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WHALE SHARK INTERACTIONS WITH THE TUNA PURSE-SEINE FISHERY IN THE EASTERN PACIFIC OCEAN: SUMMARY AND ANALYSIS OF AVAILABLE DATA

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CONTENTS

1. INTRODUCTION

The whale shark, *Rhincodon typus* is the world's largest fish species, commonly exceeding 1000 cm total length (TL), with 1800 cm as the maximum length measured, but possibly reaching about 2000 cm TL (Compagno 2001; Stevens 2007). It inhabits all tropical and warm temperate ocean areas, and unlike almost all other sharks, feeds mainly on plankton (Compagno 2001). It is globally classified as "endangered" under IUCN Red List criteria (Pierce and Norman 2016), and since 2003 has been listed by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in Appendix II (CITES 2017).

Interactions between whale sharks and the purse-seine fishery for tunas are known to occur in the eastern Pacific Ocean (EPO), although they are relatively uncommon. Observers of the Inter-American Tropical Tuna Commission (IATTC) and of the national programs that constitute the On-Board Observer Program of the Agreement on the International Dolphin Conservation Program (AIDCP), who are required aboard all large[1] purse-seine vessels, collect data on these interactions.

This document provides a summary description of the types of data on whale sharks in the EPO available in IATTC databases, and some preliminary analyses of the data.

2. SOURCES OF DATA ON WHALE SHARKS IN THE EPO

On-board observers have routinely collected data on bycatches in the EPO, including whale sharks, since 1993. However, prior to 2005, the only data collected were for sharks that died as a result of interactions

[1] Defined as of carrying capacity 363 t or greater

with the fishery. Interactions with whale sharks are rare, and the number of mortalities of whale sharks recorded by observers is very small. Moreover, on the forms used by the observers, whale sharks were grouped with several other shark species in an "*Other identified shark*" category. Therefore, there are essentially no data available prior to 2005.

IATTC Resolution C-00-08, adopted in 2000, called for fishers on purse-seine vessels to "promptly release unharmed, to the extent practicable", all non-target species, including sharks, and encouraged them to develop techniques and equipment to facilitate this. It did not mention whale sharks specifically. Implementing this measure required a better understanding of the interactions of whale sharks with the tuna fishery, including their fate after release, and the development of suitable release techniques, and during 2003-2004 an experimental program was implemented during which on-board observers collected some information on these interactions. This resulted in data on the date, time, location, and set type, as well as the fate of the whale shark, in 130 interactions; however, no size data were collected.

Resolution C-05-03, adopted in 2005, was the first to address sharks exclusively. It resulted in the *Shark Record* (Appendix 1), a dedicated data-collection form for sharks (including whale sharks), on which observers record information on sharks released alive, as well as biological data such as length.

Resolution C-13-04 on fish-aggregating devices, adopted in 2013, and currently in force as Resolution C-16-01, was the first to address whale sharks specifically. Although it did not establish any data-reporting requirements, it did require that any bycatches of whale sharks be reported "*to the relevant authority of the flag CPC, including the number of individuals, details of how and why the encirclement happened, where it occurred, steps taken to ensure safe release, and an assessment of the life status of the whale shark on release*."

Resolution C-16-01, like its predecessors, requires that CPCs prohibit their flag vessels from setting on tunas associated with live whale sharks. An unintended result of this is that observers, who are required to record only whale sharks involved in sets, do not record sightings of whale sharks that are not subsequently set on, thus potentially losing data that could be useful for abundance analyses.

In this document, the analyses based on length use data collected on the *Shark Record* during 2005-2016; other analyses include data from the experimental program in 2003-2004.

3. ANALYSIS OF AVAILABLE DATA

3.1. Interaction rates

From 2003 through 2016, 867 whale sharks have been involved in 718 interactions[2] with the tuna purse-seine fishery in the EPO. The rate of interactions was very low, averaging about 3 per 1000 sets, but quite variable, with a peak of about 12 in 2006, and a low and steady trend since 2014 (Figure 1). Of the three set types made by this fishery (on tunas associated with dolphins, tunas associated with floating objects, and unassociated tuna schools), whale sharks are most commonly involved in unassociated sets (Figure 2), possibly because tunas and whale sharks converge in the same areas where their prey occurs, or whale sharks are incidentally caught when the vessel is targeting a school of tunas, or whale sharks attract tunas in a manner similar to floating objects and the vessel targets them in order to easily catch the tunas.

In an analysis of 5°-areas in which at least 500 sets were made during 2003-2016, both the number and rate of interaction during that period were highest in the area southwest of the Galápagos Islands, between 0° and 5°S from 90° to 95°W (Area 1; Figures 3-5), and off Ecuador and Peru between 0° and 10°S (Area 2; Figures 3-5). Unassociated sets had the highest absolute values of interactions in Area 2 (max = 312) and interaction rates (range 13.3 to 67.2; Figure 4). Interactions in floating-object sets were more

[2] An interaction is defined as the presence of one or more individuals in a purse-seine set

widely distributed (Figure 5), with the higher values located west of Area 1, but had much lower absolute values (max = 10) and interaction rates (range 2.9 to 3.7). Interactions in dolphin-associated sets were not included in the analyses, as they were extremely rare, with only three recorded cases during the entire period.

On average, 93% of whale sharks caught were released alive, although release rates vary among years (Figure 6). In 2007 it was 100%; the low of 77.5% in 2013 was distorted by a single set which resulted in six of the seven mortalities of whale sharks recorded in the fishery in that year.

