Marine Ecosystems

SOUTH AUSTRALIAN RESEARCH & DEVELOPMENT INSTITUTE
PIRSA

Residency and photographic identification of white sharks *Carcharodon carcharias* in the Neptune Islands Group Marine Park between 2013 and 2015

Rogers, P. J., and Huveneers, C.

SARDI Publication No. F2015/000825-1
SARDI Research Report Series No. 893

SARDI Aquatics Sciences
PO Box 120 Henley Beach SA 5022

April 2016

Report to Department of Environment, Water and Natural Resources

PREMIUM FOOD AND WINE FROM OUR CLEAN ENVIRONMENT

Government of South Australia
Department of Environment, Water and Natural Resources

SOUTH AUSTRALIA

Government of South Australia
Primary Industries and Regions SA

SARDI
SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

Residency and photographic identification of white sharks *Carcharodon carcharias* in the Neptune Islands Group Marine Park between 2013 and 2015

Report to Department of Environment, Water and Natural Resources

Rogers, P. J., and Huveneers, C.

SARDI Publication No. F2015/000825-1
SARDI Research Report Series No. 893

April 2016

This publication may be cited as:
Rogers, P. J., and Huveneers, C. (2016). Residency and photographic identification of white sharks *Carcharodon carcharias* in the Neptune Islands Group Marine Park between 2013 and 2015. Report to Department of Environment, Water and Natural Resources. South Australian Research and Development Institute (Aquatic Sciences), Adelaide. SARDI Publication No. F2015/000825-1. SARDI Research Report Series No. 893. 109pp.

South Australian Research and Development Institute
SARDI Aquatic Sciences
2 Hamra Avenue
West Beach SA 5024

Telephone: (08) 8207 5400
Facsimile: (08) 8207 5406
http://www.pir.sa.gov.au/research

Printed in Adelaide: April 2016

SARDI Publication No. F2015/000825-1
SARDI Research Report Series No. 893

Author(s): Rogers, P. J. and Huveneers, C.

Reviewer(s): Linnane, A. and Beckmann, C.

Approved by: Mayfield, S.
Science Leader - Fisheries

Signed:

Date: 12 April 2016

Distribution: DEWNR, SAASC Library, University of Adelaide Library, Parliamentary Library, State Library and National Library

Circulation: Public Domain

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

ACKNOWLEDGEMENTS

This project was carried out under the Department of the Environment and Natural Resources permits Q26216-1 and Y26308-1, and PIRSA Exemption ME9902693. Tagging was undertaken under Flinders University ethics approval E398 and PIRSA Animal Ethics Committee permit 15/14. Photographic identification and Fulcrum™ electronic logbook data were managed and maintained by Crystal Beckmann in 2013–14, and Ian Moody and Leo Mantilla in 2014–15.

Project funding was provided by the Department of the Environment, Water and Natural Resources, SARDI Aquatic Sciences and Flinders University. SARDI Aquatic Sciences provided significant capital investment to this monitoring program including the Vemco VR4G, VR2AR and VR2W receivers, and mooring equipment. Flinders University provided use of VR2AR acoustic receivers. The authors would like to thank Adventure Bay Charters, Calypso Star, and Rodney Fox Shark Expeditions for providing the fulcrum e-logbook data, images and logistical support during the deployment of acoustic tags. We also thank Hugh Pederson (Vemco) for technical advice and product support for the Vemco VR2AR and VR4G equipment. We are grateful to Russ Bradford (CSIRO, Hobart), Barry Bruce (CSIRO, Hobart) and Rory McAuley (WA Department of Fisheries) who co-facilitated the development of national data-sharing agreements during 2014–15. We thank Adrian Linnane, Crystal Beckmann, Steven Mayfield and Richard McGarvey, who provided valuable reviewer comments and advice that helped to improve this report.

GLOSSARY

Array: Geographical area in which tagged organisms are likely to be detected by acoustic receivers.

Berley: Fish-based minced products used to attract sharks to the vessel.

Detection: A set of pulses produced by transmitters that is identified and recorded by acoustic receivers.

Highly Migratory Species: Species that perform cyclical movements between distinct geographical areas, some of which are coastal and oceanic regions that may represent breeding, foraging and aggregation areas.

Receiver: Acoustic monitor deployed underwater that listens for pulses produced by acoustic transmitters. When a transmitter is within the detection range of a receiver, it records the date, time and identification number of the transmitter when acoustic pulses are received. Detection range varies with transmitter power and environmental conditions and can be 800–1000 m.

Residency period: Number of days between the first and last detection of a tagged shark, without any gaps in consecutive days of detection greater than five days.

Teaser bait: Baits tethered under floats at the surface to attract sharks to within the vicinity of boat and underwater viewing cages.

Transmitter: Acoustic tag deployed on sharks to monitor their movements and residency. Transmitters produce a set of pulses every pre-determined intervals (e.g., every 2 minutes), which can be detected by acoustic receiver

EXECUTIVE SUMMARY

The primary aim of this report is to provide estimates of residency for white sharks (*Carcharodon carcharias*) in the Neptune Islands Group Marine Park between a) 14 September 2013 and 30 June 2014, b) 1 July 2014 and 30 June 2015 and c) across the complete time series from 14 September 2013 to 30 June 2015. The report also describes preliminary results from analysis of the South Australian Research and Development Institute (SARDI) white shark photographic identification catalogue, and summarises daily electronic logbook (e-logbook) data describing white shark cage-diving industry activities.

A total of 37 white sharks ranging in size from ~180–450 cm total length were monitored using acoustic telemetry between 14 September 2013 and 30 June 2015. Mean residency estimates for each shark at the North Neptune Islands ranged from 0.3 to 117.3 days in 2013–14, and 0–52.1 days in 2014–15. The mean residency estimate averaged across sharks at the North Neptune Islands was 18.9±31.7 days (mean ± standard deviation; n=15) in 2013–14 and 9.1 ± 12.3 days (n=25) in 2014–15. The mean residency estimate for the South Neptune Islands was 1.7±1.8 days (range: 0–4.5; n=9) in 2013–14 and 9.3±14.8 days (range: 0–64.9; n=22) days in 2014–15.

On 2 February 2015, a visit by killer whales (*Orchinus orca*) was reported at the North Neptune Islands. Acoustic telemetry data indicated that five tagged white sharks were present on 1 February 2015. All tagged individuals had departed the Neptune Islands Group Marine Park by 3 February 2015. No tagged white sharks were detected on acoustic receivers until late April 2015.

The e-logbook showed that reported numbers of individual white sharks sighted per day ranged from 0 to 14 individuals (mean sightings=5±3 sharks per day) between 1 July 2014 and 30 June 2015. Operators reported using 12,100 litres of berley, 6,598 sets of southern bluefin tuna (SBT) gills and entrails and 1,551 portions of SBT as teaser baits between 1 July 2014 and 30 June 2015. Use of sound emission was reported on 87 days between 1 July 2014 and 30 June 2015. Durations of sound use ranged between 10 minutes–6:45 hours.

A photographic identification catalogue was established for white sharks that visited the Neptune Islands Group Marine Park between 4 October 2013 and 31 October 2014 based on analysis of 35,904 images. Complete photo-identification profiles were compiled for 78 sharks. An estimated 21% of the white sharks identified using photographic identification were electronically tagged.

A quantitative analysis of the residency of white sharks in the Neptune Islands Group Marine Park, cage-diving industry activities, environmental, and demographic factors will be completed using three years of data in 2016.

1. INTRODUCTION

1.1 Background

The white shark (*Carcharodon carcharias*) is a large, highly migratory pelagic shark species found throughout South Australia's gulf, continental shelf and oceanic ecosystems (Bruce *et al.* 2006). Considerable community interest in conservation and management of this species stems from its propensity to interact with humans that use the marine environment. Studies of white sharks suggest the species plays a key role as a top predator in southern hemisphere ecosystems (Hussey *et al.* 2012), yet is highly vulnerable to sources of additional mortality (Rogers *et al*. 2013).

The white shark is listed globally as Threatened (Vulnerable) under the International Union for Conservation of Nature Red List (IUCN), and under the *Convention on International Trade in Endangered Species, of Wild Fauna and Flora*, and *Convention on Conservation of Migratory Species of Wild Animals*. In mid-1999, the white shark was listed under the Australian Commonwealth Government *Environmental Protection, Biodiversity and Conservation Act* (1999) following evidence of population declines derived from beach meshing data, game fishing records, and anecdotal sighting frequencies (White Shark Recovery Plan 2002). In South Australian State waters, the white shark is protected under the *Fisheries Management Act* (2007) regulated by PIRSA Fisheries and Aquaculture.

Subsequent to the EPBC Act listing, a recovery plan with objectives aimed at supporting white shark population growth was developed in 2002 (Environment Australia 2002, White Shark Recovery Plan). The plan was reviewed and its objectives were revised in 2008. Priorities and objectives of both plans included the identification, investigation, and management of the impacts of tourism on white sharks. The revised plan lists one of the objectives and the priorities for State and Commonwealth research organisations as: Investigate and manage (and where necessary reduce) the impact of tourism on the white shark (Department of the Environment 2013, Recovery Plan for the White Shark). Actions within these objectives incorporate the need to: 1) investigate impacts of increased cage-diving activity and develop appropriate management responses if required, 2) maintain daily e-logbook reporting of white shark interactions by cage- dive operators, and 3) engage cage-dive operators in shark research and education programs (Department of the Environment 2013, Recovery Plan for the White Shark). The Department of Environment Water and Natural Resources (DEWNR) Great White Shark Tourism Policy aims to minimise the potential impacts of activities associated with the white shark cage-diving industry in the Neptune Islands Group Marine Park on this State protected and EPBC listed species. This policy aims to develop and maintain the industry in a manner agreed to be in accordance with the Act, whilst supporting and facilitating the Commonwealth Government Recovery Plan objectives.

The white shark cage-diving industry is one of five key marine-based wildlife tourism ventures in South Australia that is managed by DEWNR. The others include southern right whale (*Eubalaena australis*) viewing at Head of Bight, swimming with Australian sea lions (ASL) (*Neophoca cinerea*) at Hopkins Island, Spencer Gulf and Bairds Bay, Eyre Peninsula and ASL viewing and educative interpretation at Seal Bay, Kangaroo Island. The white shark cage-diving industry is only licensed to operate in the Neptune Islands Group Marine Park. Prior to 2011, the industry comprised two licensed operators in the Neptune Islands Conservation Park with exemptions to use berley to attract white sharks to vessel for viewing by customers. A third operator joined the white shark cage-diving industry in 2011, and is only licensed to use sound to attract white sharks (Bradford and Robbins 2013).

Acoustic tagging techniques have been used to collect information on the residency behavior of white sharks in relation to white shark cage-diving industry operations at the Neptune Islands Group Marine Park and Dangerous Reef since the early 2000s (Bruce and Bradford 2011, 2013; Rogers *et al*. 2014; Robbins *et al.* 2015). Long-term tagging programs (Bruce and Bradford 2011, 2013), and studies of the fine-scale three dimensional variation in movements (Huveneers *et al*. 2013) have shown that cage-diving activities are associated with behavioral modification of individual white sharks, however, the potential impacts on population-level processes remain poorly understood. Residency is a quantitative behavioural indicator that allows researchers to develop time budgets for individual sharks, and it has been shown to be sensitive to changes in tourism activities (Bruce and Bradford 2011). Annual acoustic telemetry-based mean estimates of residency of white sharks in the Neptune Islands Group Marine Park inform decision points that underpin the draft management decision-making framework outlined by Smith and Page (2015).

