

# HOTSPOTS WITHIN HOTSPOTS? HAMMERHEAD SHARK MOVEMENT AT WOLF ISLAND, GALAPAGOS

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## Background

Since the start of the century, a growing body of literature points to widespread declines in shark populations around the world.

Poorly managed fisheries have resulted in declining catches and predicted collapses over the next decades.

Ecological impacts of fishery declines and loss of top predators are unknown but probably severe and long lasting.

There is a need to create protected areas for these and other threatened marine species, yet how to protect open-water, highly mobile groups of species?



Fig.2 School of scalloped hammerheads, Wolf Island (Alex Hearn)

## Research Questions

- To what extent do sharks utilize the entire available habitat around oceanic islets and seamounts?

- Do they display site fidelity?

- Do sharks from other islands display the same site fidelity upon migrating to Wolf?

- Might hammerheads be suitable umbrella species to represent the spatial composition of pelagic assemblage?

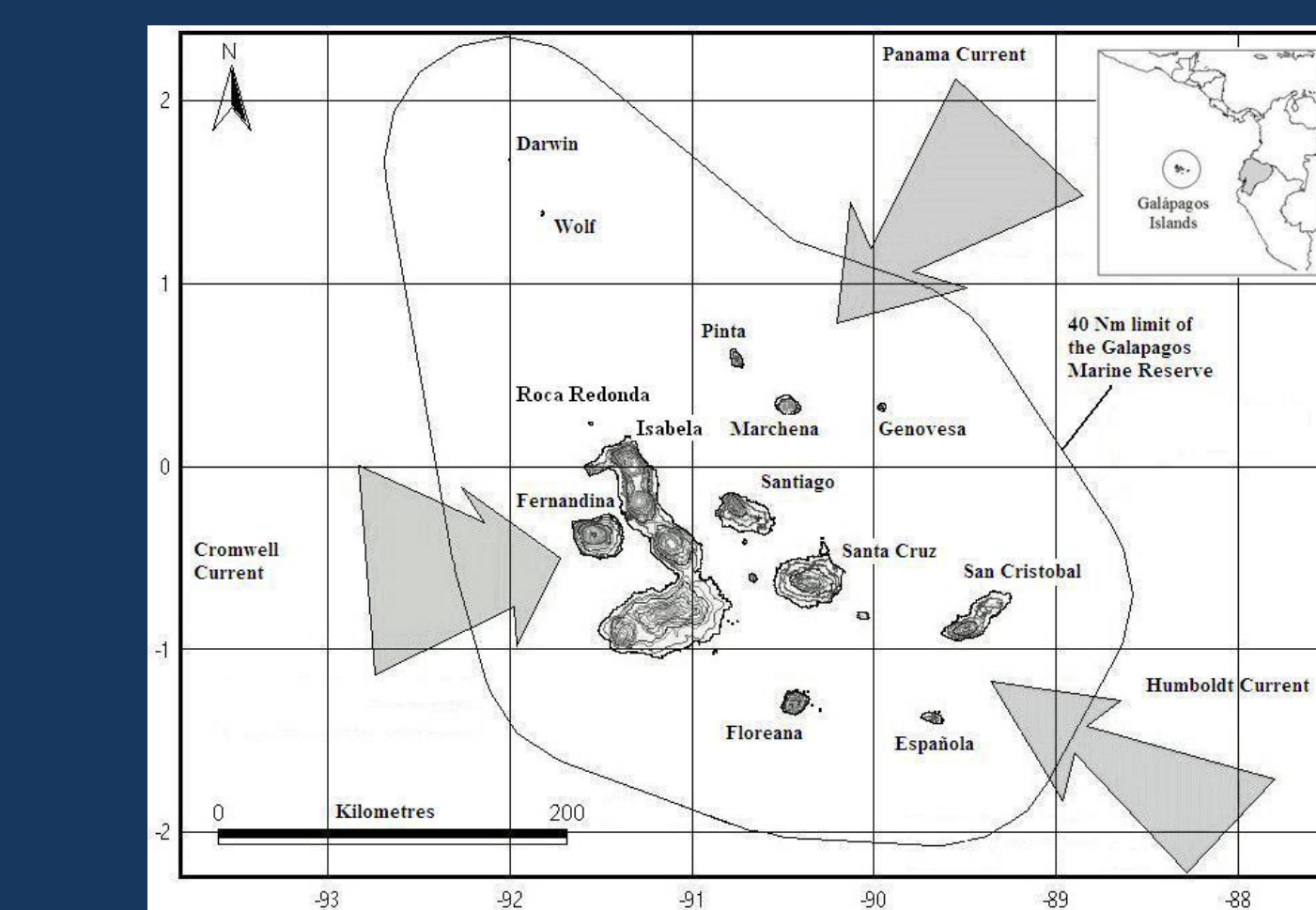


Fig.4 Major currents affecting the Galapagos Islands

## Introduction

In the Eastern Tropical Pacific, progress has been made by providing some level of protection to oceanic islets (Cocos, Malpelo and Galapagos Marine Reserves).

Oceanic islands and seamounts provide structure to both ocean bathymetry and current patterns, and are associated with hotspots of pelagic biodiversity and in particular with apex predators.

Scalloped hammerhead sharks (Figs. 1 & 2) school in large numbers at many of these sites... no-one is really sure why. They often seem to be associated with other pelagic species. Might they be useful indicators for sites of high pelagic biodiversity?

## Study Site

The Galapagos Islands (Fig. 3) are located straddling the equator 1000 km from coast of Ecuador.

Affected by 3 major current systems

- warm Panama bight from north
- cool Humboldt from south
- cold upwelling Cromwell from west

Wolf island (134.4 Ha), remnants of old volcano – steep coast drops rapidly (Fig. 4). Main current from southeast.