3.2. Spatiotemporal distribution of interactions

Whale sharks have been found in aggregations (Last and Stevens 1994; Compagno 2001; Stevens 2007). In the tuna purse-seine fishery they are involved both as individuals and in aggregations, although sets with more than one whale shark, which are mostly unassociated sets (Figure 7) during the first quarter of the year (Figure 8), are much less frequent than sets with only one.

The greatest numbers of whale sharks involved in interactions with the fishery occurred in Area 2, mainly in unassociated sets, during the first quarter of the year (Figure 9), when this area is associated with the peaks of primary production of the Humboldt Current system (Martínez *et al*. 2015; Thomas *et al*. 1994). It is estimated that over 50% of these individuals are over 900 cm in length, and therefore probably adults (Colman 1997) (Figure 9). The apparent absence of whale sharks in Area 2 during the third quarter (Figure 9) may be an artefact of the exceptionally low purse-seine effort in that time-area stratum.

4. REFERENCES

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Figures:

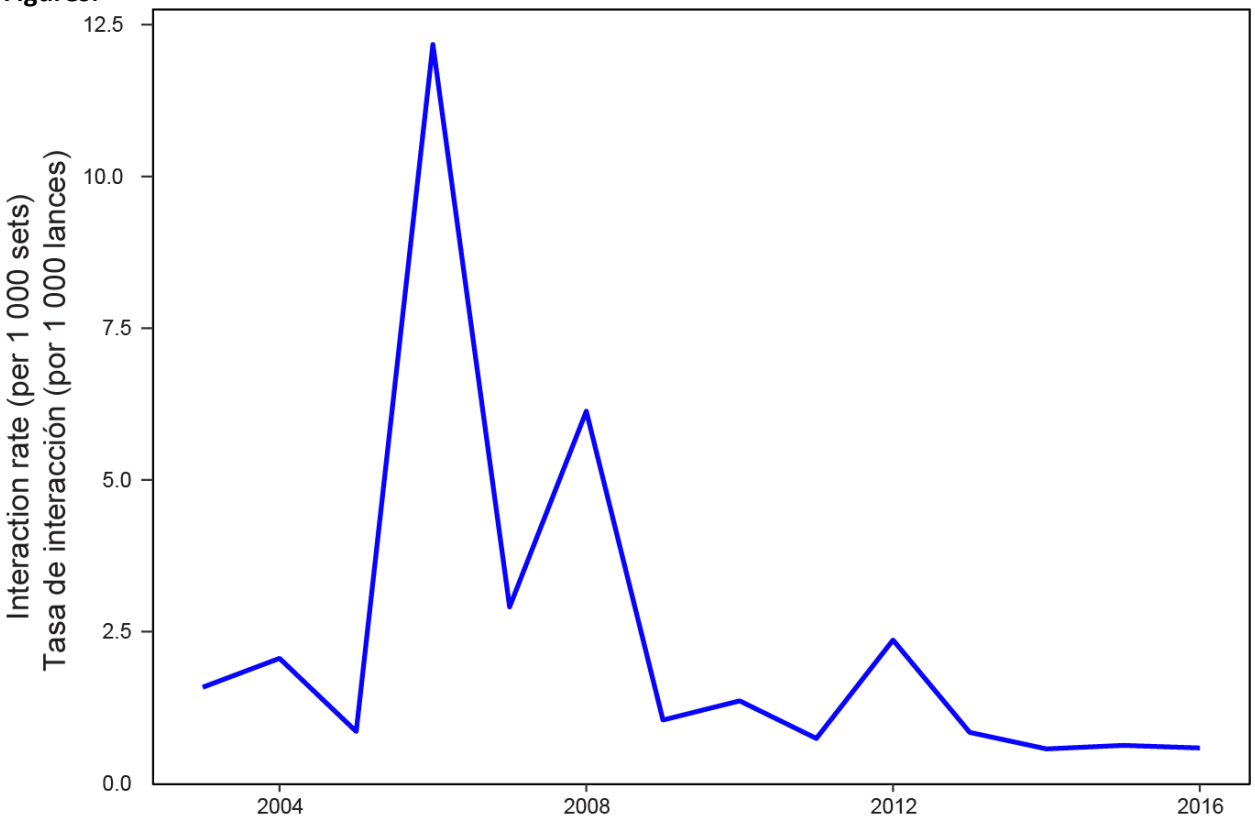


FIGURE 1. Interaction rates of whale sharks with the purse-seine fishery, per thousand sets, all set types combined, 2003-2016.