SARDI and the cage-diving industry have developed a collaborative, long-term photographic identification catalogue of white sharks that visit the Neptune Islands Group Marine Park to assess alternative methods for estimating residency. Establishment of this method was based on previous photo-identification studies (Anderson and Goldman 1996; Klimley and Anderson 1996; Bonfil *et al.* 2005; Domeier and Nasby-Lucas 2006). Photographic identification is being used to estimate the minimum number of white sharks that visit the Neptune Islands Group Marine Park on operator days, and to record re-sights of known individuals. In the longer term, this catalogue will be used to evaluate if this method provides suitable and cost-effective assessments of residency on operator days that can be used to compare with telemetry-based estimates.

Aims and Objectives

This report provides an update of information on white sharks and the white shark cage-diving industry in the Neptune Islands Group Marine Park. Specifically, this includes:

1. Estimates of residency of white sharks during three periods including, a) 14 September 2013 to 30 June 2014, b) 1 July 2014 to 30 June 2015 and c) the complete time series from 14 September 2013 to 30 June 2015.
2. Patterns of sightings of white sharks collected using e-logbooks between 2014 and 2015;
3. Summaries of daily activities of the white shark cage-diving industry collected using e-logbooks between 2014 and 2015;
4. Photographic-identification, re-sight and sex ratio information derived from images provided by operators in the white shark cage-diving industry.

2. METHODS

2.1 Reporting periods

Residency estimates presented in this report were based on white sharks tagged in the Neptune Islands Group Marine Park between September 2013 and May 2015 (n=37).
Estimates of residency are provided for three periods to encompass the start of the monitoring period: (1) 14 September 2013 to 30 June 2014, the most recent season (2) 1 July 2014 to 30 June 2015, and (3) the complete time series from 14 September 2013 to 30 June 2015.

2.2 Geographical area

The Neptune Islands Group (Ron and Valarie Taylor) Marine Park is located near the approach to Spencer Gulf, ~30 nm from Port Lincoln, South Australia, and 14 nm from the southern Australian mainland (Fig. 1). The Neptune Islands Group Marine Park was proclaimed in October 2014. The group comprises the North and South Neptune Islands, which are ~12 km apart. There is a Sanctuary Zone (SZ), Restricted Access Zone (RAZ) and Habitat Protection Zone (HPZ) at the North Neptune Islands and RAZ and HPZ at the South Neptune Islands (Marine Park Management Plan Summary 2014). Cage-diving operators mostly anchor in two bays, Action Bay and Main Bay at the North Neptune Islands, and in the eastern bay at the South Neptune Islands (Fig. 1).

2.3 Acoustic telemetry

Receiver deployments

Three satellite-linked VR4-Global (VR4G) near-real time acoustic receivers (Amirix, VEMCO Ltd., Halifax, Canada) were deployed at the North and South Neptune Island Groups using a mooring system similar to that described in Bradford *et al*. (2011). The VR4G receivers used an Iridium satellite modem to remotely access tag detection data.

In September 2013, two VR4G receivers were deployed at Main Bay and Action Bay at the North Neptune Islands, and a third was deployed in the embayment on the north-east side of the South Neptune Islands (Fig. 1). Technical issues occurred with the VR4G system between mid-November 2014 and late January 2015. Faults were detected in the VR4G receiver in Action Bay in November 2014, in Main Bay in mid-January 2015, and at the South Neptune Islands in June 2015. The VR4Gs at the North Neptune Islands were replaced with Vemco VR2AR (acoustic release) receivers that were moored on the bottom with polystyrene rock lobster floats in January 2015. The VR4Gs at the North Neptune Islands were recovered in March 2015 using *RV Ngerin*. In July 2015, the two VR2ARs at the North Neptune Islands were recovered and the detection data were retrieved. The remaining VR4G and mooring at the South Neptune Islands was also recovered in July 2015. Three VR2W receivers, demarcated with 70 cm surface floats with navigation beacons on 50 mm diameter multi-strand rope attached to train wheel weights were deployed in the three bays within the two island groups.

Transmitter deployments

White sharks were tagged with V16-6H acoustic transmitters programmed to send signals at random intervals of 70–150 seconds (VEMCO Ltd., Halifax, Canada). Tags were deployed throughout the monitoring period depending on the number of sharks reported at the study site. Tags were tethered to a plastic umbrella dart using a 10- to 15-cm-long stainless wire leader (1.6 mm diameter), and implanted in the dorsal musculature of white sharks from the vessel using an aluminium pole and applicator, or from the dive cage using a modified spear-gun and applicator.

2.4 Detection summary and residency

Tagged white sharks were considered ‘present’ in the array if detected at least twice within a 24-hour period (Pincock 2011). Daily detection summaries were plotted to examine the pattern of overall presence of tagged sharks during the study period. A residency period was calculated based on the number of days between the first and last detection of a tagged shark in the study area(s), where no gaps in consecutive days of detection were >5 days, defined as a ‘residency period’ (Bruce and Bradford 2013). A period of five days was allowed for sharks remaining in the vicinity of the Neptune Islands Group but without registering detections at either island. If sharks were not detected for periods of greater than five consecutive days they were assumed to have left the island group and any subsequent return was considered to represent a new residency period.

The previous report (Rogers *et al.* 2014) presented mean residency estimates averaged across all sharks. This approach was adopted due to the low sample size of tagged sharks in the first year of monitoring, e.g., nine tagged individuals were detected at the South Neptune Islands Group in 2013–14. In this report, we present residency estimates based on the grand (overall) mean of individual estimates for each tagged shark. This method was reapplied to data for the 2013–14 monitoring period to allow direct comparison with the estimates for 2014–

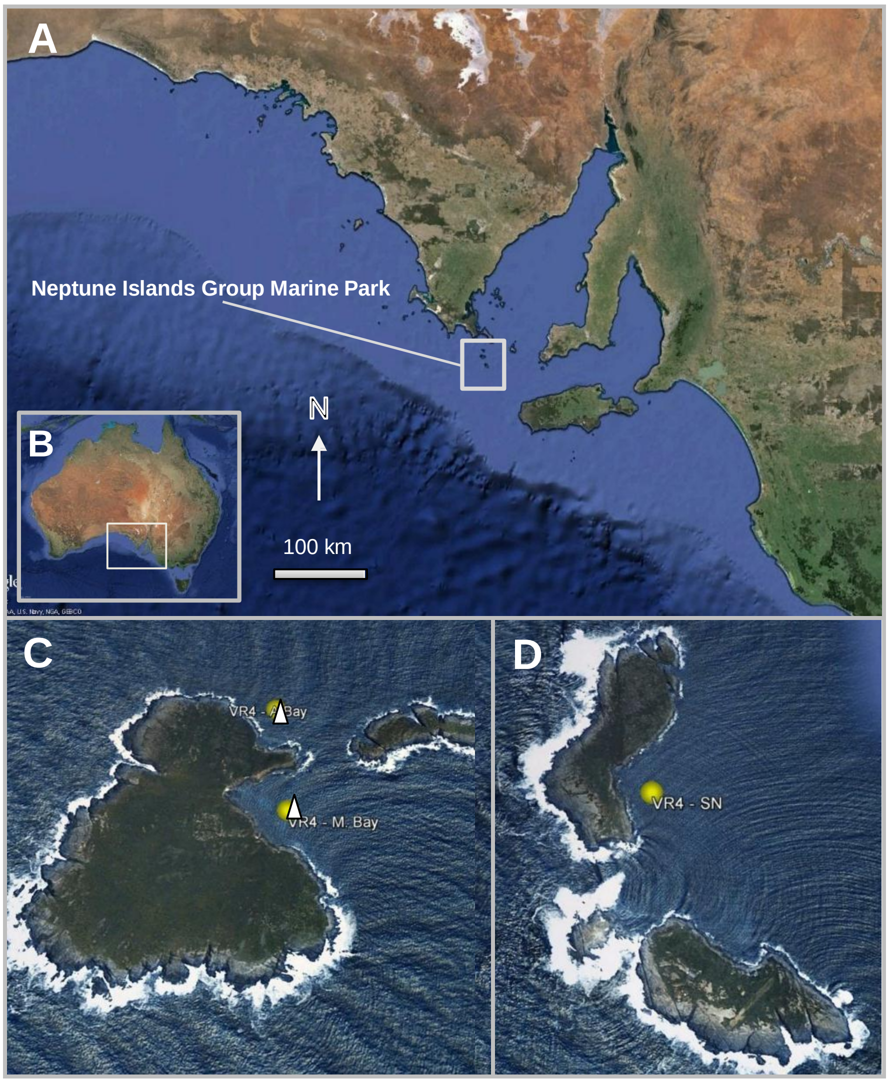


Figure 1. Map A shows the location of the North and South Neptune Islands in continental shelf waters off southern Eyre Peninsula, South Australia. Inset B shows the location of the monitoring area in relation to South Australia. Map C shows the North Neptune Islands and the locations of two VR4 acoustic receivers (yellow symbols) and VR2AR (acoustic release) (white symbol) receivers in Action Bay (A. Bay) and Main Bay (M. Bay). Map D shows the South Neptune Islands and the location of a single VR4 acoustic receiver (VR4-SN). (Images sourced from Google Earth Pro).

2.5 Electronic Logbooks

White shark cage-diving operators were issued with a mini-iPad loaded with the Fulcrum™ application to input voluntary daily electronic logbook (e-logbook) entries in September 2013. Regular follow-up telephone conversations took place between SARDI and white shark cage-diving industry operators for data validation and quality assurance purposes. Development of the structure and fields in the e-logbook is described in Rogers *et al.* (2014).

The e-logbook was used to collect data on daily activities and sighting frequency of white sharks between 1 July 2014 and 30 June 2015.

2.6 Photo Identification

Photographs and videos of white sharks were submitted to SARDI by operators between 4 October 2013 and 31 October 2014 with date and location data for each image. Photo-ID and 'Orphan' catalogues were created that included images of each individual linked to documented physical characteristics. If there were only images of one side of an individual, the images set and associated meta-data were classified as an 'orphan' until further images and information were available to verify an identification. Distinguishing marks, scars, tag locations and pigmentation patterns (Fig. 2) were compared to identify individuals as outlined in Domeier and Nasby-Lucas (2006). Sex of photographed sharks was determined where possible through the presence and absence of claspers. Each shark was assigned a unique alpha-numeric identification code (e.g. NI001) to match the date data. The pigment patterns on the gills, pelvic and caudal fins were assigned a unique numerical characteristics code to aid searching the catalogue. This code was based on the following: LG • LP • LC x or RG • RP • RC x where LG=left gill, LP=left pelvic region and LC=left side caudal fin, and RG=right gill, RP=right pelvic region and RC=right side caudal fin. The degree of pigmentation in each region was scaled as 0 (not visible), 1, 2, 3 or 4 based on the methods of Domeier and Nasby-Lucas (2006). Only caudal fins had classification 4 assigned. Keywords used to identify and re-sight known-ID individuals included, Lscar: left scar Rscar: right scar, Lscr: left scratch, Rscr: right scratch, LT: left tag, RT: right tag, DT: dorsal tag, Wspot: white spot, fin damage, colorations, and tag scars.

Dorsal fin profiles were not used due to low image quality and a lack of images taken from above the water-line. Identification profiles were considered to be complete when quality images of the gills, pelvic fin and caudal fin zones were collected. Some images were digitally enhanced using Photoshop and IrfanView software. Once all images were assigned, groups of left or right images were matched with known-ID sharks in the two catalogues. After comparing all the group pictures on the sorting sheet, the photos fell into 1 of 3 categories: 1) match an existing shark ID, 2) match an existing orphan, 3) new complete ID shark or new orphan if insufficient information was available for a positive identification.

