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**Understanding and Mitigating Impacts to Whale Sharks in Purse Seine Fisheries of the
Western and Central Pacific Ocean**

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1 Abstract

CMM 2012-04 prohibits setting a purse seine on a school of tuna associated with a whale shark if the whale shark is sighted prior to commencement of the set. Implementation of this CMM on 1 January 2014 extended similar rules applicable within PNA waters to the entire WCPF Convention Area. With one year of data in hand, it is now possible to evaluate the scientific evidence for reduced impacts on whale sharks as a result of the measure. This paper supplements the review to be provided by the Secretariat as part of the Annual Report on the Regional Observer Programme (ROP) by considering this from two aspects: non-ROP reporting and the potential for advancement of simple guidelines on behaviors to avoid when releasing whale sharks. Findings on whale shark post-release survival from studies in the Atlantic purse seine fishery in 2014 are highlighted.

2 Introduction

The whale shark (*Rhincodon typus*) is the world's largest fish and occurs globally throughout tropical and warm temperate seas. It has the highest fecundity of any shark species known to date, but its slow growth rate and high longevity (and consequently low natural mortality) makes the species highly vulnerable (Clarke et al. 2015). The whale shark was listed on Appendix II of the Convention on International Trade in Endangered Species (CITES) in 2003, on Appendix II of the Convention of Migratory Species (CMS) in 1999, and as a Western and Central Pacific Fisheries Commission (WCPFC) key shark species in December 2012.

Parties to the Nauru Agreement (PNA)¹ adopted a ban on “fishing or related activity in order to catch tuna associated with whale sharks” under their Third Implementing Arrangement in September 2010 (PNA 2011). The WCPFC strengthened regional protection for the whale shark by adopting a conservation and management measure (CMM) in December 2012 prohibiting “setting a purse seine on a school of tuna associated with a whale shark if the animal is sighted prior to commencement of the set” (CMM 2012-04). With these measures in place it might be expected that the number of Western and Central Pacific Ocean (WCPO) purse seine sets interacting with whale sharks would decrease over time. However, as explicitly acknowledged in the WCPFC CMM, the presence of a whale shark may go unnoticed until the set is made. Therefore, even with gradual implementation leading to full compliance with the measures, they would be expected to reduce interactions only in those sets where the whale shark is known to be present prior to setting. Previous analysis of observer data suggests that more than two-thirds of the sets with whale shark interactions (73%) were not known by the observer to be set on a whale shark until the animal was discovered in the net during the brailing process (SPC-OFP 2012). Assuming the observer's knowledge is similar to the fishing master's, it may be presumed that less than one-third of the interactions can be knowingly avoided (Clarke 2013).

Given that a large proportion of the interactions between whale sharks and the purse seine fishery are thus not expected to be mitigated by a ban on intentional setting alone, it is important to develop techniques to safely release whale sharks with minimal harm. This topic has been considered by the WCPFC's Scientific Committee (SC) since 2011 (SC7), but to date while guidelines are discussed and revised each year, they remain in draft form and have not yet been adopted by the Commission (WCPFC 2014a, Annex I).

¹ The PNA is comprised of the Federated States of Micronesia, the Republic of Kiribati, the Republic of the Marshall Islands, the Republic of Nauru, the Republic of Palau, Papua New Guinea, Solomon Islands and Tuvalu.

This paper summarizes the available information from WCPFC members' Annual Reports-Part 1 on their implementation of CMM 2012-04 (now available for the first time), and available Regional Observer Programme (ROP) for 2010-2014, to explore the extent of interactions between whale sharks and the WCPO purse seine fishery. It then summarizes existing information on release techniques and proposes some basic proscriptions (i.e. prohibited actions). These could be adopted as a minimum and interim set of safe release guidelines while studies, such as those now available from the Atlantic, continue to research appropriate positive techniques.

3 Updated Analysis of Interaction Rates

3.1 Data used in this Analysis

As described by Harley et al. (2013) interactions between whale sharks and the purse seine fishery may be identified from observer data in three ways. The first way is when the observer identifies the set type's school association as "live whale shark". However, for reasons described above many sets for which a whale shark catch or interaction is ultimately recorded are not marked as "live whale shark-associated" in the set type data (SPC-OFP 2012). Similarly, as noted by Harley et al. (2013) it is also possible that not all live whale shark-associated sets necessarily result in the encirclement of the whale shark. In the 2014 ROP data available at the time of writing only 24% of sets which reported whale sharks as catch were marked as 'live whale shark-associated' sets. For this reason, set type was not used as an indicator of interactions in this analysis.