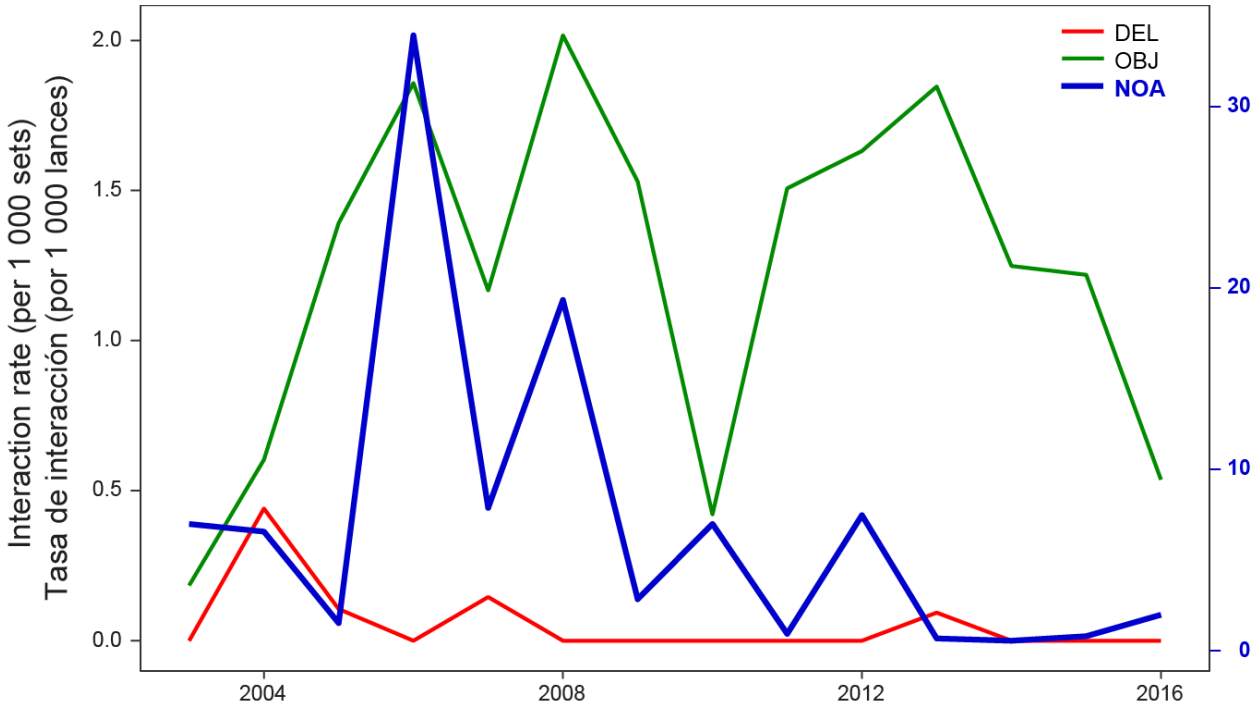


FIGURE 2. Interaction rates of whale sharks with the purse-seine fishery, per thousand sets, by set type (dolphin (red), floating-object (green), and unassociated (blue)), 2003-2016. Note that the scale for unassociated sets on the right y-axis is different.

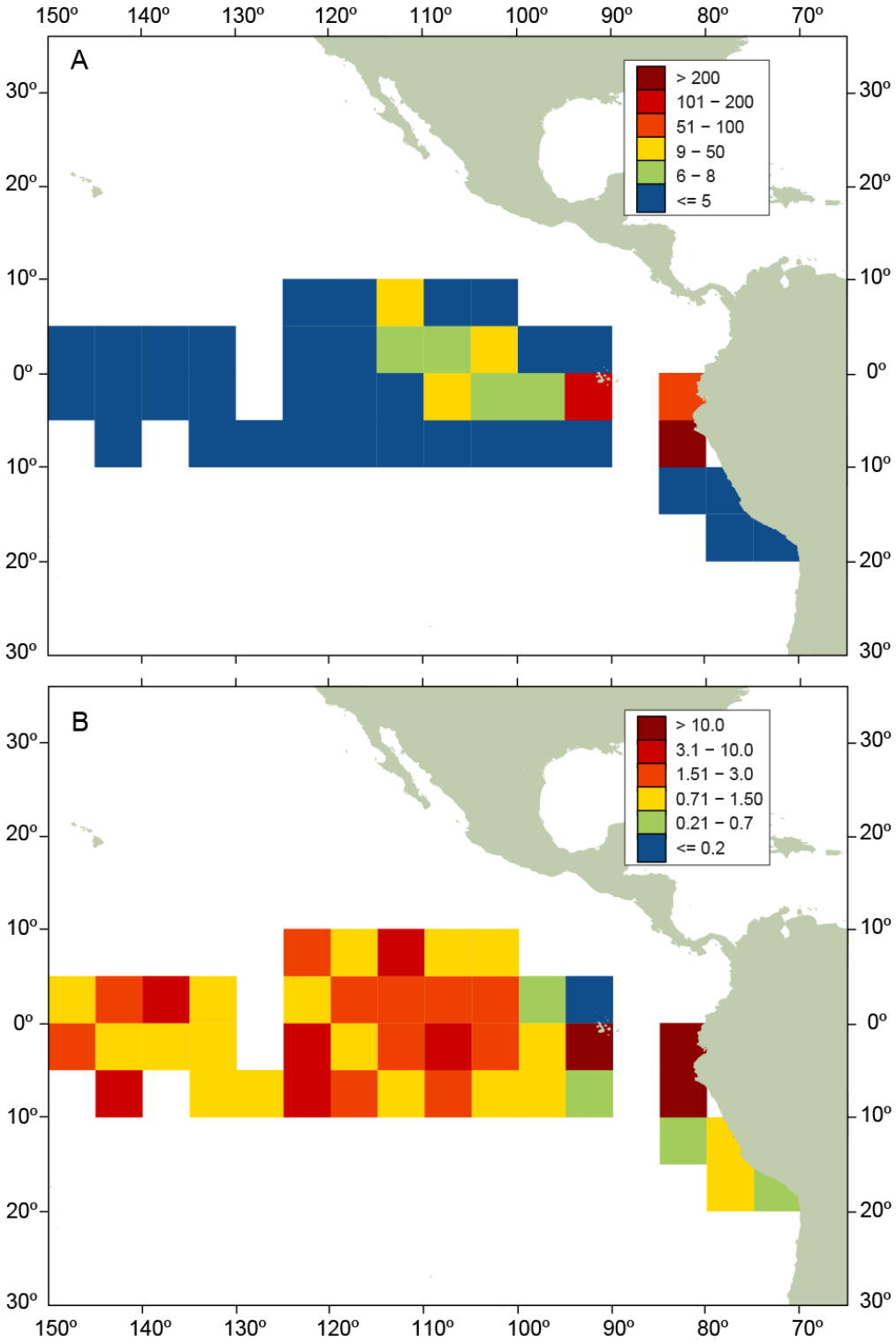


FIGURE 3. Spatial distribution of (a) interactions and (b) interaction rates (per 1000 sets) of whale sharks, all set types combined, 2003-2016 year-period, by 5° area. Includes only areas with more than 500 sets made during that period.

