Monitoring the presence and residency of sharks at key locations off Victor Harbor (Encounter Bay Marine Park)

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Photo: Andrew Fox

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DISCLAIMER

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White sharks were acoustically tagged as part of the white shark cage-diving industry monitoring program funded by the Department of Environment, Water and Natural Resources and Flinders University. Adventure Bay Charters, Calypso Star, and Rodney Fox Shark Expeditions are thanked for providing logistical support during the deployment of acoustic tags. Tagging of white sharks was carried out under the Department of Environment, Water and Natural Resources permit number Q26292-9, Q26292-10 and MR00047-6-V, PIRSA Exemption number ME9902693, and Flinders University ethics approval number E398.

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EXECUTIVE SUMMARY

This report provides a summary of sharks detected by acoustic receivers deployed in the Victor Harbor region in Encounter Bay Marine Park (South Australia). It contributes towards an assessment of the *Adequacy* (Biophysical Design Principle 3) and *Connectivity* (Biophysical Design Principle 5) of the South Australian Marine Parks network through the determination of white shark (*Carcharodon carcharias*) and bronze whaler (*Carcharhinus brachyurus*) visitation patterns and residency within marine parks near the Victor Harbor area.

Five VR2W acoustic receivers were deployed at key sites in the Victor Harbor region, including areas where sharks are likely to frequent naturally (Seal Island), shallow nearshore areas (Granite Island), and strategic headlands likely to be migratory paths when sharks enter the region (Kings Head, the Bluff, and Port Elliot). The receivers were deployed for a period of 20 months from March 2016 to November 2017. Sixteen months into the study period (July 2017), Oceanic Victor Pty Ltd opened a 45-m diameter fish pen near Granite Island that provides people with the opportunity to swim with a range of native fish species. The monitoring period included 16 months before the pen was installed (March 2016–July 2017) and four months after the pen was installed (July–November 2017). In addition, 80 acoustic receivers were deployed throughout the South Australian gulfs (41 inside and 39 outside the South Australian Marine Park network) as a part of other monitoring programs. Sites included the Neptune Islands Group (Ron and Valerie Taylor) Marine Park, the Upper Gulf St Vincent Marine Park, the Aldinga region (Encounter Bay Marine Park), and the metropolitan coast of Adelaide. Sixty-one white sharks, 55 bronze whalers, and nine dusky sharks (*C. obscurus*) were acoustically tagged in South Australia outside of Victor Harbor as part of separate shark monitoring projects led by or involving Flinders University. The total number of tagged sharks at liberty during the Victor Harbor monitoring period is unknown because external tags can be shed through time, and species were acoustically tagged by other agencies and could also be detected by the receivers deployed in Victor Harbor. Acoustic tracking was used to determine the number of tagged sharks that visited the monitored area in Victor Harbor, the amount of time (days) each shark spent in the area, and which receivers logged the highest number of detections. Marine Park connectivity was examined by determining the last known location of each shark prior to being detected in the Victor Harbor area.

Eleven sharks (10 bronze whalers, 1 white shark) were detected a total of 636 times in the Victor Harbor region. Individuals were present in Victor Harbor for 1 to 12 days (mean ± standard deviation = 3.0 ± 3.75) and were detected on 1 to 4 receivers (1.45 ± 0.93). The Granite Island receiver recorded the highest number of detections (69%), unique individuals (6 bronze whalers), and number of days detected/shark (1.5 ± 2.7). The Bluff recorded the second highest number of detections (24%) and number of days detected/shark (1.0 ± 3.3). These findings indicate that both bronze whalers and white sharks use the Victor Harbor area. Overall, the majority of tagged sharks detected in Victor Harbor stayed in the area for relatively short periods of time and primarily used the areas near Granite and Seal Island. The majority of detections and sharks were recorded in spring (September–November; 61%, 5 bronze whalers), followed by autumn (March–May; 37%, 1 white shark, 2 bronze whalers), and summer (December–February; 1%, 3 bronze whalers). There were no detections during winter 2016 and 2017 (June–August). The small number of receivers in Victor Harbor and the relatively short timeframe over which receivers were deployed prevents a thorough examination of local fine-scale movement patterns. Increased and long-term monitoring of locally tagged sharks is necessary to provide a greater understanding of shark movement and residency in the Victor Harbor area.

Three of the bronze whalers detected in Victor Harbor were originally tagged in Western Australia in 2016 and 2017. Seven bronze whalers were originally tagged in the Upper Gulf St Vincent Marine Park, and were subsequently detected in the Gulf St Vincent Marine Park, the metropolitan Adelaide coast, and the Aldinga area, before arriving in Victor Harbor. Two bronze whalers were originally tagged in Spencer Gulf. The single white shark was last detected within the Neptune Islands Group Marine Park before visiting the Victor Harbor area. These data indicate individuals moved between distinct areas along the southern Australian coast. For some sharks, Victor Harbor and the Encounter Bay Marine Park may be part of a large regional home range or migratory pathway that includes multiple South Australian marine parks. The specific importance of the Victor Harbor area to shark populations remains unclear, but the Encounter Bay Marine Park may help to provide adequate coverage and connectivity between important shark habitats within the broad South Australian Marine Park network. Additional study is needed to determine if the current Marine Park network is comprehensive, adequate, and supports important habitat linkages for South Australian shark populations.

1. INTRODUCTION

Marine Protected Areas (MPAs), also known as marine parks, are widely recognised as an essential tool in ocean conservation (Agardy 1994; Blyth-Skyrme *et al.* 2006; Angulo-Valdés and Hatcher 2010). By preventing damaging activities such as habitat destruction (Haddad *et al.* 2015), over-exploitation (Jackson *et al.* 2001), and pollution (Islam and Tanaka 2004), protected areas can conserve all the relevant biogeochemical processes, habitats, and species in an area. Marine parks can also provide important socio-economic benefits, such as increased ecotourism and employment, increased scientific capacity, and a stronger public connection to nature (Balmford *et al.* 2002; West *et al.* 2006; Apps and Huveneers 2016). Well-designed and effective marine parks ultimately provide a holistic and precautionary approach to marine management that cannot necessarily be achieved using other methods.