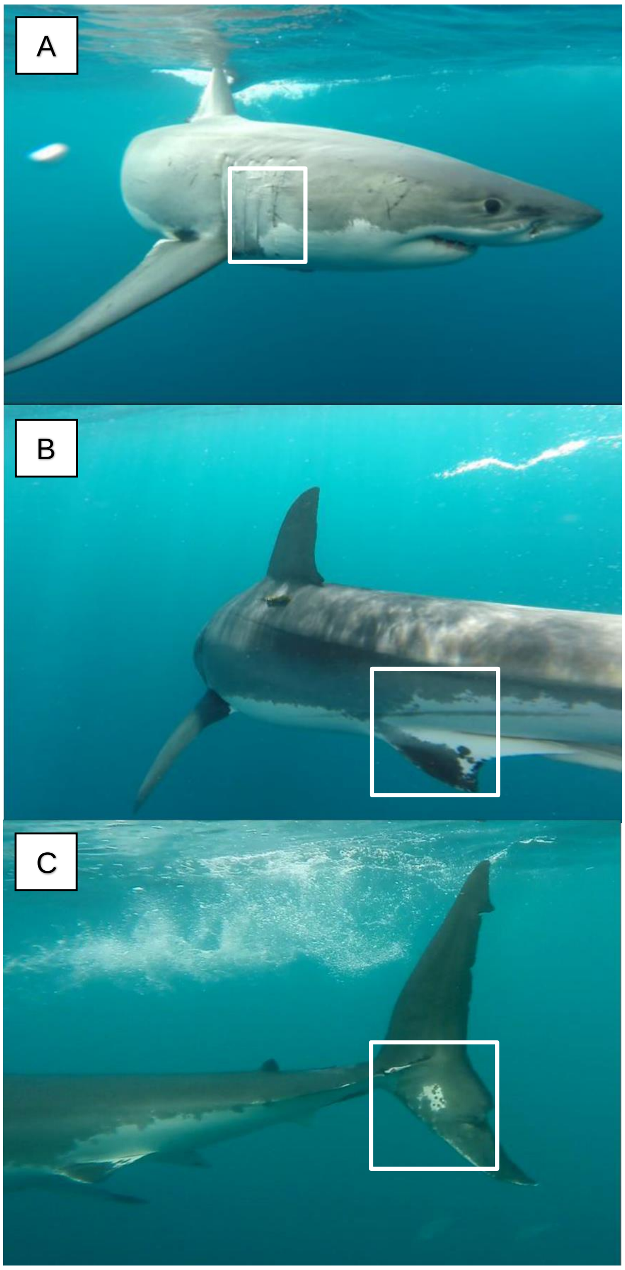


Figure 2. Examples of physical characteristics including. (A) gill flaps, (B) pelvic fin/area and (C) caudal fins used for identification of white sharks visiting the Neptune Islands Group Marine Park (following Domeier and Nasby-Lucas 2006).

3. RESULTS

3.1 Acoustic transmitter deployments

A total of 37 white sharks (8 females, 24 males, 5 unknown sex) ranging in size from 180 to 450 cm total length were tagged in the Neptune Islands Group Marine Park using V16 acoustic transmitters between 14 September 2013 and 7 May 2015 (Table 1).

3.2 Acoustic detections

A total of 74,758 acoustic detections were recorded (Table 2). Of these, 50,124 (67%) detections were recorded on two receivers at the North Neptune Islands and 24,634 (33%) were recorded on one receiver at the South Neptune Islands (Table 2).

Seasonal patterns in detections

Between September and November 2013 (spring), infrequent acoustic detections were recorded for eight white sharks. Six individuals were present in summer 2013–14 (Fig. 3). Detections were less frequent between March and June 2014 (autumn and early winter) with only three sharks detected. Eight sharks were detected between August and September (mid- to late-winter) 2014. Ten and 12 white sharks, respectively, were detected between October and November 2014 (spring) and December to February 2014–15 (summer). In late January and early February 2015 (late summer), six sharks were detected. Three were tagged in January 2015, while the other three were tagged in October 2013, February 2014 and November 2014. All individuals left the range of the receivers between 27 January and 2 February, and four departed from the North Neptune Islands on the 2 or 3 February. No white sharks were detected until late April when one was detected briefly at the North and South Neptune Islands. In May 2015, 13 white sharks were detected and eight individuals were detected in June.

Return visitors

Of the 15 white sharks tagged during September 2013 to June 2014, five sharks, including shark 1, 4, 6, 12, and 14 were detected again during 2014–15, and three shed their tag (Shark 3, 5, and 9) (Fig. 3). This showed that a minimum of 42% of the white sharks present in 2013–14 were return visitors.

Table 1. White shark acoustic transmitter deployment information between 14 September 2013 and 7 May 2015. Total length=TL, Female=F, Male=M, and NS=not sexed. Locations are shown as South Neptune Islands=SNI, and North Neptune Islands=NNI.

Shark#	TL	Sex	Date deployed	Location deployed
1	410	F	14/09/13	SNI
2	330	M	15/09/13	SNI
3	450	M	28/09/13	NNI
4	410	M	9/10/13	NNI
5	450	M	14/10/13	NNI
6	300	M	26/10/13	NNI
7	450	M	26/10/13	NNI
8	200	M	15/11/13	NNI
9	400	M	29/01/14	NNI
10	350	M	29/01/14	NNI
11	380	M	29/01/14	NNI
14	430	M	23/02/14	NNI
12	240	M	24/02/14	NNI
13	450	F	26/02/14	NNI
15	300	M	28/02/14	NNI
16	360	M	19/07/14	SNI
17	390	F	19/07/14	SNI
18	330	M	20/07/14	SNI
19	370	F	20/07/14	SNI
20	420	M	21/07/14	NNI
21	400	M	18/10/14	SNI
22	300	F	19/10/14	NNI
23	450	M	19/10/14	NNI
24	3500	M	15/11/14	NNI
25	380	M	15/11/14	NNI
26	320	M	16/11/14	NNI
27	390	M	24/01/15	NNI
28	370	M	24/01/15	NNI
29	270	M	24/01/15	NNI
30	420	F	2/05/15	SNI
31	180	F	6/05/15	SNI
32	420	F	6/05/15	SNI
33	450	NS	7/05/15	SNI
34	260	NS	7/05/15	SNI
35	300	NS	7/05/15	SNI
36	340	NS	7/05/15	SNI
37	280	NS	7/05/15	SNI

Table 2. Detections for white sharks at the Neptune Islands Group Marine Park. South Neptune Islands=SNI, and North Neptune Islands=NNI.

Shark#	Location tagged	N of detections			N of days detected		
		Both	N	S	Both	N	S
1	SNI	11769	1346	10423	96	20	81
2	SNI	1888	1828	60	56	48	9
3	NNI	7884	7882	2	112	111	1
4	NNI	2448	2364	84	63	53	12
5	NNI	1813	1813	*	13	13	*
6	NNI	5678	2902	2776	96	62	34
7	NNI	1787	1769	18	42	40	4
8	NNI	863	479	384	19	9	10
9	NNI	2557	2553	4	49	49	1
10	NNI	131	131	*	6	6	*
11	NNI	208	207	1	19	19	1
14	NNI	1328	913	415	39	27	13
12	NNI	14	14	*	2	2	*
13	NNI	1196	1196	*	15	15	*
15	NNI	17	17	*	1	1	*
16	SNI	5804	5195	609	70	60	11
17	SNI	1248	48	1200	25	5	21
18	SNI	6053	5598	455	53	47	6
19	SNI	736	140	596	25	8	18
20	NNI	3202	3187	15	52	51	2
21	SNI	618	5	613	26	2	24
22	NNI	4	4	*	1	1	*
23	NNI	1821	1815	6	26	26	1
24	NNI	497	349	148	32	19	13
25	NNI	139	137	2	6	5	1
26	NNI	145	145	*	5	5	*
27	NNI	58	58	*	3	3	*
28	NNI	354	354	*	10	10	*
29	NNI	269	259	10	7	6	1
30	SNI	1644	81	1563	27	2	25
31	SNI	726	100	626	7	3	4
32	SNI	2772	*	2772	24	*	24
33	SNI	119	24	95	2	1	1
34	SNI	2489	1234	1255	31	14	18
35	SNI	94	*	94	1	*	1
36	SNI	1891	1612	279	34	29	6
37	SNI	4494	4365	129	47	45	2

3.3 Residency patterns

Residency estimates for white sharks at the North Neptune Islands ranged from 0.3 to 117.3 days in 2013–14, and 0–52.1 days in 2014–15. The mean residency estimate averaged across all sharks at the North Neptune Islands was 18.9±31.7 days (mean ± standard deviation; n=15) in 2013–14 and 9.1± 12.3 days (n=25) in 2014–15. The mean residency estimate for the South Neptune Islands was 1.7±1.8 days (range: 0–4.5; n=9) in 2013–14 and 9.3±14.8 days (range: 0–64.9; n=22) days in 2014–15. Table 3 provides mean residency estimates for the North and South Neptune Islands for 2013–14, 2014–15 and 2013–15. Appendix 1 shows the residency estimates for individual white sharks at the North Neptune Islands in the 2013–14 and 2014–15 seasons. Appendix 2 shows a summary of residency statistics for the North and South Neptune Islands between 2013 and 2015. Figure 4 shows the frequency of residency periods for white sharks at the South and North Neptune Islands between 2014 and 2015.

Table 3. Mean estimates of residency at the North and South Neptune Islands during three periods, including 2013–14, 2014–15, and the complete time series of 2013–15.

Location	2013–14	2014–15	2013–15
North Neptune Islands	18.9±31.7	9.1±12.3	14.0±23.1
South Neptune Islands	1.7±1.8	9.3±14.8	5.9±7.7