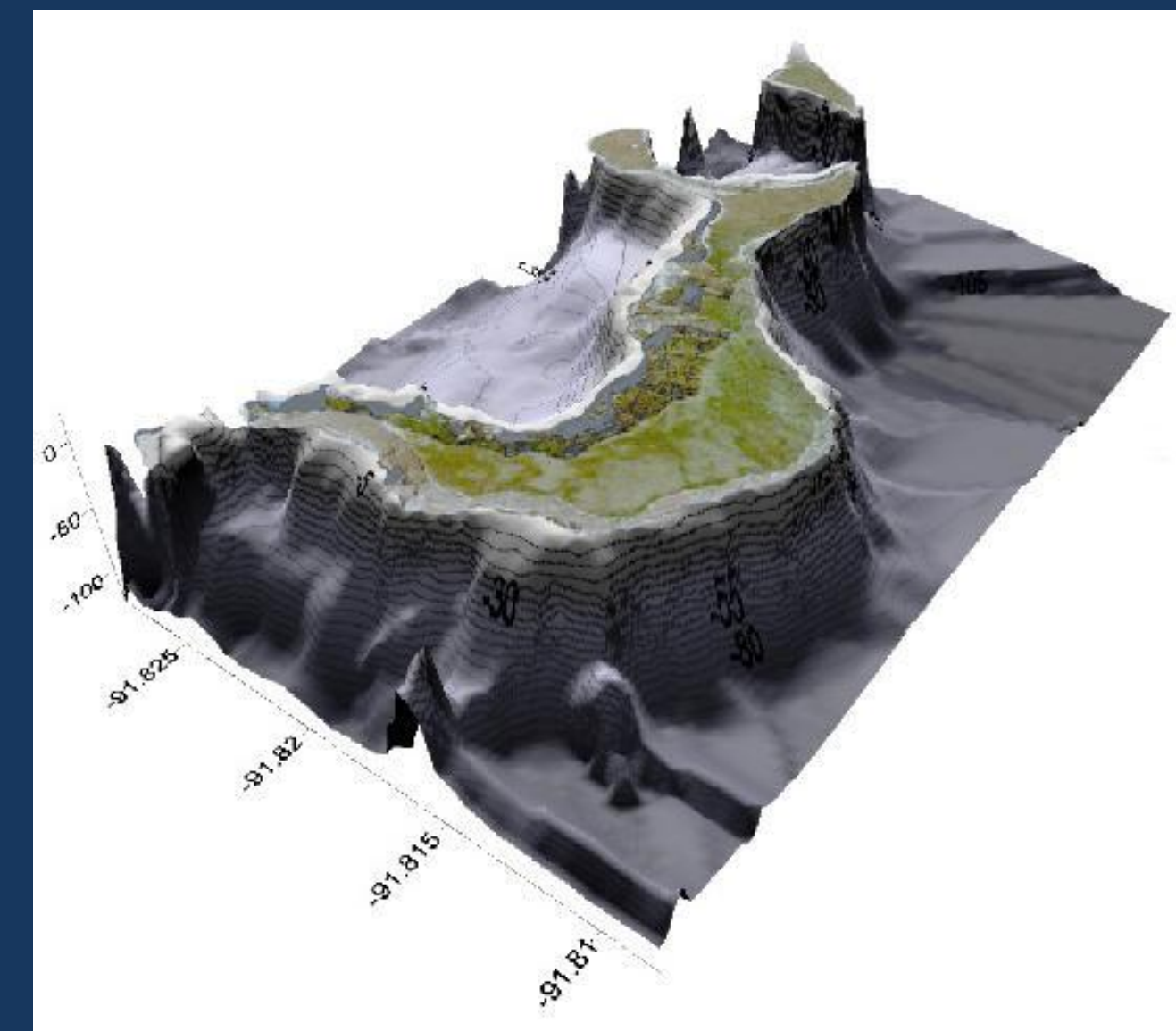


Fig.4 3-D map of Wolf island showing fine scale bathymetry (Cesar Peñaherrera).

## Methods

**Tagging:** ultrasonic VEMCO V16 tags emit a coded signal at 69 KHz every minute. Applied to the sharks externally by free diving with pole spears (Fig. 5). Detected by array of underwater receivers placed at sites around Wolf (6) and Darwin (3) (Fig. 6). Tagged animals detected within a range of 200 m from the receivers.

**Censuses:** pairs of trained SCUBA divers record species and abundance of all pelagic organisms for 30 minute drift dive facing out to sea, at 15 m depth at each study site.



Fig.5 Free divers tagging hammerheads with pole spears (Eduardo Espinoza, German Soler)

