Tagging of Pelagics
British Indian Ocean Territory
The Bertarelli Foundation (bertarelli-foundation.org) was founded in 1998, and is active in those fields that have a historic and current significance to the Bertarelli family, such as life sciences, marine conservation, education and sport.

The Bertarelli family has a passion for the world’s oceans, not least because of their competitive sailing activities; and in recent years it has embraced a position of leadership in promoting global marine conservation. With its chosen partner, the Blue Marine Foundation (bluemarinefoundation.com), it sponsors the world’s largest marine reserve around the Chagos Islands in the British Indian Ocean Territory, and has also recently supported the creation of a marine reserve centred around the Turneffe Atoll in Belize, which is the most sizeable unprotected fragment of the largest and most biodiverse coral reef system in the Western Hemisphere.
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Overview

In February and March 2013, having been kindly granted permission by the territory’s Commissioner, the Bertarelli Foundation, in partnership with Stanford University and the University of Western Australia, launched a scientific expedition to the British Indian Ocean Territory (BIOT).

The expedition had two broad objectives. First, to provide members of the Bertarelli Foundation with the opportunity to see the marine protected area (MPA) that their support helps to protect and maintain, as well as to meet members of the British contingent responsible for protecting it. Second, the expedition would be piloting an electronic tagging project to examine the capacity to use remote technologies to monitor the movements of large pelagics in the region.

To initiate electronic tagging in the region of BIOT, the Bertarelli Foundation enlisted the expertise provided by Dr. Barbara Block’s group at Stanford University. Recommendations included deployment of satellite tags (Wildlife computers mini-PAT and SPOT), as well as an acoustic receiver network inclusive of a live acoustic satellite buoy. This project represents an important tagging initiative, including deployment of the first satellite tagged tags and acoustic receiver arrays in the BIOT. It is therefore a pivotal contribution to both the study of the MPA and marine science in the Indian Ocean more generally.

As reported below, the first tagging project was a great success, both in terms of results achieved and also lessons learned for future tagging projects. A total of 99 electronic tags were placed on 95 animals, along with an acoustic array consisting of 28 sub-surface receivers and two surface iridium receivers.

Figure 1. Location of the BIOT MPA
Animal Tagging and Tracking in the BIOT

The BIOT MPA was created to ensure the protection of some of the last remaining relatively unspoiled reef systems in the Indian Ocean. As the largest contiguous no-take MPA in the world, the BIOT MPA also has the potential to provide a large sanctuary for heavily fished pelagic species such as tunas and sharks. These apex predators have shown steep population declines since the advent of industrial fishing, with some species estimated to have declined to less than 20% of their pre-exploitation numbers. Their migratory nature makes them relatively difficult to protect using ‘spatial management’ techniques (i.e. geographical restrictions on fishing), since MPAs may be too small to encompass more than a small fraction of the animals’ range.

The BIOT MPA is the world’s first ‘mega-MPA’, enclosing over a quarter of a million square miles of open water in one of the most heavily exploited oceans. Its large size, combined with the localised foraging opportunities associated with the reefs and seamounts within its borders, may mean that vulnerable pelagic species will spend significant parts of their life cycle inside the MPA and so enjoy a significant increase in protection.

Tagging is the key to answering the questions of how large pelagics such as sharks and tuna are utilizing the MPA, and how much protection the no-take MPA is providing.

Five different types of electronic tags were deployed in this study: Wildlife Computer’s pop-up mini pat archival tags (PATs), Wildlife Computer’s Smart Position or Temperature Transmitting tag (SPOTs), Lotek internal archival tags, Vemco coded acoustic transmitters, and conventional identification tags.
**PATs** are designed to track the large-scale movements and behavior of fish. The latest version of the PAT is a small 25g tag suitable in size for juvenile sharks and tunas. The tag is attached externally to the animal and records depth, water temperature and light-level (which can be used to estimate geolocation). The tags are programmed to record data on the animal for a specific number of days (e.g. 180/270/360) before releasing and floating to the surface where they transmit the archived data to a satellite. Since PAT tags can yield data without the animal being recaptured, they offer a fisheries-independent means of tracking a target species.

**Acoustic Tags** produce a uniquely coded ‘ping’ that is detected by an acoustic receiver deployed in the water. The receiver logs the event time and the identity of the tag, typically within a distance of 800m, and the data can be used to answer questions about residency within an area and also to look for patterns in animal movements. To ensure that animals are detected, receivers can be arranged either in a grid type array covering the survey area or across ‘gateways’ such as the entrances to bays or atolls that direct the animals past the receivers. It is the second approach that has been predominately used in this study as gaps in the fringing reefs of the atolls provide many such gateways.

**SPOTs** are attached to the dorsal fin of an animal (shark) and transmit a position whenever the salt-water “on/off switch” on the tag breaks the surface of the water.

**Internal Archival Tags** are surgically implanted into the fish to record depth, external and internal temperature, and light level (which can be used to calculate position). The tag must be recovered in order to download the archived data. They are only put in tunas as large commercial fisheries provide the capacity to retrieve the tags. A green conventional tag externally located helps alert the fishers to the archival tag’s presence in the peritoneal cavity.
Table 1. Summary of tagging activities

<table>
<thead>
<tr>
<th>Fish Species</th>
<th>Acoustic</th>
<th>Satellite</th>
<th>SPOT</th>
<th>Archival</th>
<th>Conventional</th>
<th>Total Tags</th>
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<td>19</td>
<td>5</td>
<td>2</td>
<td>5</td>
<td>99</td>
</tr>
</tbody>
</table>

*Four of the SPOT tagged sharks were double tagged (three with PATs and one with an acoustic tag).*