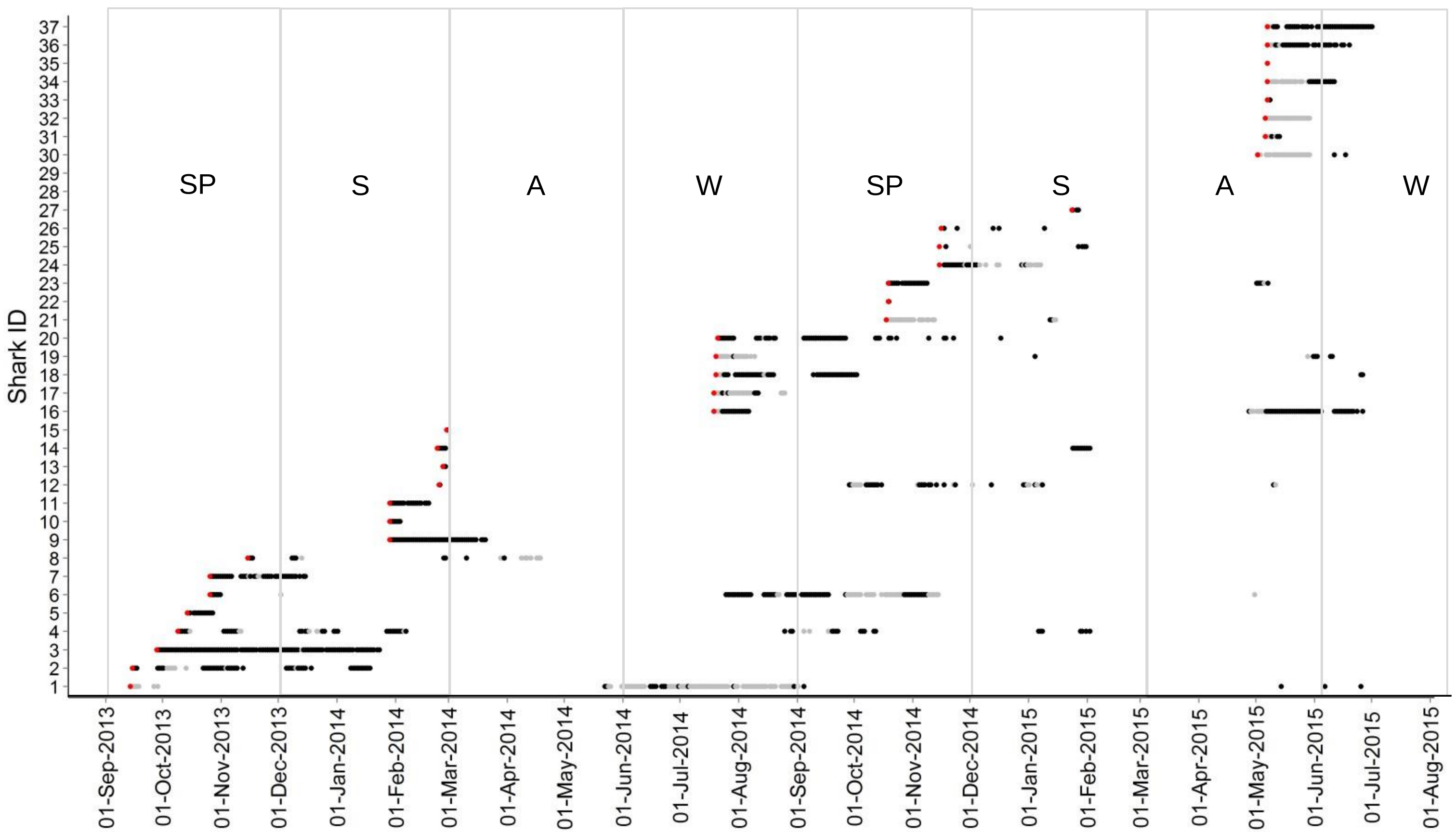


Figure 3. Daily detection summaries for white sharks at the North (black symbols) and South Neptune Islands (grey symbols) between 2013 and 2015. Red symbols indicate the tagging dates. Austral seasons are indicated by labels in grey rectangles, where SP=spring, S=summer, W=winter and A=autumn.

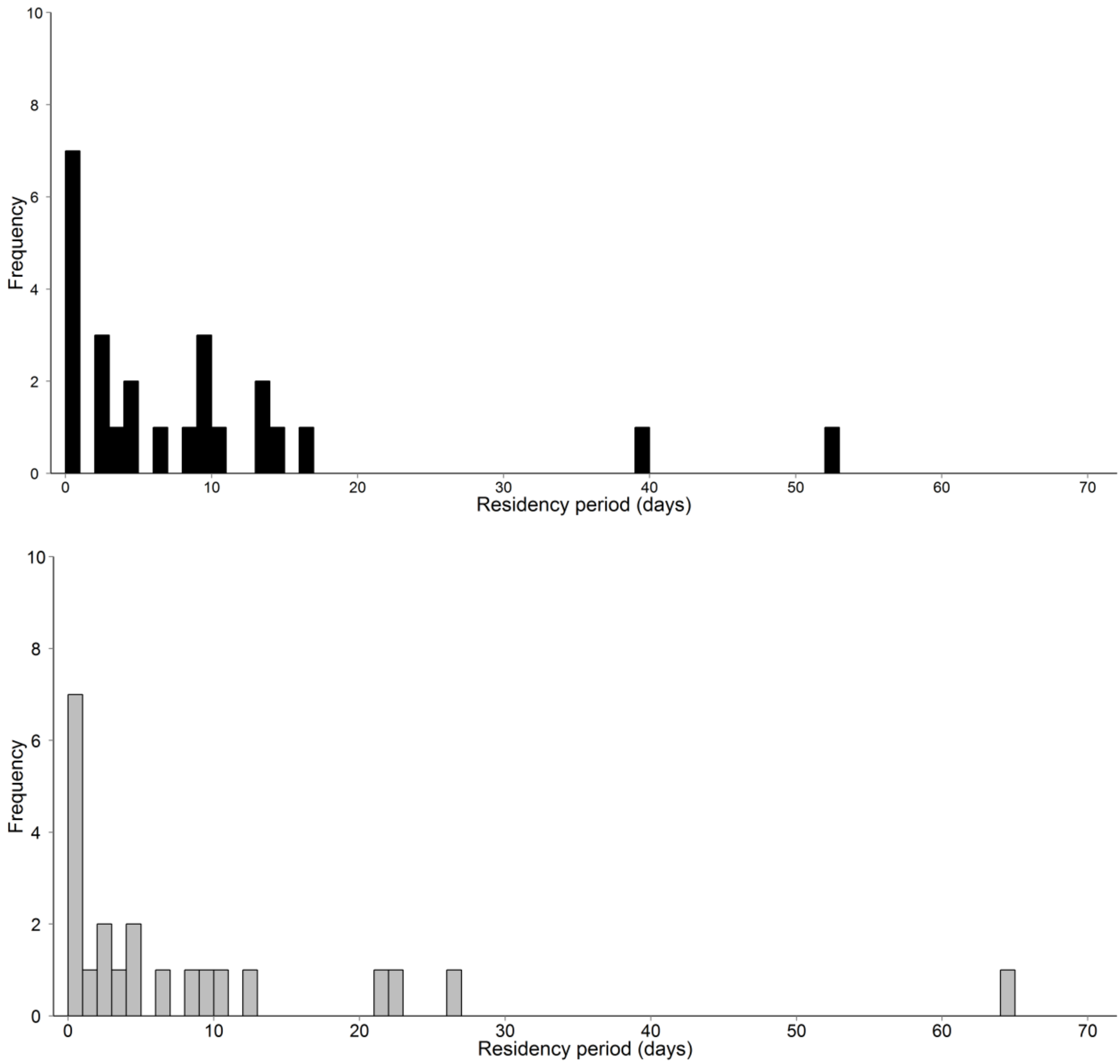


Figure 4. Frequency of residency periods averaged across sharks in the Neptune Islands Group Marine Park between 2014 and 2015. North Neptune Islands=black bars and the South Neptune Islands=grey bars.

3.4 Electronic logbook

Sighting frequency and seasonality

Reported estimates of the counts of individual white sharks sighted per day ranged from 0 to 14, based on 406 records provided (Fig. 5). Peaks in daily shark sightings occurred during the August to September and December to January periods. Lowest frequencies of daily sightings occurred between February and April. The overall mean number of sightings was 5±3 sharks per day.

Killer whale visit

A killer whale visit was reported by two operators on 2 February 2015 at the North Neptune Islands. This month had low reported days onsite by the three operators of 9, 3 and 2 days, respectively, mean=4.7±3.8 d; 60% lower than the overall annual mean number of days onsite (mean=11.9±5.4 d) based on the number of effort days when sightings were reported (shown under *x*-axis, Fig. 5).

Berley and teaser bait use

The white shark cage-diving industry reported the use of 12,100 litres of berley, 6,598 sets of southern bluefin tuna (SBT) gills and entrails, and 1,551 individual portions of SBT between 1 July 2014 and 30 June 2015. The proportion of SBT teaser baits or gills and entrails recovered (not consumed) or consumed by white sharks and/or other shark and teleost species is unknown.

Sound use

Use of sound emission to attract white sharks to the vessel at the Neptune Islands was reported on 87 operating days. Sound durations ranged between 10 minutes and 6 hours 45 minutes per day. A total of 98% of the sound was emitted at the North Neptune Islands, with the remaining 2% emitted at the South Neptune Islands.

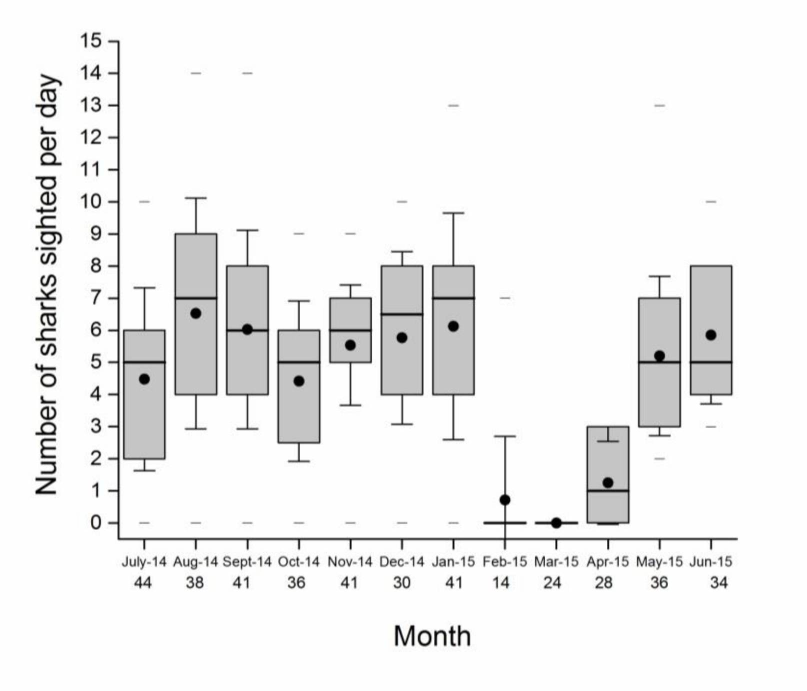


Figure 5. Mean daily sightings of white sharks reported in e-logbook by three operators and between 1 July 2014 and 30 June 2015. Number of sighting days reported by month is shown under the *x*-axis.

3.5 Photographic identification

A photographic identification catalogue was established for white sharks that visited the Neptune Islands between 4 October 2013 and 31 October 2014 based on analysis of 35,904 images provided by operators. Complete profiles were developed for 78 individual white sharks (Appendix 3). Each individual was given an alpha-numeric identification code. A further 28 ‘orphan’ or incomplete images sets were established for other white sharks based on preliminary identification of one side of the body. Based on the minimum number of complete identifications, and the maximum number provided by the addition of the ‘orphans’, we estimate that ~106 white sharks visited the Neptune Islands Group Marine Park over the 12-month period during operator days.

Sex ratio

Sex ratios of white sharks identified at the Neptune Islands during the October 2013 to October 2014 period were skewed slightly toward males (1.1: 0.9, N=37 M, 33 F and 8 unsexed). Insufficient gender data were available to statistically assess annual, seasonal or monthly trends in sex ratios. Length estimates were not made due to difficulties associated with accurately estimating the size of free-swimming sharks from images.

Physical characteristics

Evidence of bite marks and lacerations from con-specifics, scars and physical evidence of human interactions was present on white sharks recorded in the photo-ID catalogue. These included the presence of fin damage and/or partial loss, dermal scrapes, bites on gill flaps (Fig. 6), deep scars, ropes and fishing hooks. Some characteristics were not considered to be temporally stable, and whilst they were used to cross-reference the identification of some individuals, they were not used as primary tools for verification.

Re-sights

Re-sight data of known-ID individuals were processed from 4 August to 31 October 2014. A total of 27 of the 78 profiled white sharks were re-sighted by operators over durations ranging between 1 and 12 days (mean=5±3.35 d; median=3). A total of 21% of the white sharks identified in the photo-identification catalogue had been electronically tagged. Re-sight durations were not inclusive of time gaps between the first and last sightings as consecutive daily re-sighting may be biased by gaps in operator days and resultant photographic coverage, the potential for different sharks to interact with vessels, and behavioural and demographic factors that may influence the frequency at which certain sharks approach within a suitable proximity of vessels to be photographed.

Figure 6. Bite marks on the gill flaps of a white shark at the Neptune Islands.