The goals and design of any MPA are context-dependant. Nonetheless, effective conservation-oriented MPAs share a consistent set of ecological features (Edgar *et al.* 2014). South Australia's Marine Parks network explanatory document (DEWNR 2012) details the seven key biophysical principles that were used to establish the South Australian Marine Parks network. It highlights that effective MPAs must include *comprehensive* (Biophysical Design Principle 2; cover a full range of habitats and species), *adequate* (Biophysical Design Principle 3; be an appropriate size so as to provide sufficient protection for a given species), and must also support *connectivity and linkages* within the environment (Biophysical Design Principle 5; provide for the sharing of plants, species, and materials between sites). Marine parks designed using these core principles are more likely to provide broad and lasting protection for its plants, animals, and ecosystems (Claudet *et al.* 2008; Agardy *et al.* 2011). However, adequacy and connectivity are far more difficult to achieve for highly mobile species, such as sharks, marine mammals, or tunas (McLaren *et al.* 2015). This is because the home ranges of these species are usually much larger than the MPAs themselves, and mobile species generally use a wide assortment of distinct and distant habitats. As a result, mobile species often spend the majority of their time outside marine parks and remain exposed to potentially damaging human activities (Claudet *et al.* 2008; Grüss *et al.* 2011; McLaren *et al.* 2015). Therefore, mobile species require large, well-connected MPA networks, and marine parks need to be regularly evaluated to ensure they include both the key habitats and movement paths of different mobile and vulnerable species.

Sharks are highly mobile aquatic predators that exert top-down control on marine food webs (Heupel *et al.* 2014). Sharks help to maintain healthy marine ecosystems by limiting prey population size and altering prey behaviour, which in–turn reduces competition between prey and preserves species biodiversity (Heithaus *et al.* 2008). Sharks across the globe are, however, experiencing unprecedented levels of population decline. Approximately 25% of all chondrichthyan fishes (sharks, rays, and chimaeras) are threatened with extinction, primarily due to overfishing and habitat destruction (Dulvy *et al.* 2014). Large and well-connected MPA networks can provide effective protection from these critical threats (Dulvy 2006; Garla *et al.* 2006). For example, Knip *et al.* (2012) used an array of acoustic receivers to examine the movement and space use of two tropical coastal shark species, juvenile pigeye (*Carcharhinus amboinensis*) and adult spottail (*Carcharhinus sorrah*), within two MPAs in the Great Barrier Reef Marine Park, Australia. The authors found that sharks used large areas inside the MPAs over relatively long periods of time, indicating the MPAs could have substantial conservation benefits for these populations. This study, and others like it (Garla *et al.* 2006; Dewar *et al.* 2008; Espinoza *et al.* 2014), also demonstrate that acoustic monitoring is a highly efficient way to evaluate and improve MPAs for shark species.

Limited acoustic monitoring within the South Australian Marine Parks network has already helped to identify important shark habitat. Fifty-five bronze whalers (*Carcharhinus brachyurus*) and nine dusky sharks (*C. obscurus*) were tagged with acoustic transmitters in Gulf St Vincent between 2010 and 2013 as part of a study monitoring shark species of conservation concern within the Adelaide metropolitan and Gulf St Vincent regions (Huveneers et al 2014a; Huveneers *et al*. 2014b). Twenty white sharks (*Carcharodon carcharias*) have and continue to be tagged yearly at the Neptune Islands group (Ron and Valerie Taylor) Marine Park since 2013 as part of the white shark cage-diving industry monitoring. Many of these sharks have been detected in several South Australian marine parks, including in the Neptune Islands group Marine Park, the Encounter Bay Marine Park (e.g., Aldinga Reef Sanctuary Zone), and the Upper Gulf St Vincent Marine Park (e.g., Zanoni Sanctuary Zone; see Huveneers *et al*. 2014a; 2014b; Rogers *et al*. 2014; Rogers and Huveneers 2016; Huveneers and Lloyd 2017 for more details about residency and detections within these locations). These studies strongly indicate that the Gulf St Vincent and the Neptune Islands are essential habitat for a variety of shark species. For example, the Gulf St Vincent is likely a key nursery ground for juvenile bronze whalers (Rogers *et al.* 2013). However, the relative importance of other marine parks within the South Australian network to shark populations has not been investigated, and shark connectivity between distinct marine parks has yet to be evaluated. It is currently unclear if the South Australia Marine Park network provides comprehensive and adequate protection, or if it supports important habitat linkages, for South Australian shark populations.

Victor Harbor is located on the south coast of the Fleurieu Peninsula, approximately 80 km from Adelaide. It is the largest population centre on the peninsula and is a popular tourist destination, especially during summer. Victor Harbor sits within the Encounter Bay Marine Park, which extends off the coast of southern Adelaide within Gulf St Vincent, to the exposed Coorong coast. The park itself is one of the largest marine parks in South Australian waters (3,121 km^2) and is considered a key component of South Australia's Marine Park network. The Victor Harbor region and the southern range of the Encounter Bay Marine Park is home to wide range of diverse habitats including reefs, high-energy dissipative beaches, and wetlands (Encounter Marine Park Management Plan, 2012). The park also provides a significant link between the Gulf St Vincent and the southern coast. Given its potential importance to South Australian sharks, the local economy, and the wider Marine Park network, shark movement patterns within the Victor Harbor area need to be examined to ensure that the park is providing sufficient protection for regional populations.

1.2 *Aims and objectives*

The primary aim of this report was to use passive acoustic telemetry to evaluate the presence and residency of sharks at key locations within the Victor Harbor region. Overall, the deployment of receivers in Victor Harbor will contribute to the DEWNR Monitoring, Evaluation and Reporting program by assisting in assessing the *Adequacy* of the South Australian Marine Parks network (Biophysical Design Principle 3) through the determination of white shark and bronze whaler visitation patterns and residency within marine parks and sanctuary zones. The proposed project will also contribute to assessing the level of *Connectivity* between marine parks where receivers are deployed (Biophysical Design Principle 5).