When observers find whale sharks encircled in the net they are instructed to record them as catch (Form PS-2) and as a species of special interest (SSI, Form GEN-2). As anticipated, the numbers of whale sharks recorded on these two forms for 2014 were quite close, i.e. 106 versus 109, but since the latter number was higher and is accompanied by release condition data the SSI dataset was used for this analysis. This is also useful because the SSI data are used in the Secretariat's required report to the Technical and Compliance Committee (TCC) each year under CMM 2012-04 (WCPFC 2014b).

This year for the first time there are also data on whale shark interactions available from WCPFC members' Annual Reports (AR)-Part 1. At the time of writing all ARs-Part 1 were available on the WCPFC website except for those from Ecuador and Wallis & Futuna.

3.2 Comparison of ROP and AR-Part 1 Reported Encirclements

Previous analysis of whale shark interaction rates was based on data through 2010 (SPC-OFP 2012), i.e. before either the PNA or WCPFC whale shark measures were fully implemented. This analysis found that vessel logsheets tend to report both whales and whale sharks associated with tuna schools as 'whale-associated' sets rather than distinguishing between 'whale-associated' and 'whale shark-associated' sets as observers do. Furthermore, the analysis found that even if 'whale-associated' and 'whale-shark associated' sets were summed, the logsheets 'severely' under-reported these sets as compared to observer records in 2007-2009 (by 72%) and to a slightly lesser degree in 2010 (by 65%). As catches, or encirclements, of whale sharks were not recorded on purse seine logsheets it was not possible to make a comparison between actual encirclements recorded by observers versus vessels. In summary, the only comparative data available (i.e. the set-type data) suggested that observer records would be a much more reliable source of estimating whale shark interactions.

This may have changed with the implementation of CMM 2012-04 on 1 January 2014. This new CMM contains a requirement to report incidents of whale shark encirclement, including the number of individual fish involved, to the flag State. These vessel-based reports of interactions for 2014 are reported in the ARs-Part 1 in July 2015 and should represent all fishing activities in the WCPFC Convention Area (assuming full implementation). These vessel-based records can be compared to observer records but this comparison is complicated by two issues. First, there is a lag in the availability of observer data for the most recent years; SPC reported in July 2014 that 79%, 72%, 69% and 41% of the observer trips for 2010-2013, respectively, were available for analysis (Williams et al. 2014). Second, although 100% observer coverage has been required for the purse seine fleet since 1 January 2010, this only applies to waters between 20°N and 20°S². In recent years effort in the northern purse seine fishery has expanded to between 5-11% of the total WCPO purse seine fishing effort (Figure 1). This northern fishery has historically reported an incidence of setting on whale sharks that is five times higher than in the tropical fishery (Matsunaga et al. 2003). For these reasons, using the observer data may thus underestimate the number of whale shark interactions, particularly for the most recent years.

The number of whale sharks reported to have been encircled by the WCPO purse seine fishery according to ROP observer reports (as of the time of writing) do not show that the interactions have decreased, either in PNA waters or as a whole, between 2010-2013 (Table 1). Data for 2014 are incomplete and so cannot validly be compared to previous years. A tally of reported interactions from the ARs-Part 1 indicates that in 2014 a total of 297 whale sharks were encircled.

Table 1. Number of whale sharks reported as encircled in the WCPO purse seine fishery, 2010-2014, by observers and in ARs-Part 1, total purse seine effort between 20°N-20°S, and a calculated annual interaction rate.

Year	Number of Whale Sharks					Effort Total number of Sets (20°N-20°S)	Interaction Rate Whale sharks encircled per 1000 sets
	Observer Data			ARs-Part 1	Taking the higher estimate for each CCM		
	PNA waters	Non-PNA waters	Total				
2010	126	52	178	NA	NA	51,192	3.5
2011	119	15	134	NA	NA	51,920	2.6
2012	206	21	227	NA	NA	56,713	4.0
2013	212	6	218	NA	NA	55,819	3.9
2014	105*	4*	109*	297	323*	55,804	5.8

* incomplete due to a lag in receiving observer data

Sources: WCPFC ROP database, WCPFC CCM's Annual Reports-Part 1 and Williams and Terawasi (2015)

² It should be noted that while the requirement for 100% observer coverage applies to purse seine vessels fishing entirely within a single national jurisdiction, such observer data may be not required to be submitted to the WCPFC's ROP database.