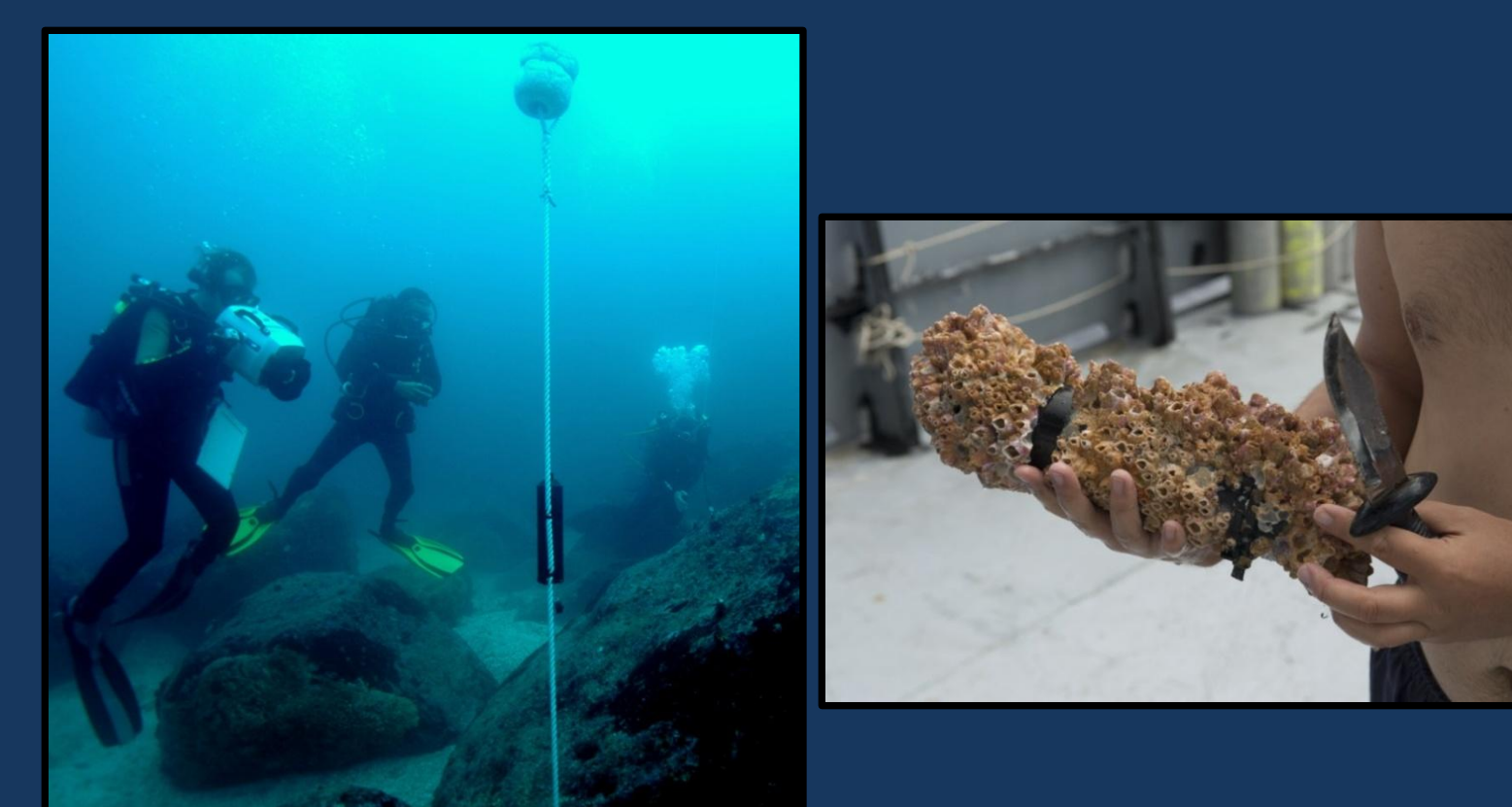


Fig.6 (Left) Underwater receiver deployment, (right) Fouling on receiver upon recovery (photos: Anon)

## Results (Site fidelity)

- Hammerheads showed preference for southeastern sites, upstream of main current according to visual censuses (Fig. 7) and tag detection rates (Fig. 8).

- Seasonal pattern to presence at island, according to visual censuses (Fig. 7) Seasonal presence of tagged individuals, suggests migration in March-May (see shark #5520, Fig. 9)

- Presence at restricted mainly to daylight hours in both hot and cool seasons (see shark #5520, Fig. 10).