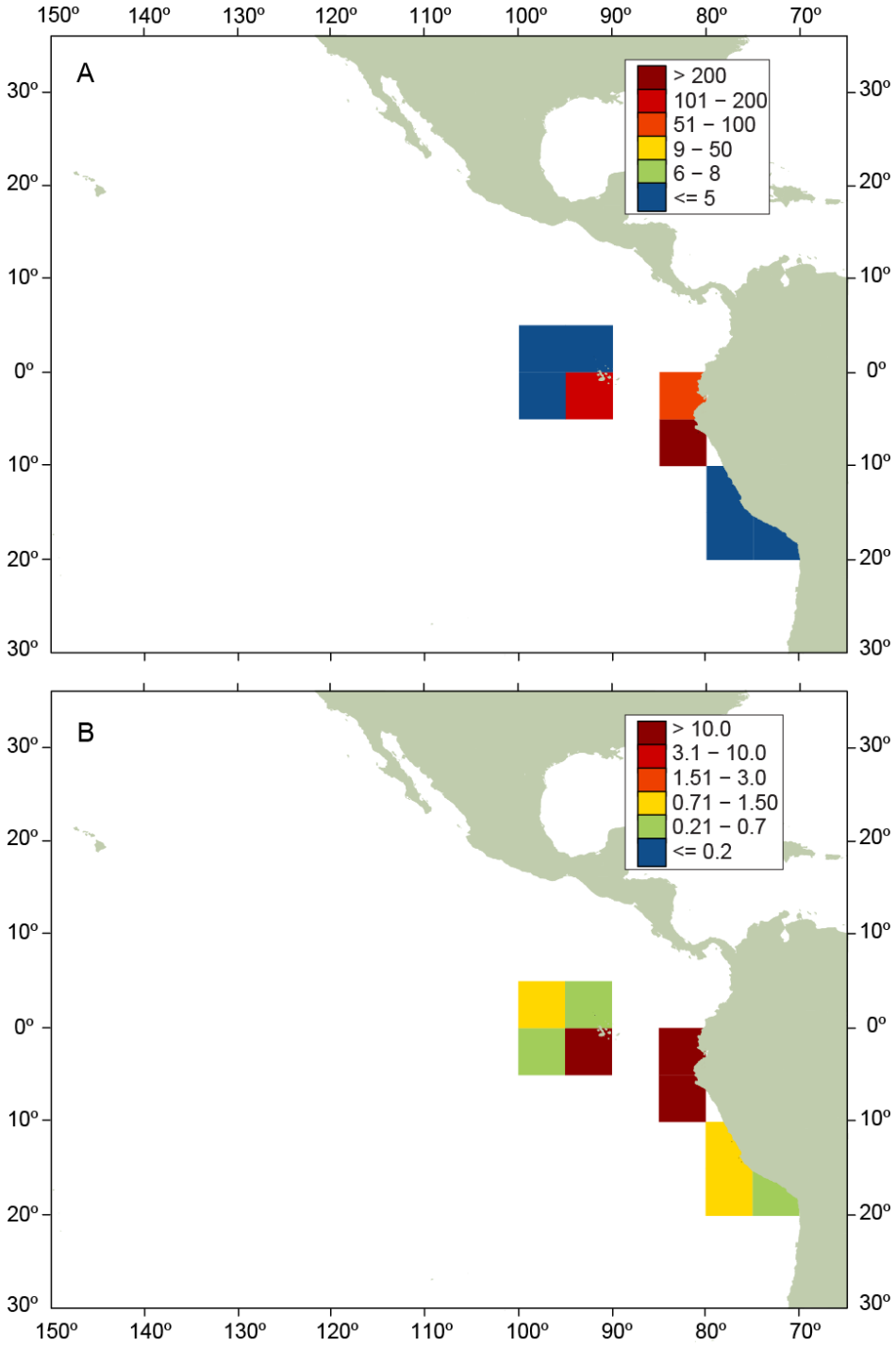


FIGURE 4. Spatial distribution of (a) interactions and (b) interaction rates (per 1000 sets) of whale sharks in unassociated sets, 2003-2016 year-period, by 5° area. Includes only areas with more than 500 sets made during that period.