Tagging of Target Species

A total of 95 fish from seven different species (see Table 1) were caught and tagged on hook and line using a combination of trolling and hand lines. The fish were caught using barbless circle hooks and brought onto the boat, the hook was removed, a hose inserted into the mouth to irrigate the gills, and a cloth placed over the eyes in order to decrease stress on the animal. A small incision (2cm) was made below the dorsal fin, and the transmitter was placed 10-15cm into the muscle. The fish was then measured, sexed, a fin clip was taken for DNA analysis, and the fish was released. We deployed 19 PAT tags on five species of pelagic sharks, mantas and tunas to look at large-scale movement patterns, and connectivity of the fish and shark community within the MPA. Additionally, the acoustic tags will permit studying of site fidelity, connectivity and habitat use patterns of sharks and tuna around two atolls (Salomon and Peros Banhos) in the north of the archipelago.

We tagged 68 animals (38 grey reef sharks, 28 silvertip reef sharks and two dogtooth tuna) with Vemco acoustic transmitters. The tags are “coded tags” and have a semi-randomized delay between pulse trains which reduces the chance for acoustic collisions between pulse trains from neighbouring transmitters. Transmitters can be detected by underwater listening stations (omni-directional Vemco VR2W receivers), which can record the presence of transmitters every time a fish swims within range (up to 800m). These receivers will monitor the movements of the 66 sharks and two dogtooth tuna that were tagged acoustically.
Satellite Tag Detections

Satellite tags of two types were placed on pelagic sharks, mantas and scombrid fishes. PAT tags will report at the programmed release date. Spot tags provide a hit via radio communications to Earth-orbiting Argos satellite receivers when the shark carrying the spots surfaces. Detections from several sharks have been consistent and are predicted to improve as surface temperatures cool in winter months.

Figure 2. Satellite detections from two silky sharks and a silvertip in BIOT
Acoustic Tagging

Thirty acoustic receivers (hydrophones) were installed in passes and reef flats around Salomon and Peros Banhos Atolls, and on outlying sites at Benares Shoals and Blenheim Reef (Fig. 4, overleaf), to monitor the movements of sharks and tunas tagged with Vemco acoustic transmitters during the expeditions. Fish were tagged with a titanium dart and tether. Once tagged, the tags provide absence/presence information and detections improve the capacity to discern the visitation rate to atolls and connectivity of sharks and habitat in the BIOT archipelago. Each tag puts out a coded ping that is detected by a receiver when the shark is within a radius of about 800m.

The acoustic array currently deployed comprises two Vemco VR4G type surface receivers, with Iridium antennas for real time data transmission, and 28 Vemco VR2W type subsurface receivers. The VR4 originally installed at Peros Banhos (#57) had a hydrophone failure after deployment (potentially due to breakage during shipping), and was replaced with an identical unit (#64) during the March expedition. As of April 5, eight individual sharks have been detected a total of over 800 times at Peros Banhos, and two sharks have already been seen to cross from Peros Banhos to Salomon Atoll. Eleven individual sharks have been detected in total.

Figure 3. An example of detections for several sharks
Acoustic Receiver Installation

Current receiver locations

21 receivers were moored around Peros Banhos, and six in the entrance of and around Salomon Atoll. The remaining three were placed at Benares Shoals and Blenheim Reef. Most atoll passes were narrow enough to be covered with a single VR2W or VR4 receiver (assumed radius of detection ~400m). Wider passes, such as the entrance to Salomon Atoll, were covered with multiple receivers to both increase the certainty of detecting animals, as well as to provide information about the direction of travel.

Receivers were placed outside the atolls in such a way as to detect movement of sharks around and between the sites. For example, a receiver was placed outside Ile Pierre at Peros Banhos at the closest point to Benares Shoals in order to detect sharks crossing between the two reefs.

Figure 4. Location of acoustic receivers deployed in the study
Mooring operations

VR4 Global receivers provide iridium-enabled connections to underwater hydrophones enabling real-time detections of acoustic tagged animals. Receivers were moored by two-person dive teams supported by a rescue boat and crew at the surface. During the first trip, the units were tethered to the seabed by attaching lengths of chain or heavily protected polypropylene rope to bare coral heads, with heavy sandbags used to weigh down the equipment during mooring and as backup anchors. On the second visit, pre-made cement anchors (weight approx. 40kg) were used as the primary anchor, with a claw anchor on 2m of chain as a backup.

Divers made use of descent lines (surface floats anchored to the bottom with light line and weights), and Surface Marker Buoys deployed once on the work site, to mark their position for the surface support team and to give themselves visual references while descending and ascending. Liftbags were used when moving anchors.

The VR4 units were anchored to two adjacent coral heads with 3m lengths of stainless chain shackled together to a single 20mm spectra or double 10mm polypropylene rope riser. The riser length was at least 10m greater than the water depth to allow for tide and wave height effects on the surface float, and to dampen the load on the coral anchor points. All spliced eyes were reinforced with stainless steel thimbles or lengths of hose to reduce chafing. All shackle pins were locked in place with cable ties to prevent them working loose with wave action.

Since the VR4 unit’s hydrophone and umbilical are slightly buoyant, a weight was attached to the riser line ~2m below the hydrophone tip to keep the unit oriented vertically downwards and so ensure that maximum possible coverage was achieved.

The hydrophone tip was set 6-7m below the surface to give it some insulation from surface wave noise.

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VR4 mooring arrangement

1. Iridium antenna and float
2. Umbilical (looped to take strain off connectors)
3. Hydrophone
4. Weight
5. Riser (spectra or polypropylene line)
6. Bow shackle
7. 3m stainless chain
8. Coral head
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