Common dolphin capture rate analysis for MSC audit

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1. INTRODUCTION

The South Australian Sardine Industry Association (SASIA) collates a 'real-time database', a collection of vessel logsheet data, that are used to monitor common dolphin (*Delphinus delphis*) interactions and mortalities in the South Australian Sardine Fishery (SASF). These logsheets are forwarded to the South Australian (SA) government and this data is reported by the South Australian Research and Development Institute (SARDI) annually in their interactions and fisher behaviour assessment reports (e.g., Kirkwood & Goldsworthy 2022). However, these reports take several months to produce. This report is based on data from the real-time database and provides an early snapshot of some of the information contained within SARDIs interactions and fisher behaviour assessment reports.

2. METHODS

Data from the real-time database was provided by SASIA in August 2023 and included logsheets from January to July 2023 (Table 1). The rows of the real-time database are defined mathematically in Table 2.

Table 1: Number of records/rows by month, quota year, calendar year, and financial year (July to June) in the 'real-time database' provided by SASIA in August 2023.

Quota/calendar year	Financial year	Month	Number of records/rows
2023	2022-23	January	47
2023	2022-23	February	99
2023	2022-23	March	211
2023	2022-23	April	285
2023	2022-23	May	216
2023	2022-23	June	83
2023	2023-24	July	25

Table 2: Variables defined in equations.

Variable	Description
i	An individual fishing event
N_i	The number of net-sets per fishing event, either 0, 1, or missing (assumed to be 0)
O_i	If an observer was present during a fishing event, either 0 or 1
E_i	If a common dolphin encirclement occurred during a net-set, either 0 or 1
E_i^n	The number of common dolphins encircled per net-set
M_i	If a common dolphin mortality occurred during a net-set, either 0 or 1
M_i^n	The number of common dolphin mortalities per net-set
C_i^L	The estimated catch (tonnes) of sardines per net-set
C_i^R	The estimated catch (tonnes) of sardines per net-set that were released
I_i	The catch per unit effort (CPUE) of sardines as the estimated catch (tonnes) per net-set

Fishing effort (the number of net-sets), the number of dolphin encirclements, and the number of dolphin mortalities were summarised as tables and figures. The total number of net-sets was calculated from the number of net-sets (N) per fishing event (i) as

$$\sum_i N_i$$

The total number of observed net-sets was calculated as

$$\sum_i N_i O_i$$

where O_i indicates if an observer was present on a fishing event (1) or no observer was present (0). Note that this differs from the outputs contained within the real-time database which calculated the total number of observed net-sets as

$$\sum_i O_i$$

This approach may not be desirable because it counts fishing events for which there were no net-sets. However, there were only four events where an observer was onboard and the number of net-sets was set to zero, and there were 32 events where no observer was onboard and the number of net-sets was set to zero. Currently, there is no way to determine why a net-set was set to zero (i.e., was it because cetaceans were present and the fisher moved on, or for some other reason). Another variable may be needed on the logbook sheets to indicate why a net does not go in the water (or at least it should be recorded when a net is not set due to cetacean presence).

Similarly, the total number of common dolphin encirclements was calculated as

$$\sum_i E_i$$

where E_i indicates if a common dolphin encirclement occurred during a net-set. The total number of common dolphins encircled was calculated as

$$\sum_i E_i^n$$

Where E_i^n is the number of common dolphins encircled per net-set. These were split into observed and unobserved using the observer indicator (O_i).

Finally, the total number of events in which a common dolphin mortality occurred was calculated as

$$\sum_i M_i$$

Where M_i indicates if at least one common dolphin mortality occurred during a net-set. The total number of common dolphins killed was calculated as

$$\sum_i M_i^n$$

where M_i^n is the number of common dolphin mortalities per net-set. These were split into observed and unobserved using the observer indicator (O_i).

Catch per unit effort (CPUE) of sardines was defined as the catch (tonnes) per net-set for each fishing event

$$I_i = \left(C_i^L + C_i^R\right)N_i$$

where C_i^L was the estimated catch (tonnes) per net-set and C_i^R was the estimated catch per net-set that was released.