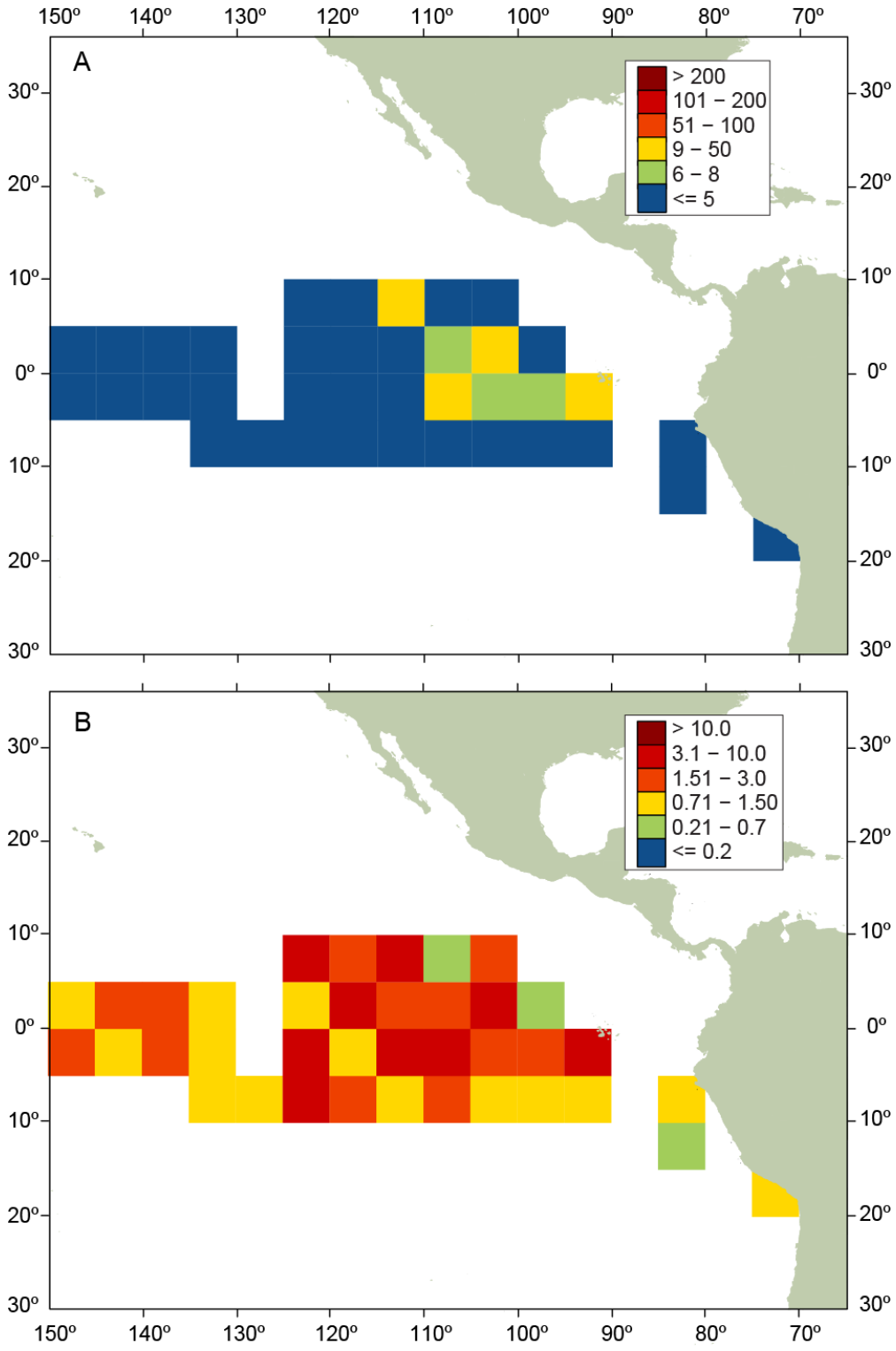


FIGURE 5. Spatial distribution of (a) interactions and (b) interaction rates (per 1000 sets) of whale sharks in floating-object sets, 2003-2016 year-period, by 5° area. Includes only areas with more than 500 sets made during that period.