Over 1,000 acoustic receivers are also deployed throughout Australia and the receivers deployed off Victor Harbor will contribute to the national network of acoustic receivers managed by the Integrated Marine Observing System Animal Tracking Facility (IMOS ATF). These receivers can be used to determine shark connectivity with other regions around Australia, including areas protected through the National Representative System of Marine Protected Areas (NRSMPA). For example, bronze whalers and dusky sharks tagged in South Australia have been detected in Victoria (Corner Inlet) and Western Australia (off Perth) (Huveneers *et al*. 2014b), while white sharks tagged at the Neptune Islands have been detected across their distribution from Ningaloo Reef, Western Australia to the Great Barrier Reef, Queensland (McAuley *et al.*, 2017; Bruce and Bradford; unpublished data). Ultimately, the Victor Harbor monitoring program will contribute to nation–wide evaluations of animal movement patterns.

2. METHODS

2.1 Study site and receiver deployments

Five VR2W (Vemco Ltd., Halifax, Canada) acoustic receivers were deployed at key sites in the Victor Harbor region including areas where sharks are likely to frequent naturally (Seal Island), shallow nearshore areas (Granite Island), and strategic headlands likely to be migratory paths when sharks enter the Victor Harbor region, i.e. Kings Head, the Bluff, and Port Elliot (Fig. 1). Receivers were coated in anti-fouling paint and affixed to a 1.65 m long steel post that was hammered into the substratum to at least 0.6–0.8 m depth. The receivers were deployed for a period of 20 months from March 2016 to November 2017. Sixteen months into the study period (July 2017), a new wildlife tourism opportunity for people to swim with a range of native fish species opened near Granite Island. The Oceanic Victor operations consists of a 45 m diameter fish pen which hosts less than 5 tonnes of Southern Bluefin tuna that are fed a minimum of 5% body weight per day (when weather permits) to meet metabolic demands. Therefore, the monitoring period opportunistically included 16 months before the pen was installed (March 2016–July 2017) and four months after the pen was installed (July–November 2017). In addition, 80 acoustic receivers were deployed throughout the South Australian gulfs (41 inside and 39 outside the South Australian Marine Park network) as a part of other monitoring programs (see Huveneers et al. 2014a; 2014b; Rogers et al 2014; Rogers and Huveneers 2016; Huveneers and Lloyd 2017). Sites included the Neptune Islands Group (Ron and Valerie Taylor) Marine Park, the Encounter Bay Marine Park (e.g., Aldinga Reef Sanctuary Zone), the Upper Gulf St Vincent Marine Park (e.g., Zanoni Sanctuary Zone), and the metropolitan coast of Adelaide (Fig. 2).

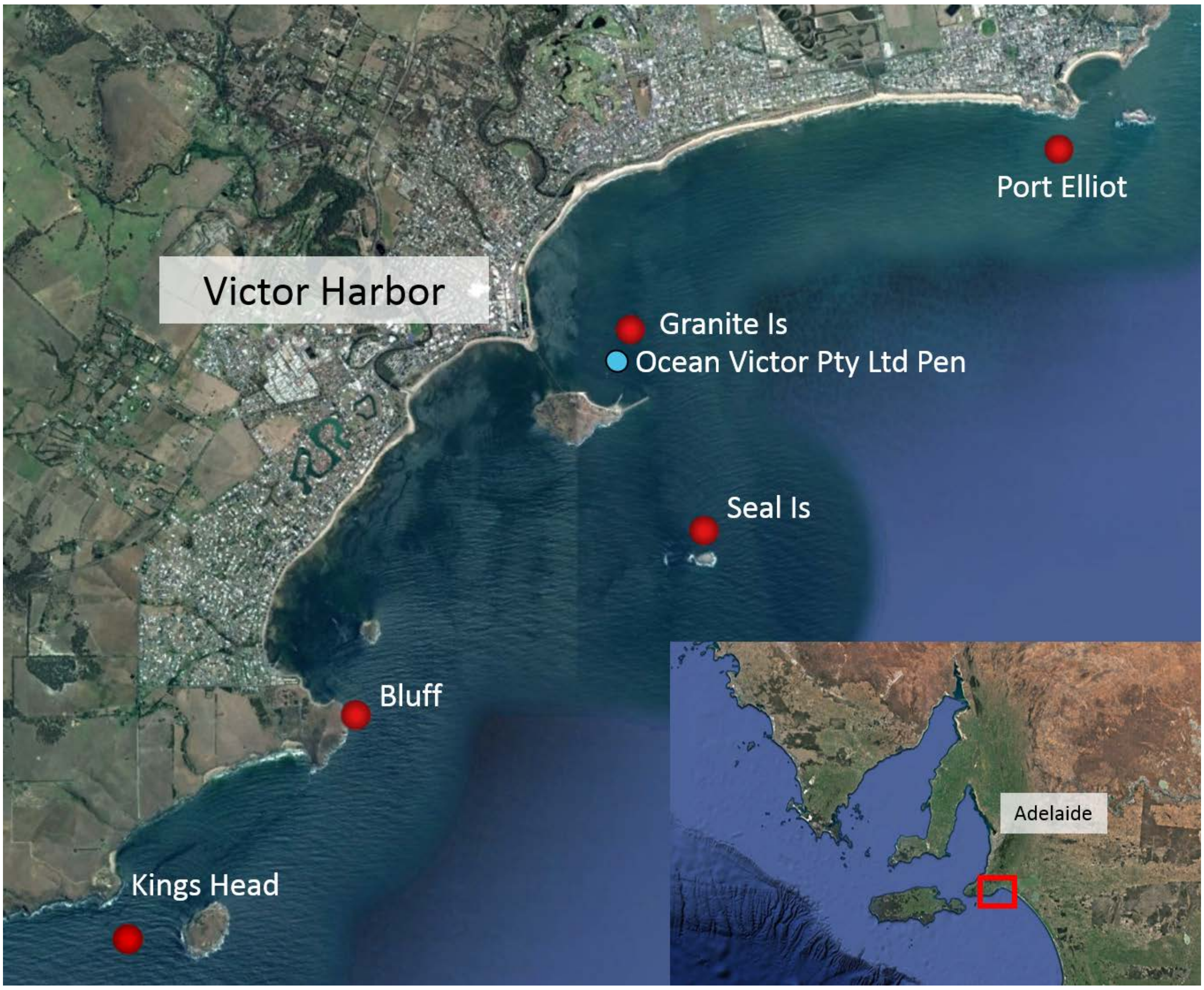

Figure 1. Map of acoustic receiver and fish pen locations within the Victor Harbor region.