The number of observed common dolphin mortalities per 100 net-sets was defined as

$$\frac{\sum_i M_i^n O_i}{\sum_i N_i O_i/100}$$

and the observed annual mortality estimate was

$$\frac{\sum_i M_i^n O_i}{\sum_i N_i O_i/100} \times \sum_i N_i$$

3. RESULTS

The logbooks recorded a total of 907 net-sets for which catch was landed in the 2022-23 financial year or 930 net-sets from January to July of the 2023 calendar year (Table 3). This includes most of the main fishing period, which typically runs from November to July, with a peak in effort from March to May (Kirkwood & Goldsworthy 2022). Hence, this data extract is likely to include the majority of net-sets during the 2022-23 financial year. Peak fishing effort in 2023 was during March to May (Figure 1), consistent with the second half of the previous financial year (Kirkwood & Goldsworthy 2022), and observer coverage was near or above 10% in all months (Figure 2) and for all vessels (Figure 3).

During 2023, a total of 129 encirclement events were reported, which included a total of 430 encircled common dolphins (Table 3). Of the 129 encirclement events, 19 were during net-sets with observers onboard, with a total of 63 dolphins encircled. The dolphin encirclement rates were similar comparing net-sets with and without an observer onboard, with 15.8 encirclement events per 100 net-sets with an observer onboard, or 13.6 without an observer onboard during 2023 (Table 4). The number of dolphins encircled per 100 net-sets was 52.5 with an observer onboard and 45.3 without (Table 4). A total of two events in which a dolphin mortality occurred were reported, with one dolphin mortality per event (Table 3). Both these mortalities were during net-sets without observers onboard.

The median catch (tonnes) of sardines per net-set was generally lower when an observer was present, which was true of most months (Figure 4) and for most vessels (Figure 5). The number of net-sets per day was generally greater when an observer was present, which was true for most vessels (Figure 6).

Because there we no observed dolphin mortalities, the number of observed dolphin mortalities per 100 net-sets was calculated to be zero, and therefore the annual observed mortality estimated was also zero (Table 5). This also occurred in the 2013-14 and 2017-18 financial years and highlights the limitations of the methods used in this analysis (and by Kirkwood & Goldsworthy 2022). It was unclear how Kirkwood & Goldsworthy (2022) calculated the 5-year mean estimate of annual mortalities, so the numbers presented in this report differ a little to their estimates during the 2019-20 to 2021-22 financial years. However, the numbers are similar enough. During the 2022-23 financial year, the 5-year mean estimate of annual mortality was 18.8 dolphins (Table 5).

Table 3: Summary of fishing effort (net-sets), observer coverage, number of dolphin encirclements, and number of mortality events recorded in the South Australian Sardine Fishery (SASF), by financial year. The 2020-21 and 2021-22 rows are from Kirkwood & Goldsworthy (2022); the 2022-23 row is an incomplete year as it only includes data from January 2023 to June 2023 (i.e., July 2022 to December 2022 are missing); the 2023 row includes data from January 2023 to July 2023 (i.e., this is not a financial year).

	Fishing effort (net-sets)					Encirclement events (no. dolphins)						Mortality events (no. dolphins)					
Financial year	Total	With obs.	W/out obs.	% observed	% target	Total		With obs.		W/out obs.		Total		With obs.		W/out obs.	
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	11.4	10	109	(396)	11	(36)	98	(360)	3	(5)	2	(4)	1	(1)
2022-23	907	111	796	13.9	10	129	(430)	19	(63)	110	(367)	2	(2)	0	(0)	2	(2)
2023	930	120	810	14.8	10	129	(430)	19	(63)	110	(367)	2	(2)	0	(0)	2	(2)

Table 4: Encirclement rates in the SASF based on data collected with and without observers onboard.

	Encirclement events per 100 net-sets		Dolphins encircled per 100 net-sets	
Year	With obs.	W/out obs.	With obs.	W/out obs.
2022-23	17.1	13.8	56.8	46.1
2023	15.8	13.6	52.5	45.3

Table 5: 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 2018-19, as was done in the Kirkwood & Goldsworthy (2022) report.