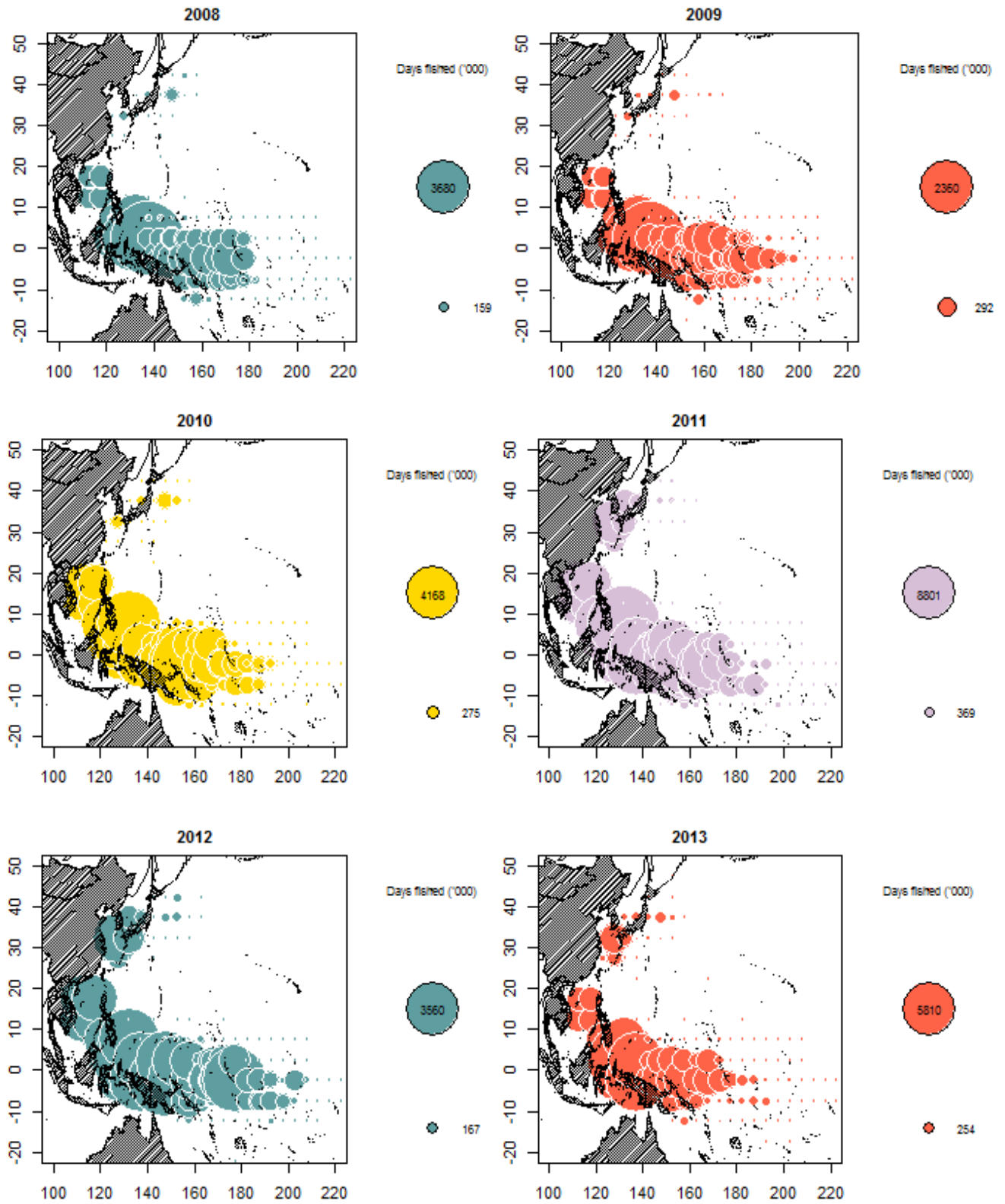


Figure 1. Purse seine effort in days, 2008-2013 (Source: SPC Catch and Effort Query System (CES), public domain data, downloaded July 2015)

There are eleven flag States with whale shark interactions in the [partial] ROP database in 2014 and of these, five were shown to have a higher number of interactions in the [partial] ROP data for 2014 than was reported in their ARs-Part 1. If the number of interactions in 2014 is tallied using the higher of the ROP and the AR-Part 1 figures for each CCM, the total is 323 encircled whale sharks (Table 1). While this number of encirclements is higher than any of those in the preceding years it may still represent an underestimate due to incomplete ROP data and/or incomplete reporting by vessels (with or without observers) to their flag States. This comparison suggests that relying solely on the ROP dataset may not provide an accurate depiction of the extent of interactions in the WCPO fishery, particularly for the immediately preceding year.