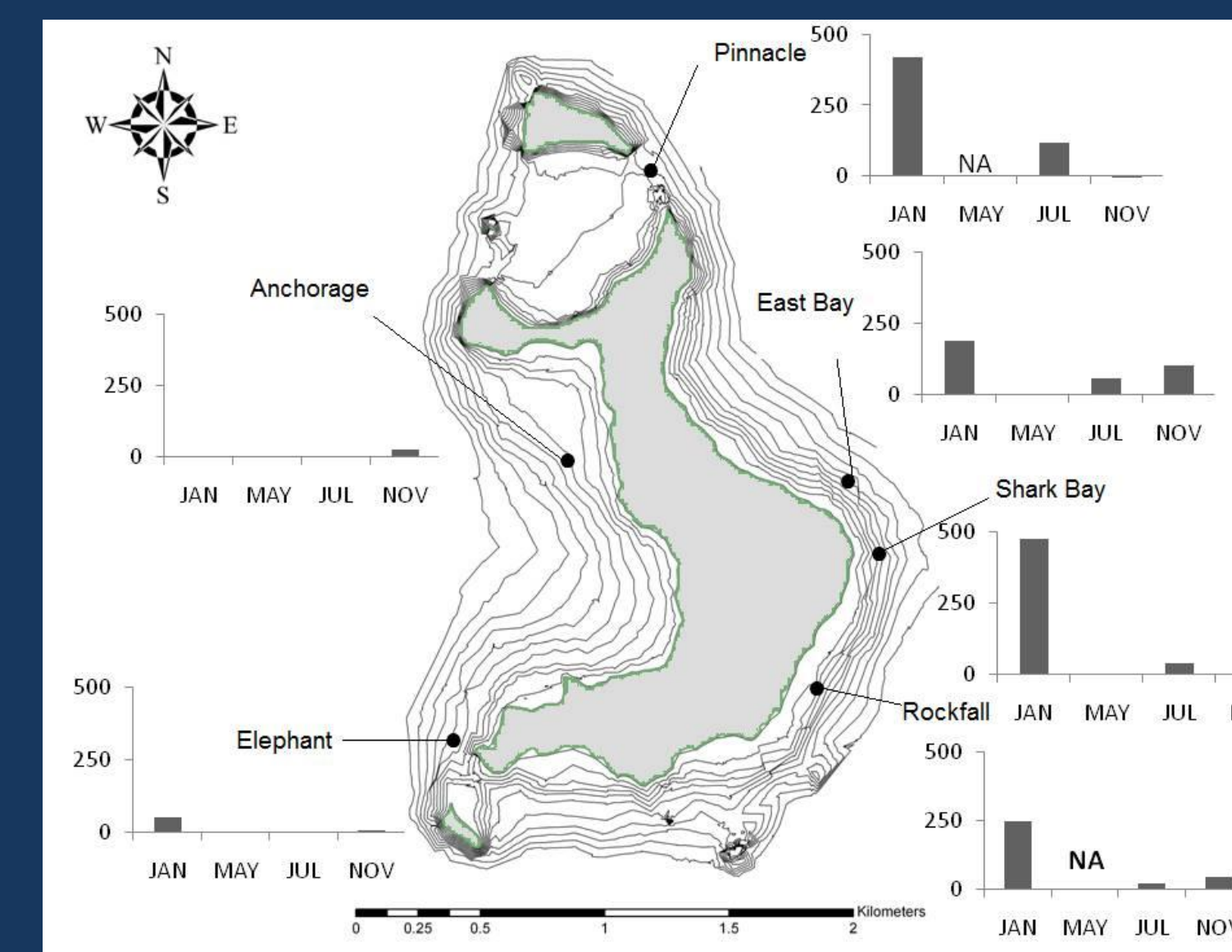


Fig.7 Relative abundance of hammerheads (number per diver hour) observed at each study site at Wolf, 2008.