4. DISCUSSION

Estimates of white shark residency

Estimates of white shark residency at the North Neptune Islands varied substantially from 0.3–117.3 days (mean=18.9 days) in 2013–14 to 0–52.1 days (mean=9.1 days) in 2014–15. During the previous monitoring period between December 2009 and April 2011, residency estimates for the Neptune Islands system (combined) ranged between 1 and 92 days (mean =21.0 days), and the duration of visits at the North Neptune Islands ranged from 1 to 52 consecutive days (mean=11.0 days) (Bruce and Bradford 2011). Potential factors explaining this observed variation in residency between years and within and between individual(s) are difficult to uncouple, yet could include combinations of social, demographic factors, and density-dependent processes, prey selection, migration dynamics and effects of cage-diving and other human activities (Bruce *et al*. 2006; Bruce and Bradford 2015). As the sample size of tagged white sharks increases, there will be greater opportunity to address these questions. In 2014–15, the presence of revisiting tagged white sharks from the previous seasons was encouraging from the perspective of assessing the retention rates of externally deployed acoustic tags, which is important when assessing the viability of the current tagging approaches.

Killer whale visit

Killer whales have been observed to interact with, and predate upon pelagic sharks, including white sharks at Southeast Farallon Island, California (Pyle *et al.* 1999), common threshers (*Alopias vulpinus*), smooth hammerhead (*Sphyrna zygaena*) (Visser 2005), and shortfin makos (*Isurus oxyrinchus*) in New Zealand (Visser *et al*. 2000). Killer whales were reported to be present at the North Neptune Islands on 2 February 2015. Up until late January 2015, six tagged white sharks were being detected at the North Neptune Islands. Five tagged sharks were present on 1 February 2015. All tagged individuals departed from the Neptune Islands Group Marine Park on either the 2nd or 3rd of February. Subsequent to the visit by killer whales, no tagged white sharks were detected until late April, ~13 arrived in May, and eight in June that included four tagged during winter 2014. Following reported sighting of the killer whales, the e-logbook data showed a reduction in mean daily sightings of white sharks at the Neptune Islands for 12 weeks. Further analysis of the e-logbook and acoustic data relating to the reported killer whale visit will be completed in 2016–17.

E-logbook data

Operator collected e-logbook data continued to be an important step in the process of monitoring visits by white sharks and cage-diving industry activities at the Neptune Islands during the operator days. E-logbook data allowed the estimation of the annual input of berley and teaser baits into the marine ecosystem in the Neptune Islands Group Marine Park. There remains a lack of information regarding the consumption rates of berley and teaser baits by white sharks and other visiting and residential marine species in the Neptune Islands Group Marine Park. Berley and teaser bait input was the subject of discussions between managers, scientists and white shark cage-diving industry operators in 2014–15, and has been the subject of previous discussions relating to changing patterns of residency and potential impacts on ecosystem functioning/predator prey dynamism (Laroche *et al.* 2007; Bruce and Bradford 2011). A recent review of the e-logbook included addition of measures of the consumption of teaser baits in 2015–16. Steps are being taken to develop an industry Code of Conduct, and review management processes to reduce berley inputs and minimise the frequency at which teaser baits are consumed.

White shark photographic identification catalogue

The white shark photographic identification catalogue was developed in 2013 and now integrates analysis of >35,000 individual images. Development of this catalogue was based on the methods outlined in the study of Domeier and Nasby-Lucas (2006). This led to the identification of 78 individual white sharks that visited the Neptune Islands Group Marine Park during operator days over the period from 4 October 2013 and 31 October 2014. Previous studies identified 76 white sharks during operator days on one vessel between January 2006 and December 2007 (Beckmann 2008), and 306 immature and mature-sized individuals over two longer periods between 2001–03 and 2009–11 at the Neptune Islands (Robbins and Fox 2012a). Whilst this method has inherent uncertainties with regard to temporal stability of some features (Robbins *et al.* 2012b), it has potential benefits for future ongoing monitoring of re-sights and provision of alternative biological indicators. An important component of assessing the ongoing utility of this method is weighing up the staff costs to operators and scientific personnel required to process the images relative to the logistical costs of established methods for estimating residency, including the use of acoustic telemetry. Prioritisation of future resources toward research and monitoring in the Neptune Islands Group Marine Park should scale the acoustic tagging-based residency estimates higher than collection of further photo-identification data.

Future directions

A quantitative analysis of the relationships between residency of white sharks in the Neptune Islands Group Marine Park, cage-diving industry activities, environmental and demographic factors will be undertaken using three years of data in 2016. SARDI is currently undertaking research to assess residency of white sharks in several areas where the white shark cage-diving industry does not operate. This will provide valuable information with which to assess the relative importance of the Neptune Islands Group Marine Park compared to other habitats in Spencer Gulf and the Great Australian Bight.

5. REFERENCES

Anderson, S.D., Chapple, T.K., Jorgensen, S.J., Klimley, A.P., Block, B.A. (2011). Long-term individual identification and site fidelity of white sharks, *Carcharodon carcharias*, off California using dorsal fins. *Marine Biology* 158, 1233–1237.

Anderson, S.D., and Goldman, K.J. (1996) Photographic Evidence of White Shark Movement in California Waters. *California Fish and Game* 82**,** 182–186.

Beckmann, C. (2008). Using photographic identification to determine the behavioural ecology of the great white shark (*Carcharodon carcharias*). Honours Thesis. School of Biological Sciences. Flinders University. 86 pp.

Bradford, R.W, Bruce, B.D, McAuley, R.B., Robinson, G. (2011). An Evaluation of Passive Acoustic Monitoring Using Satellite Communication Technology for Near Real-Time Detection of Tagged Animals in a Marine Setting. *The Open Fish Science Journal* 4, 10–20.

Bradford, R.W., and Robbins, R. (2013). A Rapid Assessment Technique to Assist Management of the White Shark (*Carcharodon carcharias*) Cage Dive Industry, South Australia. *The Open Fish Science Journal* 03/2013; 6:13-18. DOI: 10.2174/1874401X01306010013.

Bruce, B.D., Stevens, J.D., Bradford, R.W. (2005). Site fidelity, residence times and home range patterns of white sharks around pinniped colonies. CSIRO Final Report to the Australian Government Department of the Environment and Heritage. 45 pp.

Bruce, B.D., and Bradford, R.W. (2011). The effects of berleying on the distribution and behaviour of white sharks, *Carcharodon carcharias*, at the Neptune Islands, South Australia. Final Report to the Department of Environment and Natural Resources, South Australia, 50 pp.

Bruce, B., and Bradford, R. (2015). Segregation or aggregation? Sex-specific patterns in the seasonal occurrence of white sharks *Carcharodon carcharias* at the Neptune Islands, South Australia. *Journal of Fish Biology* 87, 1355–1370.

CITES (2004). Convention of International Trade in Endangered Species of Wild Fauna and Flora - Appendix II Listing of the White Shark (revision 1). [Online]. Available from: http://www.environment.gov.au/coasts/publications/pubs/great-white-cites-appendix2-english.pdf.

Department of the Environment (2013). Recovery Plan for the White Shark *(Carcharodon carcharias).* *http://www.environment.gov.au/resource/recovery-plan-white-shark-carcharodon-carcharias.*

Environment Australia (2002). White Shark *(Carcharodon carcharias)* Recovery Plan. July 2002. Marine Conservation Branch. 43 pp.

Domeier, M. L., Nasby-Lucas, N. (2006). Annual resightings of photographically identified white sharks (*Carcharadon carcharias*) at an eastern Pacific aggregation site. *Marine Biology* 150, 977–984.

Fisheries Management Act. (2007). http://www.legislation.sa.gov.au/LZ/C/A/FISHERIES%20MANAGEMENT%20ACT%202007.aspx

Hussey, N. E., McCann, H. M., Cliff, G., Dudley, S. F. J., Wintner, S. P., Fisk, A. T. (2012) Size-Based Analysis of Diet and Trophic Position of the White Shark (*Carcharodon carcharias*) in South African Waters. Ed. Michael L. Domeier. In: Global perspectives on the biology and life history of the great white shark. Chapter 3. Pg 27–49.

Huveneers, C, Rogers, P. J., Beckmann, C., Semmens, J. M., Bruce, B. D., Seuront, L. (2013). The effects of cage-diving activities on the fine-scale swimming behaviour and space use of white shark. *Marine Biology* DOI 10.1007/s00227-013-2277-6.

IUCN (2014) Red List of Threatened Species (Year Assessed: 2005-10-01). *Carcharodon carcharias* http://www.iucnredlist.org/details/3855/0

Klimley, A. P., Anderson, S. D. (1996). Residency patterns of white sharks at the South Farallon Islands, California. In: Klimley AP, Ainley DG (eds) Great white sharks: the biology of *Carcharodon carcharias*. Academic, San Diego, pp 365–373.

Laroche, R. K, Kock, A. A., Dill, L. M., Oosthuizen, W. H. (2007) Effects of provisioning ecotourism activity on the behaviour of white sharks, *Carcharodon carcharias*. *Marine Ecology Progress Series* 338,199–209.

Neptune Islands Group Ron and Valarie Taylor Marine Park Marine Park (2014). Management Plan Summary. 4 pp.

Pincock, D. G. (2011). False detections: what they are and how to remove them from detection data. DOC-004691 Version 02, April 13, 2011.

Pyle, P., Schramm, M. J., Keiper, C., and Anderson, S. D. (1999). Predation on a white shark (*Carcharodon carcharias*) by a killer whale (*Orchinus orca*) and a possible case of competitive displacement. Marine Mammal Science 15 (2), 563–568.

Robbins, R. L., Enarson, M., Bradford, R. W., Robbins, W. D. and Fox. A. G. (2015). Residency and Local Connectivity of White Sharks at Liguanea Island: A second aggregation site in South Australia? *The Open Fish Science Journal* 8, 23–29.

Robbins, R., Fox, A., (2012a). Use of the photographic identification of white sharks (*Carcharodon carcharias*) to determine seasonal abundance and site fidelity patterns, at the Neptune Islands, South Australia. Final Report to the Norman Wettenhall Foundation. Fox Shark Research Foundation. 22 pp.

Robbins, R., Fox, A. (2012b). Further evidence of pigmentation change in white sharks, *Carcharodon carcharias*. *Marine and Freshwater Research* 63, 1215–1217.

Rogers, P.J., Huveneers, C., Goldsworthy, S. D., Cheung, W. W. L., Jones, G. K., Mitchell, J. G., and Seuront, L. (2013). Population metrics and movement of two sympatric carcharhinids: a comparison of the vulnerability of pelagic sharks of the southern Australian gulfs and shelves. *Marine and Freshwater Research*. dx.doi.org/10.1071/MF11234.

Rogers, P.J., Huveneers, C, and Beckmann, C. (2014). Monitoring residency of white sharks, *Carcharodon carcharias* in relation to the cage-diving industry in the Neptune Islands Group Marine Park. South Australian Research and Development Institute (Aquatic Sciences), Adelaide. SARDI Publication No. F2014/000801-1. SARDI Research Report Series No. 818. 75pp.

Smith, J. K. and Page, B. (2015). Decision points for White Shark Tourism Policy, DEWNR Technical note 2015/09, Government of South Australia, through the Department of Environment, Water and Natural Resources, Adelaide. 12 pp.

Visser, I. N., Berghan, J., van Meurs, R. and Fertl, D. (2000). Killer whale (*Orchinus orca*) predation on a shortfin mako shark (*Isurus oxyrinchus*) in New Zealand waters. *Aquatic Mammals* 26(3). 229–231.

Visser, I. N. (2005). First observation of feeding on thresher (*Alopias vulpinus*) and hammerhead (*Sphyrna zygaena*) sharks by killer whales (*Orchinus orca*), which specialise on elasmobranchs as prey. *Aquatic Mammals* 3 (1) 83–88.

Appendix 1. Summary statistics showing residency estimates for white sharks at the North Neptune Islands (n=25) *denotes log transformed estimates as per decision points outlined in Smith and Page (2015).