Estimates of the number of whale sharks encircled annually need to be considered, if possible, in the context of the fishery and the whale shark population. The numbers in Table 1 would be expected to increase with an increase in effort in the purse seine fishery and/or with an increase in the whale shark population. As there is no information on the latter, further interpretation of the numbers in Table 1 inevitably focuses on the fishery but must acknowledge that changes in interaction rates may thus be ambiguous. For example, if the number of whale sharks encircled decreases while the effort in the purse seine fishery increases, it may be because the conservation and management measures are serving to reduce the number of sets on whale sets, or alternatively that the number of whale sharks is declining (or both).

If the most recent effort figures for purse seine effort between 20°N-20°S are indicative of the fishery as a whole (and assuming the whale shark population is stable), a noticeable variation in the number of encircled whale sharks would not be expected in 2012-2014 (Table 1; Williams and Terawasi 2015)³. However, calculation of an interaction rate (number of whale shark encircled per 1000 sets) based on the 2014 estimate of 323 encircled whale sharks would represent a substantial increase over all of the annual figures since 2010.

Such interaction rates can provide a basis for comparison between the purse seine fisheries managed by the tuna Regional Fisheries Management Organizations (t-RFMOs). Indicative information from the Eastern Pacific Ocean, where there is 100% observer coverage on purse seiners with carrying capacities >363 tonnes, suggests that for 2014 there were 23,569 purse seine sets with 25 whale sharks encircled giving an interaction rate per thousand sets of 1.1 (IATTC, pers. comm.). In the Atlantic Ocean, the French fleet maintained 100% observer coverage in 2014 and reported 60 whale shark-associated sets of a total of 2,033 sets for an interaction rate of 29.5 (L. Escalle, pers. comm.).

3.3 Data on the Fate of Whale Sharks Encircled in Purse Seines

Of 33 CCMs submitting ARs-Part 1 reports, it is believed that 20 had purse seine vessels operating under their flag in 2014 (L. Manarangi-Trott, pers. comm.). A review of the ARs-Part 1 showed that only twelve reported any interactions with whale shark and of these twelve, only four reported where the interaction took place and only seven reported on the life status of the released whale shark as required by the CMM (one reported life status for less than half of the dozens of

³ In addition to examining the total number of purse seine sets, it would also be interesting to examine whether recent FAD closure periods have influenced the number of reported whale shark interactions. For example, Williams and Terawasi (2015) report that “FAD closure periods (since 2010) have clearly contributed to an increase in unassociated sets”; these unassociated sets may in the end be found to contain whale sharks. The seasonality of the FAD closures versus any seasonal patterns in whale shark abundance might also be a factor.

interactions reported). None of the reports contained required information on how the animal was safely released.

As result, the most comprehensive information on the fate of whale sharks encircled in the WCPO purse seine fishery derives from the ROP database. These data were classified into categories of alive (“discarded alive” and “escaped”), dead (“discarded dead”, “retained, finned”⁴, “retained, other reason”, “retained whole weight”, and unknown (“discarded unknown”, “discarded, unwanted species”, “discarded, poor quality” and two other unknown codes) (Table 2). The data are generally consistent over the period 2010-2014 with 50-60% of encircled whale sharks surviving the encounter, 5-10% dying and 30-40% with life status unknown. Much of the interpretation of these data depends on assumptions regarding the “unknown” category. In the worst case, even without accounting for chronic post-release mortality amongst those released alive, it is possible that up to half of the whale sharks may not survive the encounter. As such, in 2014 potential mortalities range from a minimum of 11 to 42 (if those with unknown status were injured or dying), or even higher if any of those classified as alive at release subsequently died from injuries or stress. The impact of this level of mortality to Pacific whale shark populations remains unknown.

Table 2. Number and percentage of encircled whale shark reported as alive, dead or unknown life status by observers, 2010-2014.

Year	Number encircled	Number reported dead (%)	Number with unknown life status (%)	Number reported alive (%)
2010	178	12 (7%)	74 (42%)	92 (52%)
2011	134	6 (4%)	45 (34%)	83 (62%)
2012	227	16 (7%)	92 (41%)	119 (52%)
2013	218	18 (8%)	69 (32%)	131 (60%)
2014	109*	11 (10%)	31 (28%)	67 (61%)

* incomplete due to a lag in receiving observer data
Source: WCPFC ROP database

Given that intentional setting on whale sharks is already prohibited, it is clear that any further reduction in mortality rates will need to be found in better handling practices. The reporting required under the CMM appears to be designed to provide for useful safe release techniques to be reported and thus disseminated, but for 2014 no CCMs provided any information on release techniques.

