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Results of the non-lethal SMART drumline trial in south-western Australia between 21 February 2019 and 20 February 2020

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Important disclaimer

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1. Executive Summary

After a number of fatal and serious incidents involving white sharks (*Carcharodon carcharias*) in the South West of Western Australia, the Western Australian Government committed to undertaking a scientific trial of non-lethal Shark-Management-Alert-in-Real-Time (SMART) drumlines. The trial was initiated to provide the required evidence-based scientific data to inform the Western Australian Government's shark mitigation strategy. This report evaluates and summarises the data derived from the one-year trial (21 February 2019 to 20 February 2020).

The specific aim of the trial was to determine whether white sharks, which were relocated after capture on a SMART drumline and released at least 1 km from shore, remained off-shore (i.e. > 1km) or whether they returned to nearshore coastal waters and beaches. To assess white shark movements, captured sharks were tagged with an external acoustic tag, a conventional dart tag and a pop-up archival transmitting (PAT) tag. Acoustic receivers (VR2s) were deployed in six arrays, a primary array off Gracetown and five secondary arrays at adjacent surf locations in the Capes region. Five near real-time acoustic receivers (VR4G), four within the arrays and one at a nearby beach in the Capes region (Meelup) complimented these arrays of VR2s.

A contractor was responsible for setting SMART drumlines daily at 10 fixed locations across 11.5 kilometres of coastline, about 500 metres offshore from Hangmans surfbreak north of Gracetown to Ellensbrook in the south. These drumlines were continuously monitored for 252 fishing days (69.0% of the 12 month period), with risk weather conditions preventing the use of fishing equipment on 113 days. A Departmental observer inspected fishing operations on-board the contractor's vessel for 133 days (52.8% of fishing days), to provide ongoing training and to ensure the accurate recording of data. Detailed capture information was recorded for every animal, including species, size, sex, hooking location, time spent on the hook, and release condition. Video footage from on-board and under-water cameras was used to monitor the process of animal handling and to verify the release condition of animals. In addition, third party observers (3POs) representing the Conservation Council of Western Australia and Sea Shepherd were on-board the vessel for eight fishing days (3.2% of fishing days), providing feedback on daily fishing operations.

In total, 182 animals were caught including two white sharks (target species), 146 non-target sharks and 34 non-target other marine animals. Non-target sharks caught included 75 tiger sharks (*Galeocerdo cuvier*), 36 bronze whaler sharks (*Carcharhinus brachyurus*), 24 shortfin makos (*Isurus oxyrinchus*), 10 dusky whaler sharks (*Carcharhinus obscurus*) and one smooth hammerhead (*Sphyrna zygaena*). The non-target species included 30 smooth stingrays (*Dasyatis brevicaudata*), three pink snapper (*Chrysophrys auratus*), and one samsonfish (*Seriola hippos*). Excluding the three pink snapper, all animals caught on SMART drumlines were released alive with 88% (n = 160) being categorised as released in good condition. The average response time to a SMART drumline alert was 11.1 minutes (range 1 – 44 min), and the average duration for which animals were on the hook was 26.6 minutes (range 6 – 143 min). Shark captures ranged in size from a 0.91m (Total Length, TL) dusky whaler shark to a 4.60m TL white shark. Both white sharks and 15 tiger sharks larger than 3m TL were relocated >1km offshore.

On 25 April 2019, a 4.6 m (TL) female white shark was captured off North Point and relocated offshore. It was detected on three acoustic receivers on the offshore line before moving south.

The estimated track shows that in the first 24 hours the shark continued to move offshore from the release site and then south, rounded Cape Leeuwin, then moved east and arrived in waters offshore of Esperance in May before the PAT tag released on 18 June 2019. This shark travelled approximately 1,304 km in 54 days at liberty.

The second white shark was a 3.3 m (TL) female captured on 20 August 2019 south of Ellensbrook. It was relocated 1 km from shore and swam directly offshore being detected on three receivers on the offshore line before moving north-west to more offshore waters and then northwards along shelf edge waters to an area west of the Houtman Abrolhos Islands in early September. This shark then travelled along shelf waters to an area north of Bernier Island before beginning a return journey southward in early October. It was detected on acoustic receivers off Perth, and 76 days after release (6 November 2019) it was recorded on secondary arrays (Three Bears, Yallingup and Injidup) and the primary array at Gracetown where it was detected on the nearshore line of receivers. The SMART drumlines were not being fished at the time of this series of detections due to risk weather. This shark then continued moving south and then east to the Recherche Archipelago area where the tag released on 21 February 2019 travelling an overall distance of approximately 5,156 km in 182 days at liberty.

In addition to the two white sharks that were tagged and released as part of the SMART drumline trial, 12 other white sharks were detected within the Capes arrays during the 12-month period. There were four separate movements of white sharks through the Gracetown array when the SMART drumlines were actively being fished, which did not result in their capture.

In conclusion, the results from the 12-month trial confirm that it is feasible to capture large white sharks, respond to hooked animals within 30-minutes and release animals in good condition. However, additional movement information obtained from other white sharks caught, tagged and relocated in the Gracetown area would be required to scientifically demonstrate the effectiveness of SMART drumlines as a shark mitigation measure in Western Australian conditions. Nevertheless, it must be acknowledged that there are inherent difficulties in obtaining a larger sample size for white sharks and predicting potential future catches.

2. Background

Human encounters with sharks are uncommon and rarely result in injuries, however shark bites can have traumatic consequences for those involved, their families, friends and affected communities (Curtis *et al.*, 2012). Between 2000 and 2018 there were 70 shark bite incidents in coastal waters of Western Australia (WA) of which 15 were fatal (Australian Shark Attack File 2018). The 11 fatalities that took place over the 6-year period between August 2010 and April 2017 all reportedly involved white sharks. Despite the annual frequency of such encounters in WA being highly variable and low since official records began, there has been an increasing trend since the 1970s (West, 2011; DoF, 2012; McPhee, 2014).

Consequently, during this recent period of increased frequency of white shark bites and encounters along the WA coast, the State Government of Western Australia adopted various shark mitigation strategies, including a website to inform the public about shark safety information and these mitigation tools provided (see https://www.sharksmart.com.au/). This strategy was designed to reduce the likelihood of shark-human encounters. These strategies also included the development and maintenance of an extensive acoustic tagging and receiver program for predominantly white sharks in WA waters in order to provide detailed information on when and where white sharks are detected in WA. When satellite-linked receivers in coastal waters detect a tagged shark, the public are alerted in near real-time through websites, mobile notifications and text messages, and in some coastal locations lights and sirens. This allows the public to make informed decisions on where they undertake water-based activities.

A range of studies have contributed to developing an enhanced understanding of the complex and dynamic interactions between shark and human abundance, distribution and behaviours that contribute to white shark bite incidents (e.g. DoF 2014; McPhee, 2014; Chapman and McPhee, 2016; McAuley *et al.*, 2017) and this knowledge is utilised within a framework of shark hazard mitigation strategies. Data derived from research aligned to this program has resulted in an improved understanding of the movement ecology of white sharks in coastal waters of WA (McAuley *et al.*, 2016; McAuley *et al*., 2017) and their interactions with fisheries (Taylor *et al*., 2016; Taylor *et al*., 2018).

In Australia, there have been shark control programs in place in both NSW and Queensland for decades (McPhee, 2012) in response to public concerns about hazards posed by sharks. These programs use large mesh nets and baited hooks on drumlines (QLD only) close to popular beaches. There is also an ongoing program of shark mesh nets used along part of the east coast of South Africa. The drumline method was trialed off beaches in the Perth metropolitan, Geographe Bay and Capes region in Western Australia in 2014, but this was not continued as an ongoing method of shark hazard mitigation.

The effectiveness of mesh nets and drumlines in reducing shark bite incidents remains unclear from a statistically testable perspective, in part due to the rarity of occurrences. Nonetheless, in comparing long periods of before and after mesh-based shark control programs in Queensland, New South Wales and South Africa Dudley (1997) found that "the apparent successes of the programs in reducing total numbers of shark attacks at meshed beaches are impressive". The reductions in catch rates of sharks led Dudley (1997) to conclude that the programs work by reducing the numbers of sharks in an area and then continually harvesting any new immigrants that come into an area to keep numbers down. In his review, McPhee (2012) concurs that if shark nets and drumlines are effective it is through reducing numbers of sharks in an area as neither method actually forms a barrier between the coast and the open ocean. The basic premise is to reduce shark numbers, and thereby the probability of an encounter between a shark and a water user near a beach (Dudley, 1997). McPhee further noted that shark bite incidents have been recorded from beaches where shark nets are deployed, so while such programs reduce risk they do not eliminate it. Although these shark control programs are generally considered to have improved the safety of people in the water (McPhee, 2012), there are concerns with mortality of non-target (bycatch) species including iconic animals of high social value (i.e. whales, dolphins, turtles). There is also community concern with mortality of sharks caught in mesh nets and drumlines given the premise that effectiveness as a stand-alone mitigation method is based on reducing the numbers of potentially dangerous sharks.

One innovative response to the need for better environmental outcomes for target and non-target species in the context of shark hazard mitigation in oceanic waters is the SMART (Shark-Management-Alert-in-Real-Time) drumline, which is intended to be non-lethal. This method was first deployed as part of a shark mitigation strategy at Reunion in the southern Indian Ocean (Guyomard *et al*. ,2019; Guyomard *et al*., 2020). The system uses a baited hook, as for traditional drumlines, but has an added communication buoy tethered to the drumline that detects when a bait is taken and immediately alerts personnel via phone. This initiates an immediate response with the aim to reach the drumline before the shark (or bycatch) dies. The State Government of NSW implemented a trial of a modified version of SMART drumlines in 2015, with target sharks tagged and relocated 1 km from shore (https://www.dpi.nsw.gov.au/fishing/sharks/management/smart-drumlines).

The Government of Western Australia instigated a trial of this technology in order to determine whether it could be integrated into the suite of ongoing shark hazard mitigation strategies in WA. Because the SMART drumline method is designed to be non-lethal, its application when combined with live-release of sharks after relocation offshore is not intended to reduce the local shark population over a long period as is the case with traditional drumline and beach mesh programs. Rather, the SMART drumline aims to provide a short-term reduction in shark numbers by removing them from nearby surf beaches, thereby decreasing the likelihood of encounters. That is, the goal is to achieve an immediate risk reduction. The challenge from a hazard mitigation perspective is demonstrating how long a relocated shark remains away from beaches and how does this translate into a change in risk levels to water users.

The objective of this study is to evaluate the efficacy of the non-lethal SMART drumline method for reducing risk to humans in south-western Australia while maximizing welfare outcomes for target and non-target species. This report evaluates the data derived from the non-lethal SMART drumline trial in south-western Australia from 21 February 2019 to 20 February 2020, with specific reference to the movement patterns of white sharks (*Carcharodon carcharias*).

3. Methods

3.1 SMART Drumline Configuration

The scientific framework for the trial was decided following community consultation, including the configuration of the SMART drumlines in the Gracetown area. A SMART Drumline Trial Ministerial Reference Group was formed, with representatives from State and Local Government Agencies, the Conservation Council of Western Australia, Sea Shepherd, Surfing WA and Surf Life Saving Western Australia. The Reference Group assisted in many aspects of the trial, provided regular feedback on the process, and assisted in communicating the trial objectives and preliminary results to interested community members.

The configuration of the SMART drumline locations surrounding Gracetown was open to public consultation from 13 September 2018 until 10 October 2018. The preferred option was that 10 SMART drumlines be deployed evenly, about 500m from shore, along 11.5km of the coast.

3.2 SMART Drumline Operations

Weather permitting, the 10 SMART drumlines were deployed and retrieved daily by a commercial contractor to the Department of Primary Industries and Regional Development. Commencement of SMART drumline deployment occurred no later than one hour after sunrise and was completed no later than two and a half hours after sunrise. During periods of risk weather conditions in the morning or operational limitation to vessel launching (i.e. peak recreational boat launching), the delayed commencement of fishing operations was approved. Retrieval of SMART drumlines did not occur earlier than two hours before sunset, and was completed by sunset. When the weather conditions changed to become not conducive to the safe handling of animals, or the fishing operations staff, fishing gear was retrieved earlier (risk weather). The set and retrieval times of each SMART drumlines was recorded (Appendix 7 Gear sheet).

Each SMART drumline was baited with either Western Australian salmon (*Arripis truttaceus*) or sea mullet (*Mugil cephalus*) which was one kilogram in weight. Each SMART drumline was checked every three hours and empty hooks or those where part of the bait had been removed were re-baited. These regular checks were also designed to minimize harm to any animals that may not have triggered the alarm. The time and the bait present at each check was recorded (Appendix 7 Gear sheet). In the event of an alarm, the fisher was required to attend the triggered SMART drumlines within 30 minutes, and to determine whether an animal was on the hook or if it was a false alarm (Appendix 7 Gear sheet).

3.3 Capture, Tagging and Relocation of White Sharks

Animal ethics approval for the trial was granted through the DPIRD Animal Ethics Committee as project AEC 18-5-14.

On-board cameras were activated as soon as the crew confirmed that an animal was on a hook. When the animal was ready, it was secured to the vessel as per Departmental tagging procedures such that pain and distress was minimised (e.g. shark's head and gills are submerged at all times). Once secured, the species identification of the animal was confirmed and a series of measurements were made (Appendix 8 Catch sheet).

For tag application, a pilot hole was made with a tagging applicator before inserting the tags. A yellow identification tag was inserted in all animals at the base of the dorsal fin. An acoustic tag and pop-up archival transmitting (PAT) tag was inserted into the base of the dorsal fin for all white sharks. The PAT and the acoustic tags were inserted on different sides of the fin.

Once all data collection and tagging was completed the animal was released. All white sharks and tiger sharks three metres or greater in total length (TL) were relocated at least one kilometre offshore and released, weather permitting. The relocation of the shark was only undertaken when both the health and safety of the crew and shark could be guaranteed. If the crew or shark welfare was in doubt, the relocation ceased and the shark was released as soon as possible, regardless of distance from shore. It was of paramount importance to this trial to avoid or minimise harm, including pain and distress.

3.4 Animal Welfare Metrics

A series of metrics related to animal welfare were generated and can be found in the appendices. These include;

- Response Time (9.3 Appendix 3)
- Hooked Time (9.4 Appendix 4)
- Hooking Location (9.5 Appendix 5)
- Release Condition (9.6 Appendix 6)

3.5 Acoustic Tracking

Acoustic tracking is used to determine the movement patterns by attaching an acoustic transmitter to the individual to be tracked. Acoustic receivers then detect the unique acoustic signal that is emitted by the transmitter. Acoustic receivers can provide near real-time notifications via satellite linked receivers (VR4; Vemco) or store the data for subsequent retrieval and downloading (VR2; Vemco). This study externally attached an acoustic transmitter (V16-6H; Vemco) upon capture (3. Methods: 3.3 Capture, Tagging and Relocation of White Sharks), which permitted the detection of the shark on acoustic receivers in the Shark Monitoring Network (SMN; https://www.sharksmart.com.au/research/shark-monitoring-network/), as well as acoustic receivers (VR2) deployed as part of this study (Figure *1*-left).

