sardine CPUE (tonnes per net-set) by financial year: **a)** including zero-catch net-sets, and **b)** excluding zero-catch net-sets (error bars are \pm SE).

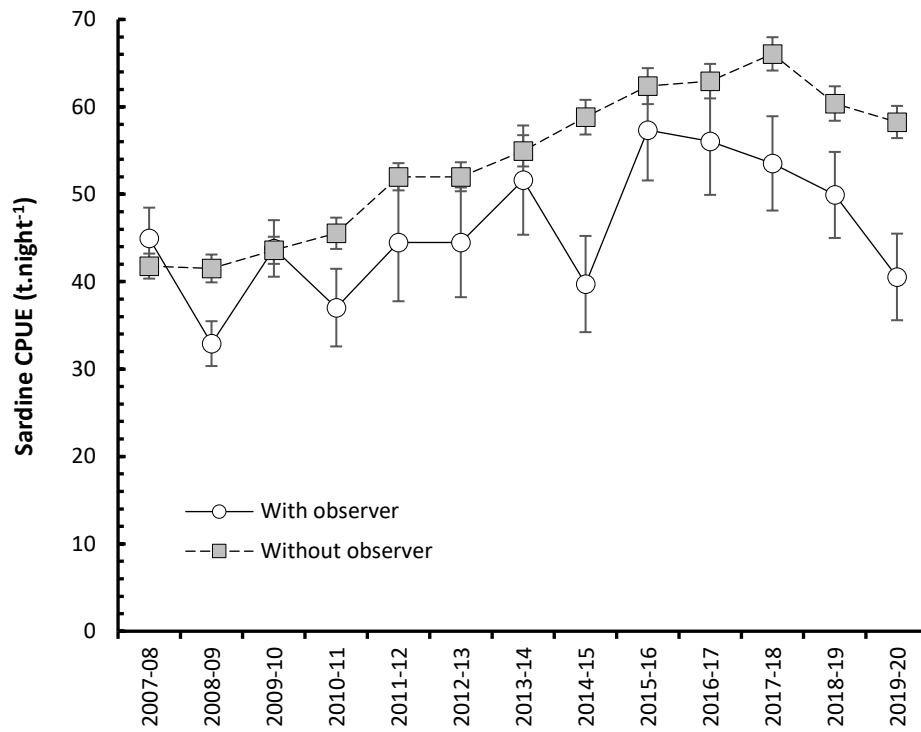


Figure 9. Sardine CPUE (tonnes per night) by financial year (error bars are \pm SE).

4. DISCUSSION

4.1. Observer coverage

Restrictions related to reducing spread of the COVID-19 virus prevented achievement of the 2019-20 target of 20% observer coverage of fishing effort (net-sets). However, because observers were able to achieve the 20% target up until when restrictions came into force on 19 March 2020, overall coverage for 2019-20 was 8% (just short of the 10% target set in most years). Unfortunately, coverage did not coincide with the peak-period of fishing effort in April-May. Up to 19 March 2020, observer coverage was spread well across months and vessels.

4.2. Dolphin interaction rates

The number of encirclement events (122) and total number of dolphins encircled (455) in 2019-20 were the highest on record. In part, this was due to the high number of net-sets (1051 compared with the long-term average of 950), but also reflects the high rates of encirclement reported by fishers (11.8 events and 43 dolphins per 100 net-sets), compared to long-term averages (7.9 events and 23 dolphins per 100 net-sets). The rates were comparable with those recorded by observers in 2019-20 (9.5 events and 43 dolphins per 100 net-sets), and the long-term averages recorded by observers (10.7 events and 38 dolphins per 100 net-sets). Hence, the high rates recorded may, in part, reflect more accurate recording of encirclement events in 2019-20 compared with previous years.

Implementation of Covid-19 restrictions on 19 March 2020 provided an opportunity to compare dolphin interactions reported by fishers with and without an observer program running. While the observer program was in-place, 38% of net-sets for the year were conducted and fisher-reported encirclement rate was 12.8 events per 100 net-sets. When the observer program was not running, 62% of net-sets were conducted and the fisher-reported encirclement rate was 11.3 events per 100 net-sets. Assuming dolphin abundance and vulnerability to encirclement remained constant, the similarity of these figures suggests consistent reporting of encirclements throughout the 2019-20 fishing season.

Observed mortality events and dolphin mortality rates were four times those reported in the absence of an observer. Discrepancies between rates recorded with and without an observer may reflect the low level of observer coverage and low number of mortality events. For example in 2019-20, observers recorded just one mortality. With the 8% observer-coverage, this mortality

provided the estimate of 13 dolphins for the year across the fishery. Had that mortality not been observed or had an observer been on-board for a second mortality, the estimate would be 0 or 26 dolphins (double the annual average), respectively. As mortalities occur in about one in every 100 net-sets, it is not possible to estimate mortality rates robustly from 10% observer coverage. In most years since 2007-08 in the SASF, observed mortality rates have been higher, suggesting under-reporting of mortalities in the absence of an observer.

4.3. Code of Practice assessment

The assessment of the CoP is made with caveats. It relies on comparisons between observer datasheets and WIFs submitted by fishers, and the focus of these participants differs. The observer's role is to document their observations impartially whereas fishers are attempting to catch fish, avoid dolphins, and operate safely at night. Accordingly, observers have a greater attention to detail when filling out forms relating to wildlife interactions. Some differences between the observed and unobserved data probably relate to WIFs not being fully completed and submitted. This problem relates to ambiguity resulting from a statement on older WIFs, indicating that CoP details were only required to be provided when dolphin encirclements occurred and observers were not present. Fishes have been provided with new forms to be used during the 2020-21 fishing season that clearly state that CoP details are required to be recorded when a dolphin is sighted during searching and/or when an encirclement occurs.