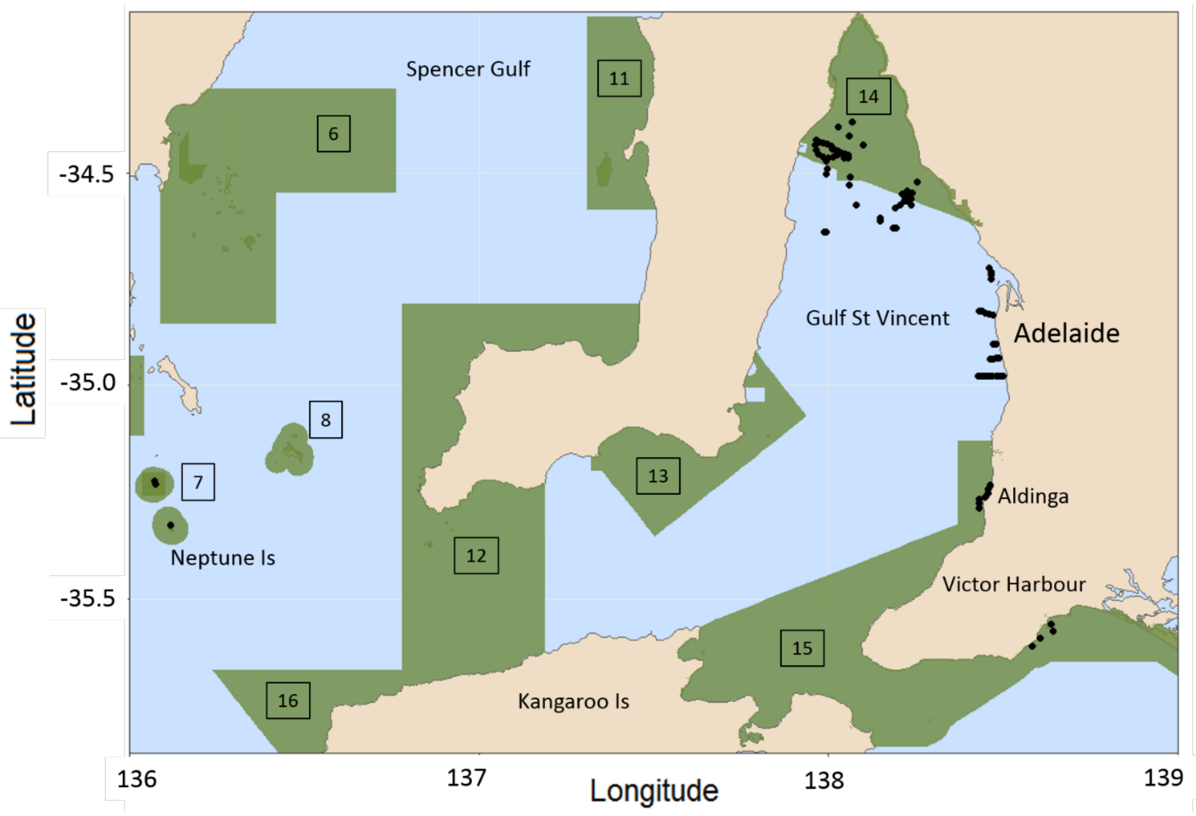

Figure 2. Acoustic receiver locations (black circles) near Adelaide, South Australia. Green areas indicate (6) Sir Joseph Banks Group Marine Park, (7) Neptune Islands Group Marine Park, (8) Gambier Islands Group Marine Park, (11) Eastern Spencer Gulf, (12) Southern Spencer Gulf Marine Park, (13) Lower Yorke Peninsula, (14) Upper Gulf St Vincent Marine Park, (15) Encounter Bay Marine Park, and (16) Western Kangaroo Island Marine Park.

The acoustic receivers detected electronic pulses produced by acoustic transmitters or "tags" that were attached to (Fig. 3) or surgically implanted into sharks (Fig. 4; Huveneers et al. 2014a; Huveneers and Lloyd 2017). Each tag emits a unique numerical code which allows for the identification of individuals. When a tagged shark swam within the detection range of a receiver (~500 meters; Huveneers et al 2016), the receiver recorded the date and time the shark was in the area. Sharks were not tagged within the Victor Harbor region. However, white sharks, bronze whalers, and dusky sharks have been acoustically tagged in Southern Australia as part of several projects:

1) Fifty-five bronze whalers and nine dusky sharks were internally tagged in Gulf St Vincent between 2010 and 2013 as part of a study monitoring whaler sharks in the Adelaide metropolitan and Gulf St Vincent regions (Huveneers et al 2014a; Huveneers et al 2014b);

2) Thirty bronze whalers were externally tagged in Spencer Gulf as part of a Fisheries and Research Development Corporation (FRDC) project (2014-020);

3) Fifty-three bronze whalers were internally tagged in WA as part of another Fisheries and Research Development Corporation (FRDC) project (2010-003) (Braccini *et al.* 2017);

4) Sixty-one whites sharks were externally tagged between September 2013 and May 2017 as part of the monitoring of the white shark cage-diving industry (Rogers *et al*. 2014; Rogers and Huveneers 2016; Huveneers and Lloyd 2017); and

5) 234 white sharks were either externally (197), internally (9), or double tagged (28) by the Department of Fisheries, Western Australia and colleagues as part of their shark attack mitigation program (McAuley *et al.* 2017).