3.6 Range Testing

Due to significant temporal and spatial variation in transmitter performance (How and de Lestang, 2012), range testing was conducted at inshore and offshore locations around Gracetown to determine the acoustic range of the transmitter used in the tracking of white sharks. Range tests informed appropriate receiver spacing and consisted of 10 VR2 acoustic receivers deployed in each of two lines (n=20) within the Gracetown area. Receivers were located 0, 50, 100, 150, 200, 250, 300, 400, 500, 600 m from an acoustic transmitter. The relative number of detections recorded at each receiver each hour was examined to determine the profile of acoustic attenuation. The replication of this over a number of weeks permitted temporal changes in the acoustic range, coupled with the spatial variation, to better inform acoustic array design.

3.7 Acoustic Arrays

Acoustic receivers (n=240; VR2; Vemco) were deployed in six arrays in the Capes region and were complimented by five near real-time acoustic receivers (VR4), which are part of the SMN (Table 1; Figure *1*a). The primary array of acoustic receivers was located off Gracetown and encompassed the 10 SMART drumlines (Figure *1*a). The secondary arrays were located approximately 1 km offshore at other known surf break locations (Figure 2). Spacing of receivers in the primary and secondary arrays were based on the results of range testing, such that detection ranges from adjacent receivers should overlap under a range of conditions.

The Gracetown array was designed to determine the initial movements of relocated white sharks from the SMART drumlines. The array consisted of an inshore line of receivers from north of Hangmans to south of Ellensbrook approximately 500 m from the shore (Figure 1b). An associated offshore line complimented the inshore line, and was located approximately 2 km from shore. There were 10 cross-shore lines that joined the offshore and inshore lines creating the gated (Heupel *et al*., 2006) design (Figure 1b). Once a shark was captured on a SMART drumline and relocated 1 km offshore, its release would be between the inshore and offshore lines. Therefore, if it was detected on either of the offshore, or inshore lines its post-release movement could be established. It is possible to be detected on one of these lines and not pass through the line (see Heupel *et al*., 2006), hence the use of gates within the array to detect if it moved north or south through the array.

The secondary arrays (Figure 2) were designed to detect if a relocated shark moved to an adjacent surf break. Therefore, they consisted of a single line of receivers approximately 1 km from shore with receivers closer to shore at each end of the array to "box" out the area and permit detection of a white shark in the area (Figure 2).

Both the primary and secondary arrays as well as the associated VR4 receiver at Meelup permitted the detection of other acoustically tagged species. This report includes details of other acoustically tagged white sharks that were detected on acoustic receivers from Meelup to Prevelly (Figure 1a) from 21 February 2019 to 20 February 2020 inclusive.

Table 1 Number and type of acoustic receivers located in each of the arrays and the Meelup site in the Capes region.

Region	VR2	VR4G	Total
Meelup		1	1
Windmills	14		14
Three Bears	10		10
Yallingup	19	1	20
Indjidup	27		27
Gracetown	132	3	135
Prevelly	38		38
TOTAL	**240**	**5**	**245**

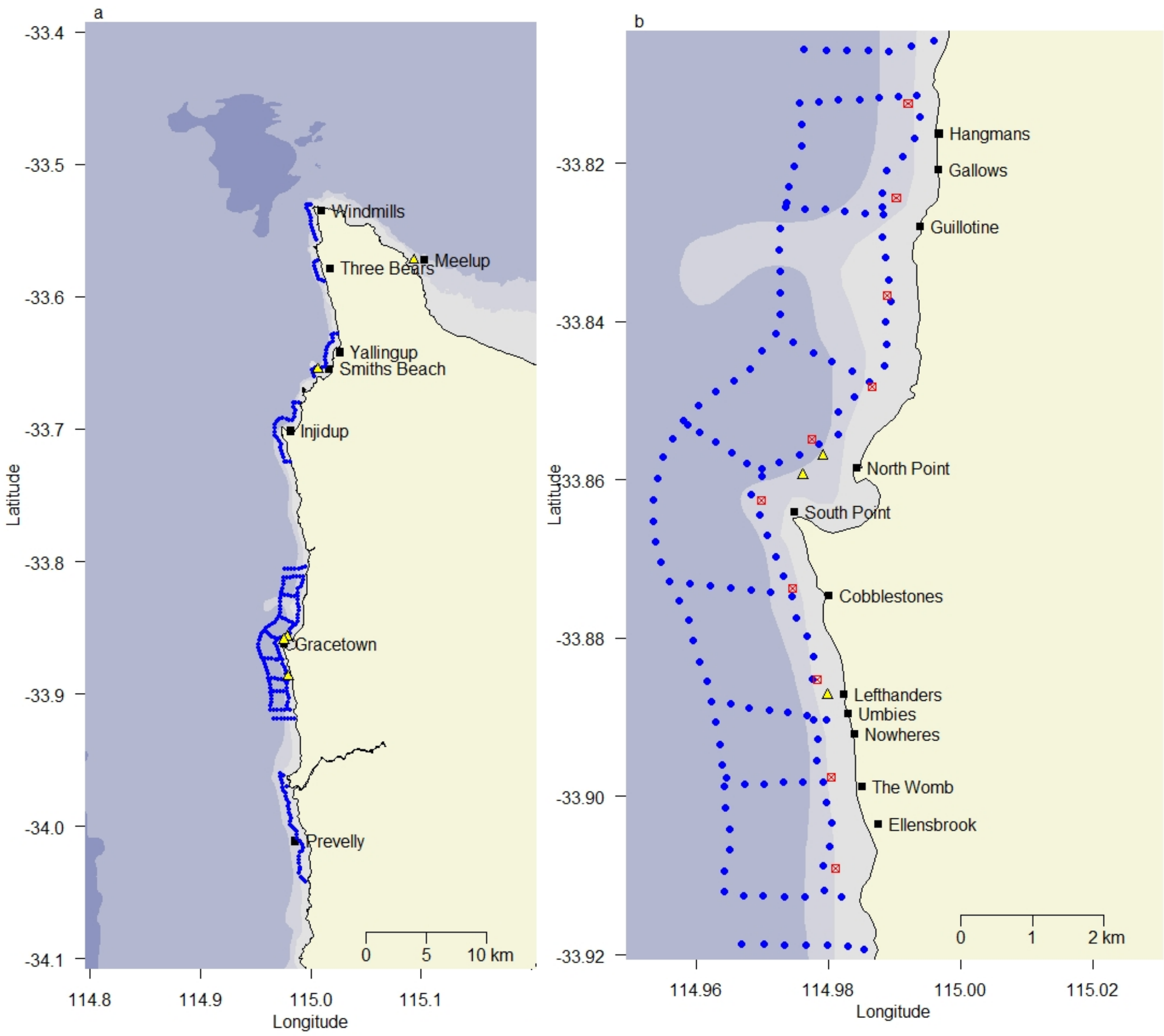

Figure 1 Location of VR2 (blue dots) and VR4 (yellow triangles) acoustic receivers a) in the Capes region, and b) off Gracetown with major surf breaks (black squares) and SMART drumline locations (red crossed squares) and isobaths (0-10, 10-20, 20-50, 50-100, 100-200 >200 m; light to dark blue) are also indicated.

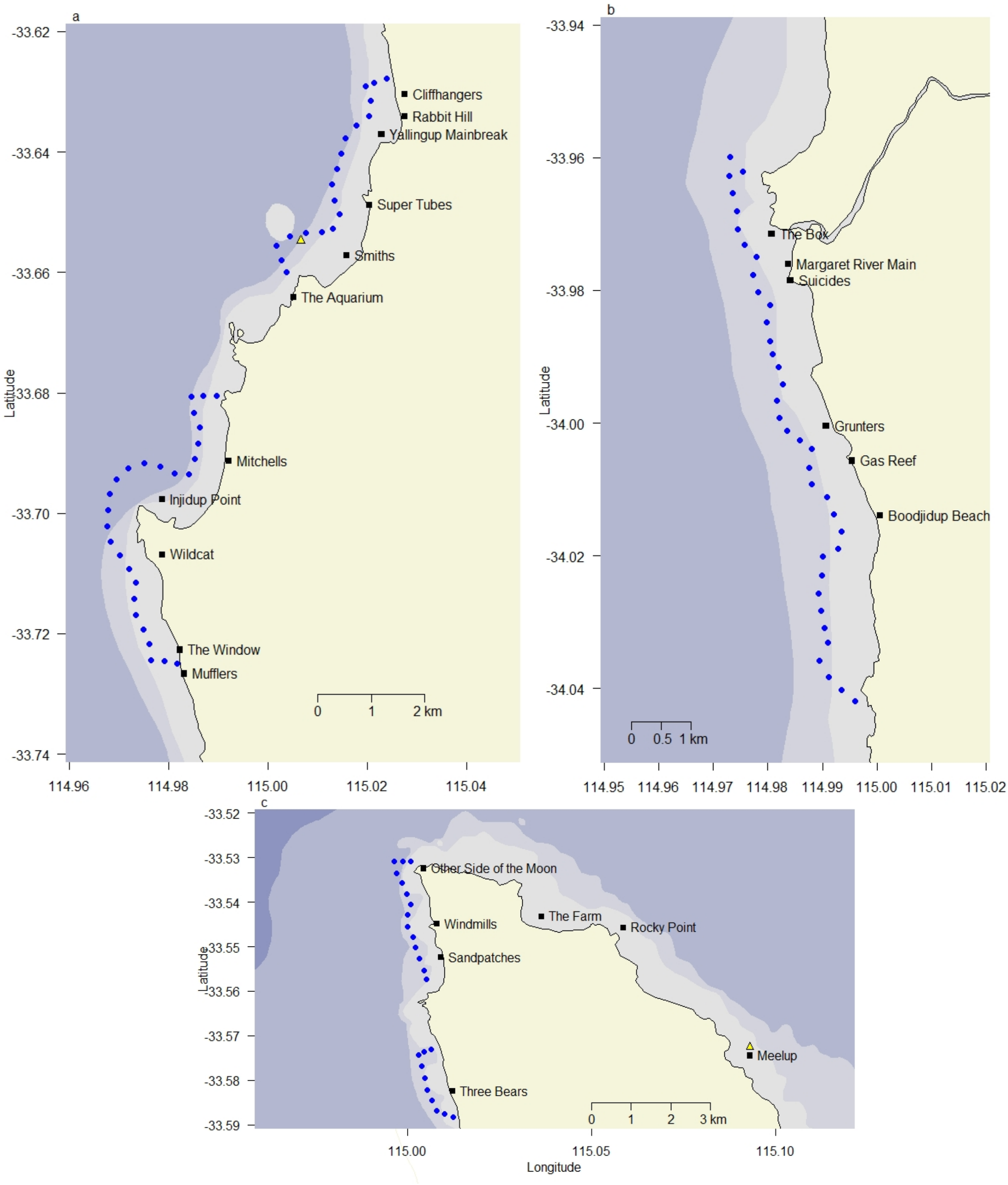

Figure 2 Location of VR2 (blue dots) and VR4 (yellow triangles) acoustic receivers a) off Yallingup and Injidup; b) off Prevelly and c) off Meelup, Windmills and Three Bears. Key as per Figure 1.

3.8 PAT Tagging

Each white shark caught in the trial was fitted with a pop-up archival transmitting (PAT) tag (miniPAT 348; Wildlife Computers Ltd) to estimate broadscale patterns of movement post-capture. PAT tags, also referred to as pop-up satellite archival tags (PSATs), have been used frequently to track the movements of white sharks in various oceanic regions (e.g. Bruce *et al*., 2006; Francis *et al*., 2015; Skomal *et al*., 2017). They record and archive data on depth, temperature, acceleration and light-level which, along with any additional positional data from acoustic tags, can be used to provide geo-locational data (Hill and Braun, 2001; Teo *et al*., 2004) as well as dive profiles and habitat utilization information. These data are stored in the tag, and should the tag be retrieved, full data sets can be downloaded. However, the primary mode of data retrieval is through satellite transmission of summary data sets (e.g. time-at-temperature and time-at-depth histograms as well as depth-temperature profile summaries and depth corrected dawn and dusk light level curves) through the Argos satellite system when the tag releases from the shark and floats to the surface. Release of the tag from the shark can be pre-programmed, but can also occur independently based on constant depth, rapid increase in temperature (tag ingestion) or when depth exceeds 1400 meters. These features aid in tag recovery should a mortality occur resulting in the shark remaining on the sea floor, or sinking to depths which would result in crushing of the tag.

Each tag was programmed to collect ambient light levels, temperature and depth at 10-second intervals, with data pooled into 6-hour bins for histogram transmission. Daily geographical positions were estimated using Global Position Estimator (GPE3) software, which runs within the Wildlife Computers' Data Portal. The GPE3 software uses a Hidden Markov state-space model (time series) at a 0.25° grid resolution incorporating environmental variables, such as temperature, daylight and barriers to movement, and the maximum swimming speed of the study species (Bruce *et al*., 2006), which in this study was estimated at 3.6 km h^{-1}.

4. Results

4.1 Fishing Days

Fishing activity occurred on 252 (69.0%) of the days between February 21 2019 and February 20 2020 (Table 2). A DPIRD observer was present on-board the vessel for 133 fishing days (52.8% of fishing days).

Table 2 Days fished, not fished and the monthly proportion of days fished during the first year of the SMART Drumline trial.

Year	Month	Days Fished	Days Not Fished	Proportion
2019	February	8	0	100
	March	23	8	74
	April	21	9	70
	May	24	7	77
	June	12	18	40
	July	18	13	58
	August	13	18	42
	September	17	13	57
	October	22	9	71
	November	25	5	83
	December	28	3	90
2020	January	24	7	77
	February	17	3	85

4.2 Catch Data

In total, 182 animals were caught including two white sharks, 146 other sharks, 34 other animals including 30 rays and four finfish (Table 3). Detailed capture information is presented in Appendix 1.

Table 3 Number of animals captured by category and species during the first year of the SMART Drumline trial.

Category	Species	Scientific name	Number
Target	White Shark	*Carcharodon carcharias*	2
Non-target sharks	Bronze Whaler	*Carcharhinus brachyurus*	36
	Dusky Whaler	*Carcharhinus obscurus*	10
	Shortfin Mako	*Isurus oxyrinchus*	24
	Smooth Hammerhead	*Sphyrna zygaena*	1
	Tiger Shark	*Galeocerdo cuvier*	75
Rays	Smooth Stingray	*Dasyatis brevicaudata*	30
Finfish	Pink Snapper	*Chrysophrys auratus*	3
	Samsonfish	*Seriola hippos*	1

4.3 White Shark Movements

4.3.1 White Shark SDL 1

This white shark (WS SDL 1) was a 4.6 m (TL) female hooked at 15:23 on 25 April 2019 at SMART drumline station 5 (off North Point). The vessel arrived 10 minutes after the alert and the shark was secured alongside the vessel at 16:03. A PAT tag and an acoustic transmitter were attached and biological measures taken. The shark was released ~2 km from shore at 16:35. A specific relocation operation was not required due to the prevailing offshore winds, as the shark (and vessel) were already past the 1 km from shore mark at the conclusion of the tagging operations.