	Mortalities per 100 net-sets		Annual mortality estimate		5-year mean estimate				
Financial year	With obs.	W/out obs.	With obs.	W/out obs.	N	With obs.	SE	W/out obs.	SE
2015-16	1.064	0.126	9.436	1.119					
2016-17	0.855	0.000	8.333	0.000					
2017-18	0.000	0.000	0.000	0.000					
2018-19	3.361	0.594	32.303	5.707					
2019-20	1.190	0.310	12.512	3.261		7.570	2.674	1.095	0.769
2020-21	3.261	0.266	27.489	2.245	4	12.084	5.756	1.376	0.821
2021-22	1.786	0.114	35.286	1.128	4	18.822	7.854	1.658	0.704
2022-23	0.000	0.251	0.000	2.279	4	18.822	7.854	2.227	0.436
2023	0.000	0.247	0.000	2.296	4	18.822	7.854	2.227	0.436

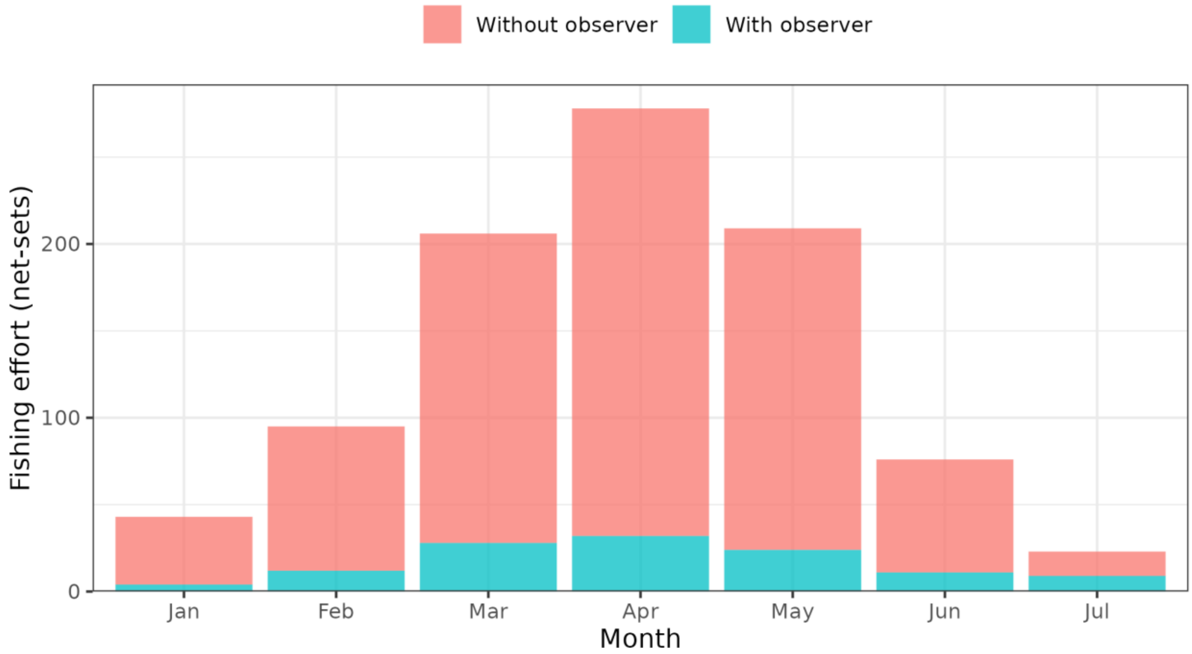

Figure 1: Observer coverage (number of net-sets) by month in 2023.