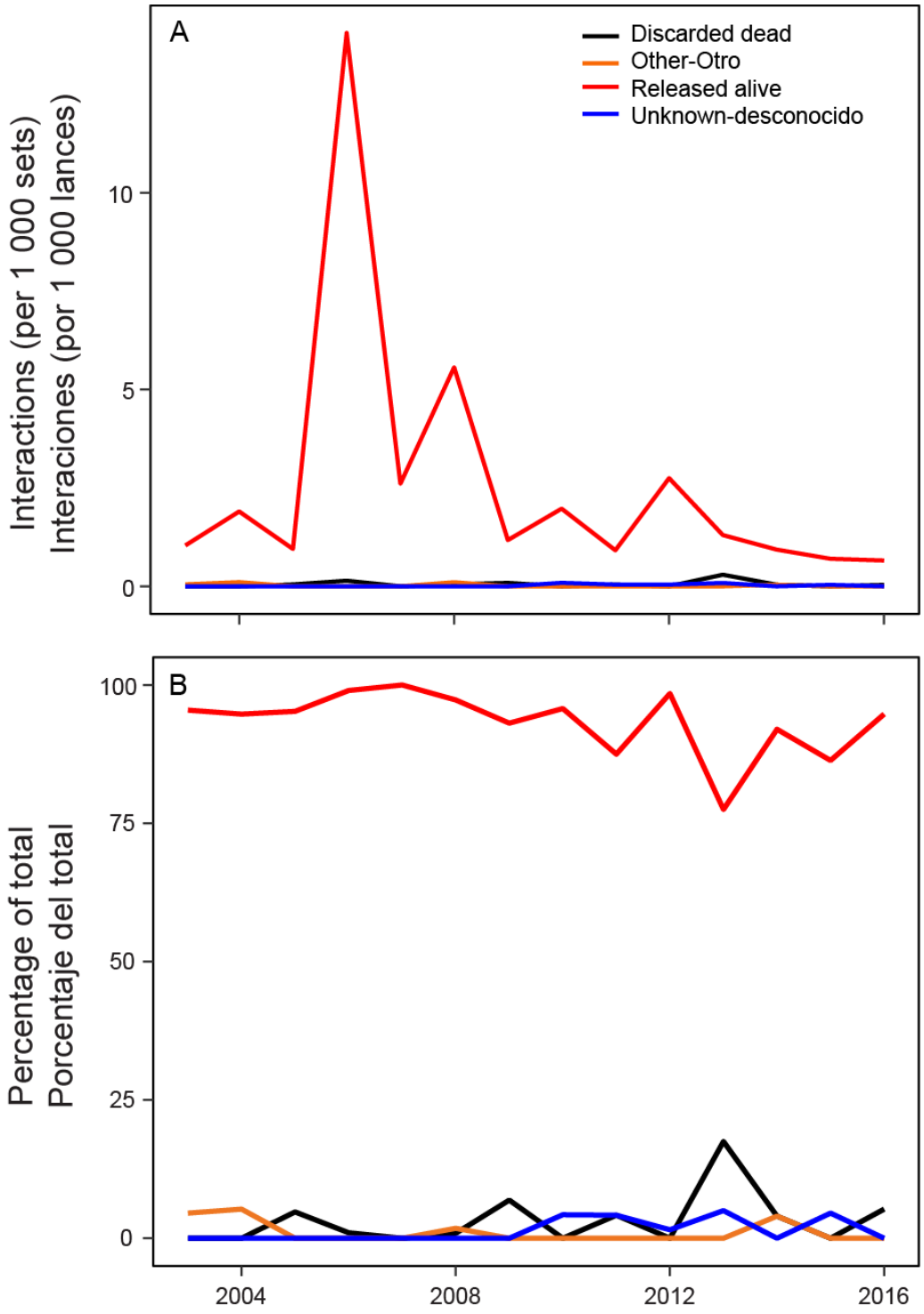


FIGURE 6. Fate of whale sharks involved in interactions with the tuna purse-seine fishery, all set types combined, 2003-2016, (a) per 1,000 sets, and (b) as percentages.

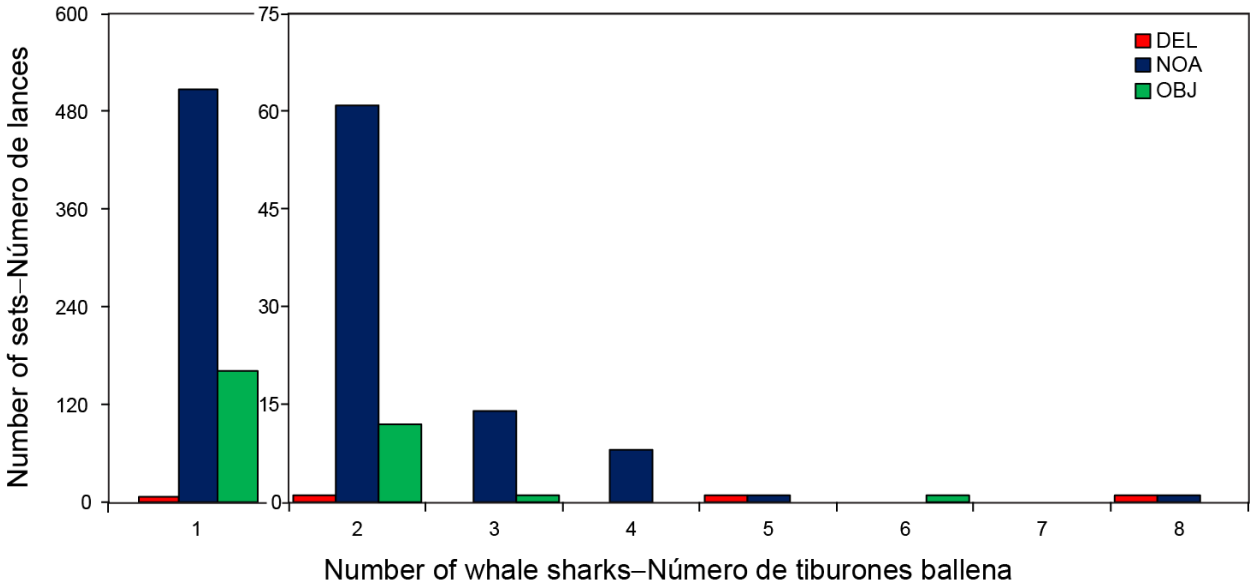


FIGURE 7. Number of sets with interactions with single whale sharks and with two or more whale sharks caught in a set, 2003-2016, by set type (DEL: dolphin; NOA: unassociated; OBJ: floating-object). Note the different scales on the y-axis.