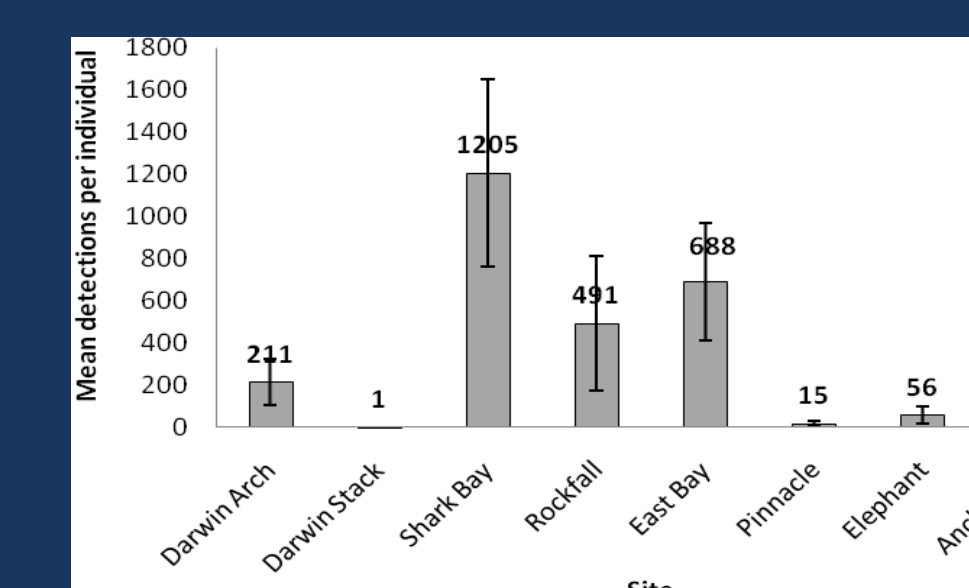


Fig.8 Mean number of detections per individual at each study site of sharks tagged at Wolf Island (Jul. & Oct. 2007).

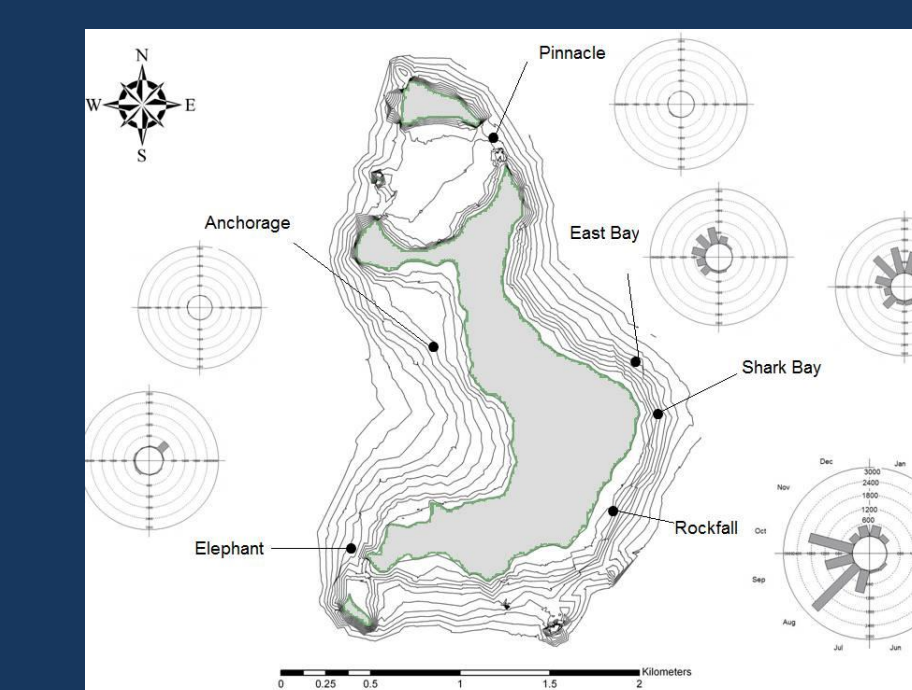


Fig.9 Monthly detections at each site in Wolf of hammerhead #5515. Note complete absence March-May.