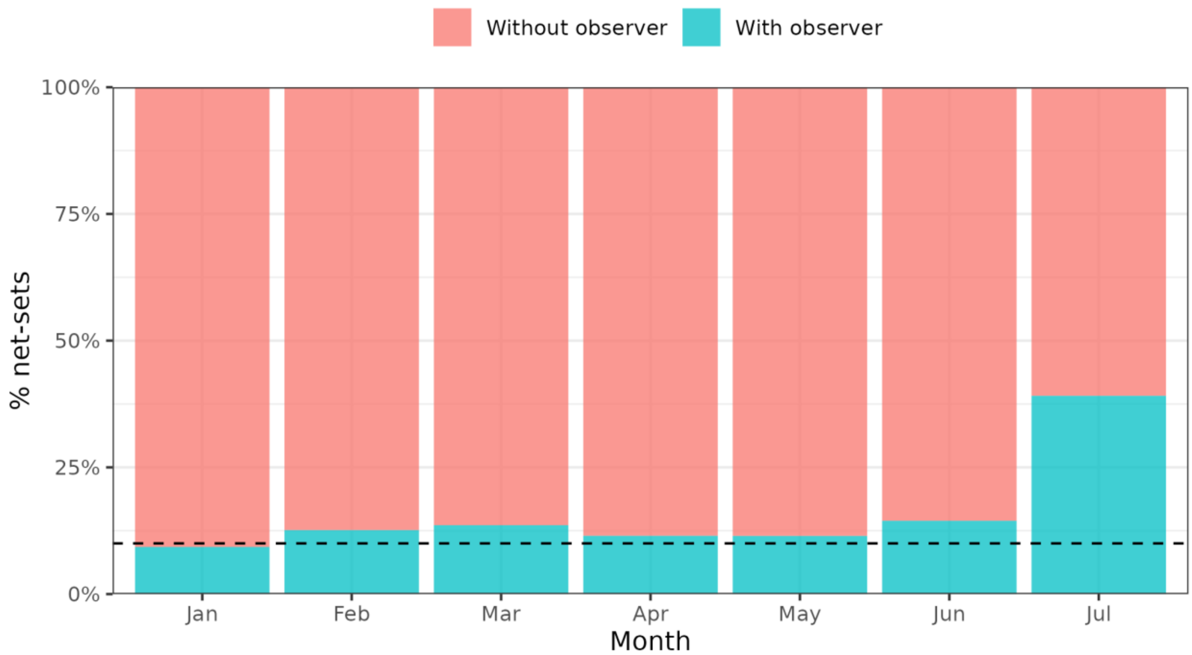

Figure 2: Observer coverage (percentage of net-sets) by month in 2023. The dashed line represents the target of 10% observer coverage and is included for reference.

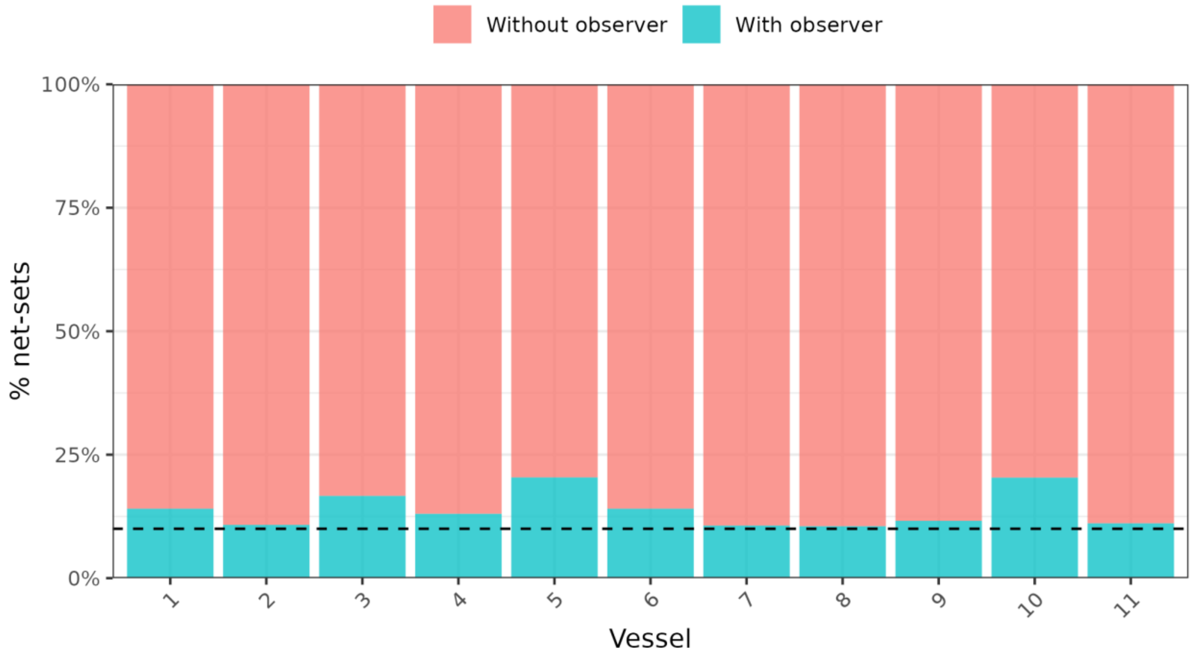

Figure 3: **Observer coverage (percentage of net-sets) in 2023 by vessel (numbers assigned to vessels randomly). The dashed line represents the target of 10% observer coverage and is included for reference.**