Shark ID	2013–14	2014–15	Log10 2013–14	Log10 2014–15
1	3.6	1.0	0.6	0.0
2	9.7		1.0	
3	117.3		2.1	
4	4.7	4.2	0.7	0.6
5	13.0		1.1	
6	4.3	10.8	0.6	1.0
7	49.5		1.7	
8	1.0		0.0	
9	50.0		1.7	
10	4.9		0.7	
11	19.8		1.3	
12	0.3	4.7	-0.5	0.7
13	1.0		0.0	
14	4.2	9.0	0.6	1.0
15	0.3		-0.5	
16		14.4		1.2
17		2.5		0.4
18		16.8		1.2
19		0.9		-0.1
20		6.3		0.8
21		0.5		-0.3
22		0.0		-2.2
23		13.0		1.1
24		9.5		1.0
25		2.2		0.4
26		0.9		-0.1
27		3.0		0.5
28		8.9		0.9
29		10.0		1.0
30		0.2		-0.7
31		4.0		0.6
32				
33		0.1		-1.0
34		13.5		1.1
35				
36		39.2		1.6
37		52.1		1.7

Appendix 2. Summary statistics showing residency estimates (Res. est.) and mean residency estimates (Mean res. est.) for tagged white sharks at the North and South Neptune Islands between 14 September 2013 and 30 June 2015. SD=standard deviation.

Shark ID	North Neptune Islands							South Neptune Islands						
	N res. Periods	Res. est. (days)	Mean res. est. (days)	median	sd	min	max	N res. Periods	Res. est. (days)	Mean res. est. (days)	median	sd	min	max
1	9	-	2.4	0.6	3.5	0.0	9.8	5	-	17.7	3.4	30.0	0.1	70.8
2	5	-	9.7	9.6	7.5	2.2	20.7	4	-	1.1	0.2	1.9	0.0	3.9
3	1	117.3	-	-	-	-	-	1	0.0	-	-	-	-	-
4	11	-	4.5	4.2	2.8	0.6	9.8	6	-	2.0	0.8	2.7	0.0	6.8
5	1	13.0	-	-	-	-	-	-	-	-	-	-	-	-
6	6	-	9.7	9.3	7.5	0.7	21.2	5	-	6.9	0.7	12.4	0.1	28.9
7	1	49.5	-	-	-	-	-	2	-	3.1	3.1	4.4	0.0	6.3
8	5	-	1.0	1.0	0.8	0.2	2.2	3	-	3.8	1.2	5.6	0.0	10.2
9	1	50.0	-	-	-	-	-	1	0.2	-	-	-	-	-
10	1	4.9	-	-	-	-	-	-	-	-	-	-	-	-
11	1	19.8	-	-	-	-	-	1	0.0	-	-	-	-	-
12	8	-	4.1	0.7	5.3	0.0	12.8	6	-	1.7	0.0	2.9	0.0	6.8
13	1	1.0	-	-	-	-	-	-	-	-	-	-	-	-
14	2	-	6.6	6.6	3.4	4.2	9.0	-	-	-	-	-	-	-
15	1	0.3	-	-	-	-	-	-	-	-	-	-	-	-
16	4	-	14.4	14.3	11.4	0.4	28.3	2	-	4.8	4.8	2.4	3.1	6.5
17	2	-	2.5	2.5	1.0	1.8	3.2	2	-	10.4	10.4	12.6	1.5	19.3
18	3	-	16.8	22.6	13.3	1.6	26.2	2	-	2.3	2.3	1.3	1.4	3.2
19	4	-	0.9	0.7	0.9	0.0	2.1	2	-	9.9	9.9	14.1	0.0	19.9

20	8	-	6.3	4.2	7.4	0.1	22.5	2	-	0.1	0.1	0.2	0.0	0.3
21	1	0.5	-	-	-	-	-	2	-	12.8	12.8	17.0	0.8	24.9
22	1	0.0	-	-	-	-	-	-	-	-	-	-	-	-
23	2	-	13.0	13.0	9.7	6.2	19.8	1	0.0	-	-	-	-	-
24	2	-	9.5	9.5	11.2	1.5	17.4	4	-	3.3	2.0	4.3	0.0	9.3
25	2	-	2.2	2.2	3.2	0.0	4.5	1	0.0	-	-	-	-	-
26	4	-	0.9	0.2	1.5	0.0	3.1	-	-	-	-	-	-	-
27	1	3.0	-	-	-	-	-	-	-	-	-	-	-	-
28	1	8.9	-	-	-	-	-	-	-	-	-	-	-	-
29	1	10.0	-	-	-	-	-	1	0.3	-	-	-	-	-
30	2	-	0.2	0.2	0.1	0.1	0.3	1	26.9	-	-	-	-	-
31	1	4.0	-	-	-	-	-	1	4.9	-	-	-	-	-
32	-	-	-	-	-	-	-	1	22.8	-	-	-	-	-
33	1	0.1	-	-	-	-	-	1	0.2	-	-	-	-	-
34	1	13.5	-	-	-	-	-	1	21.8	-	-	-	-	-
35	-	-	-	-	-	-	-	1	0.3	-	-	-	-	-
36	1	39.2	-	-	-	-	-	1	6.0	-	-	-	-	-
37	1	52.1	-	-	-	-	-	1	1.0	-	-	-	-	-

Appendix 3. White shark photo identification catalogue summary. November 2013 to November 2014. Photos shown represent samples of those held in the catalogue for each individual (n=78).

Photo ID	NI001
LS photo	 
Pigmented Regions Types	LG2LP1LC2
RS photo	
Pigmented Regions Types	RG2RP2RC2

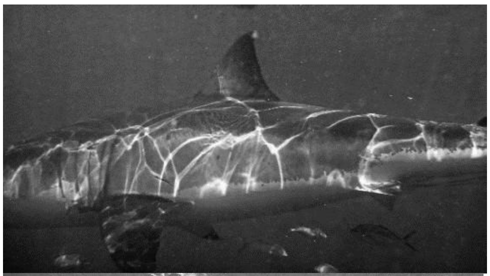
Photo ID	NI002
LS photo	 
Pigmented Regions Types	LG2LP2LC0
RS photo	 
Pigmented Regions Types	RG2RP3RC4

Photo ID	NI003
LS photo	
Pigmented Regions Types	LG3LP1LC0
RS photo	
Pigmented Regions Types	RG3RP2RC2

Photo ID	NI004
LS photo	
Pigmented Regions Types	LG1LP0LC0
RS photo	
Pigmented Regions Types	RG1RP0RC0

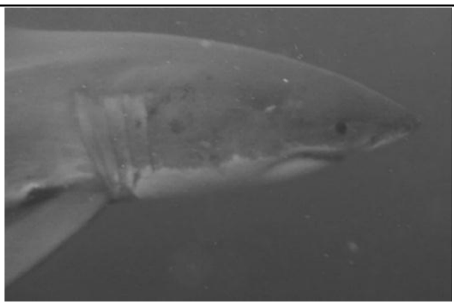
Photo ID	NI005
LS photo	
Pigmented Regions Types	LG2LP0LC0
RS photo	
Pigmented Regions Types	RG3RP1RC4

Photo ID	NI007
LS photo	
Pigmented Regions Types	LG2LP1LC4
RS photo	
Pigmented Regions Types	RG2RP1RC4

Photo ID	NI011
LS photo	
Pigmented Regions Types	LG1LP0LC0
RS photo	
Pigmented Regions Types	RG2RP1RC0

Photo ID	NI013
LS photo	
Pigmented Regions Types	LG2LP1LC0
RS photo	
Pigmented Regions Types	RG3RP0RC0

Photo ID	NI016
LS photo	
Pigmented Regions Types	LG3LP1LC1
RS photo	
Pigmented Regions Types	RG2RP0RC0

Photo ID	NI020
LS photo	
Pigmented Regions Types	LG2LP1LC4
RS photo	
Pigmented Regions Types	RG2RP1RC4

Photo ID	NI025
LS photo	
Pigmented Regions Types	LG2LP0LC2
RS photo	
Pigmented Regions Types	RG3RP0RC0

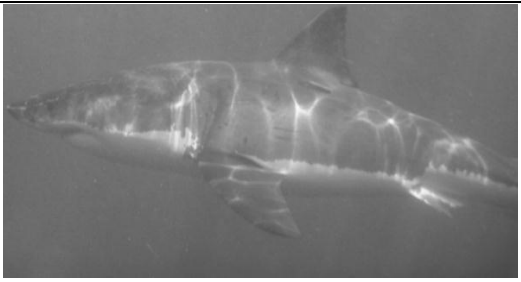
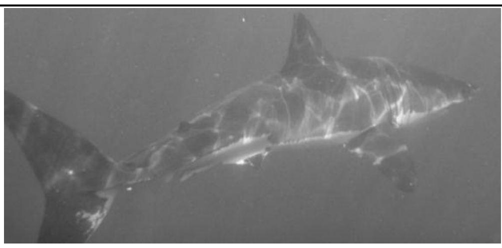
Photo ID	NI026
LS photo	
Pigmented Regions Types	LG3LP2LC4
RS photo	
Pigmented Regions Types	RG3RP2RC4

Photo ID	NI027
LS photo	
Pigmented Regions Types	LG3LP1LC2
RS photo	
Pigmented Regions Types	RG3RP0RC0

Photo ID	NI028
LS photo	
Pigmented Regions Types	LG3LP1LC0
RS photo	
Pigmented Regions Types	RG3RP0RC0

Photo ID	NI029
LS photo	
Pigmented Regions Types	LG3LP3LC0
RS photo	
Pigmented Regions Types	RG2RP0RC0

Photo ID	NI036
LS photo	
Pigmented Regions Types	LG3LP0LC4
RS photo	
Pigmented Regions Types	RG3RP0RC4

Photo ID	NI040
LS photo	
Pigmented Regions Types	LG3LP0LC0
RS photo	
Pigmented Regions Types	RG3RP0RC0

Photo ID	NI045
LS photo	
Pigmented Regions Types	LG3LP3LCO
RS photo	
Pigmented Regions Types	RG3RP1RC0

Photo ID	NI050
LS photo	
Pigmented Regions Types	LG3LP0LCO
RS photo	
Pigmented Regions Types	RG3RP0RC0

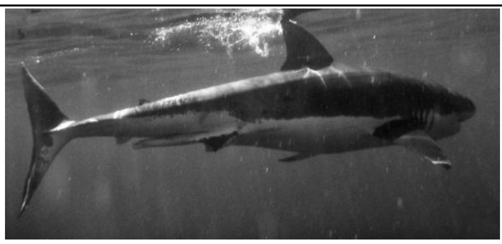
Photo ID	NI052
LS photo	
Pigmented Regions Types	LG3LP2LC0
RS photo	
Pigmented Regions Types	RG3RP2RC4

Photo ID	NI056
LS photo	
Pigmented Regions Types	LG3LP1LC4
RS photo	
Pigmented Regions Types	RG2RP0RC0

Photo ID	NI059
LS photo	
Pigmented Regions Types	LG3LP3LC4
RS photo	
Pigmented Regions Types	RG3RP3RC4

Photo ID	NI062
LS photo	
Pigmented Regions Types	LG1LP1LC1
RS photo	
Pigmented Regions Types	RG1RP1RC1

Photo ID	NI067
LS photo	
Pigmented Regions Types	LG3LP1LC4
RS photo	
Pigmented Regions Types	RG3RP1RC0

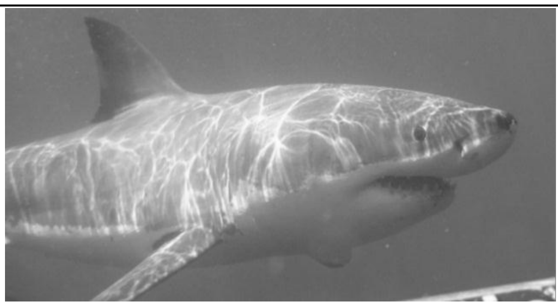
Photo ID	NI078
LS photo	
Pigmented Regions Types	LG3LP0LC0
RS photo	
Pigmented Regions Types	RG3RP0RC0