4 Safe Release

Discussions held at annual WCPFC Scientific Committee meetings since 2011 have failed to result in agreed safe release guidelines for encircled whale sharks. This situation appears to be due to a lack of documentation of the effectiveness of various methods which prevents a decision on recommending some techniques over others. In order to address this, a limited programme of whale shark post-release mortality tagging research has been initiated (NOAA Fisheries 2015) but it will likely be some time before statistically robust information can be presented for the WCPO.

In a similar vein, European researchers have attached tags to six whale sharks released from French and Spanish purse seiners operating in the Atlantic Ocean’s Gulf of Guinea (Escalle et al. 2014, Murua et al. 2014). Preliminary results report that five sharks survived to at least 21 days after

⁴ One whale shark was reported by an observer to have been finned in 2012.

release and the tag attached to the sixth shark did not report (Escalle et al. 2014, Murua et al. 2014). The safe release technique used in the experiments to release large (8-12 m) whale sharks involved placing a cable under the sack after brailing to roll the whale shark over the float line as follows:

- a cable was passed through and under the net on deck
- the cable was then passed, on the outside of the sack, to a member of the crew on the speed boat
- the crew member attached the cable to the cork sack ring
- the corkline is slacked from the power block and the brailing boom
- when the cable is tightened, it positions itself under the sack by slipping along the gunwale; and then it will pull down the cork line, leading to the whale shark's head passing over the cork line (L. Escalle et al., in prep).

Recognizing that agreement on recommending certain safe release methods over others will take time, it may still be possible to agree on techniques that should not be used because they are clearly harmful to encircled whale sharks. Some examples may include:

- do not vertically hoist by the tail
- do not attach a line or cable through the gills and attempt to tow or pull
- do not bore a hole through any fin and attempt to tow or pull
- do not gaff
- do not attempt to brail whale sharks larger than 2 meters and if brailing do not bring on deck

CCMs and other experts are invited to contribute additional proscriptions to this list and to consider its adoption as an initial WCPFC safe release guideline which can be expanded further as new information becomes available.

5 Summary

The conclusions of this paper are as follows:

- Although a previous study showed that logsheets 'severely' under-estimate the number of encircled whale sharks as compared to observer data, flag State-reported interactions for 2014 exceed the currently available ROP-reported figures by nearly three times.
- This comparison suggests that relying solely on the ROP dataset may not provide an accurate depiction of the extent of interactions in the WCPO purse seine fishery, particularly for the immediately preceding year. This is due to lags in ROP data provision and because a portion of the fishery does not have high coverage in the ROP dataset.
- A reasonable estimate of the number of whale sharks encircled in 2014 is 323, and this is considerably higher than annual figures for 2010-2013, both in absolute numbers and as a rate of encircled sharks per 1000 sets. If ROP data (only) for 2010-2013 are considered there is an apparent increase in encirclements in 2012-2013 over 2010-2011.
- Observers consistently report that 5-10% of encircled whale sharks die, 50-60% survive and 30-40% have unknown life status at discarding/releasing. As such, in the worst case, even without accounting for chronic post-release mortality amongst those classified as alive at release, it is possible that up to half of the whale sharks may not survive the encounter.

- Given that intentional setting on whale sharks is already prohibited, it is clear that any further reduction in mortality rates will need to be found in better handling practices.
- CCMs are required to report what steps were taken to ensure safe release, but none did so for 2014 and documentation of release practices and their results remain scarce.
- Research is now underway but it will likely take some time for best practices to be identified. It is therefore recommended to adopt some basic proscriptions (i.e. prohibited actions) as an initial set of safe release guidelines.

WCPFC SC11 is invited to consider adopting the following proscriptions as a basic set of safe release guidelines for encircled whale sharks: i) do not vertically hoist by the tail; ii) do not attach a line or cable through the gills and attempt to tow or pull; iii) do not bore a hole through any fin and attempt to tow or pull; iv) do not gaff; and v) do not attempt to brail whale sharks larger than 2 meters and if brailing do not bring on deck.

WCPFC SC11 is also invited to recommend that CCMs be encouraged to report steps taken to ensure safe release of whale sharks in their ARs-Part 1 as required, and to report any national safe release requirements implemented in parallel with the implementation of CMM 2012-04 in ARs-Part 2. Any new information on safe release techniques in either report should be highlighted by the reporting CCM or by the Secretariat for an annual review of the safe release guidelines by the WCPFC Scientific Committee.

6 Acknowledgements

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