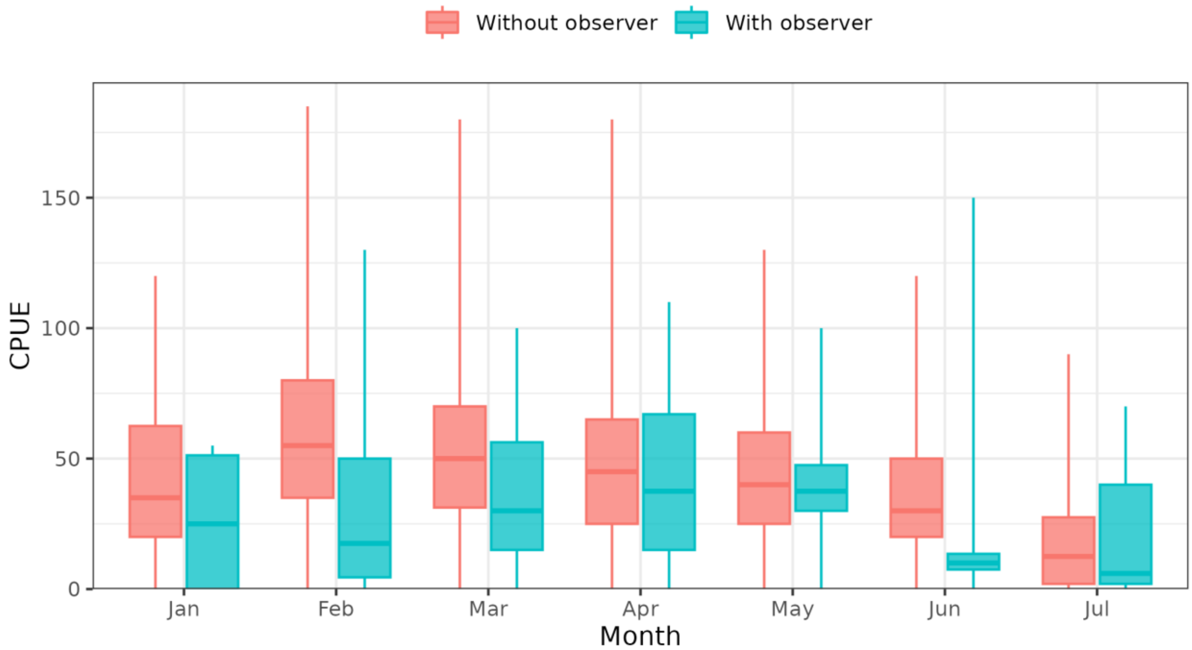

Figure 4: **Catch (tonnes) per net-set (CPUE) by month in 2023 for fishing events with and without an observer present. Note that this includes fish returned to the water.**