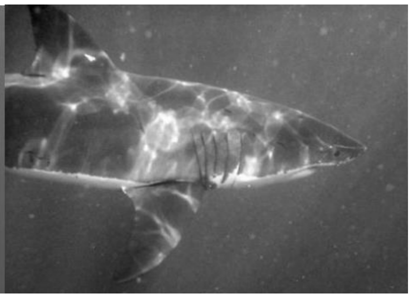
Photo ID	NI079
LS photo	
Pigmented Regions Types	LG3LP2LC2
RS photo	  
Pigmented Regions Types	RG3RP1RC1

Photo ID	NI080
LS photo	
Pigmented Regions Types	LG2LP0LC0
RS photo	
Pigmented Regions Types	RG3RP0RC0

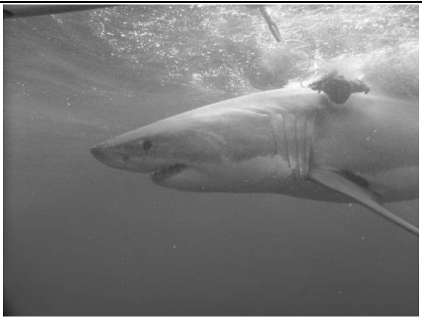
Photo ID	NI084
LS photo	
Pigmented Regions Types	LG3LP0LC0
RS photo	
Pigmented Regions Types	RG3RP1RC2

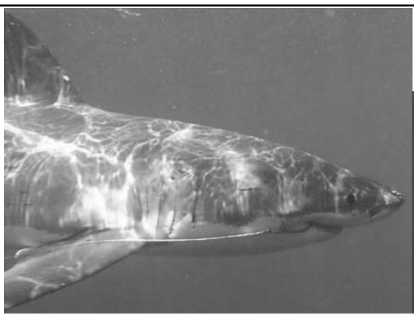
Photo ID	NI086
LS photo	
Pigmented Regions Types	LGLPLC
RS photo	 
Pigmented Regions Types	RG2RP3RC4

Photo ID	NI087
LS photo	
Pigmented Regions Types	LG2LP1LC0
RS photo	
Pigmented Regions Types	RG2RP1RC0

Photo ID	NI088
LS photo	
Pigmented Regions Types	LG3LP0LC0
RS photo	
Pigmented Regions Types	RG3RP0RC0

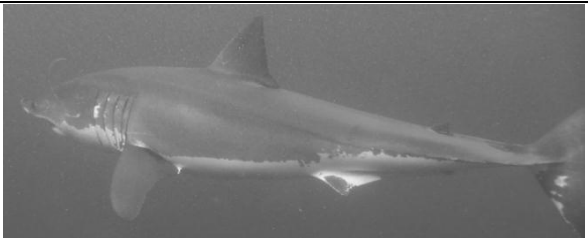
Photo ID	NI089
LS photo	
Pigmented Regions Types	LG3LP3LC4
RS photo	
Pigmented Regions Types	RG3RP3RC4

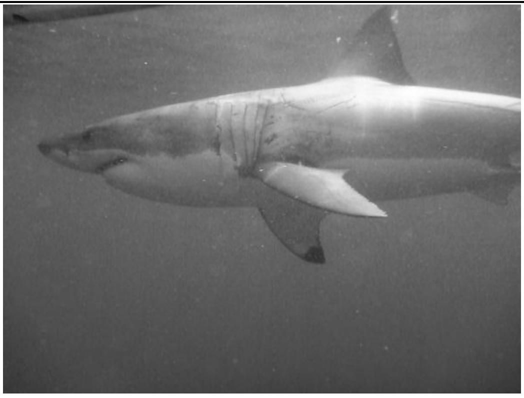
Photo ID	NI090
LS photo	
Pigmented Regions Types	LG2LP0LC0
RS photo	
Pigmented Regions Types	RG2RP1RC0

Photo ID	NI092
LS photo	
Pigmented Regions Types	LG3LP0LC0
RS photo	
Pigmented Regions Types	RG3RP0RC0

Photo ID	NI094
LS photo	
Pigmented Regions Types	LG3LP3LC4
RS photo	
Pigmented Regions Types	RG3RP3RC4

Photo ID	NI095
LS photo	 
Pigmented Regions Types	LG3LP3LC0
RS photo	 
Pigmented Regions Types	RG3RP3RC0

Photo ID	NI096
LS photo	 
Pigmented Regions Types	LG2LP1LC2
RS photo	
Pigmented Regions Types	RG2RP1RC1

Photo ID	NI104
LS photo	
Pigmented Regions Types	LG3LP1LC1
RS photo	
Pigmented Regions Types	RG3RP2RC1

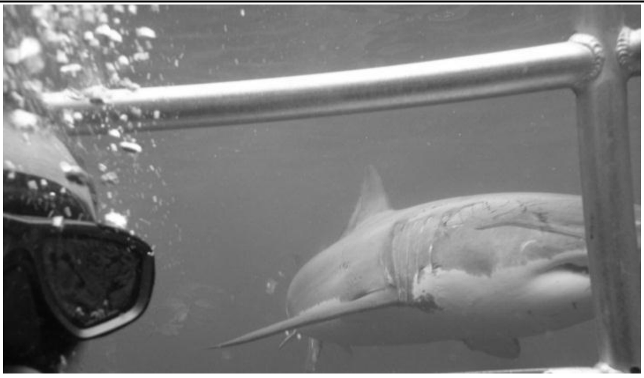
Photo ID	NI130
LS photo	
Pigmented Regions Types	LG2LP1LC4
RS photo	
Pigmented Regions Types	RG2RP1RC4

Photo ID	NI101
LS photo	
Pigmented Regions Types	LG3LP0LC0
RS photo	 
Pigmented Regions Types	RG3RP0RC0

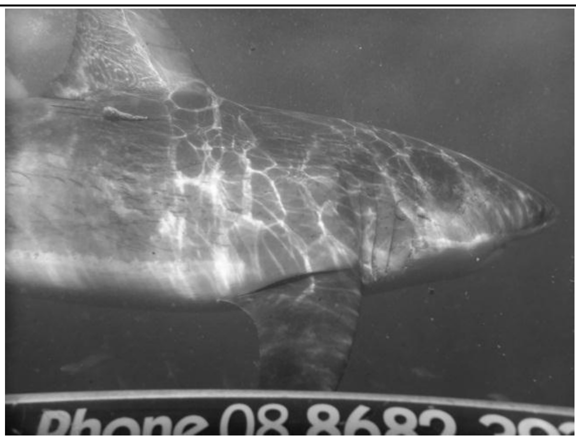
Photo ID	NI102
LS photo	
Pigmented Regions Types	LG3LP3LC0
RS photo	
Pigmented Regionns Types	RG3RP0RC0

Photo ID	NI107
LS photo	
Pigmented Regions Types	LG2LP0LC0
RS photo	
Pigmented Regions Types	RG3RP1LC1

Photo ID	NI109
LS photo	
Pigmented Regions Types	LG3LP1LC0
RS photo	
Pigmented Regions Types	RG1RP1RC3

Photo ID	NI110
LS photo	
Pigmented Regions Types	LG3LP3LC4
RS photo	
Pigmented Regions Types	RG3RP3RC4

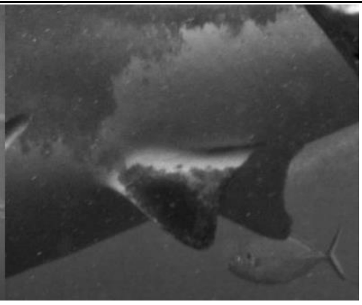
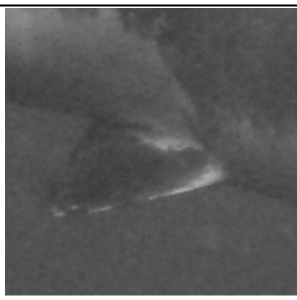
Photo ID	NI111
LS photo	 
Pigmented Regions Types	LG3LP2LC2
RS photo	 
Pigmented Regions Types	RG3RP1RC4

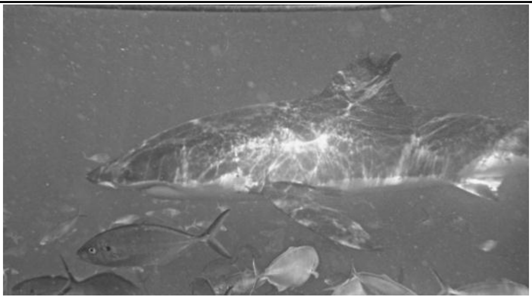
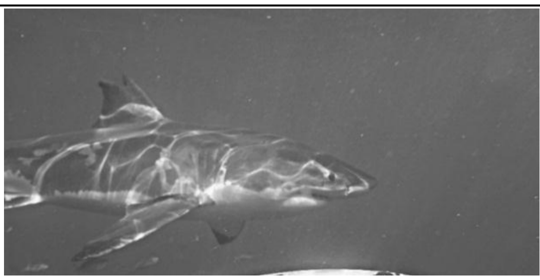
Photo ID	NI113
LS photo	
Pigmented Regions Types	LG2LP1LC0
RS photo	
Pigmented Regions Types	RG2RP0RC0

Photo ID	NI116
LS photo	
Pigmented Regions Types	LG2LP1LC4
RS photo	
Pigmented Regions Types	RG2RP0RC0

Photo ID	NI119
LS photo	
Pigmented Regions Types	LG3LP1LC0
RS photo	
Pigmented Regions Types	RG2RP1RC4

Photo ID	NI120
LS photo	
Pigmented Regions Types	LG3LP1LC4
RS photo	
Pigmented Regions Types	RG3RP1RC4

Photo ID	NI122
LS photo	
Pigmented Regions Types	LG3LP2LC4
RS photo	
Pigmented Regions Types	RG3RP2RC4

Photo ID	NI128
LS photo	
Pigmented Regions Types	LG3LP3LC2
RS photo	
Pigmented Regions Types	RG3RP0RC0

Photo ID	NI131
LS photo	 
Pigmented Regions Types	LG3LP1LC0
RS photo	
Pigmented Regions Types	RG2RP3RC4

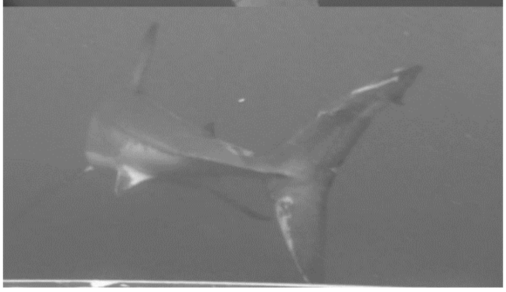
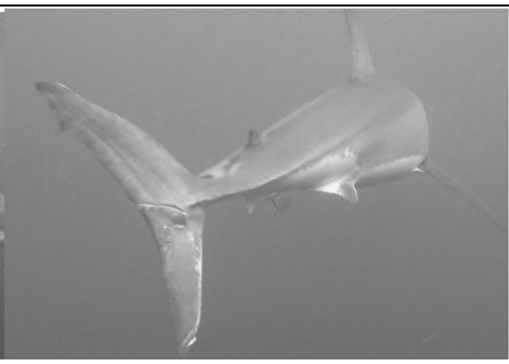
Photo ID	NI132
LS photo	 
Pigmented Regions Types	LG3LP1LC4
RS photo	 
Pigmented Regions Types	RG3RP1RC3

Photo ID	NI143
LS photo	
Pigmented Regions Types	LG2LP0LC0
RS photo	
Pigmented Regions Types	RG2RP0RC4

Photo ID	NI145
LS photo	
Pigmented Regions Types	LG0LP0LC0
RS photo	 
Pigmented Regions Types	RG3RP1RC4