It is important to note that the total number of tagged white sharks and bronze whalers at liberty during the Victor Harbor monitoring period is unknown because external tags can be shed through time. For example, white sharks tagged by the Department of Fisheries, Western Australia were fitted with tags between 20 December 2007 and 30 December 2015 and many external tags would have either run out of battery or shed. As a result, it is not possible to ascertain how many externally tagged sharks carried acoustic tags throughout the study period.

Figure 3. Example of a white shark (*Carcharodon carcharias*) tagged with acoustic transmitters below the dorsal fin.

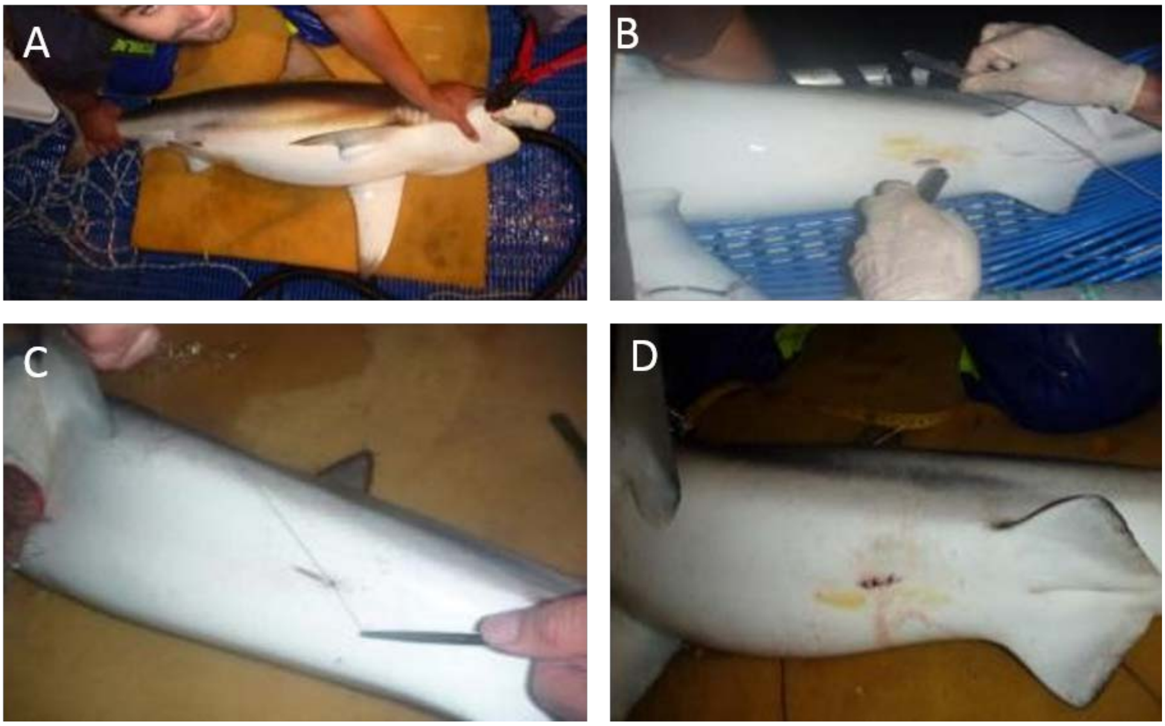

Figure 4. Internal tagging procedure of a bronze whaler (*Carcharhinus brachyurus)* showing (a) captured shark, (b) incision and tag insertion, (c) suturing, and (d) finished sutures.

2.2 Data analysis

Acoustic detections were used to determine the number of tagged sharks that were present in the Victor Harbor region during the monitoring period. Detection data were then used to determine the amount of time (days) each shark spent in the area, and which receivers recorded the highest number of detections, unique individuals, and mean number of days detected/shark. Sharks were considered present on any given day within the area or at a specific receiver if the receiver recorded a single detection. A minimum of two detections per day is usually required for a shark to be considered present to eliminate false detections (Simpfendorfer *et al.* 2015). However, false detections most often occur as a result of overlapping acoustic transmissions from co-occurring sharks. False detections were considered highly unlikely in Victor Harbor given the low number of tagged sharks that were present in the area during the monitoring period. Marine park connectivity was examined by determining the last known location of each shark prior to entering the Victor Harbor area. The last known location of each shark was assigned using detections from acoustic receivers outside of Victor Harbor.

4. RESULTS AND DISCUSSION

The receiver deployed off Port Elliot could not be recovered due to the location being exposed to large swell and ensuing sand movement, likely resulting in the receiver being buried. The receiver was not replaced. Residency and detection patterns were determined using the four remaining receivers. From March 2016 to November 2017, 11 sharks (10 bronze whalers, 1 white shark) were detected a total of 636 times in the Victor Harbor region (Table 1). Sharks were present in Victor Harbor for a cumulative total of 34 days, or approximately 5% of the total monitoring period. Individuals were present in Victor Harbor for 1 to 12 days (mean ± standard deviation = 3.0 ± 3.75) and were detected on 1 to 4 receivers (1.45 ± 0.93; Fig. 5). Most detections were recorded at the Granite Island receiver (69%), followed by the Bluff (24%), Seal Island (8%), and Kings Head (< 1%) receivers (Fig. 6). The Granite Island receiver also recorded the highest number of days detected/shark (1.5 ± 2.7), followed by the Bluff (1.0 ± 3.3), Seal Island (0.9 ± 0.8), and Kings Head (0.5 ± 1.2). Overall, differences in mean number of days detected/day were small. The Granite Island receiver also recorded the highest number of unique individuals (6 bronze whalers). The Seal Island receiver recorded five individuals (1 white shark, 4 bronze whalers). The Bluff and Kings Head receivers recorded only 1 and 2 unique individuals respectively (all bronze whalers). Thus, the high percentage of detections at the Bluff was dominated by a single shark, while detections at Granite and Seal Island were the result of multiple sharks using these areas across the entire monitoring period.

Table 1. Summary of acoustically tagged shark biological and detection data in the Victor Harbor area. Column headings are as follows: Tag identification number (Shark ID), fork length (FL), total length (TL), Tagging date, original tag location (State), date of first and last detection in Victor Harbor (First detection, Last detection), number of days detected (# Days), and number of receivers that detected each shark (#Rec). FL and TL were not recorded for all individuals.