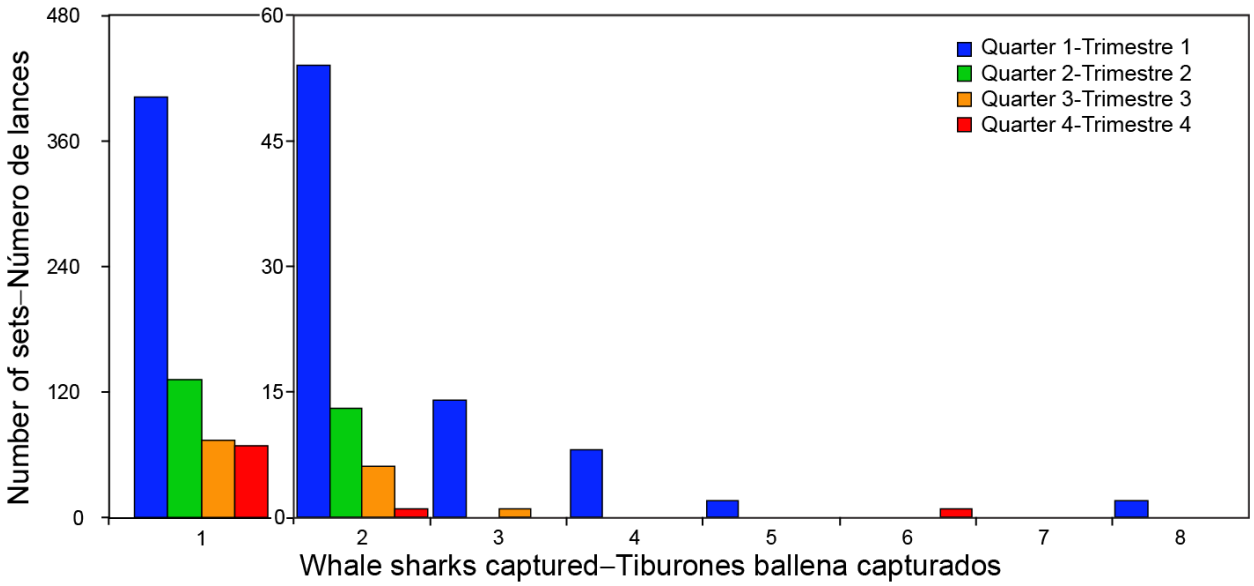


FIGURE 8. Number of sets with interactions with single whale sharks and with two or more whale sharks caught in a set, 2003-2016, by quarter of the year. Note the different scales on the y-axis.

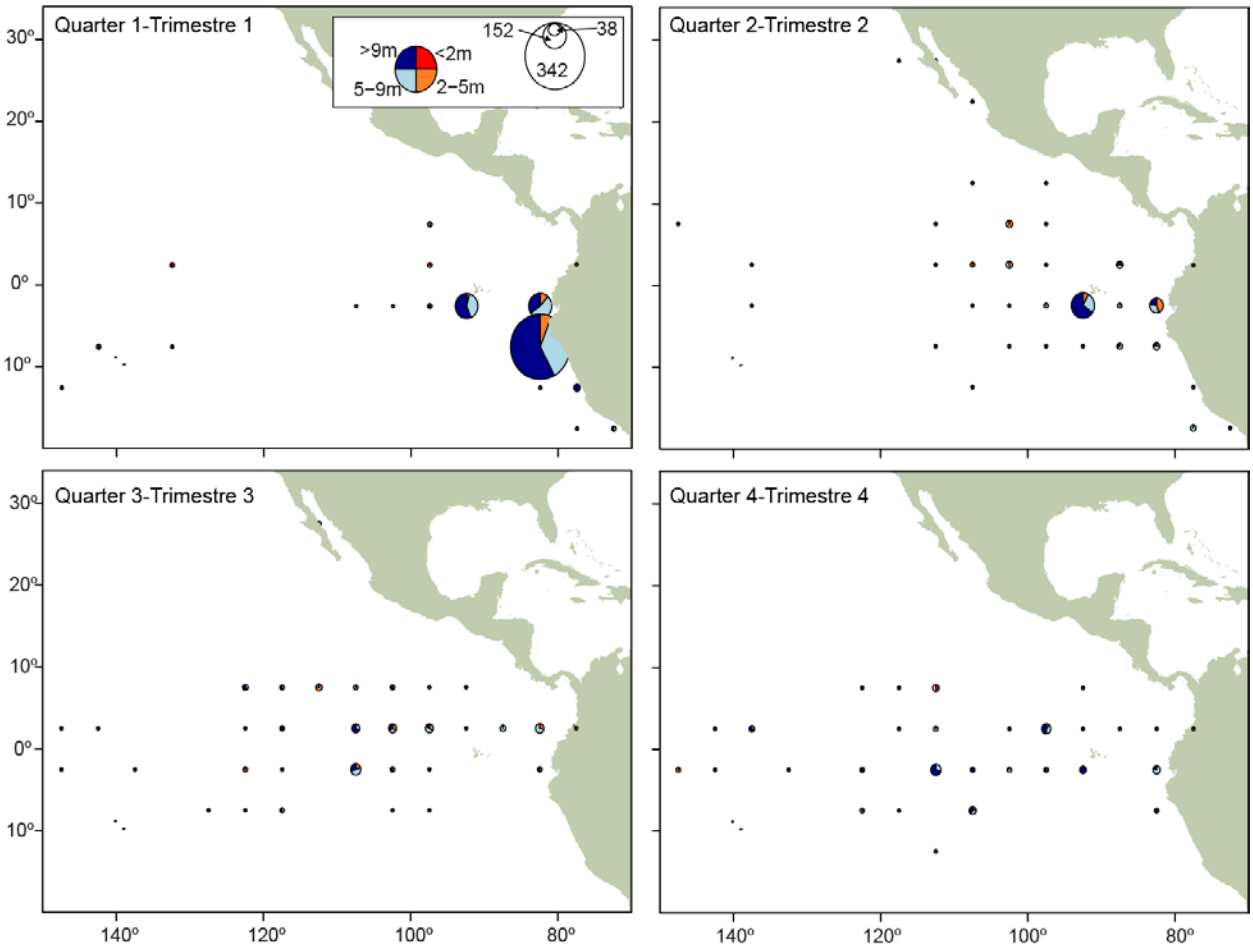


FIGURE 9. Spatial distribution, by 5° area, of interactions of whale sharks, by length category, with the purse-seine fishery, all set types combined, by quarter, 2005-2016.