Upon release, WS SDL 1 was detected on the offshore line of receivers moving in a southerly direction. This shark was not detected again on any of the receivers in the Capes region during the 12-month trial period (Figure 3).

Deployment duration for this PAT tag was 54 days during which the shark travelled approximately 1,304 km (an average of 24 km/day). The estimated track shows that in the first 24 hours the shark moved offshore from the release site and then south, rounded Cape Leeuwin, then moved east and arrived at an area to the south-west of Esperance on 9 May 2019 (Figure 4). The shark remained in this offshore area until 9 June 2019 when it moved to an area south of Esperance before the PAT tag released from the animal 66km south-east of Esperance on the pre-programmed date of 18 June 2019.

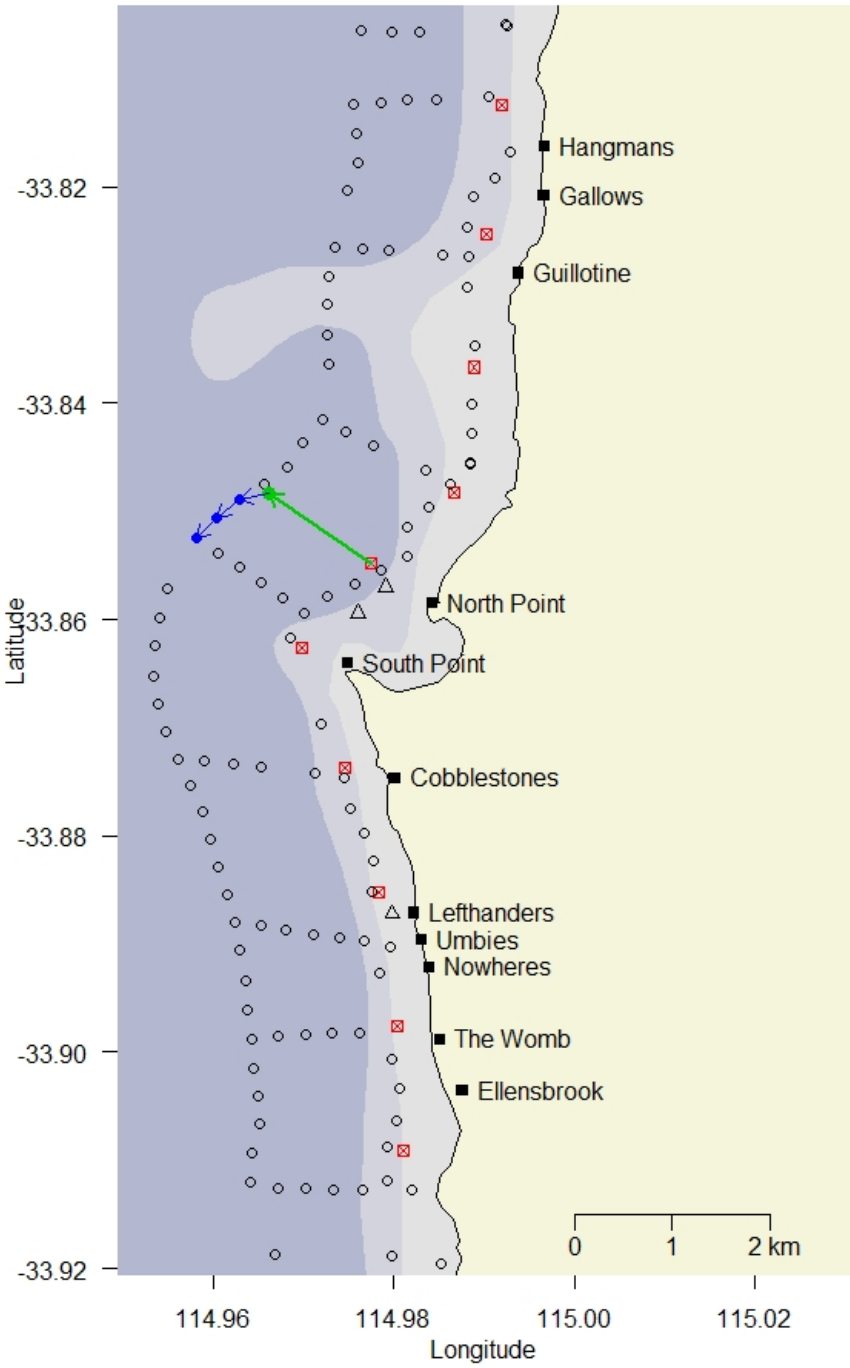

Figure 3 Acoustic detections (blue dots) and inferred straight line movements (blue arrows) of white shark (WS SDL 1) tagged on 25 April 2019. The relocation (green arrow) from SMART drumline (red crossed squares) to release location (green dot) and acoustic receivers. Key as per Figure 1.

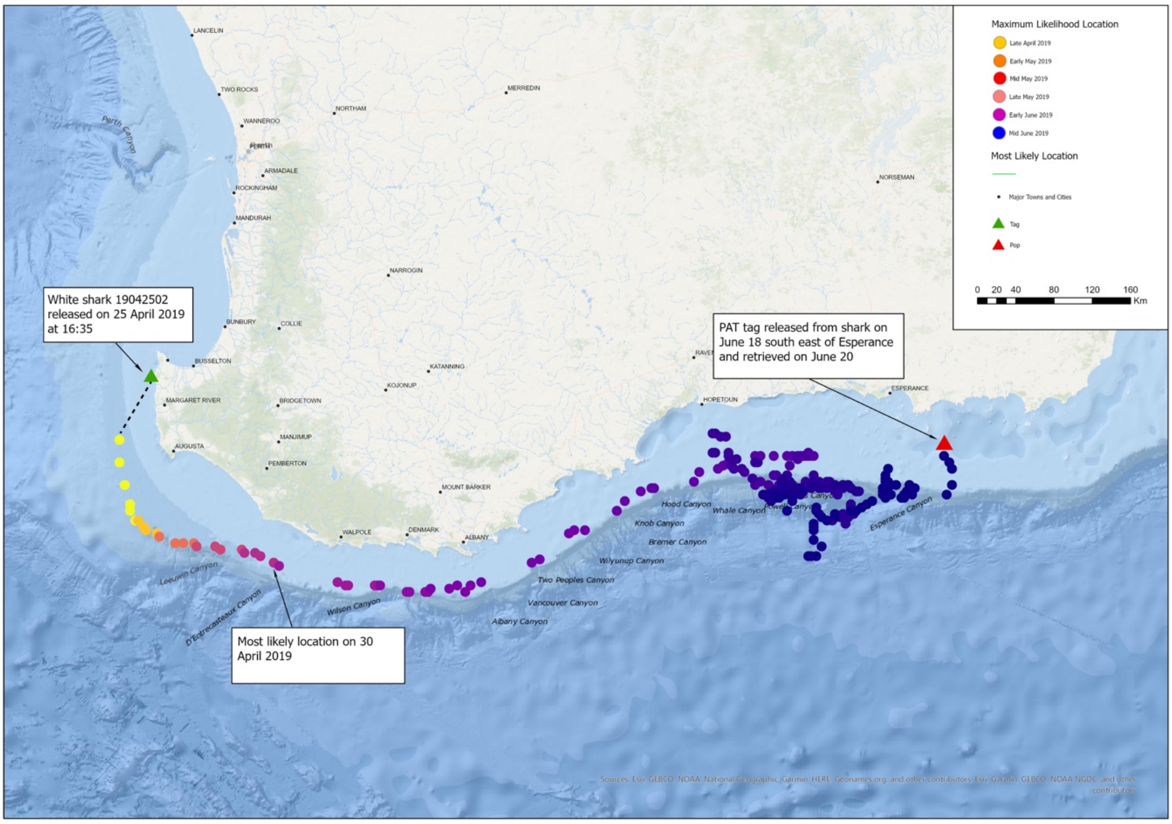

Figure 4 Estimated track of white shark (WS SDL 1) tagged on 25 April 2019 derived from PAT tag. Track is based on model-estimated daily locations using GPE3.

4.3.2 White Shark SDL 2

This white shark (WS SDL 2) was a 3.3 m (TL) female that was hooked at 14:29 on 20 August 2019 at SMART drumline station 10 (Ellensbrook). The vessel arrived 13 minutes after the alert and the shark was secured alongside the vessel at 15:20. A PAT tag and acoustic transmitter were attached and biological measures taken. The shark was relocated 1 km offshore, which took six minutes, before it was released at 15:37. WS SDL 2 was subsequently detected six times on three receivers offshore of its release location over a 9-minute period (Figure 5). It was not detected on the Gracetown or any secondary arrays again that day.

Almost three months later (76 days) on 6 November 2019 WS SDL 2 was detected moving through the acoustic arrays in the Capes region (Figure 6a). From approximately 06:30, WS SDL 2 moved through the Three Bears array, being detected once on each of three receivers before being detected off Yallingup. For almost an hour from 08:25 it was detected 21 times on nine VR2 receivers and the VR4 at Smiths Beach. Eighty minutes after leaving the Yallingup array it was detected twice on a receiver at Injudup (Figure 6a). It was detected moving through the Gracetown array from 17:10 to 20:00 being detected 14 times on 11 receivers. It was detected on the nearshore line of receivers from Hangmans to the South Point. From South Point it was detected further offshore before its final detection offshore from The Womb (Figure 6b). Weather conditions on 6 November restricted the setting of SMART drumlines to a 6-hour period (from ~07:00 to 13:00). As a result, WS SDL2 moved through the study region when no fishing occurred.

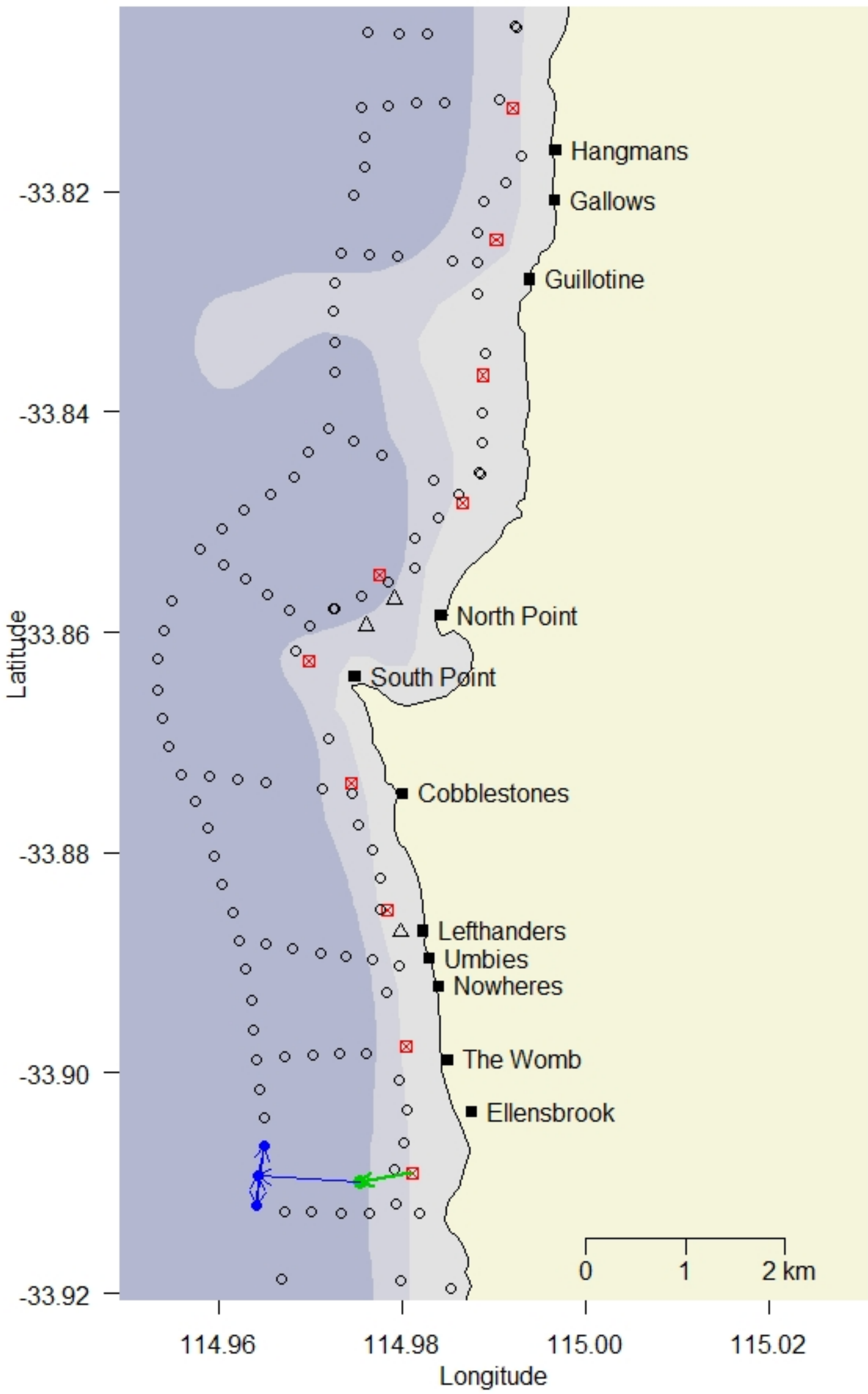

Figure 5 Acoustic detections (blue dots) and inferred straight line movements (blue arrows) of white shark (WS SDL 2) tagged on 20 August 2019. Key as per Figure 1.