Shark ID	Species	Sex	FL (cm)	TL (cm)	Tagging date	State	First detection	Last detection	# Days	# Rec
1	*C. brachyurus*	Female	210		2/10/2014	WA	2/05/2016	14/05/2016	12	4
2	*C. brachyurus*	Female	150		07/02/2015	SA	14/10/2016	14/10/2016	1	1
3	*C. brachyurus*	Male	91	115	3/11/2011	SA	14/10/2016	15/10/2016	2	2
4	*C. brachyurus*	Female		232	23/11/2012	SA	10/10/2016	10/10/2016	1	1
5	*C. brachyurus*	Female	129	156	6/12/2012	SA	26/12/2016	26/12/2016	1	1
6	*C. brachyurus*	Male	203		07/02/2015	SA	11/01/2017	11/01/2017	1	1
7	*C. brachyurus*	Female	230		17/10/2012	WA	23/02/2017	23/02/2017	1	1
8	*C. carcharias*	Male		330	1/12/2016	SA	24/04/2017	25/04/2017	2	1
9	*C. brachyurus*	Female	232		18/10/2012	WA	10/05/2017	10/05/2017	2	2
10	*C. brachyurus*	Female	75	90	24/01/2013	SA	10/09/2017	11/09/2017	2	1
11	*C. brachyurus*	Male	94	114	15/02/2012	SA	29/09/2017	7/10/2017	9	1

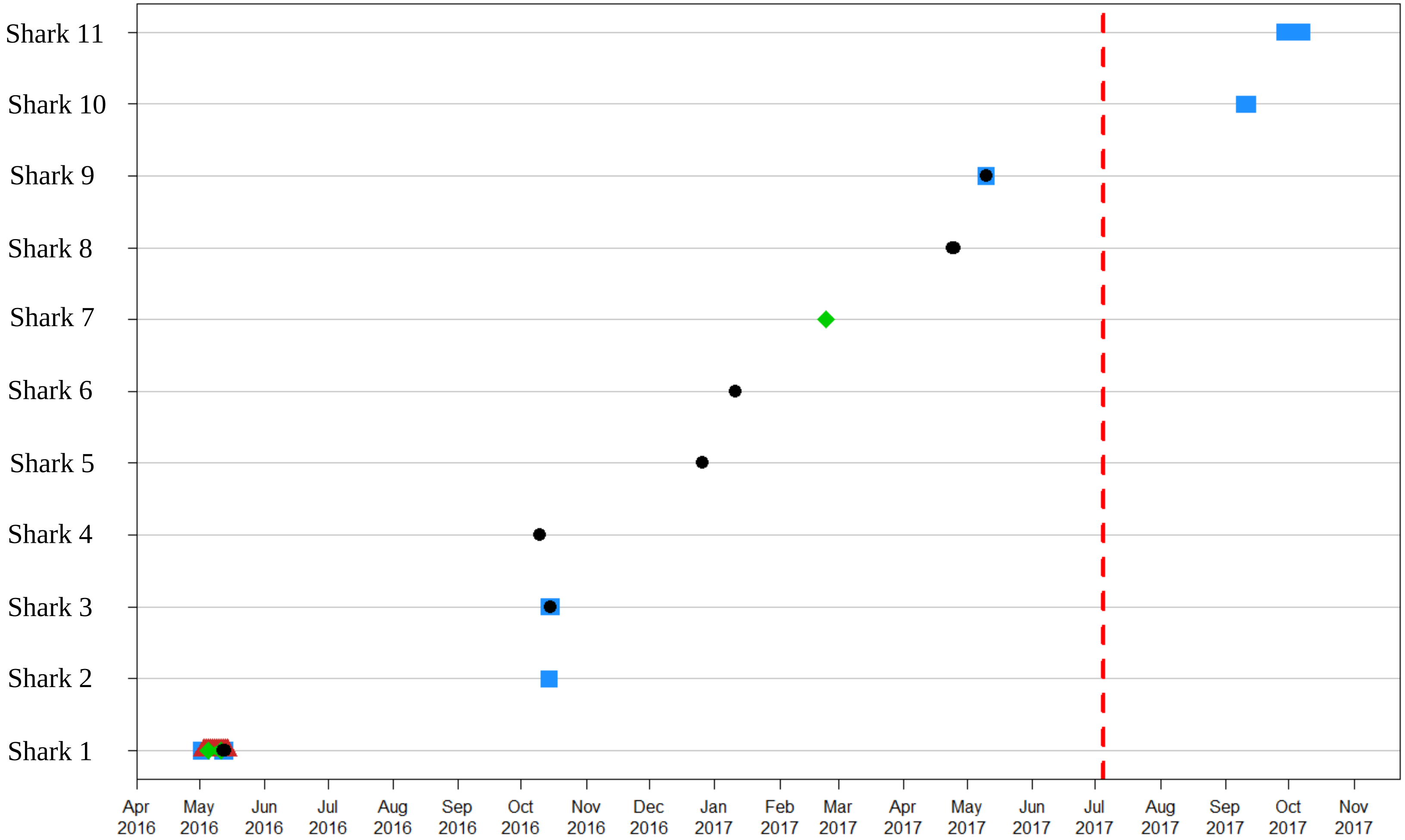

Figure 5. Daily presence of sharks (indicated by tag identification number) in the Victor Harbor region. Each point indicates a day a shark detected at the Granite Island (blue squares), Seal Island (black circles), Bluff (red triangles), and Kings Head (green diamonds) receivers. The red dotted line denotes the date the Oceanic Victor pen was installed.