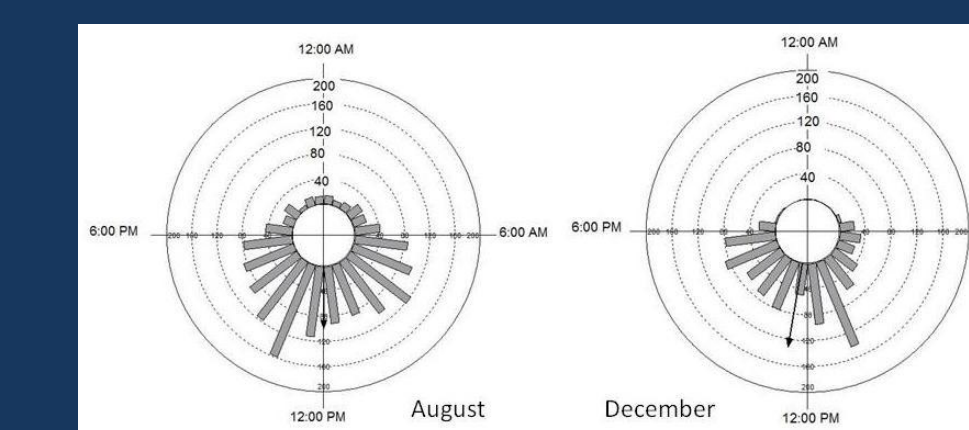


Fig.10 Diel detections of hammerhead # 5520 at Shark Bay in cool (August) and warm (December) seasons.

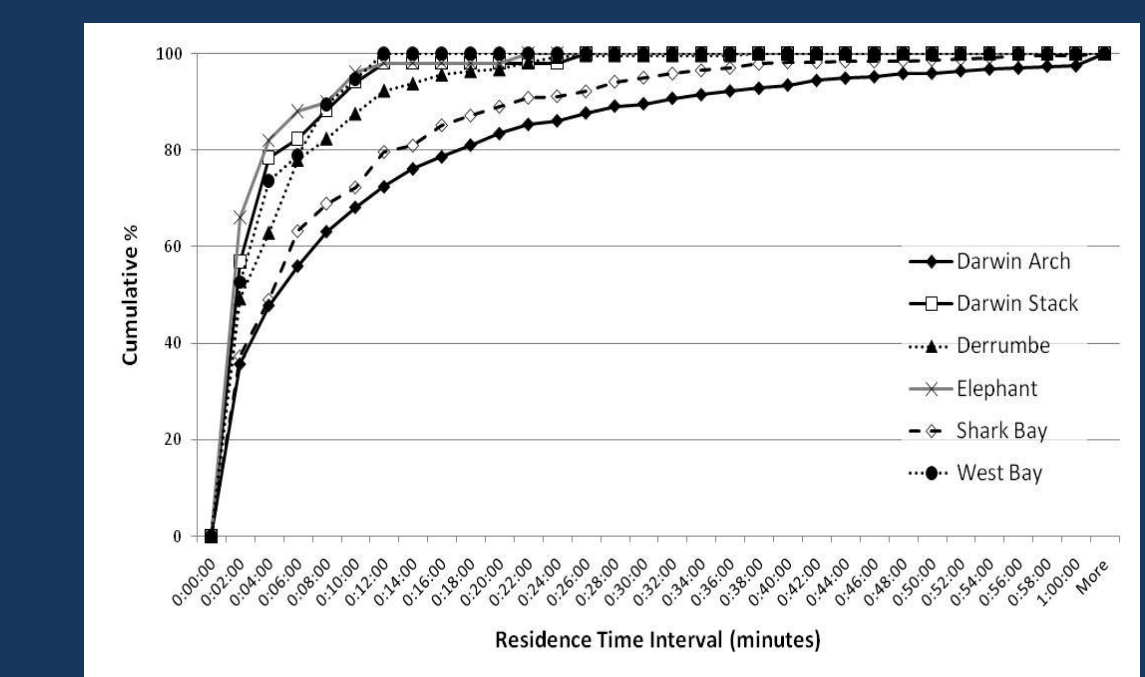
## Results (Shark hotspot)

Sharks tagged at Darwin island migrated to Wolf and also showed preference for southeastern corner (Fig. 11)

Residence time of Darwin Sharks at each site was similar for Darwin Arch and Shark Bay (both upstream of current). Other sites shorter residence time (Fig. 13) – passing through?

Shark ID	Darwin		Wolf				Total
	Arch	Stack	Rockfall	East Bay	Elephant	Shark Bay	
5517	415						415
5629	1646	11					1681
5632	1011	28	12	5	2	899	2145
7275	119	25	12	7		98	261
7276	14		2			2	18
7280	662		82	7		2226	2979
7281	106	24	170	38		380	743
7282	292	4			16		312
7283	254		2		5	98	364
7284	248	1	180	6		454	890
12663	723	13					736
<b>Total</b>	<b>5490</b>	<b>106</b>	<b>658</b>	<b>9</b>	<b>83</b>	<b>4160</b>	<b>10544</b>

Fig.12 Detections of sharks tagged at Darwin Arch at each underwater receiver site.