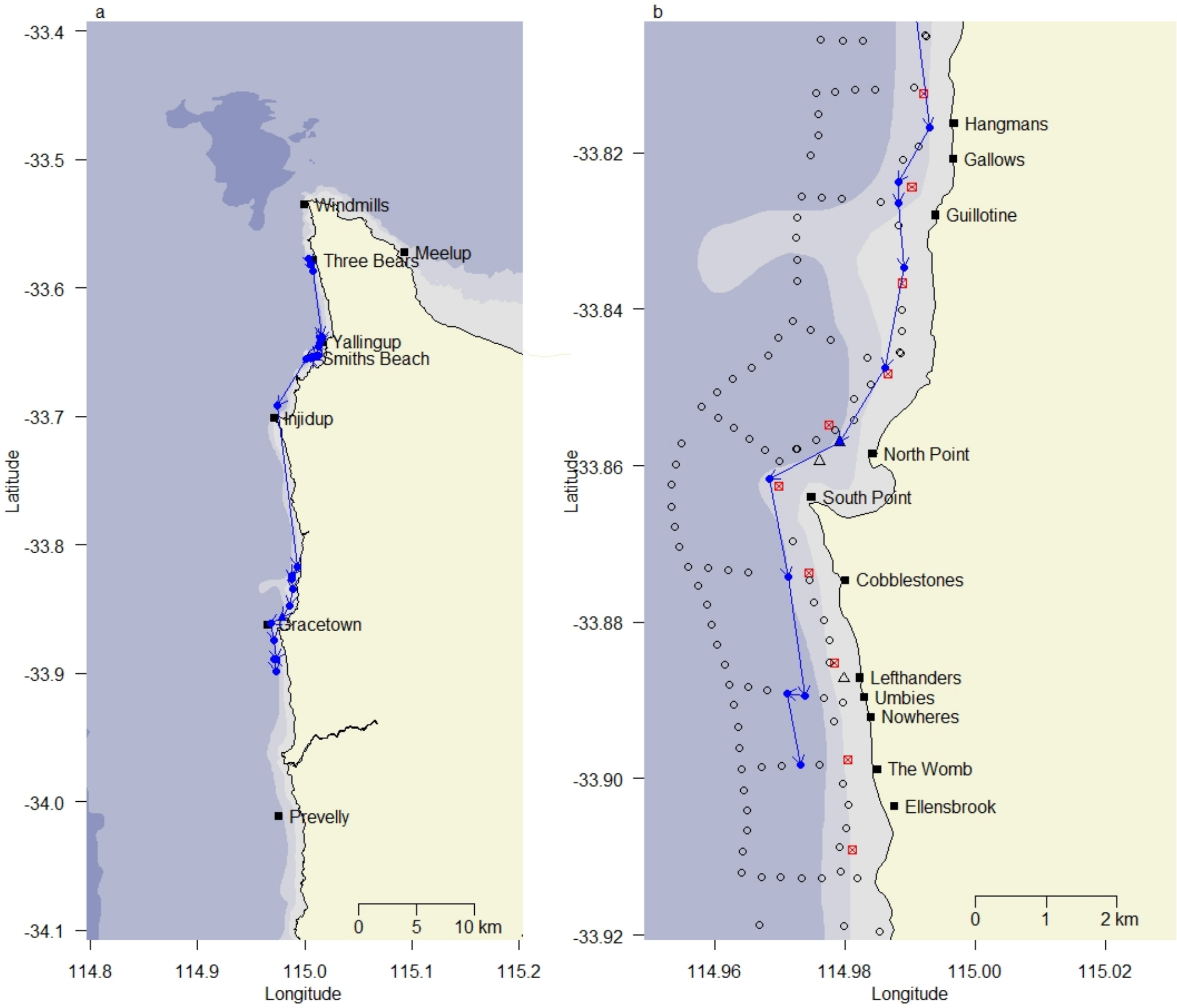

Figure 6 Detections (blue dots) of acoustically tagged white shark (WS SDL 2) on 6 November 2019 a) in the Capes region and b) within the Gracetown array. Arrows are inferred straight-line movements between successive detection locations and represent an indicative path only. Key as per Figure 1.

Deployment duration for the PAT tag deployed on shark WS SDL2 was 182 days during which the animal travelled approximately 5,156 km (an average of 28km/day). The model-estimated daily positions show that subsequent to being tagged and relocated this shark initially moved in a north-west direction to more offshore waters and then northwards along the shelf edge, reaching an area west of the Houtman Abrolhos Islands in early September (Figure 7a). It then travelled along more inner shelf waters to an area north of Bernier Island (Shark Bay area) before beginning a return journey southward in early October. The shark remained west of the Houtman Abrolhos Islands and in late October travelled close to Rottnest and Garden Islands, where it was detected by acoustic receivers in the Shark Monitoring Network, on 28 and 29 October (Figure 7b). The shark then moved south-west and through the Gracetown array on 6 November (Figure 6) before continuing south to deeper, more offshore waters in the vicinity of the Leeuwin and D'Entrecasteaux Canyons through November. In early December this shark travelled eastward along offshore shelf edge waters before an extensive move southward into oceanic waters down to 38°S before heading north towards the coast in the vicinity of the Recherche Archipelago in late December. In January, the shark travelled through offshore waters of the Recherche Archipelago and across to the Salisbury Island region until the PAT tag released from the animal on the pre-programmed date 20 February 2020, 38 km from shore (Figure 7b).

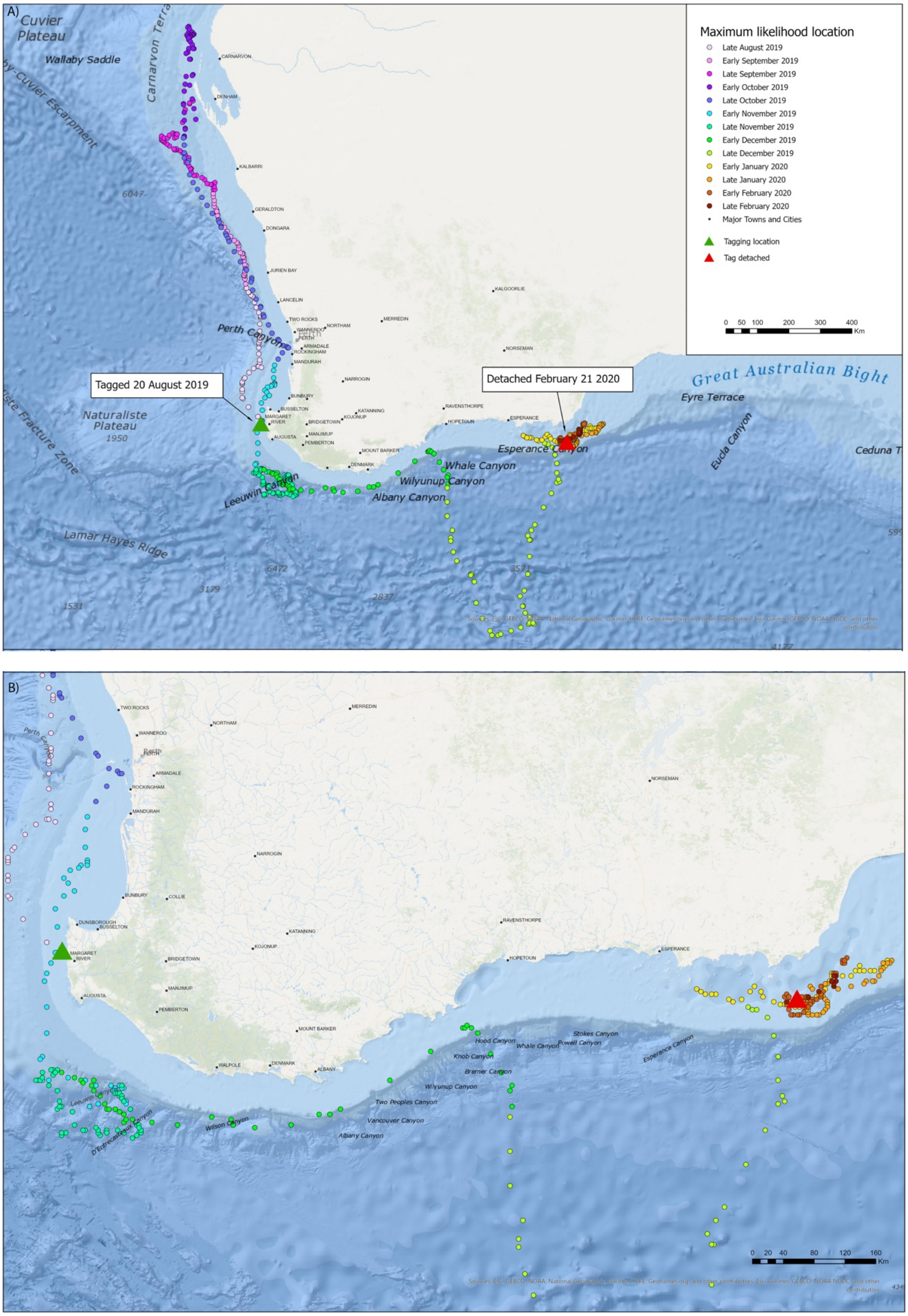

Figure 7 Estimated track of a) white shark (WS SDL 2) tagged on August 20 2019 and b) zoomed extent of track in south-western waters. Track is based on model-estimated daily locations from PAT tag using GPE3.

4.3.3 Additional White Shark Detections

Twelve other white sharks tagged outside of the Gracetown trial area were detected within the Capes arrays during the first year of the trial (21 February 2019 - 20 February 2020). Eight of the sharks detected were tagged as part of broader white shark tagging operations in Western Australia. Three of the sharks detected originated from South Australia, with one shark tagged in New South Wales. Males dominated the other white sharks detected (9 of 12), with sharks ranging in size from 2.8 to 4.2 m (TL) in length at the time of tagging. These white sharks were recorded on the array of acoustic receivers in the Capes region from May to November (**Table *4***). There were no detections of non-SMART drumline captured white sharks until early May, with the detection of a white shark (WS H) on the Meelup receiver (Figure *2*). However, between July and December, multiple white sharks were detected by receivers in the various acoustic arrays in the Capes region. Furthermore, no white sharks were detected on these receivers from 28 December 2019 until the completion of the first 12 months of the SMART drumline trial, (**Table *4***).

Within the more extensive Gracetown acoustic array, there were some areas where there were more detections and more individual white sharks detected (Figure 8). There appeared to be very few detections recorded on the offshore line north of Gracetown, while the corresponding inside line had a greater number of detections, with the greatest number of white shark detections occurring on a receiver just offshore of Hangmans on the inshore line (Figure 8a). South of Cobblestones there appeared to be greater parity between the offshore and inshore lines in terms of the number of detections (Figure 8a). More detections were reported at receivers off Hangmans, Guillotines, North Point and South Point on the inshore line, and offshore from Cobblestones, and two receivers to the south of Ellensbrook on the offshore line (Figure 8b). However, it is important to note that the number of detections overall is very low.

Table 4 Details of acoustic detections of white sharks (WS A-L) that moved through the SMART drumline trial area but were tagged in separate tagging programs.

	Month	**May**	**July**								**August**						**September**								**October**					**November**				**December**		
	Day	*3*	*13*	*18*	*19*	*20*	*26*	*27*	*28*	*31*	*5*	*12*	*13*	*23*	*27*	*31*	*1*	*13*	*19*	*22*	*23*	*24*	*27*	*28*	*5*	*6*	*7*	*13*	*14*	*6*	*7*	*16*	*19*	*8*	*27*	*28*
Meelup	WS A														X																					
	WS B																																	X		
	WS C																																	X		
	WS D																					X														
	WS E													X					X				X													
	WS F						X					X													X											
	WS H	X																																		
	WS J																																X			
Windmills	WS F												X																							
	WS I																																		X	
	WS K		X																																	
Three Bears	WS D																					X														
	WS E																			X																
	WS F												X																							
Yallingup	WS E																										X									
	WS F							X					X													X										
	WS G																	X																		
	WS L																													X	X					
Injidup	WS B																																	X		
	WS C																																	X		
	WS E				X																															
	WS F												X													X										
	WS I																																			X
	WS K		X																																	
Gracetown	WS D																											X								
	WS E			X		X				X											X			X					X							
	WS F				X				X		X		X			X	X									X										
	WS I																																			X
	WS L											X																		X						
	WS K		X																																	
Prevelly	WS F								X		X		X													X	X									
	WS I																																			X
	WS J																															X				

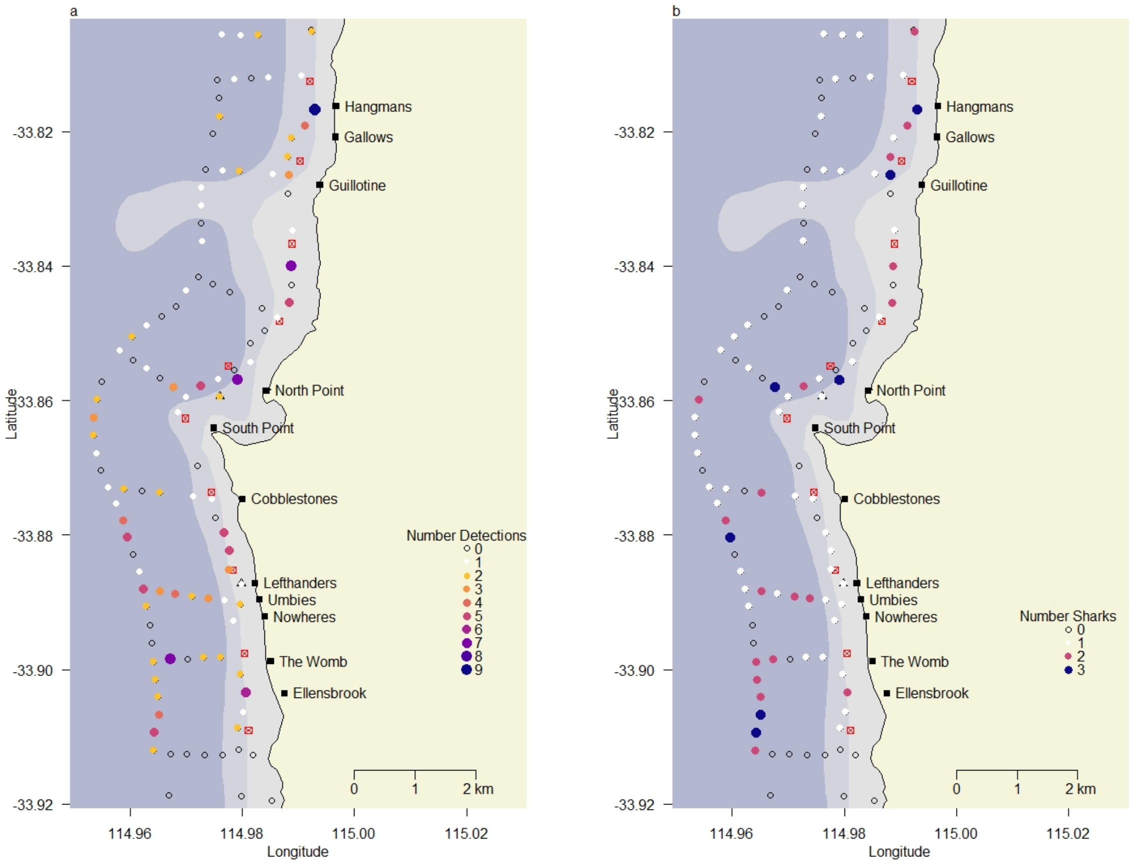

Figure 8 a) Number of detections, and b) number of individual sharks detected on acoustic receivers in the Gracetown array.

Six white sharks not tagged as part of the SMART drumline trial, were detected in the Gracetown acoustic array (Table 4), with WS SDL 2 also moving back through the array 76 days after relocation. These seven shark movements' were alongshore, with sharks tending north or south through the array (Figure 9). There were only a few movements where the shark moved from the inshore array line to offshore array lines or *vice versa*, though these tended to remain as part of the alongshore movement pattern. There was no apparent direct inshore / offshore movements for these seven sharks (Figure 9).

White sharks were detected in the Gracetown array on 13 occasions. However, nine of these 13 movements occurred at times either when the SMART drumlines were not actively being fished on that day, or before the SMART drumlines were deployed, or after they were retrieved. Therefore, there were only four movement of white sharks through the array during times when SMART drumlines were being actively fished.

One shark (WS E) moved through the Gracetown array on three occasions when the SMART drumlines were actively being fished (Figure 9a), with another white shark (WS F) moving past actively fishing SMART drumlines on one occasion (Figure 9b).

1. WS E was detected on receivers adjacent to SMART drumline stations 1 and 2 on 23 September, being detected adjacent to SMART drumline station 1 at 1551 with a bait check occurring on that SMART drumline eight minutes later finding 100% bait present. It was subsequently detected on receivers adjacent to SMART drumline station 2 at 1623 & 1625, which was recovered at 1628 with bait present on retrieval (Figure 9a-dark blue).
2. Five days later (28 September) WS E again entered the Gracetown array being detected on cross-shelf receivers from 1720. However, the final and closest SMART drumline was retrieved 1725 when the shark was still over 1 km away (Figure 9a-light blue).
3. Finally, WS E moved through the array again and was detected on the VR4 off North Point on 14 October at 1058. This receiver is adjacent to SMART drumline station 5, which was actively being fished. The SMART drumline was fully baited on both bait checks at 0924 & 1220 and no alerts occurred at this time (Figure 9a- magenta).
4. On 28 July, WS F was detected on acoustic receivers near SMART drumline stations 1 and 2 between 1518-1524. These two SMART drumlines were retrieved at 1621 and 1616 respectively with bait still present (50 and 40% respectively) when they were checked (Figure 9b-magenta).

Therefore, both of these sharks likely swam past baited SMART drumlines without being intercepted by the system.

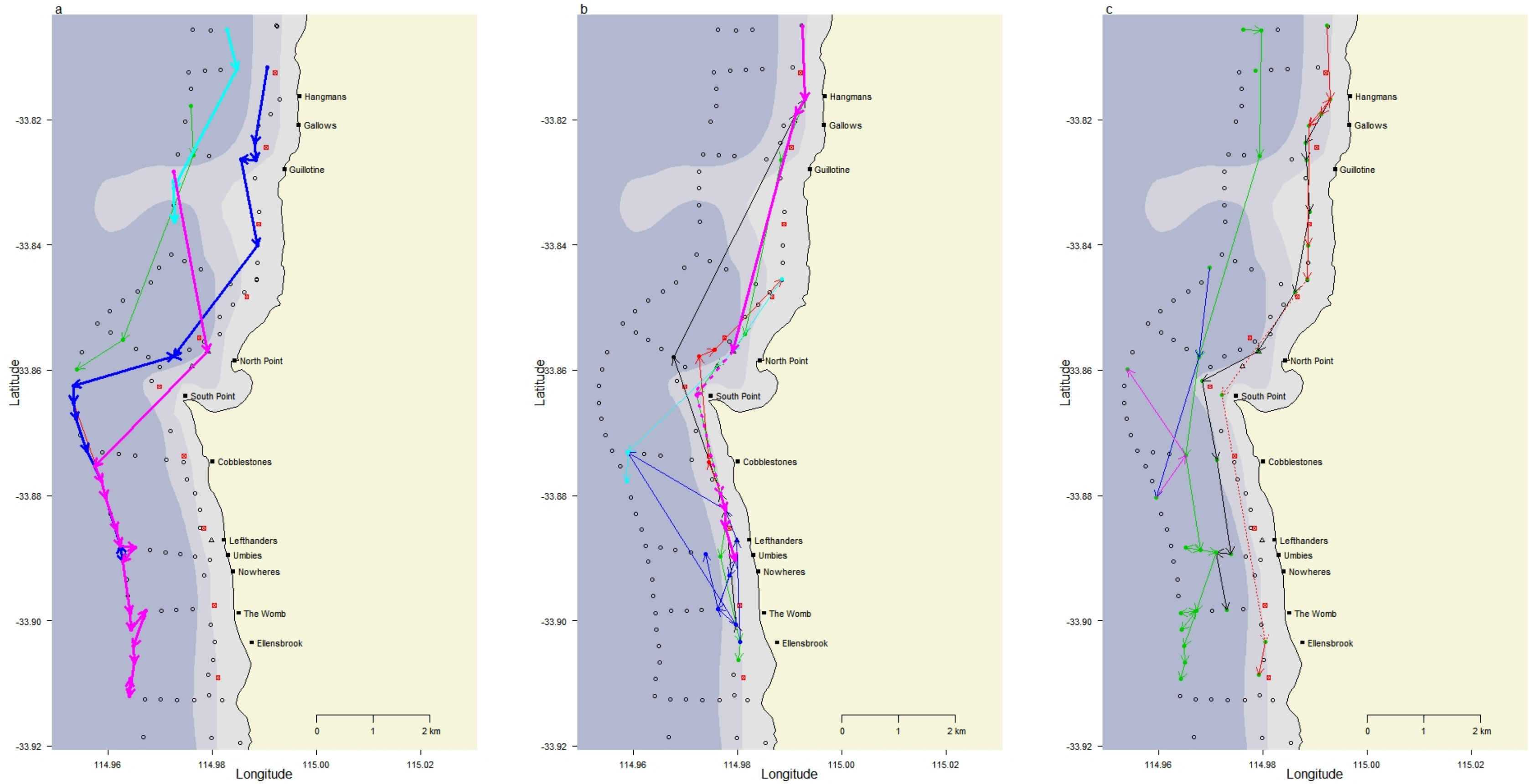

Figure 9 Inferred straight line movements (solid line arrows) of a) WS E, b) WS F and c) WS SDL 2 (black), WS D (pink), WS I (red), WS K (green) and WS L (light and dark blue) through the Gracetown array. Thick lines denote when the SMART drumlines were actively being fished. Dotted lines denotes a modified straight line movement to avoid inferred movement over land.

5. Discussion

This SMART drumline trial has collected movement data from a limited number of white sharks (n = 2) captured from the 252 fishing days during the period from 21 February 2019 (when the trial began) until 20 February 2020 (1 year). During the trial period, 12 other previously acoustically tagged white sharks were detected by acoustic receivers, six of which were recorded by receivers within the Gracetown acoustic array where the fishing methods were trialled. Two white sharks were detected a total of four times during actual fishing operations. These data indicate that the SMART drumlines do not catch or interact with all white sharks present in an area. In addition, while a low number of white sharks were captured, the trial demonstrated that the SMART drumlines have the ability to capture large sharks (WS SDL 1 – 4.6 m TL female) and relocate them at least 1 km offshore.

5.1 White Shark Movements

The initial movements of the two white sharks captured during the SMART drumline trial were directly offshore after relocation and release. As a hazard mitigation strategy, the direct offshore movement exhibited by the two SMART drumline white sharks would reduce the risk to coastal water users. WS SDL 1 was not recorded in nearshore waters from the time of release until the end of the trial period on 21 February 2020 and the PAT data indicated it remained in offshore waters for the entire 54 days of data recording while the tag was attached. However, WS SDL 2 was subsequently detected in nearshore waters again, first being detected by the Perth Metropolitan Shark Monitoring Network (SMN) array on 28 October, and was then detected in the Capes region on the acoustic arrays 8 days later on 6 November 2019, 76 days after being released in Gracetown.

The direct offshore movement pattern exhibited after release by the two SMART drumline caught white sharks was not recorded by the other six white sharks not tagged as part of the SMART drumline trial, which moved through the Gracetown array. These other sharks, as well as the subsequent detection of WS SDL 2 seventy-six days later, all demonstrated general movements along the coast, being detected on receivers either on the inshore, mid-shore or on the offshore lines. Some white sharks did move between these lines though none of the inferred movement patterns demonstrated the direct offshore movement patterns.

The data derived from the PAT tags revealed that they detached on the dates specified for release and there was no mortality of these white sharks. The PAT tag data for each white shark shows that they travel large distances and that travel is not unidirectional. Movement occurred to areas as far north as Carnarvon, with both sharks moving around the south coast of Western Australia before the tags released. White sharks move broadly through coastal and offshore waters of Western Australia. There is currently an ongoing investigation of the movement patterns of white sharks in Western Australia through the deployment of PAT tags on white sharks as part of the DPIRD tagging programs.

A consistent seasonal movement pattern was not apparent from those white sharks detected in the Capes region. There was considerable variation in the direction of movement of white sharks in the Capes region. Some white sharks were detected moving north through the arrays, only to be detected moving in a southerly direction weeks later, with a pattern of alternating directions persisting over several months. These findings concur with a previous Departmental study that reported limited evidence of predictable return behavior, seasonal movement patterns or coordination to the direction or timing of individual white shark's movements

(McAuley *et al*., 2017). At a finer scale, white sharks tagged as part of other Departmental tagging programs were detected moving past actively fished SMART drumlines. Clearly, these white sharks did not consume the available baits and thus did not trigger the alarms. As these baits were present on the subsequent bait checks, it indicates that not every white shark is intercepted by the SMART drumlines.

5.2 Catch Composition and Release Condition

Due to the lack of long-term catch records on white sharks in Western Australia (Taylor *et al*., 2018), it cannot be reliably determined whether or not the observed white shark catch is 'typical' for the study region. Nevertheless, the results are broadly consistent with those observed in the previous lethal drumline trial, whereby no white sharks were caught in the Perth metropolitan, Geographe Bay or Capes region between 25 January and 30 April 2014, with up to 30 drumlines being used daily (DoF, 2014). During the previous trial, tiger sharks were the most commonly-caught species, a result which is replicated in this study.

Catches of white sharks in completed NSW SMART drumline trials varied considerably between locations (https://www.sharksmart.nsw.gov.au/technology-trials-and-research/smart-drumlines). A six-month trial (November 2017 to May 2018) at Ulladulla and Narrawallee resulted in the capture of three white sharks, while one white shark was caught at Kiama and Shell Cove during the same period. A six-month trial (August 2017 to February 2018) at Forster/Tuncurry resulted in the capture of 65 white sharks, while 16 white sharks were caught at Coffs Harbour and Sawtell during the same period. More recently, a two-month trial (1 March to 28 April 2019) in the Bega Valley region resulted in the capture of six white sharks while no white sharks were caught in a three-month trial off Sydney (10 February to 12 May 2019) and Newcastle (1 February to 30 April 2019). The low white shark catches at some of these NSW locations is consistent with the results from the current study. However, while a summary report for the NSW North Coast has not yet been completed, catch statistics for this region reported on the NSW Department of Primary Industries website indicate much higher catches (311 white sharks between December 2016 and December 2019) than those in WA or in other regions of NSW.

The two white sharks caught in the current trial were much larger animals than the majority of white sharks caught in NSW. Female white sharks are believed to mature at between 4.5 and 5.0m TL (Malcolm *et al*., 2001), suggesting that WS SDL1 (4.6 m TL, female) was an adult, while WS SDL2 (3.3 m TL, female) was a sub-adult. The sizes of these two sharks are consistent with those caught in Departmental tagging programs in Western Australia. The capture of these large sharks in addition to the lack of straightened hooks or damaged snoods indicate that the equipment used during the trial was appropriate for targeting large white sharks. Furthermore, the bait used in the trial (Australian salmon or sea mullet) has successfully been used to catch white sharks in ongoing Departmental tagging programs and in the NSW drumline program (https://www.sharksmart.nsw.gov.au/__data/assets/pdf_file/0005/871682/SMART-drumlines-faqs.pdf).

On average, animals spent only a short time on the hook (<30 minutes in most cases) which resulted in the majority of animals being released in good condition (88%, *n* = 160). The survival of the two white sharks following their release was also confirmed by the acoustic and satellite data. Blood samples taken from white sharks caught in the NSW Smart drumline program indicate that this capture method may be a relatively low-stress capture method if short response times are used, as was the case in the current trial (Madlinger, 2019; Tate *et al*., 2019). Therefore, the process of capturing and relocating white sharks is unlikely to cause population-level impacts for white sharks off Western Australia.

5.3 Stakeholder Engagement

This trial has been pivotal in establishing and maintaining stakeholder engagement and involvement in the oversight of the program. Importantly, the Ministerial Reference Group has played a valuable role in informing the wider community about the objectives of the trial, ensuring that the Government maintained transparency throughout the process. Members of the Ministerial Reference Group strongly supported the use of a non-lethal shark mitigation measure. Overall, formal feedback from all third party observers that were placed aboard the contractor's vessel was very positive, indicating that the crew and DPIRD staff were competent and professional during fishing operations and that the processes and procedures developed and implemented for the SMART drumline trial were rigorous and robust. Feedback indicated that on-board processes were aligned to maximizing animal welfare by striving to release animals quickly and in good condition. It has been a key feature of the SMART drumline trial that animal welfare has been paramount and integral to the success of the program. Where appropriate, recommendations made by third party observers and the local community were incorporated into the standard operating procedures. For example, the suggestion to record underwater video footage of released animals was enacted in April 2019. The use of third party observers in this manner from external organisations such as the Conservation Council of WA and Sea Shepherd has been beneficial in regard to informing and educating their members on the trial, and providing feedback from the communities they represent on the design, implementation and progress of the SMART drumline trial.

5.4 Trial Improvements

The SMART drumline trial has been undertaken in a challenging logistical operating environment. The area off Gracetown in the southwest region of Western Australia contains a number of world class surf break locations. This environment is dynamic, and is characterized by large swells, wave heights and difficult operating conditions for vessels at sea. In general, tracking trials for large marine animals are not undertaken in locations characterised by these challenging operating conditions. The SMART drumline trial involved the deployment of 240 VR2 acoustic receivers. These VR2 acoustic receivers were deployed attached to anchor weights via ropes and thimbles in an operating design that sought to ensure unrestricted detection of acoustic tags within their range of detection. Given the dynamic nature of the operating environment within the array area, a number of VR2 acoustic receivers broke free during the SMART drumline trial and had to be recovered and replaced in the array design. To reduce the potential for any future gear breakage, the design of the gear attached to the VR2 acoustic receivers was modified and the deployment locations changed to reduce the potential for any future losses. A key learning from this aspect of the SMART drumline trial is that the design of anchor points needs to be carefully considered both prior to deployment and subsequently during any trial to ensure success. These considerations are an important feature of the success of tracking programs and should not be underestimated.

6. Conclusions

The SMART drumline trial was conducted in a challenging environment. Despite the logistical difficulties these conditions provided, the tracking of the two white sharks showed that they survived the capture-relocation process, ultimately resulting in a successful outcome for the project.

The initial movements of the two white sharks captured during the SMART drumline trial were directly offshore after relocation and release. The direct offshore movement exhibited by the two SMART drumline caught white sharks provides evidence of an immediate reduction in risk posed by the particular shark in each instance. However, it is important to note that the sample size is low and any results must be interpreted with caution.

The SMART drumline gear has proven to be capable of capturing large white sharks but the trial only yielded a small number of white sharks and did not capture all white sharks that were moving through the area. The numbers and sizes of animals caught in this SMART drumline trial differ to those reported from trials in NSW. This is a reflection of the different operating environments of each study, the different populations of white sharks that occur off WA and NSW (Hillary et al., 2018), and the fact that several of the NSW trials occurred in known white shark nursery grounds.

The trial has exemplified the need for animal welfare to be paramount. Consequently, animals spent only a short time on the hook (<30 minutes in most cases) which resulted in the majority of animals being released in good condition (88%) and no mortalities of any shark species. Further tracking of SMART drumline captured white sharks would however be required to provide the necessary evidence-based assessment of SMART drumlines as a shark hazard mitigation measure.