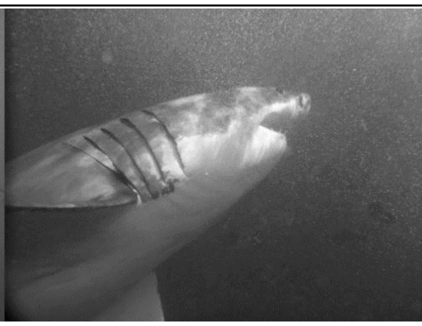
Photo ID	NI148
LS photo	 
Pigmented Regions Types	LG2LP1LC2
RS photo	 
Pigmented Regions Types	RG2RP1RC2

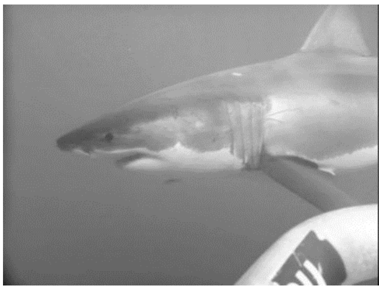
Photo ID	NI157
LS photo	 
Pigmented Regions Types	LG2LP1LC0
RS photo	 
Pigmented Regions Types	RG2RP1RC0

Photo ID	NI200

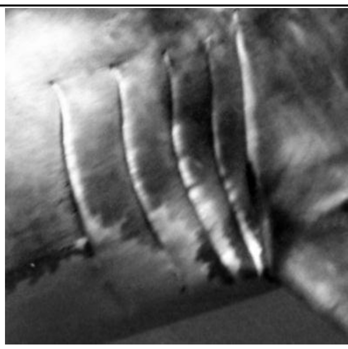
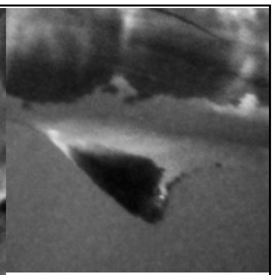
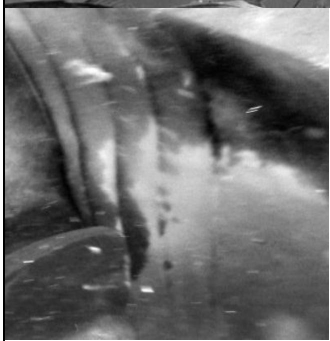
LS photo	 
Pigmented Regions Types	LG3LP3LC4
RS photo	 
Pigmented Regions Types	RG3RP3RC2

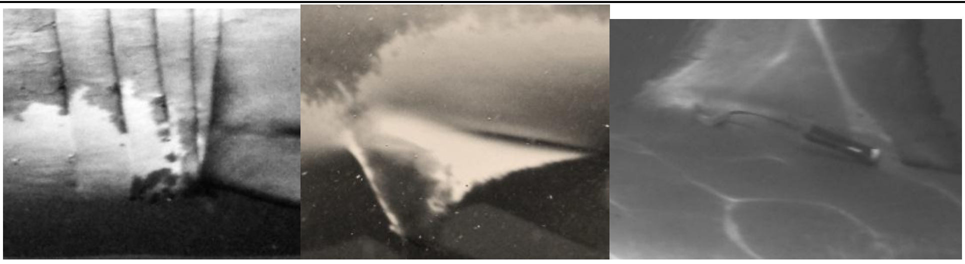
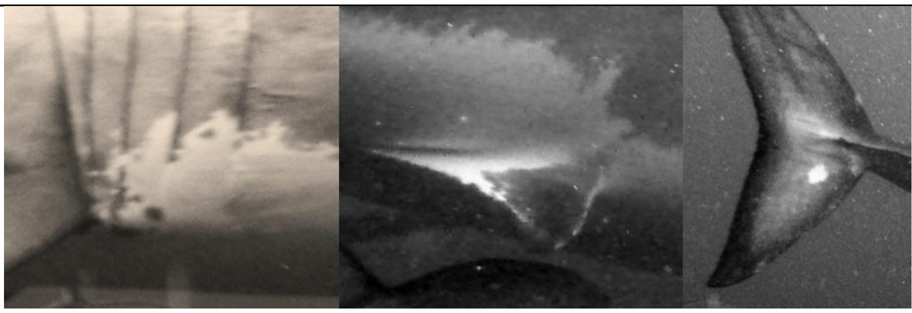
Photo ID	NI201
LS photo	
Pigmented Regions Types	LG3LP1LC0
RS photo	
Pigmented Regions Types	RG3RP2RC2

Photo ID	NI202
LS photo	
Pigmented Regions Types	LG3LP0LC0
RS photo	
Pigmented Regions Types	RG2RP1RC0

Photo ID	NI203
LS photo	
Pigmented Regions Types	LG1LP1LC0
RS photo	
Pigmented Regions Types	RG1RP1RC3

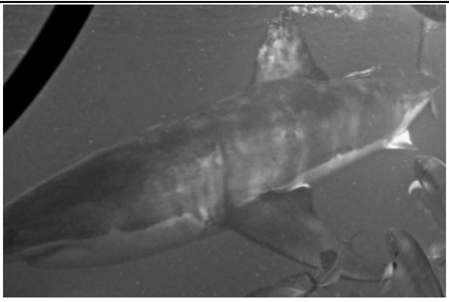
Photo ID	NI204
LS photo	
Pigmented Regions Types	LG2LP3LC2
RS photo	
Pigmented Regions Types	RG2RP1RC2

Photo ID	NI205
LS photo	
Pigmented Regions Types	LG2LP1LC2
RS photo	
Pigmented Regions Types	RG2RP1RC0

Photo ID	NI206
LS photo	
Pigmented Regions Types	LP1LP0LC2
RS photo	 
Pigmented Regions Types	RG2RP2RC0

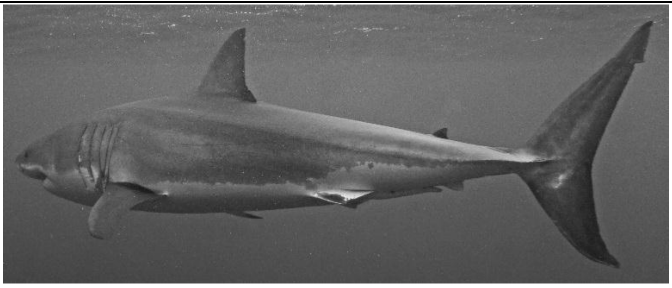
Photo ID	NI207
LS photo	
Pigmented Regions Types	LG2LP1LC2
RS photo	
Pigmented Regions Types	RG2RP1RC2

Photo ID	NI208
LS photo	
Pigmented Regions Types	LG2LP2LC4
RS photo	
Pigmented Regions Types	RG3RP2RC4

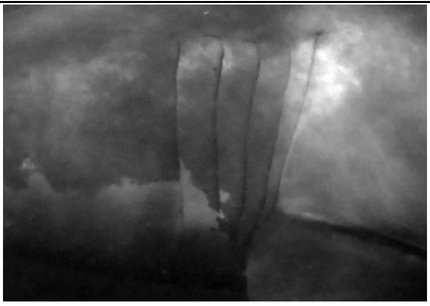
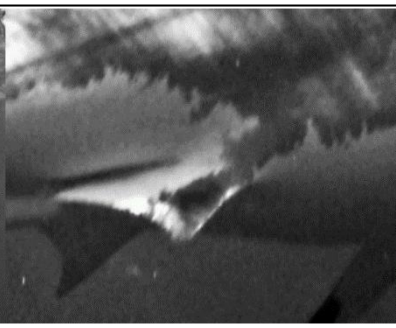
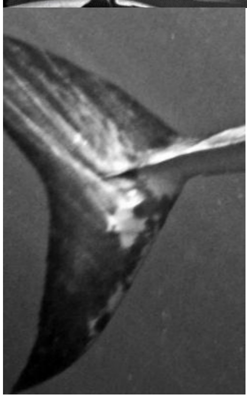
Photo ID	NI209
LS photo	
Pigmented Regions Types	LG2LP1LC0
RS photo	
Pigmented Regions Types	RG3RP1RC4

Photo ID	NI210
LS photo	
Pigmented Regions Types	LG2LP3LC0
RS photo	
Pigmented Regions Types	RG2RP2RC0

Photo ID	NI211
Dates Sighted	24,26/08/2014
LS photo	
Pigmented Regions Types	LG2LP1LC0
RS photo	
Pigmented Regions Types	RG0RP0RC0

Photo ID	NI212
LS photo	
Pigmented Regions Types	LG0LP1LC0
RS photo	
Pigmented Regions Types	RG2RP1RC0

Photo ID	NI213
LS photo	 
Pigmented Regions Types	LG2LP3LC0
RS photo	
Pigmented Regions Types	RG2RP0RC0

Photo ID	NI214
LS photo	
Pigmented Regions Types	LG3LP1LC3
RS photo	
Pigmented Regions Types	RG2RP1RC0

Photo ID	NI215
LS photo	
Pigmented Regions Types	LG3LP3LC4
RS photo	
Pigmented Regions Types	RG3RP3RC4

Photo ID	NI216
LS photo	 
Pigmented Regions Types	LG2LP1LC1
RS photo	
Pigmented Regions Types	RG3RP1RC1

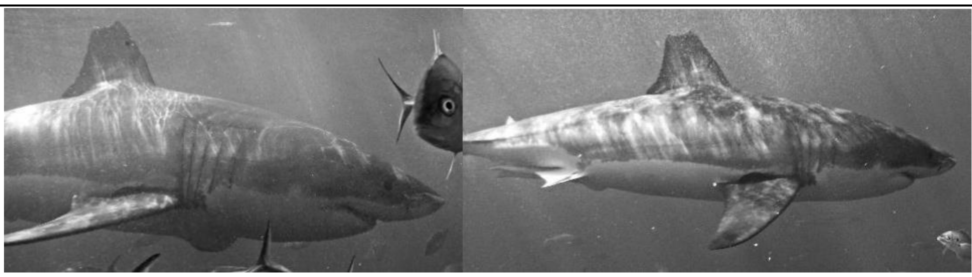
Photo ID	NI217
LS photo	
Pigmented Regions Types	LG2LP1LC0
RS photo	
Pigmented Regions Types	RG2RP1RC0

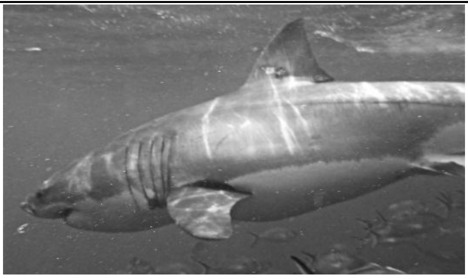
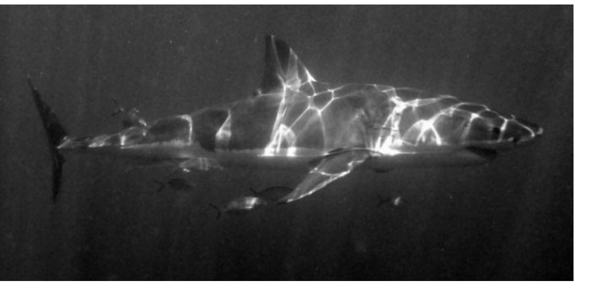
Photo ID	NI218
LS photo	
Pigmented Regions Types	LG2LP1LC3
RS photo	
Pigmented Regions Types	RG2RP1RC2

Photo ID	NI219
LS photo	
Pigmented Regions Types	LG2LP3LC0
RS photo	
Pigmented Regions Types	RG2RP1RC2

Photo ID	NI220
LS photo	
Pigmented Regions Types	LG3LP0LC0
RS photo	 
Pigmented Regions Types	RG3RP3RC4