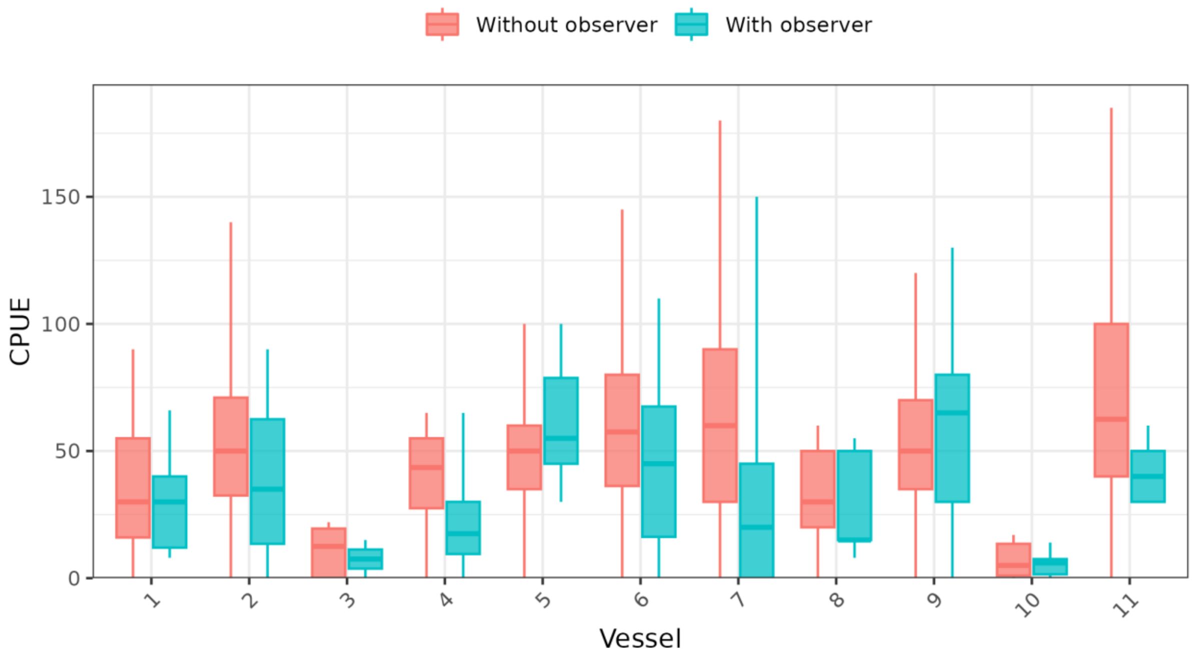

Figure 5: **Catch (tonnes) per net-set (CPUE) by vessel (numbers assigned to vessels randomly) in 2023 for fishing events with and without an observer present.**

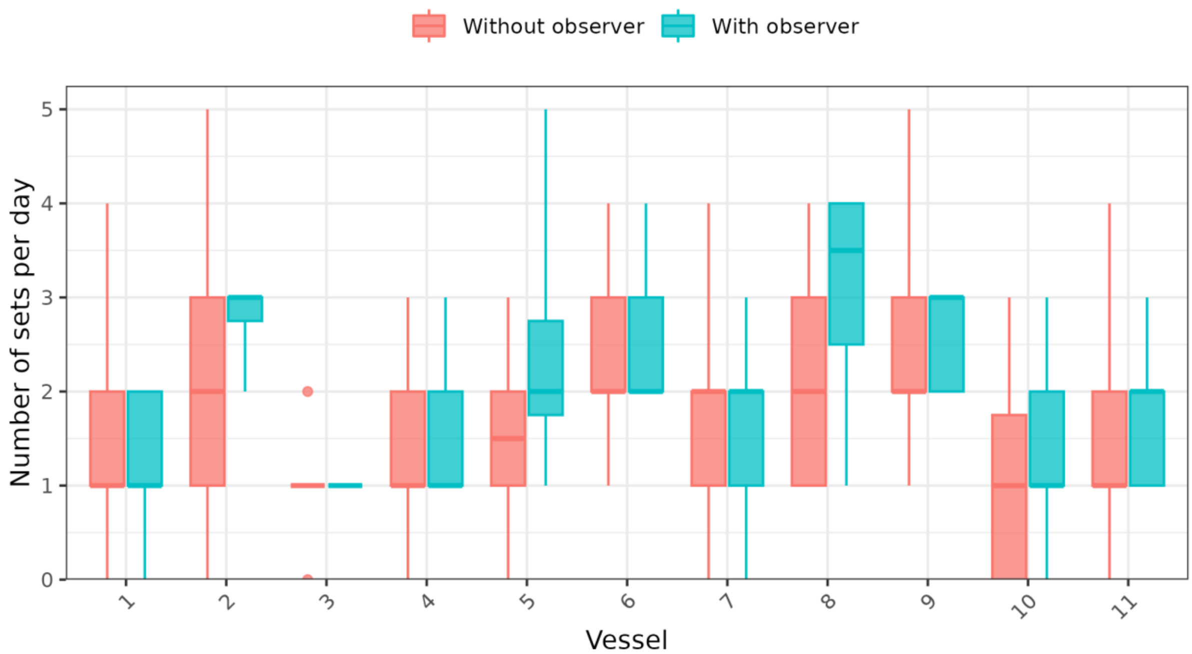

Figure 6: **Number of net-sets per calendar day by vessel (numbers assigned to vessels randomly) in 2023 for fishing events with and without an observer present.**

4. DISCUSSION

Several standard outputs including observer coverage, common dolphin interaction rate, and fishing behaviour and sardine catch rate (i.e., Kirkwood & Goldsworthy 2022) were produced for the partial extract of the real-time database that was provided.

The outputs of this characterisation were broadly similar to those reported for previous financial years, with respect to: observer coverage rate (which exceeded the 10% target value for all months and vessels); the number of reported encirclement events (which were similar comparing observed and unobserved net-sets); and the number of reported mortalities on observed and unobserved events (with two unobserved mortalities and zero observed mortalities in the extract provided).

Differences in fishing behaviour and sardine catch rate when an observer was onboard were also apparent during most months and for most vessels in the extract provided, with a general increase in the frequency of net-sets and decrease in sardine catch per net-set when observers were onboard. Along with the lower reporting rate of mortalities on unobserved events, the apparent difference in fishing behaviour was cited as evidence for an 'observer effect' on fishing behaviour by Kirkwood & Goldsworthy (2022), who therefore concluded that:

> "*…it is not possible to accurately quantify bycatch rates in this fishery and the sustainability of interaction on dolphin populations can only be evaluated with low confidence.*"

With respect to fishing effort, it is strongly recommended that the underlying causes of the increased frequency of fishing events and decreased sardine catch rate when observers are onboard are further explored and better understood, and that this conclusion is reviewed based on this exploration. This exploration should involve a model-based approach to estimating catch rates (i.e., using a CPUE standardisation model), as is best practice in fisheries stock assessment worldwide. Using arithmetic CPUE should be avoided because differences in catch rates due to uncontrolled variables (e.g., time of day, month, moon phase, tide cycle) can result in biased estimates of catch rates and inappropriate conclusions can be reached. Furthermore, some sources of bias with respect to observer coverage of fishing events (e.g., with respect to fishing location, the number of fishing events per night, or hour of the night) can be accounted for using model-based methods for estimating annual mortalities (see below).

The encirclement rates with and without observers present were relatively consistent since 2011-12 (see Table 4 and Kirkwood & Goldsworthy 2022). This consistency in encirclement rates is good to see and suggests a <u>lack</u> of an observer effect on fishing operation <u>as they relate to dolphin interactions</u>. There is some negative bias in the reporting of the number of dolphins reported encircled when an observer is not present and this occurs in this data extract and historically in some years (see Table 4 and Kirkwood & Goldsworthy 2022).

Both of these processes, along with model-based estimates of sardine CPUE and the frequency of net-sets per night, should be considered when conclusions are made about the representativeness of the observer reported data. As it stands, the current evidence for an observer effect is weak and deserves further investigation, which should also focus on dolphin interaction rates.

An observer coverage rate of around 10% across all vessels operating in the fishery over all months of the year is excellent and the consistency of these reporting rates should be commended. This level of observer coverage should be adequate for deriving robust annual estimates of the total number of events in which encirclements occurred, the total annual number dolphins encircled, and the total annual number of dolphins killed. However, the <u>empirical</u> approach used by Kirkwood & Goldsworthy (2022) for estimating these values is clearly insufficient for estimating annual mortality rate, as evidenced by the estimate of observed annual dolphin mortality collapsing to zero when no dolphin mortalities are observed within a year.

In recent years, considerable progress has been made on more sophisticated methods for estimating annual mortalities of bycatch species. For example, the Spatially Explicit Fisheries Risk Assessment (SEFRA) method is a model-based approach that has been applied for all New Zealand seabird and marine mammal species (e.g., Edwards et al. 2023; MacKenzie et al. 2022; Roberts, Webber et al. 2019) and has several advantages over simply scaling up observed mortalities based on the proportion of observed fishing events:

- many potential biases in observer coverage can be accounted for (e.g., with respect to spatial location, month, moon phase, tide, or the frequency of net-sets per night);
- Bayesian inference facilitates the estimation of uncertainty in annual captures (i.e., not just a point estimate, as provided by Kirkwood & Goldsworthy 2022);
- the catchability of dolphins can be calculated across any user-defined group of the observed events, e.g., across multiple years (which is helpful when there are few observed captures each year) or different components of the fishing effort (e.g., in the scenario where observer coverage is biased with respect to hour of the night); and
- cryptic mortality and live-release survival can be formally included in the prediction of total deaths using prior information (not included in the Potential Biological Removal calculations of Kirkwood & Goldsworthy 2022).

The information collected using logsheets and analysed in this report represent a large, complex, but thorough data set deserving of a more sophisticated model-based approach to estimate encirclement rates and dolphin mortalities. An integrated three-step model should be considered – such a model could (1) predict the occurrence of a dolphin encirclement, (2) predict the number of dolphins encircled conditional on encirclement, and (3) predict the annual number of dolphins killed, <u>with uncertainty</u>, given the number that were encircled. As is done in SEFRA, this model-based approach should consider spatial and temporal effects (e.g., more likely to encircle dolphins in some locations, during certain times of day, or different months of the year).

5. REFERENCES

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