7. Acknowledgements

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8. References

Australian Shark Attack File. 2018. Australian shark attack file annual report. Annual report summary for 2018. (Taronga Conservation Society Australia, Sydney. NEW, Australia.) Available at https://taronga.org.au/conservation/conservation-science-research/australian-shark-attackfile/2018 [Verified 09 November 2018].

Bruce, B.D., Stevens, J.D. and Malcolm, H. 2006. Movements and swimming behaviour of white sharks (*Carcharodon carcharias*) in Australian waters. Marine Biology 150: 161–172.

Chapman, B.K. and McPhee, D. 2016. Global shark attack hotspots: Identifying underlying factors behind increased unprovoked shark bite incidence. Ocean and Coastal Management 133: 72-84.

Curtis, T.H., Bruce, B.D., Cliff, G., Dudley, S., Klimley, A.P., Kock, A., Lea, R.N. and Lowe, C.G. 2012. Responding to the risk of White Shark attack. *Global Perspectives on the Biology and Life History of the White Shark. CRC Press* pp. 477-510.

DoF. 2012. A correlation study of the potential risk factors associated with white shark attacks in Western Australian waters. November 2012. Fisheries Occasional Publication No. 109, 2012 Department of Fisheries, Perth. Western Australia.

DoF. 2014. Review of the outcomes from the drum line component of the Shark Mitigation Strategy for the trial period January – April 2017. File Number 1314/14.

Dudley, S.F.J. 1997. A comparison of the shark control programs of New South Wales and Queensland (Australia) and KwaZulu-Natal (South Africa). Ocean and Coastal Management 34 (1): 1-27.

Guyomard, D., Perry, C., Ugo Tournoux, P., Cliff, G., Peddemors, V. and Jaquemet, S. 2019. An innovative fishing gear to enhance the release of non-target species in coastal shark-control programs: The SMART (shark management alert in real-time) drumline. Fisheries Research 216: 6-17.

Guyomard, D., Lee, K.A., Perry, C., Jaquemet, S. and Cliff, G. 2020. SMART drumlines at Réunion Island do not attract bull sharks Carcharhinus leucas into nearshore waters: Evidence from acoustic monitoring. Fisheries Research 225: 105480.

Francis, M.P., Duffy, C. and Lyon, W. 2015. Spatial and temporal habitat use by white sharks (*Carcharodon carcharias*) at an aggregation site in southern New Zealand. Marine and Freshwater Research 66: 900-918.

Hill, R.D. and Braun, M.J. 2001. Geolocation by light level, the next step: latitude. In: *Electronic Tagging and Tracking in Marine Fisheries Reviews: Methods and Technologies in Fish Biology and Fisheries.* J.R. Sibert & J.L. Nielsen (eds) Dordrecht: Kluwer Academic Press, pp. 315–330.

Hillary, R.M., Bravington, M.V., Patterson, T.A., Grewe, P., Bradford, R., Feutry, P., Gunasekera, R., Peddemors, V., Werry, J., Francis, M.P., Duffy, C.A. and Bruce, B.D. 2018. Genetic relatedness reveals total population size of white sharks in eastern Australia and New Zealand. Scientific Reports 8: 2661.

How, J.R. and de Lestang, S. 2012. Acoustic tracking: issues affecting design, analysis and interpretation of data from movement studies Marine and Freshwater Research 63: 312–324.

Heupel, M.R., Semmens, J.M. and Hobday, A.J. 2006. Automated tracking of aquatic animals: scales, design and deployment of listening station arrays. Marine and Freshwater Research 57: 1–13.

Madlinger, C.L. 2019. 'SMART' shark capture technology may keep beachgoers and sharks safe. Conserv Physiol 7 (1): coz87.

Malcolm, H., Bruce, B.D. and Stevens, J.D. 2001. A review of the biology and status of white sharks in Australian waters. p. 113. CSIRO Marine Research, Hobart.

McAuley, R., Bruce, B., Keay, I., Mountford, S., Pinnell, T. and Whoriskey, F. 2017. Broad-scale coastal movements of white sharks off Western Australia described by passive acoustic telemetry data. Marine and Freshwater Research 68: 1518-1531.

McAuley, R., Bruce, B., Keay, I., Mountford, S. and Pinnell, T. 2016. Evaluation of passive acoustic telemetry approaches for monitoring and mitigating shark hazards off the coast of Western Australia. Department of Fisheries, Government of Western Australia.

McPhee, D. 2012. Likely effectiveness of netting or other capture programs as a shark hazard mitigation strategy in Western Australia. Fisheries Occassional Publication No 108, 212. Department of Fisheries, Perth. Western Australia.

McPhee, D. 2014. Unprovoked Shark Bites: Are they becoming more prevalent? Coastal Management 42: 478-492.

Skomal, G.B., Braun, C.D., Chisholm, J.H. and Thorrold, S.R. 2017. Movements of the white shark *Carcharodon carcharias* in the North Atlantic Ocean. Marine Ecology Progress Series 580: 1–16.

Tate, R.D., Cullis, B.R., Smith, S.D.A., Kelaher, B.P., Brand, C.P., Gallen, C.R., Mandelman, J. W. and Butcher, P.A. 2019. The acute physiological status of white sharks (*Carcharodon carcharias*) exhibits minimal variation after capture on SMART drumlines. Conserv Physiol 7 (1): coz042.

Taylor, S.M., Braccini, J.M., McAuley, R.B. and Fletcher, W.J. 2016. Review of potential fisheries and marine management impacts on the south-western Australian white shark population. Fisheries Research Report No. 277. Government of Western Australia, Department of Fisheries.

Taylor, S.M., Braccini, J.M., Bruce, B.D. and McAuley, R.B. 2018. Reconstructing Western Australian white shark (*Carcharodon carcharias*) catches based on interviews with fishers. Marine and Freshwater Research 69 (3): 366–375.

Teo, S.L.H., Boustany, A., Blackwell, S., Walli, A., Weng, K.C. and Block, B.A. 2004. Validation of geolocation estimates based on light level and sea surface temperature from electronic tags Marine Ecology Progress Series 283: 81–98.

West, J.G. 2011. Changing patterns of shark attacks in Australian waters. Marine and Freshwater Research 62: 744-754.

Wilson, S., Stewart, B., Polovina, J., Meekan, M., Stevens, J. and Galuardi, B. 2007. Accuracy and precision of archival tag data: a multiple-tagging study conducted on a whale shark (*Rhincodon typus*) in the Indian Ocean. Fisheries Oceanography 16: 547-554.

9. Appendices

9.1 Appendix 1 – SMART Drumline Catch Details

Table A 1 SMART drumline (SDL) catch details in chronological order from 21 February 2019 to 20 February 2020

Date	Time	SDL Number	Species	Total Length (cm)	Sex	Release Condition
21 Feb 2019	10:25	4	Smooth Stingray	80	Female	1
22 Feb 2019	08:54	3	Tiger Shark	246	Male	1
22 Feb 2019	11:46	3	Tiger Shark	233	Male	1
22 Feb 2019	17:03	4	Smooth Stingray	180	Female	1
23 Feb 2019	14:57	10	Tiger Shark	256	Male	1
23 Feb 2019	15:00	3	Tiger Shark	236	Female	1
27 Feb 2019	13:00	1	Bronze Whaler	240	Male	1
27 Feb 2019	14:38	9	Tiger Shark	220	Male	1
02 Mar 2019	13:18	3	Tiger Shark	286	Male	1
03 Mar 2019	13:04	6	Tiger Shark	268	Female	1
06 Mar 2019	09:14	3	Tiger Shark	240	Male	1
06 Mar 2019	13:13	3	Smooth Stingray	150	Female	1
06 Mar 2019	14:06	10	Bronze Whaler	230	Male	1
07 Mar 2019	10:29	3	Tiger Shark	250	Female	1
07 Mar 2019	12:59	3	Smooth Stingray	100	Female	1
07 Mar 2019	12:55	1	Tiger Shark	238	Female	1
07 Mar 2019	13:38	3	Tiger Shark	275	Male	1
08 Mar 2019	10:12	3	Tiger Shark	275	Male	1
08 Mar 2019	10:21	4	Tiger Shark	239	Male	1
09 Mar 2019	12:00	3	Tiger Shark	310	Female	1
09 Mar 2019	12:54	3	Tiger Shark	270	Male	1
09 Mar 2019	13:28	4	Tiger Shark	320	Female	1
09 Mar 2019	14:31	3	Tiger Shark	250	Female	1
12 Mar 2019	13:02	3	Smooth Stingray	100	Female	1
13 Mar 2019	15:00	4	Shortfin Mako	309	Female	1

Date	Time	SDL Number	Species	Total Length (cm)	Sex	Release Condition
15 Mar 2019	09:15	3	Smooth Stingray	100	Unknown	1
15 Mar 2019	09:30	2	Smooth Stingray	150	Male	1
15 Mar 2019	14:01	10	Smooth Stingray	150	Female	1
16 Mar 2019	11:49	2	Tiger Shark	180	Female	1
18 Mar 2019	08:30	6	Shortfin Mako	180	Female	1
18 Mar 2019	10:29	6	Bronze Whaler	280	Male	1
18 Mar 2019	12:26	3	Smooth Stingray	130	Female	1
18 Mar 2019	13:07	7	Shortfin Mako	367	Female	1
23 Mar 2019	11:50	6	Shortfin Mako	228	Male	2
23 Mar 2019	16:22	8	Smooth Stingray	150	Unknown	1
24 Mar 2019	11:55	4	Smooth Stingray	150	Unknown	1
25 Mar 2019	16:47	4	Smooth Stingray	120	Male	1
26 Mar 2019	17:02	2	Dusky Whaler	114	Female	1
01 Apr 2019	13:31	3	Bronze Whaler	270	Male	1
02 Apr 2019	11:42	6	Shortfin Mako	180	Unknown	1
03 Apr 2019	13:19	3	Samsonfish	155	Unknown	2
05 Apr 2019	11:56	1	Tiger Shark	180	Female	1
06 Apr 2019	15:07	3	Tiger Shark	260	Female	2
06 Apr 2019	17:00	6	Shortfin Mako	210	Male	3
09 Apr 2019	11:00	4	Tiger Shark	285	Female	3
09 Apr 2019	14:46	3	Tiger Shark	299	Female	2
13 Apr 2019	11:51	9	Dusky Whaler	300	Male	2
13 Apr 2019	13:25	1	Tiger Shark	240	Female	2
18 Apr 2019	10:04	7	Dusky Whaler	250	Female	1
21 Apr 2019	16:40	1	Tiger Shark	240	Male	1
22 Apr 2019	09:32	9	Tiger Shark	200	Female	1
23 Apr 2019	10:37	4	Smooth Stingray	100	Unknown	1
24 Apr 2019	12:50	4	Dusky Whaler	200	Female	1

Date	Time	SDL Number	Species	Total Length (cm)	Sex	Release Condition
25 Apr 2019	12:07	6	Shortfin Mako	180	Unknown	1
25 Apr 2019	15:23	5	White Shark	460	Female	1
26 Apr 2019	10:29	10	Shortfin Mako	320	Female	2
26 Apr 2019	11:34	6	Dusky Whaler	240	Male	1
27 Apr 2019	12:32	9	Shortfin Mako	280	Male	1
01 May 2019	10:53	4	Smooth Stingray	92	Male	1
09 May 2019	15:27	6	Shortfin Mako	220	Male	1
10 May 2019	12:59	4	Smooth Stingray	120	Female	1
12 May 2019	10:30	3	Bronze Whaler	270	Female	1
13 May 2019	14:00	10	Dusky Whaler	91	Female	1
15 May 2019	11:54	10	Smooth Stingray	135	Female	1
15 May 2019	13:37	10	Tiger Shark	216	Female	2
15 May 2019	15:05	2	Smooth Stingray	130	Female	1
19 May 2019	11:57	2	Tiger Shark	165	Male	1
22 May 2019	09:41	5	Tiger Shark	225	Female	1
24 May 2019	11:13	8	Shortfin Mako	220	Male	1
24 May 2019	14:49	6	Shortfin Mako	160	Female	1
27 May 2019	14:56	4	Tiger Shark	185	Female	1
30 May 2019	10:44	1	Smooth Stingray		Unknown	1
02 Jun 2019	14:32	3	Bronze Whaler	260	Male	1
13 Jun 2019	09:49	2	Bronze Whaler	235	Male	1
15 Jun 2019	13:49	4	Dusky Whaler	100	Female	2
16 Jun 2019	11:25	9	Smooth Stingray	120	Female	1
16 Jun 2019	11:55	5	Tiger Shark	210	Female	1
17 Jun 2019	11:37	10	Dusky Whaler	105	Female	1
21 Jun 2019	09:07	4	Smooth Stingray	130	Female	1
10 Jul 2019	12:34	4	Bronze Whaler	250	Male	1
10 Jul 2019	14:27	8	Tiger Shark	200	Female	1

Date	Time	SDL Number	Species	Total Length (cm)	Sex	Release Condition
11 Jul 2019	09:38	10	Smooth Stingray	98	Male	1
12 Jul 2019	10:05	10	Pink Snapper	85	Female	4
12 Jul 2019	13:55	3	Bronze Whaler	250	Male	1
12 Jul 2019	14:14	2	Shortfin Mako	120	Male	1
15 Jul 2019	10:07	3	Bronze Whaler	270	Male	1
15 Jul 2019	15:51	2	Tiger Shark	260	Female	1
16 Jul 2019	14:36	9	Dusky Whaler	110	Male	1
26 Jul 2019	14:44	9	Shortfin Mako	210	Female	1
02 Aug 2019	12:11	10	Smooth Stingray	130	Male	1
02 Aug 2019	13:15	6	Shortfin Mako	300	Female	1
09 Aug 2019	15:30	9	Shortfin Mako	275	Female	1
20 Aug 2019	14:59	10	White Shark	330	Female	1
27 Aug 2019	09:33	2	Smooth Stingray	140	Female	1
28 Aug 2019	09:09	1	Bronze Whaler	230	Male	1
05 Sep 2019	12:34	2	Shortfin Mako	250	Unknown	1
16 Sep 2019	10:47	2	Bronze Whaler	310	Female	1
22 Sep 2019	10:12	5	Tiger Shark	370	Female	1
23 Sep 2019	10:26	2	Tiger Shark	310	Female	1
02 Oct 2019	15:37	10	Tiger Shark	235	Male	1
03 Oct 2019	08:18	6	Shortfin Mako	190	Female	1
03 Oct 2019	11:03	1	Tiger Shark	350	Male	1
12 Oct 2019	16:54	1	Bronze Whaler	285	Male	1
19 Oct 2019	16:43	3	Tiger Shark	380	Male	1
20 Oct 2019	13:01	3	Shortfin Mako	150	Female	1
29 Oct 2019	09:31	8	Smooth Stingray	150	Female	1
29 Oct 2019	15:32	3	Shortfin Mako	180	Unknown	1
04 Nov 2019	12:22	6	Shortfin Mako	178	Female	1
06 Nov 2019	11:07	10	Smooth Stingray	165	Female	1
09 Nov 2019	09:37	6	Tiger Shark	300	Female	1