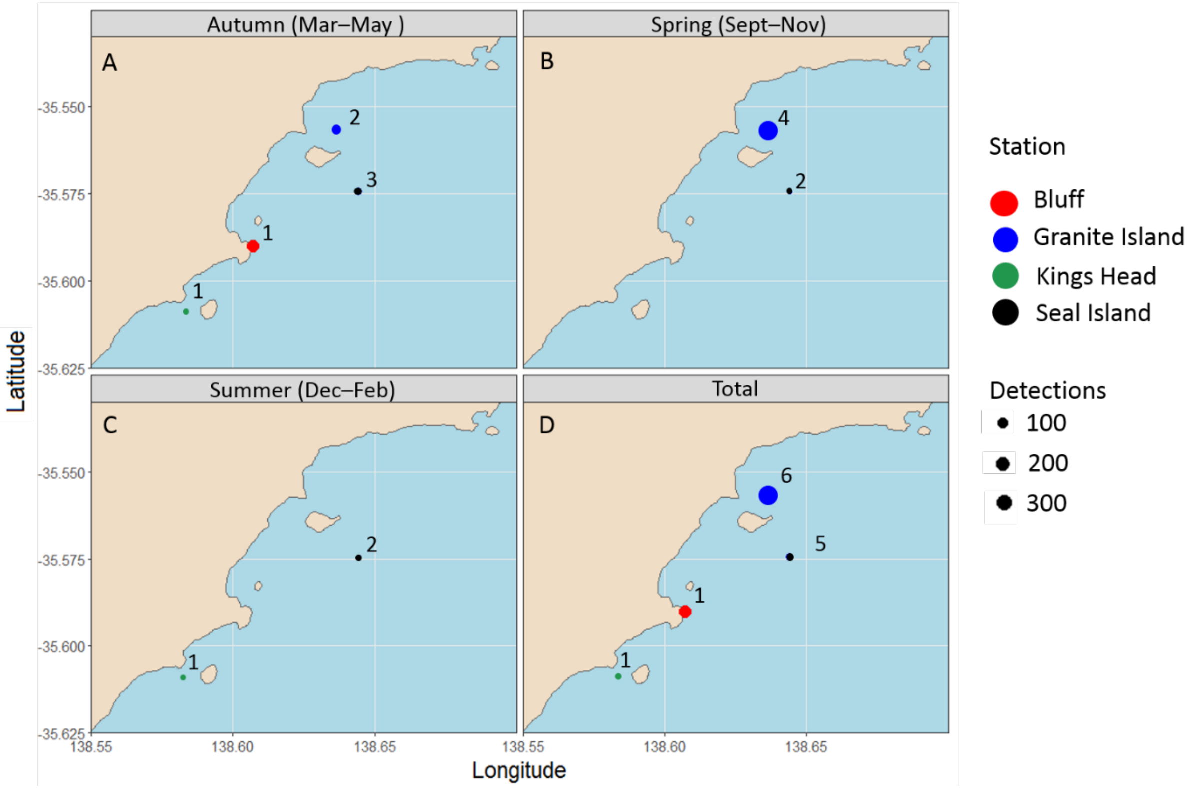

Figure 6. (**A–C)** Spatial and seasonal distribution of shark detections at Victor Harbor acoustic receivers. Circles denote receiver location and the number of detections at each site. Numbers denote the number of unique sharks detected at each receiver. There were no detections during the winter months. (**D**) Spatial distribution of the total number of detections over the entire monitoring period.

Collectively, these findings indicate that both bronze whalers and white sharks use the Victor Harbor area. The majority of tagged sharks that entered Victor Harbor stayed in the area for relatively short periods of time and consistently used the areas near Granite and Seal Island. However, not all sharks followed this trend. A female bronze whaler (Shark 1) was detected at all four acoustic receivers and remained in Victor Harbor for 12 days, indicating that some individuals will roam throughout the area for relatively long periods of time.

The majority of detections were recorded in spring (September–November; 61%), followed by autumn (March–May; 37%), and summer (December–February; 1%). There were no detections during winter 2016 and 2017 (June–August). The majority of sharks were also detected in spring (5 bronze whalers), and the same number of sharks were detected in autumn (1 white shark, 2 bronze whalers) and summer (3 bronze whalers). Bronze whalers are typically most abundant in inshore areas during the spring and summer months (Smale 1991, Cappo 1992; Cliff and Dudley 1992, Chiaramonte 1998; Huveneers et al 2014a; 2014b). Adult female bronze whalers often enter shallow inshore habitats in spring to breed. However, there is currently no evidence to suggest that Victor Harbor is a significant nursery ground for juvenile bronze whalers. It is important to note that the small number of receivers in Victor Harbor prevents a thorough examination of local fine-scale movement patterns. Increased and long-term monitoring of locally tagged sharks is necessary to provide a greater understanding of shark movement and residency in the Victor Harbor area.

The majority of tagged sharks (80%) were detected before the Oceanic Victor pen was installed. The monitoring period, however, was considerably shorter after the pen was installed (4 vs. 16 months). As a result, insufficient data is currently available to determine if the Oceanic Victor pen had any effect on shark movement and residency in Victor Harbor.

Three of the bronze whalers detected in Victor Harbor were originally tagged in Western Australia in 2016 and 2017 near Perth. These sharks were subsequently detected along the eastern and southern Western Australian coast before being detected in Victor Harbor (Fig 7A). Five bronze whalers were originally tagged in the Upper Gulf St Vincent Marine Park, and were subsequently detected by receivers in the Upper Gulf St Vincent Marine Park, the metropolitan Adelaide coast, and within Aldinga Sanctuary Zone in the Encounter Bay Marine Park, before arriving in Victor Harbor (Fig. 7B; Table 2). The two remaining bronze whalers were originally tagged in the Spencer Gulf, but no acoustic data outside Victor Harbor are currently available for these individuals. The single white shark was last detected within the Neptune Islands Group Marine Park before visiting the Victor Harbor area.