Note that for most sites, 50% of visits last <2 min, 80% last <6 min. BUT Darwin Arch & Shark Bay: 50% visits <6 min, 80% visits 12 min (SB) and 18 min (DA)

Fig.13 Cumulative percentage of visits of different lengths (in minutes) to each site by sharks tagged at Darwin Arch.

## Results (Pelagic hotspot)

- Most pelagic species prefer the southeastern corner of Wolf (same as hammerheads)
- Low biodiversity on western coast
- Galapagos sharks very specific to Rockfall

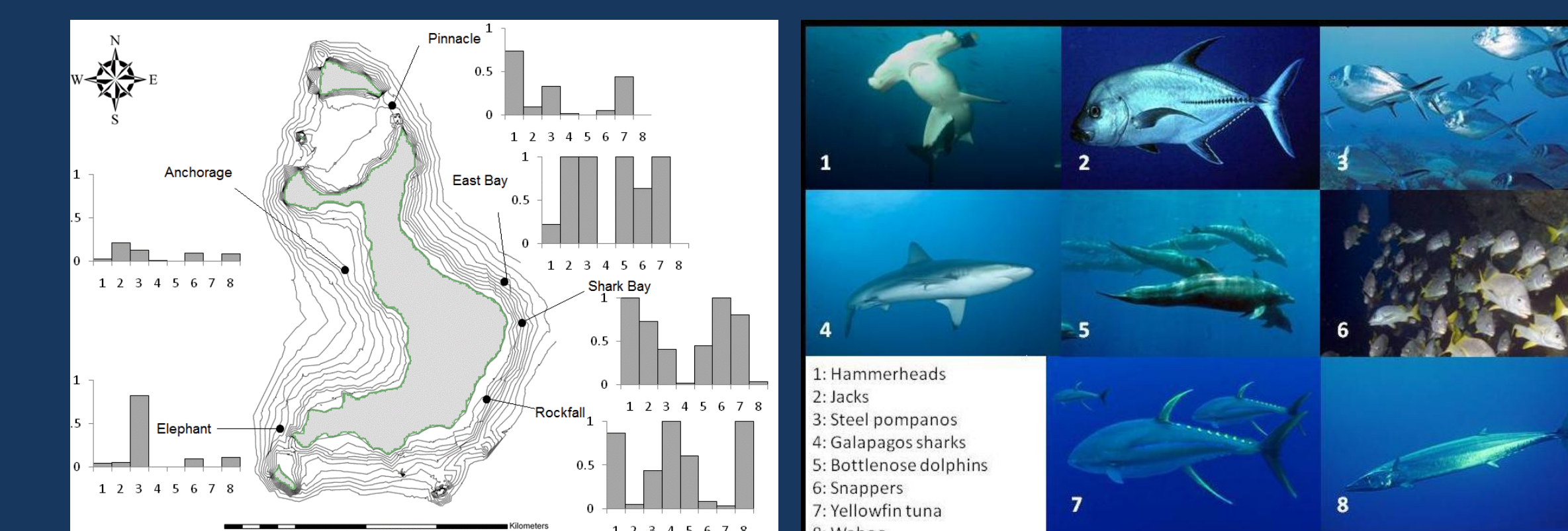


Fig.13 Normalized overall abundance of pelagic species recorded by diver census at study sites around Wolf island, 2008.

## Implications

Hammerheads display diel site fidelity for the upstream face of the island, and appear to return to the same site after nightly and seasonal absences. Other pelagic species also aggregate at this location. Some species may use the site for feeding as the current splits around the island and creates a retention zone. But hammerheads may have different uses – cleaning stations, or navigation along geomagnetic gradients created by lava flows. Future studies will determine these mechanisms.