Date	Time	SDL Number	Species	Total Length (cm)	Sex	Release Condition
09 Nov 2019	11:30	2	Tiger Shark	260	Female	1
14 Nov 2019	12:31	5	Shortfin Mako	150	Unknown	1
15 Nov 2019	11:59	3	Tiger Shark	280	Male	1
16 Nov 2019	07:25	8	Tiger Shark	370	Male	1
16 Nov 2019	12:34	10	Bronze Whaler	280	Male	1
17 Nov 2019	13:23	10	Bronze Whaler	260	Male	1
19 Nov 2019	10:45	2	Bronze Whaler	260	Female	1
19 Nov 2019	12:01	7	Bronze Whaler	240	Male	1
25 Nov 2019	07:42	7	Bronze Whaler	230	Male	1
26 Nov 2019	09:05	8	Tiger Shark	295	Female	1
26 Nov 2019	13:35	2	Tiger Shark	290	Female	1
26 Nov 2019	13:54	9	Tiger Shark	400	Female	1
27 Nov 2019	10:46	4	Bronze Whaler	265	Male	1
29 Nov 2019	07:12	4	Bronze Whaler	220	Male	1
30 Nov 2019	09:03	4	Smooth Stingray	90	Male	1
30 Nov 2019	11:13	10	Bronze Whaler	250	Male	2
02 Dec 2019	07:34	3	Bronze Whaler	230	Female	1
07 Dec 2019	07:49	6	Shortfin Mako	235	Female	1
13 Dec 2019	10:30	7	Tiger Shark	230	Male	2
13 Dec 2019	17:41	1	Tiger Shark	290	Female	1
14 Dec 2019	16:23	1	Tiger Shark	320	Female	1
18 Dec 2019	09:57	3	Bronze Whaler	295	Male	1
23 Dec 2019	10:26	3	Bronze Whaler	290	Female	1
24 Dec 2019	07:41	8	Shortfin Mako	315	Female	2
26 Dec 2019	07:40	1	Tiger Shark	245	Male	2
26 Dec 2019	09:01	2	Bronze Whaler	290	Female	2
26 Dec 2019	14:13	5	Bronze Whaler	280	Male	1
27 Dec 2019	09:52	4	Bronze Whaler	270	Male	1
27 Dec 2019	11:37	4	Tiger Shark	270	Female	1
27 Dec 2019	12:15	10	Bronze Whaler	260	Male	1

Date	Time	SDL Number	Species	Total Length (cm)	Sex	Release Condition
27 Dec 2019	15:19	1	Tiger Shark	270	Male	1
28 Dec 2019	10:52	3	Tiger Shark	236	Male	1
28 Dec 2019	14:45	1	Tiger Shark	400	Female	1
30 Dec 2019	10:26	7	Bronze Whaler	280	Male	1
30 Dec 2019	11:03	10	Tiger Shark	230	Female	1
31 Dec 2019	11:05	8	Bronze Whaler	270	Male	1
31 Dec 2019	13:23	1	Bronze Whaler	230	Male	1
01 Jan 2020	09:27	1	Tiger Shark	230	Female	1
01 Jan 2020	10:57	7	Tiger Shark	270	Female	1
01 Jan 2020	14:47	8	Tiger Shark	300	Male	1
01 Jan 2020	15:45	2	Smooth Stingray	80	Male	1
02 Jan 2020	09:08	3	Tiger Shark	290	Male	1
02 Jan 2020	10:27	2	Bronze Whaler	260	Male	1
02 Jan 2020	11:26	8	Tiger Shark	180	Female	1
05 Jan 2020	11:17	1	Tiger Shark	328	Female	1
05 Jan 2020	12:28	3	Smooth Stingray	80	Female	1
05 Jan 2020	13:14	2	Tiger Shark	290	Male	1
05 Jan 2020	16:04	1	Tiger Shark	420	Female	1
07 Jan 2020	10:52	2	Smooth Stingray	100	Male	1
07 Jan 2020	11:56	10	Pink Snapper	62	Male	5
07 Jan 2020	12:14	2	Tiger Shark	286	Female	1
08 Jan 2020	06:48	4	Smooth Stingray	90	Male	1
08 Jan 2020	07:40	4	Tiger Shark	295	Female	1
08 Jan 2020	10:13	8	Bronze Whaler	245	Male	1
08 Jan 2020	15:53	1	Tiger Shark	245	Male	2
11 Jan 2020	12:39	6	Tiger Shark	365	Male	1
12 Jan 2020	07:59	6	Tiger Shark	275	Female	1
17 Jan 2020	07:43	6	Tiger Shark	235	Male	1

Date	Time	SDL Number	Species	Total Length (cm)	Sex	Release Condition
18 Jan 2020	09:27	9	Tiger Shark	210	Female	2
19 Jan 2020	11:46	4	Tiger Shark	245	Female	1
20 Jan 2020	08:41	5	Dusky Whaler	98	Female	1
24 Jan 2020	10:50	5	Tiger Shark	264	Male	1
31 Jan 2020	08:37	6	Tiger Shark	299	Female	1
31 Jan 2020	10:02	4	Tiger Shark	240	Female	2
02 Feb 2020	08:22	9	Tiger Shark	245	Male	1
04 Feb 2020	08:28	7	Bronze Whaler	270	Male	1
07 Feb 2020	09:44	5	Tiger Shark	240	Male	1
07 Feb 2020	13:09	4	Bronze Whaler	270	Male	1
11 Feb 2020	09:46	10	Pink Snapper	95	Female	5
13 Feb 2020	07:33	3	Bronze Whaler	260	Male	1
14 Feb 2020	12:13	8	Smooth Hammerhead	155	Female	1
15 Feb 2020	09:00	4	Tiger Shark	215	Female	1

9.2 Appendix 2 - Non-target Species Capture Information

Tiger sharks dominated the catch of non-target species with 75 of the 182 captures (41%). Other commonly-caught species were bronze whaler sharks (*n* = 36; 20%), smooth stingrays (*n* = 30; 16%) and shortfin makos (*n* = 24; 13%) (Table A 2).

Table A 2 Numbers of non-target animals caught by species during the first year of the SMART drumline trial.

Category	Species	Number
Non-target sharks	Bronze Whaler	36
	Dusky Whaler	10
	Shortfin Mako	24
	Smooth Hammerhead	1
	Tiger Shark	75
Rays	Smooth Stingray	30
Finfish	Pink Snapper	3
	Samsonfish	1

Size

Animals of a range of sizes were captured on the SMART drumlines (Figure A 1). Shark captures ranged from a 91 cm TL dusky whaler shark to a 4.2m tiger shark. Smaller species such as a 62cm pink snapper were also captured (Table A 3).

Table A 3 Minimum, median and maximum total lengths of species captured during the first year of the SMART drumline trial.

Category	Species	Min	Median	Max
Non-target sharks	Bronze Whaler	2.20	2.60	3.10
	Dusky Whaler	0.91	1.12	3.00
	Shortfin Mako	1.20	2.15	3.67
	Smooth Hammerhead		1.55	
	Tiger Shark	1.65	2.60	4.20
Rays	Smooth Stingray*	0.80	1.20	1.80
Finfish	Pink Snapper	0.62	0.85	0.95
	Samsonfish		1.55	

* smooth stingrays were measured as disc width

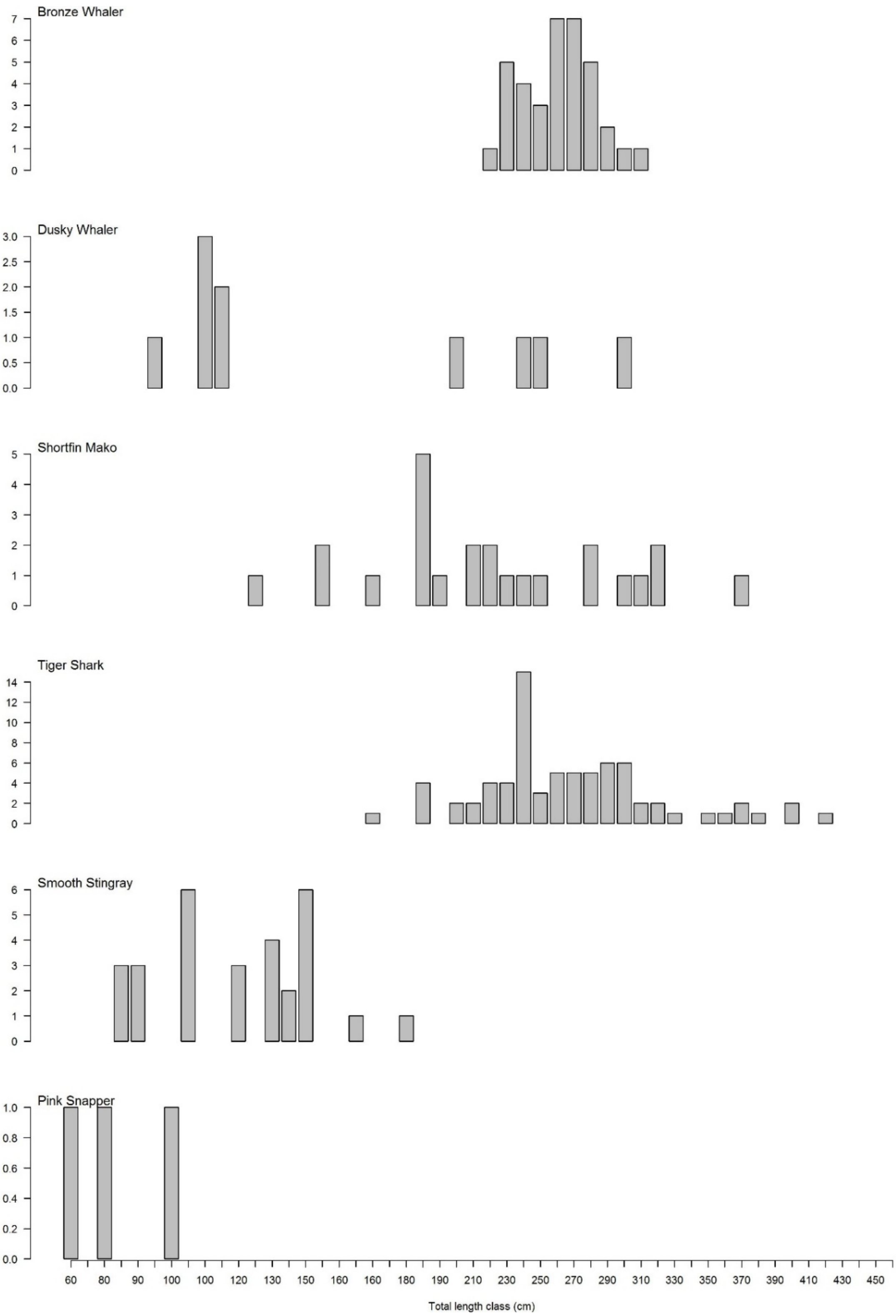

Figure A 1 Length frequency plot by species captured during the first year of the SMART drumline trial.

Temporal

Catches of all animals peaked during the austral summer, with catch rates considerably lower during autumn – spring period (Figure A 2a). This pattern is driven by the tiger shark catch rates (Figure A 2b – orange) which is the dominant species captured on the SMART drumlines (Table 3).

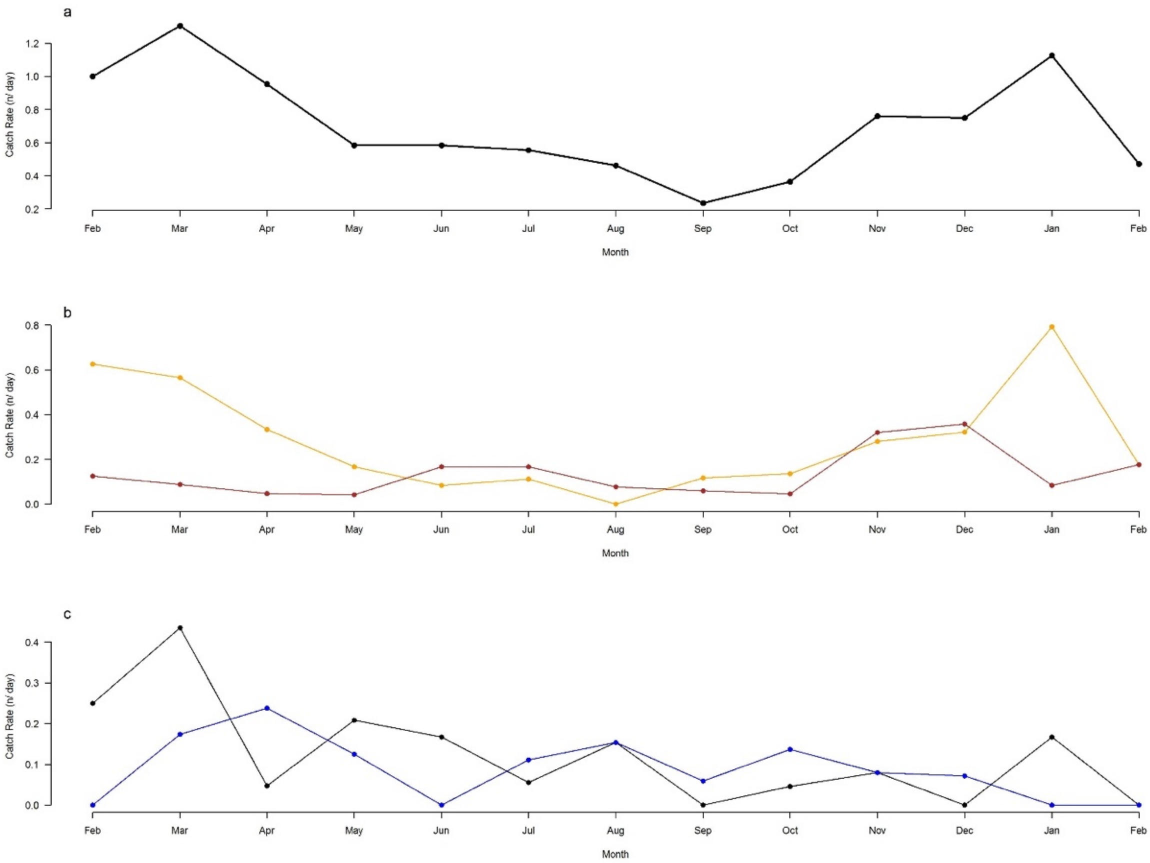

Figure A 2 Monthly catch rate (n/fishing day) of a) all animals, b) tiger sharks (orange), bronze whalers (brown) and c) smooth stingrays (black) and shortfin makos (blue).

9.3 Appendix 3 - Response Time

The response time was determined differently depending on if an animal is present on the line or not. For alerts resulting in catch, the response time was from when the SMART drumline was activated until the boat arrived. For false alarms (no catch) the response time was taken from the SMART drumline alert until the bait was back in the water as recorded on the gear sheet.

The SMART drumline buoys were activated 417 times, with an average response time of 11.1 minutes (± 0.4 min SE). Response times for alerts, which resulted in catch, were on average 10.3 minutes (± 0.5 min SE) compared with 11.7 minutes (± 0.6 min SE) when it was a false alarm. False alarm response times were, as expected, longer than those resulting in catch as they were calculated from alert until when the bait was back, not just when the vessel arrived at the SMART drumline.

There were only two occasions when the maximum response time of 30 minutes was exceeded when an individual was caught (Figure A 3). On 23 February 2019 two sharks were captured on drumlines three minutes apart at opposite ends of the SMART drumline array (SMART drumline station 10 and SMART drumline station 3). The first shark (2.6 m tiger shark) was attended to within 15 minutes and released six minutes later in good condition (release condition 1). This second shark (2.4 m tiger shark) was therefore responded to 44 minutes after capture but was also released in good condition (release condition 1). A four-meter tiger shark was hooked on 28 December 2019 during a bait check. The animal was attended to immediately after the bait check was completed which resulted in a 36-minute response time. The shark, given its size, was relocated and released in a good condition (release condition 1). There were a further 10 occasions when the response time was greater than 30 minutes, however these ultimately resulted in no catch (a false alarm; Figure A 3).

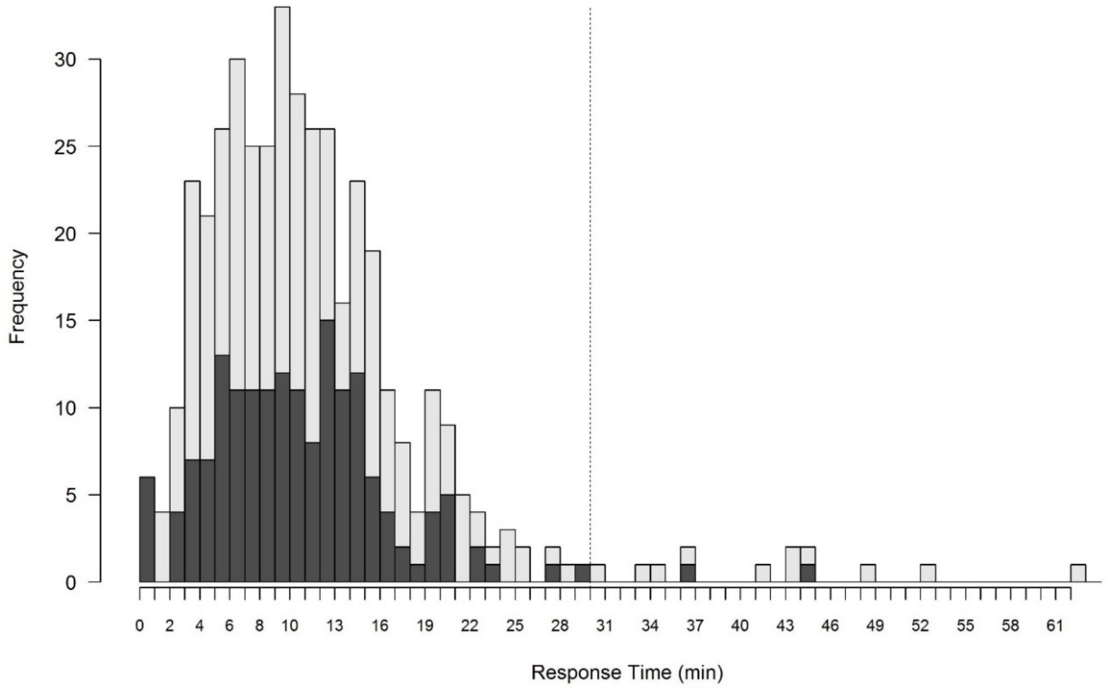

Figure A 3 Frequency of response times (minutes) to alerts from the SMART drumline buoys resulting from catch (dark grey) or false alarms (light grey). Vertical dotted line indicates the maximum allowable response time (30 minutes).

9.4 Appendix 4 - Hooked Time

The hooked time was determined for each animal as the time the animal triggered the alarm (capture), until the time of release. For animals that were relocated, this included the time of that relocation. A number of animals did not trigger the alarm and were found during the regular three-hour bait checks. Therefore it was not possible to estimate hooked times in these 14 cases. Smooth stingrays and dusky whaler sharks comprised the majority of these no-alert captures (n=5 each) with two shortfin makos, a tiger shark and pink snapper being the other species which did not trigger the alarm.

For the remaining 168 individuals, they were on the hook for an average time of 26.6 minutes (range 6 – 143 min). The summary statistics by species are presented in Table A 4.

Table A 4 Summary statistics and number of no alert captures by species.

Species	Number	Mean	Median	Minimum	Maximum	Number of No Alert Captures
White Shark	2	55	55	38	72	0
Bronze Whaler	36	31.4	28	19	143	0
Dusky Whaler	10	18.4	19	14	23	5
Shortfin Mako	24	22.3	21.5	8	45	2
Smooth Hammerhead	1	24				0
Tiger Shark	75	28.9	26	13	73	1
Smooth Stingray	30	16.3	16	6	32	5
Pink Snapper	3	39	39	38	40	1
Samsonfish	1	9				0

9.5 Appendix 5 - Hooking Location

A Mustad Giant Circle Hook 20/0 (39937NP-DT) was used during the SMART drumline trial. Circle hooks are designed to hook the animal in the corner of the mouth to reduce injury from capture. The hooking location was recorded for all observed animals and categorized as either:

- Corner: Hook is in the corner of the jaws;
- Mouth: Hook is inside the mouth. May be visible or not but can be determined by the length of trace protruding from the mouth;
- Swallowed: Hook has been swallowed and may be lodged in the gills or stomach. Hook will likely not be visible, with only a short length of trace protruding from the mouth; and
- Foul Hooked: The animal is foul hooked somewhere outside of the mouth or jaws. This includes, but is not limited to, outside of the gills, pectoral fins, flank etc.

Of the 182 animals captured, three shortfin mako sharks "spat" the hook adjacent to the boat and hence the hooking location could not be determined. Of the remaining 179 animals, 131 (73%) were hooked in the corner of their mouth. Of the 23 instances of foul hooking, 21 (91%) were smooth stingrays, with one dusky whaler (91 cm TL) hooked ventrally next to the pectoral fin and a 1.8 m TL shortfin mako. Tiger sharks (*n* = 12) comprised the vast majority of swallowed hookings, with the remainder being shortfin makos (*n* = 3). Ten animals were hooked in the mouth and were a mix of tiger sharks (*n* = 4), dusky whalers (*n* = 3) smooth stingrays (*n* = 2) and a shortfin mako.

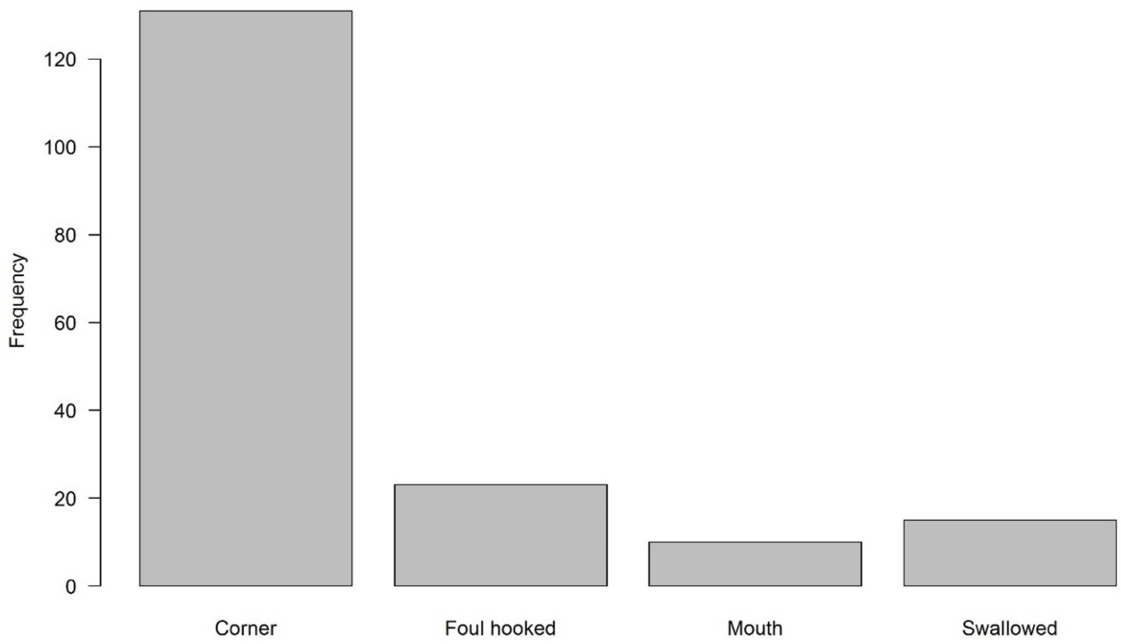

Figure A 4 Frequency of hooking location for individuals captured on SMART drumlines.

9.6 Appendix 6 - Release Condition

The condition of an individual at release was categorized numerically as;

1. Swam away strongly in good health
2. Swam away slowly
3. Failed to swim away and sunk, chances of survival appear low
4. Individual died
5. Individual was euthanized because of injuries

The vast majority (88%; *n* = 160) of animals captured were released in a good condition where the animal swam away strongly in good health (release condition 1). Of the remaining 22 animals, 17 swam away slowly (release condition 2). The two animals, which were released in condition 3, were a 2.4m Tiger Shark and a 1.8m Shortfin Mako. Both sharks were corner hooked in the mouth, and had rapid response times (3 and 0 minutes, respectively) and were on the hook for less than 30 minutes (25 and 20 minutes respectively. The shortfin mako had minor lacerations from a bite mark of the left dorsal side.

Two pink snappers were found dead on the hook when the vessel arrived at the SMART drumline. One was found 12 minutes after triggering the alarm while the other didn't set off the alarm and was found during a bait check. Finally, a pink snapper was euthanised after it was discovered suffering from severe barotrauma.

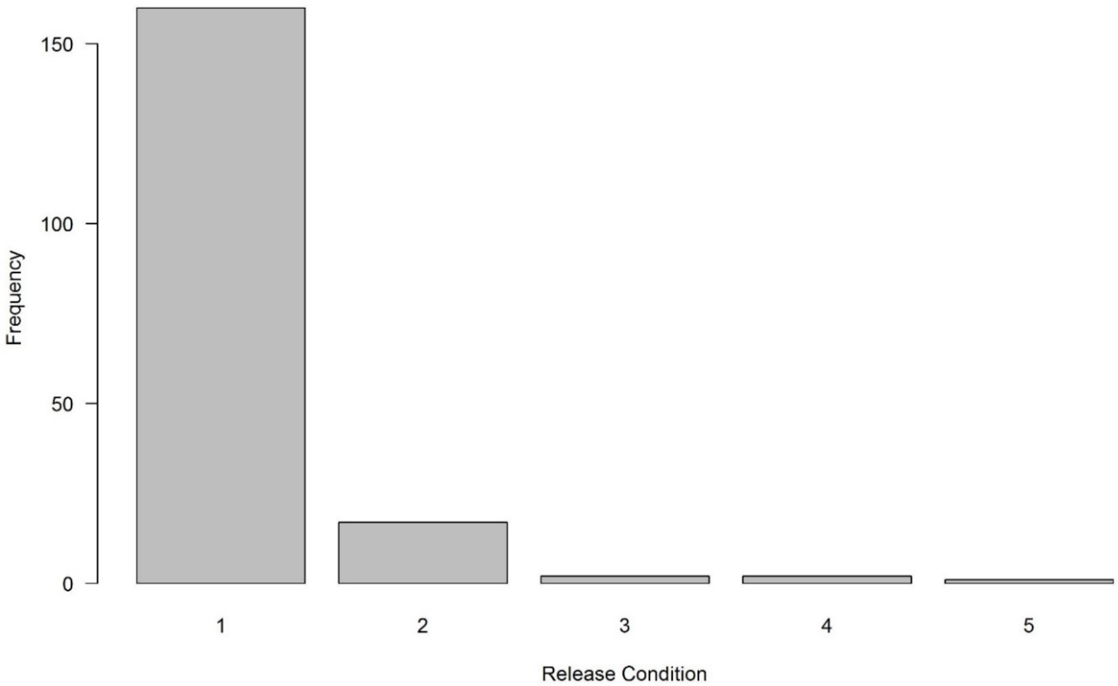

Figure A 5 Frequency of release condition for individuals captured on SMART drumlines.

9.7 Appendix 7 - Gear sheet

Contractor Crew Names			
Fished today?	Y or N	DPIRD Observer	

Observed Environmental Conditions	At Gear Setting	At Gear Retrieval
Wind Speed (kts)		
Wind Direction		
Sea State (0-9)		
Cloud Cover (%)		
Water Visibility (m)	0-2 or 3-5 or 6-10 or 11-20 or >20	0-2 or 3-5 or 6-10 or 11-20 or >20
Swell (m)		
Sea (m)		

Row #	SMART Buoy #	**Set** Time (24hr)	Water Temp (°C)	Water Depth (m)	Lat/Long or Map Mark #	Bait Type	**Retrieval** Time (24hrs)	Water Temp (°C)	Bait Remaining at end of day (%)
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									

Row #	SMART Buoy #	Event Type (Alert or Check)	Start Time (24hr) (Alert or Check)	Bait Remaining on arrival (%)	Animal No or 'False Alarm' (FA)	Comments	Bait Type	End Time (24hr)
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								

Comments

9.8 Appendix 8 - Catch sheet

Date		**Acoustic tag (check no) ID**	
Fishing Gear		Tagger name	
Smart buoy #		Side of shark	L or R
Time hooked (24 h)		**PAT tag (check no)**	
Time boat arrived (24 h)		**Serial (check no)**	
Time secured at boat (24 h) ***START GOPRO***		Tagger name	
Catch Details / Inspection		Side of shark	L or R
Animal Number		**Genetic fin clips** ***CHECK LABELS***	0 or 1 or 2
Species Common Name		**Photo (5 locations)**	**Y or N**
Alive or Dead upon first inspection	A or D	**Photo** (Full-body & Head) ***OTHER ANIMALS***	Y or N
Hooking location	C | M | SW | FH	**Release video**	Y or N
Sex	M or F or U	**Relocation and release**	
Total Length (cm)		Relocation start time (24hr)	
Fork Length (cm)		Relocation end time (24hr)	
Pre Caudal Length (cm)		Release time (24hr)	
Jaw width (cm)		Latitude (Decimal Degree)	
Recapture	Y or N	Longitude (Decimal Degree)	
Recapture Number		Distance offshore (m)	
Conventional tag (check no)		Water depth (m)	
Colour		Hook removed	Y or N
Tagger name		If N, was hook or trace cut?	H or T or N
Side of shark	L or R	Release condition (1-5)	
Other Comments:		Comments on Release:	
		Damage to fishing gear	Y or N
		If Y, describe here:	