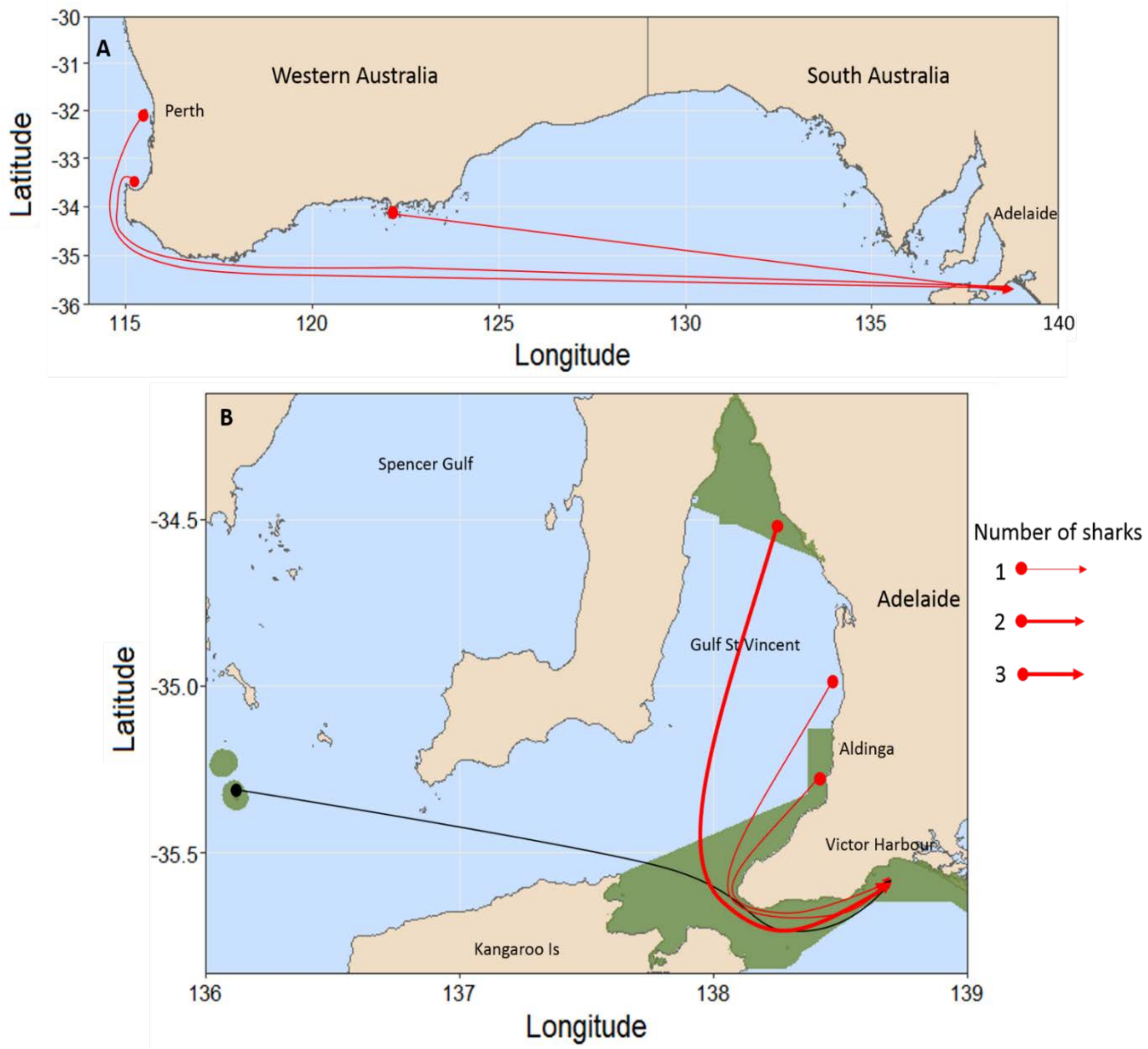

Figure 7. Last known locations of (A) Western Australian and (B) South Australian tagged sharks before entering the Victor Harbor area. Points of origin were determined using the last known detection on Australian acoustic receivers. Arrows indicate the likely general direction of travel, but are not validated movement paths. Arrow thickness indicates the number of sharks traveling to Victor Harbor from a given area. Black lines represents white sharks (*C. carcharias*), red lines represent bronze whalers (*C. brachyurus*). Green areas are South Australian Marine Parks that contain acoustic receivers and were linked by shark movement. Two bronze whalers tagged in Spencer Gulf (Shark 2 and 6) are not represented as tagging location is unknown.

Table 2. Summary of shark detection patterns in the South Australian Marine Parks network. Shark ID is the transmitter identification number, State is the Australian state where the shark was initially tagged, *n* is number of South Australian Marine Parks in which a shark was detected, and Marine Park are the specific parks in which the sharks were detected.

Shark ID	**Species**	**State**	***n***	**Marine Park**
1	*C. brachyurus*	WA	1	Encounter (Victor Harbor)
2	*C. brachyurus*	SA	1	Encounter (Victor Harbor)
3	*C. brachyurus*	SA	2	Upper Gulf St Vincent, Encounter (Victor Harbor)
4	*C. brachyurus*	SA	2	Upper Gulf St Vincent, Encounter (Aldinga, Victor Harbor)
5	*C. brachyurus*	SA	2	Upper Gulf St Vincent, Encounter (Victor Harbor)
6	*C. brachyurus*	SA	1	Encounter (Victor Harbor)
7	*C. brachyurus*	WA	1	Encounter (Victor Harbor)
8	*C. carcharias*	SA	2	Neptune Islands, Encounter (Victor Harbor)
9	*C. brachyurus*	WA	1	Encounter (Victor Harbor)
10	*C. brachyurus*	SA	2	Upper Gulf St Vincent, Encounter (Victor Harbor)
11	*C. brachyurus*	SA	2	Upper Gulf St Vincent, Encounter (Aldinga, Victor Harbor)

These data indicate individuals moved between distinct areas and marine parks along the southern Australian coast. Moreover, for some sharks, Victor Harbor may be a part of large regional home range or migratory pathway that includes multiple parks. The specific importance of the Victor Harbor area to regional shark populations remains unclear, but the results of this report suggest the Encounter Bay Marine Park contributes to providing adequate coverage and connectivity between shark habitats within the South Australian Marine Park network. Additional study is needed to examine species-specific or temporal trends in marine park shark connectivity and to determine if the current network is comprehensive, adequate, and supports important habitat linkages for South Australian shark populations.

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