A low rate of reporting delay/relocations due to dolphin sightings has been identified in previous assessments of the CoP (Goldsworthy 2018, Goldsworthy *et al.* 2019). This could be influenced by ambiguity in the WIF forms, as mentioned above. However, the trend is for improved reporting rates: from 5% in 2017-18, to 42% in 2018-19 and 63% in 2019-20. Using the new forms in future will likely further improve reporting rates.

Another recurring difference between with and without observer data is that when an observer is on-board, a smaller proportion of delay/relocations result in encirclements (20% compared with 54% without an observer). This might be influenced by the reportage issue, but could signal differences in fishing behaviour in the absence of an observer.

On the positive, this assessment demonstrates that fisher's record most, if not all, encirclement events, respond quickly to releasing encircled dolphins, and do their best to release them alive and uninjured, despite this resulting in them potentially losing part, or all, of the catch.

4.4. Fishing behaviour

Differences in observed and reported mortalities and rates of success of delay/relocations in avoiding encirclements, suggest that fishing behaviour is different in the presence of an observer. Further evidence of a difference is shown in the CPUE data and the percentage of net-sets that record zero fish catch. During 2019-20, sardine catch per night and per net-set was lower and the percentage of net-sets with zero fish catch was higher when an observer was on-board. The difference was not resolved by excluding net-sets with zero sardine catch. These differences in fishing behaviour between when observers are present and when they are not have been reported previously (Ward *et al.* 2013, 2015a, b, 2018, Mackay and Goldsworthy 2016, 2017, Goldsworthy 2018, Goldsworthy *et al.* 2019), and the reasons for them remain unresolved.

5. MANAGEMENT CONSIDERATIONS

The key findings of this report on Short-beaked Common Dolphin interactions with the SASF for the 2019-20 financial year are broadly consistent with those identified in previous years. Fishers demonstrated a capacity to apply the CoP effectively when observers were present and observed dolphin mortality rates were low. However, in the absence of observers, reported rates of dolphin mortalities were lower and fishing behaviour was different, providing uncertainty about how the CoP was applied then. Electronic monitoring systems, such as those used in Commonwealth fisheries managed by the Australian Fisheries Management Authority (AFMA), may be suitable for evaluating application of the CoP and fishing behaviour in the absence of observers.

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APPENDIX

Dolphin interactions Code of Practice (CoP): Assessment of procedures with and without observers in the SASF for the 2019-20 financial year.

1. Active searching prior to net setting

	Yes	No	CoP followed (%)
With observer	87	0	100
Without observer (WIFs)	161	0	100

CoP : success – Active searches for dolphins were conducted prior to net-sets.

2. Search outcome

	Events	(%)	Dolphins not sighted – net-set	
			No encirclement (%)	Encirclement (%)
With observer				
Dolphins sighted	23	(26)		
Not sighted	64	(74)	60 (94)	4 (6)
TOTAL	87			
Without observer				
Dolphins sighted	104	(11)		
Not sighted	863	(89)	806 (93)	57 (7)
TOTAL	967			

CoP : equivocal (possible reportage issue) – Without observer, searches less likely to report dolphins. However, when dolphins sighted and net set, the % of resulting encirclements was the same, with or without observer.

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

	Yes	No	CoP followed (%)	
With observer	*23	0	(100)	*No net-set on 3 of these
Without observer	103	1	(99)	
	Events	No encirclement (success)	(%)	Encirclement (fail) (%)
Net-sets observer				
Delay	3	2	(67)	1 (33)
Delay & relocate	17	14	(82)	3 (18)
TOTAL	20	16	(80)	4 (20)
Net-sets without observer				
Delay	9	2	(22)	7 (78)
Delay & relocate	94	45	(48)	49 (52)
TOTAL	103	47	(46)	56 (54)

CoP : equivocal – Delay/relocations made on sighting dolphins, whether or not an observer was on-board. Following delay/relocations, however, dolphins were more likely to be encircled if there was no observer on-board.

4. Active search for dolphins after setting

	Yes	No	CoP followed (%)
With observer	83	1	99
Without observer	149	12	93

CoP : success – Active searches for dolphins were conducted after net-sets.

5. Lights on**6. Immediate action once dolphin observed**

	Yes	No	CoP followed (%)
With observer	8	0	100
Without observer	Not directly assessable		

CoP : success – Immediate action was taken when dolphins were encircled.

7. Dolphin encircled - Abort all operations

	Primary action (%)		Secondary action (%)
With observer			
Open front of net	7 (88)		1 (20)
Abort net-set	1 (12)		4 (80)
Without observer			
Open front of net	78 (65)		35 (80)
Abort net-set	39 (33)		7 (16)
Cut from net	2 (1)		1 (2)
Freed self (entangled)	1 (1)		
Herd with skiff			1 (2)
<i>Position in net</i>		<i>Condition on release</i>	
	N (%)		N (%)
With observer			
Free in net	35 (97)	Uninjured	35 (97)
Entangled	1 (3)	Injured	0
		Dead	1 (3)
Without observer			
Free in net	414 (99)	Uninjured	415 (99)
Entangled	5 (1)	Injured	1 (<1)
		Dead	3 (1)

CoP : success – Net-sets were aborted if dolphins were encircled.

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

	Yes	No	CoP followed (%)
Delay/relocate no encircle	12	7	63
Encirclement	8	0	100
TOTAL	20	7	74

CoP : equivocal – WIFs report encirclements, but were less likely to report delays.