APPENDIX 1:
IATTC Shark Record

Inter-American Tropical Tuna Commission

SHARK RECORD

Trip number	Record number	Set number	Species	Total number of sharks

INDIVIDUAL RECORD

Total length (cm)	Estimation	Sex M	Sex F	Sex Unk	Fate (code)
	[ ]	[ ]	[ ]	[ ]	
	[ ]	[ ]	[ ]	[ ]	
	[ ]	[ ]	[ ]	[ ]	
	[ ]	[ ]	[ ]	[ ]	
	[ ]	[ ]	[ ]	[ ]	
	[ ]	[ ]	[ ]	[ ]	
	[ ]	[ ]	[ ]	[ ]	
	[ ]	[ ]	[ ]	[ ]	
	[ ]	[ ]	[ ]	[ ]	
	[ ]	[ ]	[ ]	[ ]	
	[ ]	[ ]	[ ]	[ ]	
	[ ]	[ ]	[ ]	[ ]	

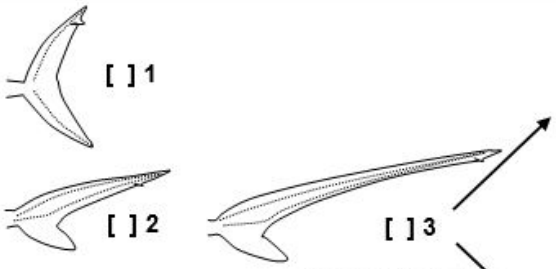
COLLECTIVE RECORD

Estimate by number of individuals: Small < 90 cm	Medium 90 – 150 cm	Large > 150 cm	Total	Fate (code)

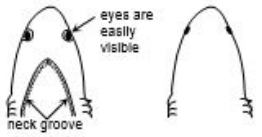
FATE CODES

1 - Human consumption
2 - Discarded
3 - Released alive
4 - Other
5 - Unknown

CAUDAL FIN SHAPE



Dorsal view of head

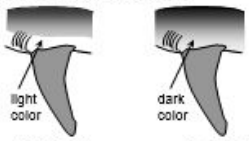


[ ] 3.1 [ ] 3.2

Neither of these [ ] 3.3

Could not determine [ ] 3.4

Flank coloration

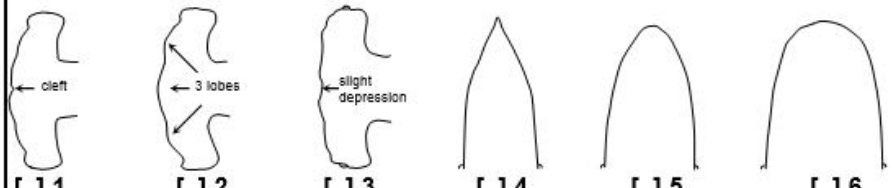


[ ] 3.1 [ ] 3.2

Neither of these [ ] 3.3

Could not determine [ ] 3.4

HEAD SHAPE



[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6

None of these [ ] 7

Could not determine [ ] 8

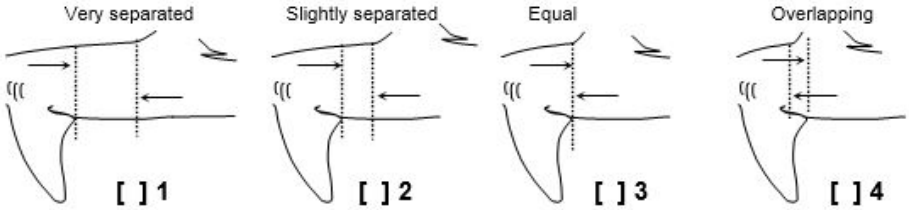
FIRST DORSAL FIN SHAPE

[ ] 1 [ ] 2 [ ] 3 [ ] 4

None of these [ ] 5

Could not determine [ ] 6

DISTANCE BETWEEN FIRST DORSAL FIN AND PECTORAL FIN

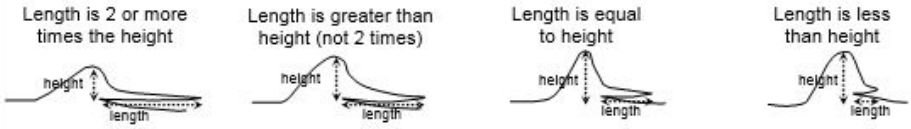


[ ] 1 [ ] 2 [ ] 3 [ ] 4

None of these [ ] 5

Could not determine [ ] 6

INTERNAL BORDER LENGTH OF SECOND DORSAL FIN

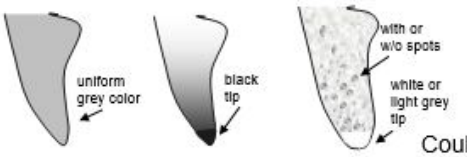


[ ] 1 [ ] 2 [ ] 3 [ ] 4

None of these [ ] 5

Could not determine [ ] 6

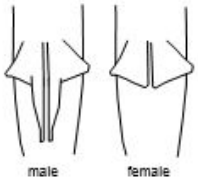
PECTORAL FIN COLORATION (external side)



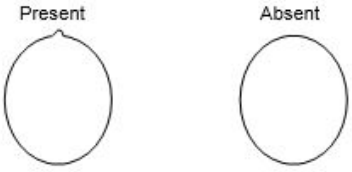
[ ] 1 [ ] 2 [ ] 3

None of these [ ] 4

Could not determine [ ] 5



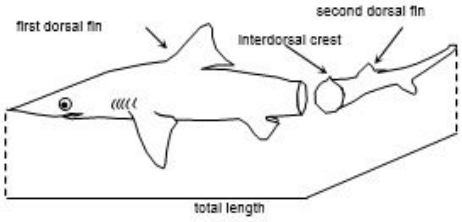
PRESENCE – ABSENCE OF INTERDORSAL CREST



[ ] 1 [ ] 2

Unsure [ ] 3

Could not determine [ ] 4



COMMENTS: