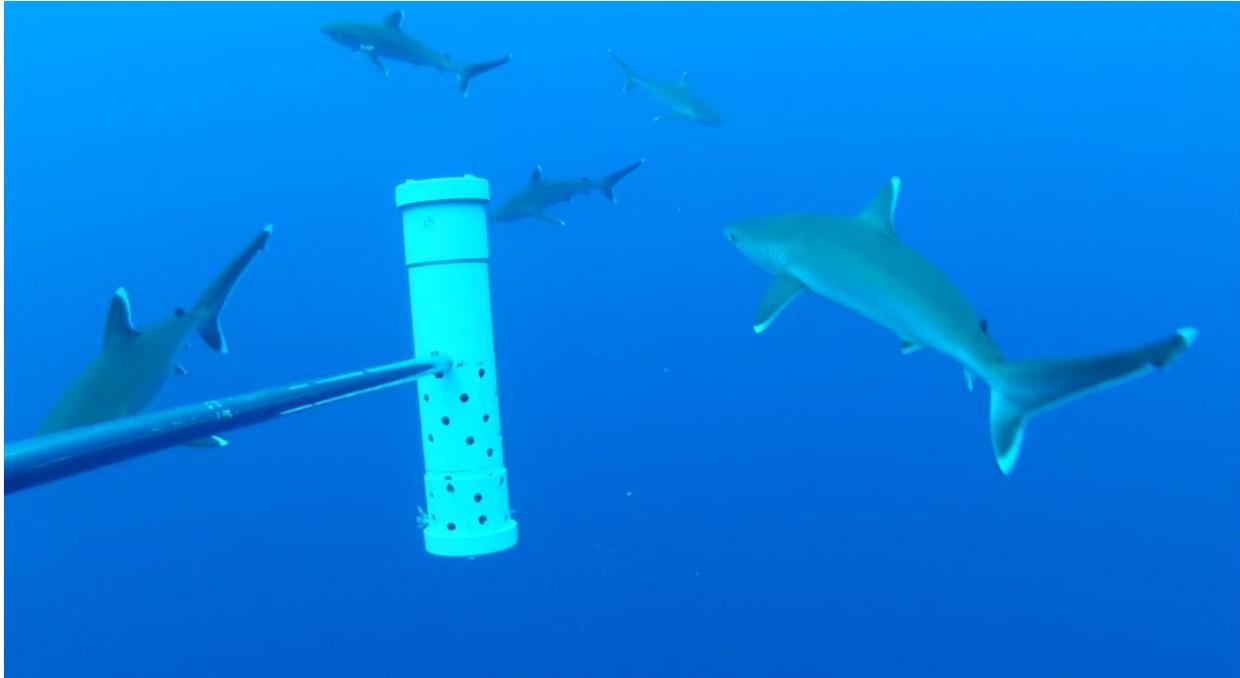


BIOT Pelagic Research Expedition Report: November 2012



Jessica Meeuwig^{5,1}, Tom B Letessier¹, Lloyd Groves¹, David Tickler^{1,2}, Philipp Boersch-Supan^{3,4}, Martin Cox⁵, Lewis Fasolo⁶, Peter Carr⁷, Rudy Pothin² and Matthew Gollock².

1 February 2013

⁵ Expedition Leader

¹Centre for Marine Futures and Oceans Institute, University of Western Australia

²Zoological Society of London, Regent's Park, London, NW1 4RY, UK

³Pelagic Ecology Research Group, Gatty Marine Laboratory, University of St Andrews, Fife, KY16 8LB, UK

⁴Department of Zoology, University of Oxford, Oxford, OX1 3PS, UK

⁵Australian Antarctic Division, Channel Highway, Kingston Tasmania 7050, Australia

⁶School for Environmental and Systems Engineering, Oceans Institute, University of Western Australia

⁷Life Sciences, University of Warwick, Coventry, CV4 7AL

Cover Picture – Silvertip sharks (*Carcharhinus albimarginatus*) (courtesy University of Western Australia)

ACKNOWLEDGEMENTS:

This work would not have been possible without the logistical and financial support of the following organisations, people and funding:

The UK Foreign & Commonwealth Office/BIOT Administration (John McManus, Michelle Moat); Department for Environment, Food and Rural Affairs, Zoological Society of London (Heather Koldewey, Xavier Hamon, Rebecca Short, Kirsty Kemp); University of Western Australia (Anya Waite, John Langan); University of St. Andrews (Prof Andrew Brierley); BIOT Science Advisory Group; Swire Shipping (Mark Celenk and the Pacific Marlin's Captain (Neil Sandes), Chief Engineer (Leslie Swart), and crew); Australia's National Environmental Research Program (Marine Biodiversity Hub); The Bertarelli Foundation; Blue Marine Foundation; Cusanuswerk; MRAG (Andrew Deary, Chris Mees); British Forces – BIOT (Karen Shortland); US Medical Personnel – BIOT; Wildlife Computers; Helen Lee in Singapore; Lesley & Charles Hilton-Brown Scholarship;; Fisheries Society of the British Isles. A special thank you goes to Charles Sheppard (University of Warwick) for his commitment to growing research in BIOT.

INTRODUCTION:

Background: The following report describes the achievements of the first “pelagic” or open water research program in the British Indian Ocean Territory (BIOT) Marine Reserve, undertaken between November 20th and December 11th, 2012. The BIOT Marine Reserve is the largest fully protected marine reserve in the world. Following its establishment in April 2010, there exists a globally significant opportunity to document the status and recovery of large pelagic predators (e.g. tunas and sharks) that were previously exploited in the region. Such documentation is critical as these large pelagic predators are fundamental to marine ecosystem health, but are, in some cases, reduced to less than 20% of their global abundance compared to pre-industrialised fishing levels (~1960).¹ Indeed, in 2011, all species of tunas, bonitos, mackerels, swordfish and marlins were assessed for the IUCN Red List of Threatened Species, with 11% of the world’s 61 species documented to be at serious risk of extinction². Further, the IUCN classed a third of oceanic shark species in threatened categories. The BIOT reserve represents a significant opportunity to provide protection for those species that occur in the reserve. However, it is crucial to establish a robust understanding of their current status and the degree to which protection supports recovery, a priority that is reflected in the draft BIOT Management Plan. Two aspects relating to the management of pelagic species within this large marine reserve were the focus of this expedition: (1) developing a methodology for long term monitoring of pelagic species; and (2) understanding how nominally “highly mobile” species use the region.

Firstly, with respect to long term monitoring, it is important to note that catch data from commercial tuna fisheries, including for BIOT, has traditionally provided the majority of, if not all, available data on the status of pelagic fish in the region. However, such time series of data are by definition destructive and thus their collection is inappropriate in a no-take marine reserve. Furthermore, fisheries dependent data may not correlate well actual population biomass³, and may provide little information on by-caught species such as sharks and rays. Therefore the establishment and implementation of consistent scientific sampling to establish baseline data of pelagic species using safe, non-destructive, and transferable technology will greatly aid the assessment of the benefits and limitations of the BIOT marine reserve, and large-scale marine protected areas (MPAs) in general.

Secondly, recovery of highly mobile species may be delivered if animals are protected in areas where they undertake biologically important activities (mating, pupping, feeding, resting etc.) or where they are protected for large periods of their lifespan. Additionally, while a species as a whole may have a large range, individuals may have much smaller ranges and demonstrate higher than expected site fidelity⁴. However, debate persists on whether mobile species are sufficiently resident within the boundaries of large marine reserves for their protection to be effective^[8] and to this end, understanding the distributions and ranges of pelagic species in BIOT is important as a first step in determining the importance of the reserve to such species.

Research Activities: Five integrated research activities and an outreach / communications program were thus undertaken on the expedition:

- (1) Deployment of novel mid-water cameras (aka Stereo Imagery System for Shark and Tuna Analysis, or SISSTAs);
- (2) Establishment of protocols for scientific long-lining of pelagic sharks and tagging;
- (3) Acoustic characterisation of zooplankton and fish distributions;
- (4) Oceanographic characterisation of water masses; and
- (5) Pelagic ornithological surveys.

¹ Baum JK et al. (2003) Collapse and Conservation of Shark Populations in the Northwest Atlantic. *Science* **299**: 389 DOI: 10.1126/science.1079777.

² Dulvy NK et al. (2009) You can swim but you can’t hide: The global status and conservation of oceanic pelagic sharks and rays. *Aquatic Conservation: Marine and Freshwater Ecosystems*. **18**: 459-482; Bruce B. Collette, et al. (2011) High value and long life: Double jeopardy for tunas and billfishes. *Science* **333**. 291-292.

³ Harley SJ, Myers RA, Dunn A. (2001) Is catch-per-unit-effort proportional to abundance? *Can. J. Fish. Aquat. Sci.* **58**: 1760–1772.

⁴ Queiroz N et al. (2012). Spatial dynamics and expanded vertical niche of blue sharks in oceanographic fronts reveal habitat targets for conservation. *PLoS ONE* **7**: e32374.doi:10.1371/journal.pone.0032374.

Each of these activities and their outcomes are described in the sections below but the linkages among them are as follows:

Activity	Objective:	
	Monitoring	Residency
(1) Deployment of SISSTAs	Trial of non-destructive monitoring technique	
(2) Establishment of protocols for scientific long-lining of pelagic sharks and tagging		Demonstration that scientific tagging can occur on the Marlin as a research platform; tagging of priority species
(3) Acoustic characterisation of zooplankton and fish distributions	Correlate imagery from SISSTAs with acoustically determined biomass estimates	Facilitate location of tagging work by identifying patterns in potential prey items (fish) of sharks and tunas
(4) Oceanographic characterisation of water masses	Facilitate location of SISSTAs monitoring sites by identifying patterns in water temperature (pelagic species will follow fronts)	Facilitate location of tagging work by identifying patterns in productivity associated with physical features
(5) Pelagic ornithological surveys	Correlate imagery from SISSTAs with seabird feeding activity	Facilitate location of tagging work as seabirds often associated with tunas and sharks foraging on bait balls

These research activities were delivered by an expedition team consisting of ten scientists from seven international research institutions, supported by a Chagossian outreach and communications coordinator, and a medical doctor (Dr. Jasjot Singhota).

Achievements: The expedition was in general highly successful. First and foremost, the expedition was injury-free despite operating novel equipment on a research platform new to most of the team members and very often under difficult weather conditions as a result of experiencing the influence of Cyclone Claudia. Significant equipment loss was limited to a single long-line of SISSTAs on the final day of the expedition, due to poor weather closing in rapidly and the need to recover the Fast Rescue Crafts (FRCs) (see Recommendations). From a research and management perspective (see individual sections for details), the expedition was successful in that we were able to demonstrate that a wide range of equipment can be effectively deployed from both the Pacific Marlin and the FRCs. This included the first ever long-line configuration of SISSTAs, scientific long-lining for shark tagging from the Pacific Marlin and the FRCs (including safe and ethical handling of caught sharks), the use of high tech acoustic equipment in FRCs, completion of oceanographic sampling to 250 m water depth, with the Pacific Marlin also proving a very effective platform for open-ocean seabird surveys. The success of this research meant that a wealth of experience and data were collected from 133 SISSTAs deployments (see section 1), 15 long-line sets for sharks (see section 2), 16 acoustic surveys (see section 3), 81 oceanographic casts (see section 4), and 118 sea bird transects (see section 5). These data are currently being analysed and will be published in the peer-reviewed scientific literature to share our increased understanding of the BIOT Marine Reserve and better inform its management. The communication program was also a success with blogs produced by all team members and then translated into Creole to facilitate engagement with the Chagossian community (see section 6).

The expedition was severely weather-challenged in comparison to, for instance, the February 2012 expedition. Of the 19 days available for field work (not including time to mobilise and demobilise), up to 35% of research time was lost for some activities due to the need to stay ahead of the weather (transiting to new locations during the day rather than overnight) or simply the inability to work in Cyclone Claudia-generated conditions. The safe and high productivity of the team reflected two issues. First, the team took an extremely disciplined and structured approach to daily planning and safety. Specifically, nightly debriefs and forward planning sessions were held with the expedition team and the Master and Chief Engineer following by daily pre-activity 'Tool Box' meetings between team members and senior members of the Marlin crew. Close collaboration between the expedition leader and the Marlin Master and Chief Engineer allowed rapid responses to changing conditions. Second, the contribution made by the professionalism, knowledge and skill of the Marlin crew, and in particular her Master, Chief Engineer and Bosuns cannot be overestimated. Having collectively been fortunate to participate in many expeditions of this nature, we can personally testify that their overall skills and the degree to which they were willing to put up with our exigent and out-of-the-ordinary requests was rather unique in our line of work.

SCIENCE REPORTS

1. Monitoring the mid-water assemblage of large migratory predators

Tom B Letessier, Lloyd Groves, David Tickler, and, Jessica Meeuwig

Background

This section describes the use of pelagic and demersal baited cameras deployed on the expedition. Pelagic and demersal cameras are henceforth referred to as SISSTAs (Stereo Imagery System for Shark and Tuna Analysis) and BRUVs (Baited Remote Underwater Video Systems) respectively. SISSTAs and BRUVs were deployed to monitor the diversity and abundance of pelagic and demersal predators in the BIOT Marine Protected Area (MPA).

Historically, catch and effort data from commercial tuna fisheries in the BIOT region provided the only available data on the status of regional fish assemblages. Such fisheries dependent data are not always strongly correlated to abundance of target and non-target species⁴, and provide little information on by-caught species. Moreover, monitoring that relies on lethal sampling of focal species is not appropriate for a no-take reserve. Therefore the establishment and implementation of consistent scientific baselines for pelagic species using safe, non-destructive, low-cost and transferable technology will greatly aid the assessment of the benefits and limitations of the BIOT reserve, and large-scale reserves in general.

To this end, a SISSTA was developed, and trialled initially in Shark Bay (Western Australia), as a collaboration between the Zoological Society of London and The Centre for Marine Futures (Oceans Institute) at the University of Western Australia. SISSTAs were further deployed in the Timor Sea in September 2012 and in New Caledonia in October 2012. The SISSTAs were developed from UWA's previous experience with BRUVs, already deployed in BIOT during the expedition in February 2012 as part of the ongoing monitoring of the coastal ecosystem of the reserve.

Objectives

To inform the management of the BIOT MPA and answer general and specific questions relating to pelagic and demersal predator ecology, we aimed to:

- 1) Deploy and demonstrate a novel, fisheries-independent method (SISSTA) for the non-destructive monitoring of pelagic species such as tuna and sharks; and
- 2) Explore patterns in spatial and temporal distribution of large oceanic predators.

Survey accomplishments

One hundred and thirty-three successful SISSTAs deployments with cameras suspended at depths between 10 and 30 m were conducted across the Archipelago. Deployments occurred over seabed depths extending below 500 m (Table 1). Whilst SISSTAs were initially individually moored to the seabed with anchors, we were also able to demonstrate that SISSTAs could be safely, and more efficiently, deployed in long-line configurations of 10 individual units.

A total of 13 BRUV deployments were conducted during the expedition (Table 1). At Salomon / Ile Anglaise deployments were conducted in parallel with acoustic activities from FRC2. Deployment and recovery off the stern of the Marlin proved time consuming, and was de-prioritised as a consequence in favour of long-line deployment of SISSTAs. On one occasion, five deployments were conducted from FRC1 in the shallow lagoon of Salomon. BRUVs were easily deployed and recovered from the FRC1. However, the engines of the vessel became waterlogged during the recovery manoeuvres (a recurring problem when using these vessels for low speed or stationary work), and further BRUV deployments from the FRCs were discontinued. The footage has yet to be reviewed thus no preliminary results are reported here.

Table 1. Summary of deployments.

Location	Latitude	Longitude	Number of deployments
SISSTAs:			
Sandes Seamount	7.08529 S	72.07743	29 (moored)
Speakers Bank	5.07169 S	72.15536	5 (1 trial long-line set)
Salomon/Peros Banos	5.20376 S	72.00572	39 (4 long-line sets)
Salomon/Fouquet	5.22463 S	72.18509	60 (6 long-line sets)
BRUVS (opportunistic)			
Sandes Seamount	7.08464 S	72.07283	4
Speakers Bank	5.03145 S	72.16234	4
Salomon/Ile Anglaise	5.19027 S	72.14394	5

Preliminary results

A preliminary assessment of the SISSTAs video footage reveals a range of coastal and oceanic species, some previously unobserved on baited cameras (Table 2). For the first time, we have video records of dogtooth tuna, a species of minor commercial importance in the Indian Ocean, and of three individual shortfin mako sharks.

We are satisfied that the SISSTAs and the Pacific Marlin are a fit working unit for the long term monitoring of the BIOT Marine Reserve. From a rough and in-the-field appraisal of footage we have observed the following fish species (Table 2).

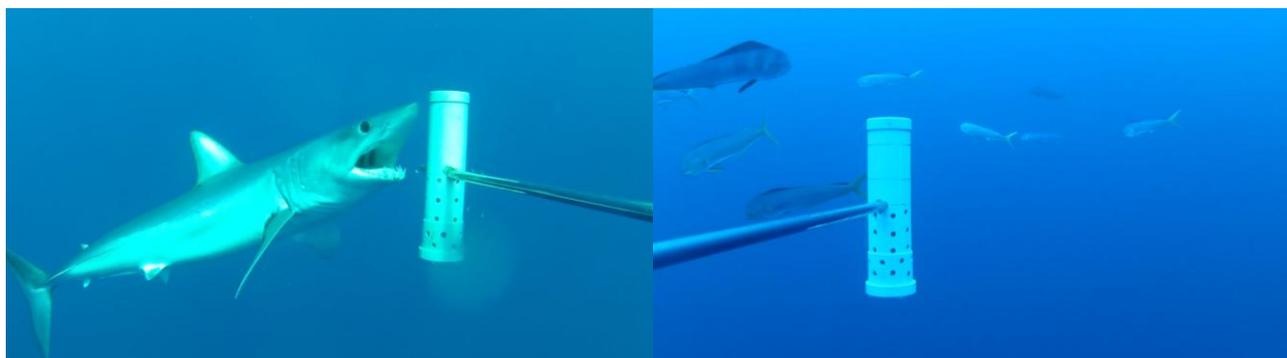


Figure 1. Shortfin mako (left) and dolphin fish (right) with bait canisters. (© Centre for Marine Futures)

Table 2. Preliminary species ID from the SISSTA deployment in BIOT.

Location	Latitude	Longitude	Species observed
Sandes Seamount	7.08529 S	72.07743	Rainbow runner, silky, silvertip, and grey reef sharks, mackerel, marlin, leatherjackets, needlefish
Salomon/Peros Banos	5.20376 S	72.00572	Mackerel, false killer whale, mackerel scad, tiger and silky sharks, dolphinfish, manta ray
Salomon/Fouquet	5.22463 S	72.18509	Shortfin mako and tiger sharks, shark sucker, marlin, sailfish, tuna, wahoo, mackerel, mackerel scad, needlefish

Recommendations

For future expeditions we make the following specific recommendations:

- (1) Tether lines should be 12 mm rope (and not 8 mm) for ease of hand-hauling.
- (2) Our experience with the SISSTAs indicates that for speed and ease of recovery, long-line deployments are preferred to tethering individual units to the seabed via anchors. The steep slope and coral seabed typical of oceanic islands is difficult terrain for the retrieval of deep anchors (>20 m).
- (3) To facilitate the recovery of the moored units, a pot hauler was purchased prior to the expedition, under the assumption that the Marlin could supply 12 volts from the ship's main power supply. As this was not possible, the pot hauler was powered using 12 volt batteries, which had to be replaced several times during recovery and subsequently recharged every night. For future expedition, an adequate transformer capable of supplying 12 Volt from the vessel's mains should be sourced. Alternatively, if extensive mooring work were scheduled, the vessel would ideally be fitted with a hydraulic pot hauler.
- (4) One constraint with the long-line configuration was the necessary requirement for the vessel to stay within close proximity of the drifting cameras. This presents a problem if the vessel is required to conduct other activities, such as recovering the FRCs, whilst the long-line is drifting (as was the case on the final day of research). The risk of kit loss can be mitigated in the future by fitting the extremities of the long-lines with DAN buoys, radar reflectors, radar beacons or GPS satellite transponders (options to be investigated).
- (5) Recovery of moorings and BRUVS proved difficult off the stern of the Marlin, despite the excellent seamanship of its Master, Chief Engineer and crew. Should mooring work constitute a major part of any future expedition on the Marlin, we recommend that the Marlin be fitted with a small manoeuvrable workboat, to serve as replacement for FRC2, from which mooring work can be conducted. Specifically we recommend that the workboat is fitted with the following: 1) a large working deck to fit kit such as coils of rope BRUVs and SISSTAs; 2) gunwale capable of supporting a pothauler; and shrouded propellers; and closed stern.

2. Development of scientific long-lining protocol and satellite tagging

Matthew Gollock and Gabriel Vianna

Background

Large, pelagic predators, such as sharks and tuna, are fundamental to marine ecosystem health, and BIOT represents a significant opportunity to provide protection for those species that occur in the reserve but this is in part dependent on understanding their current status and how protection leads to recovery.

Tagging studies provide useful information on movement patterns and residency of individuals, which is essential in relation to marine reserves to ensure that they are fit for purpose. Species such as oceanic sharks and tuna are often branded 'highly migratory'; while they undoubtedly have the potential for this behaviour, a number of studies have shown these species to exhibit site fidelity. As such it is important to highlight such behaviours in relation to BIOT specifically, with its importance as the world's largest marine reserve.

Objectives

The two main objectives of this component were to:

1. Develop a workable protocol for carrying out scientific long-lining from the Pacific Marlin and/or a FRC to catch large pelagic species such as sharks or tuna.
2. Use satellite tagging technology to determine movement, residency and behaviour of blue sharks (*Prionace glauca*) - a major elasmobranch by-catch species of tuna fisheries around the globe and the main by-catch species in the tuna fisheries that previously operated in BIOT waters. If unsuccessful in catching blue sharks we aimed to focus on other species caught in the fishery - silky (*Carcharhinus falciformis*), shortfin mako (*Isurus oxyrinchus*) and oceanic whitetip sharks (*Carcharhinus longimanus*).

Survey accomplishments

This work was the first attempt to carry out both scientific long-lining and tagging of large pelagic species within the BIOT marine reserve. We successfully deployed and retrieved fifteen long-line sets (Figure 2). Severe weather conditions during the expedition prevented the deployment of the long-line during seven days and forced us to abort one long-line operation.

During that time, we were able to optimise a number of variables of the scientific long-line operation regarding:

- Set time
- Long-line length
- Hook number
- Depth of deployment
- Baiting regimes – tuna oils / chum / teleost species
- Location

One tiger shark (*Galeocerdo cuvier*) and six silvertip sharks (*Carcharhinus albimarginatus*) were caught. We collected genetic samples and basic metrics of the tiger shark and four of the silvertips.

None of the target species were caught and as such none of the satellite tags were deployed. Despite taking every effort to reduce lethal interactions – short line length and deployment time, use of circle hook and frequent checks of the line - a juvenile silvertip shark swallowed one of the hooks resulting in what is colloquially referred to as 'gut-hooking', which led to its death. We were interested to note that the juvenile silvertip sharks were significantly more aggressive during feeding when compared to conspecifics in other locations – e.g. Palau, Fiji, Borneo – and it is possible this behavioural difference may have accounted for the mortality.

Preliminary results

We have developed an extensive long-lining protocol document that highlights the methods we trialled. This protocol includes instructions to safely operate scientific long-lines from both the Pacific Marlin and the FRCs.

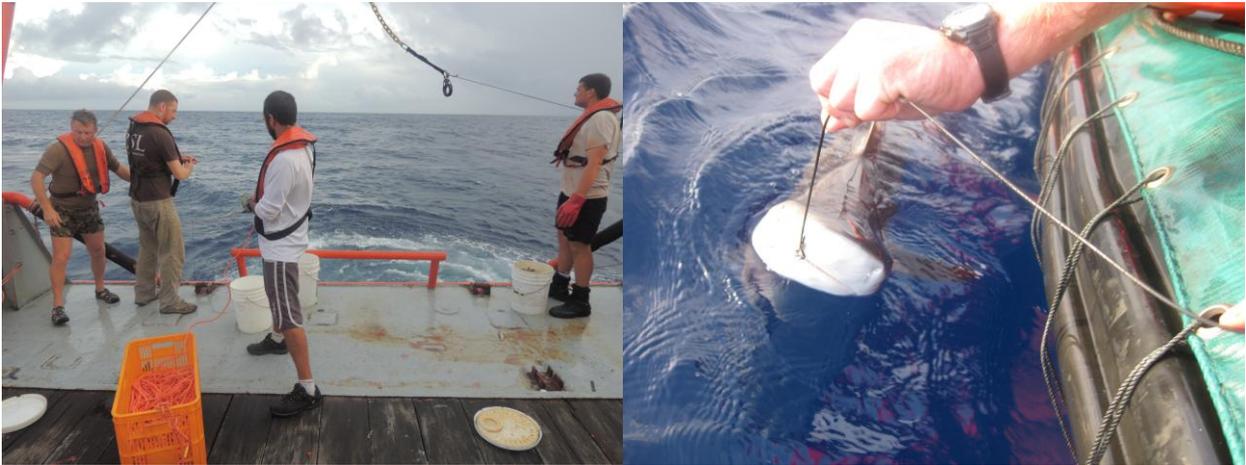


Figure 2: The team setting the long-line from the stern of the Pacific Marlin (left) and a silvertip shark being positioned prior to being measured. ©ZSL

Recommendations

There are a number of tagging-specific issues that were identified during the expedition:

Location – Due to logistical limitations, much of the sampling took place in sight of islands or in the vicinity of underwater features such as seamounts. As neither blue nor ocean whitetip sharks – species considered to be ‘truly’ oceanic – were caught or even sighted on underwater video footage, it was felt that setting the long-line in more remote waters may be beneficial. Further, we feel that future shark tagging expeditions would greatly benefit from the use of real-time oceanographic information, such as satellite imagery of front locations and sea surface temperature. This information could largely increase the chances of locating our target species.

Timing – Despite identifying both shortfin mako and silky sharks on video footage collected during daylight, our greatest success in catching fish was when the line was set during darkness and the FRC launched at first light. It was agreed amongst the tagging team that in future, setting the line at dusk would be of enormous value, however, on the present expedition logistical and health and safety constraints prevented this. It may be that a separate, smaller vessel is required specifically for tagging to allow this to take place.

Bait – We tried a number of variations of baiting during the expedition using chumming, tuna oil-soaked sponges and teleost species for hooks. Initially, frozen pilchards (*Sardina pilchardus*) were used on hooks in concert with tuna oil-soaked sponges on the lines, and pilchard and tuna oil chum being dispersed from the boat prior to setting the line. After one week of varying this method we concluded that different bait would be required and as such sought permission to fish for small numbers of locally abundant ‘tuna, and tuna-like species’ to be used – under present fisheries law in BIOT this is allowed for consumption. Using dogtooth tuna (*Gymnosarda unicolor*) and kawa kawa (*Euthynnus affinis*) as hook bait lead to us catching sharks. The use of freshly caught bait is considered to be the most effective method for catching sharks; however, it was felt that this was not a long-term solution for scientific long-lining and as such we are developing attractants based on chemicals, sound and/or movement for future expeditions.

3. Acoustic characterisation of zooplankton and fish distributions

Philipp Boersch-Supan and Martin Cox

Background

A substantial proportion of zooplankton and micronekton biomass migrates daily between the sea surface and deeper layers. Shallow topography can block the descent of these animals, exposing them to predators and/or concentrating them inside atolls and on the summits and flanks of seamounts and islands^[1]. A large proportion of tuna catches originate near seamounts^[2] but drivers of tuna aggregations around them are not well understood^[3-5]. Seamounts and island slopes appear to be important feeding places for pelagic and demersal predators^[1,9] but the ecological role of micronekton in the pelagic realm is poorly understood^[6,7].

Debate persists on whether mobile species are sufficiently resident within the boundaries of large marine reserves for their protection to be effective^[8]. Understanding the foraging ecology of key pelagic species such as tuna and the spatial structure of their prey fields is fundamental to resolving this largely data-free debate.

The fisheries acoustics surveys on this expedition thus addressed basic questions in pelagic and seamount ecology and provided a unique opportunity to investigate the energetic links between shallow-water coral reefs and deep-water ecosystems, an area of marine ecology that has not been explored.

Objectives

1. To determine the abundance and distribution of large pelagic fishes and their prey.
2. To investigate pelagic predator-prey interactions.
3. To investigate the effects of islands, atolls and seamounts on mid-water animals.

Survey accomplishments

Acoustic surveys employed two types of echosounders: (1) A dual frequency scientific split-beam echosounder (Simrad EK60) operating at 38 kHz and 120 kHz and (2) a high-frequency imaging sonar (DIDSON 300m) operating at 1.1 MHz combined with stereo video cameras. Both echo sounders were operated from Fast Rescue Craft 2 (FRC2) of the Pacific Marlin. The EK60 was deployed using a custom made pole assembly (Figure 3a) which enabled data collection while FRC2 was moving at speeds up to five knots (Figure 3b). The DIDSON was deployed inside Salomon Islands lagoon using a handline while FRC2 was anchored (Figure 3c,d).

A total of 16 acoustic surveys and two EK60 calibrations were conducted during the expedition. Survey locations and types are given in Figure 4a. Survey designs and echosounder configurations fell into four categories:

- (1) line transect surveys targeting the deep scattering layer over deep water, seamounts and island slopes using the EK60 (labelled DSL/Slope in Figure 4a)
- (2) line transect surveys targeting the shallow scattering layer along drifting camera long-lines using the EK60 (SISSTA in Figure 4a)
- (3) line transect surveys targeting fish and zooplankton over a coral reef inside Salomon Islands lagoon using the EK60 (Lagoon in Figure 4a)
- (4) point surveys inside Salomon lagoon using EK60 and DIDSON/video (DIDSON in Figure 4a)

Preliminary results

Our surveys are the first to use fisheries acoustics in BIOT, as well as the first observations of deep-sea ecosystems in the marine reserve. To our knowledge our surveys also constitute the first ever application of multi-frequency fisheries acoustics to coral reef ecosystems.

Surveys over deep water and island slopes showed a well developed deep scattering layer between 400 and 600m. The density of this layer intensified near island slopes and around seamounts. Fish schools were commonly observed on steep slope segments and topographical breaks (Figure 4b). Shallow scattering layers (<200m) varied in structure and intensity between sites, with distinct scattering layers harbouring organisms of different size classes. The differences in scattering layer structure may be linked to distinct oxygen and chlorophyll profiles at these sites, which we hope will be determined by the oceanographic study that was carried out (see section below).

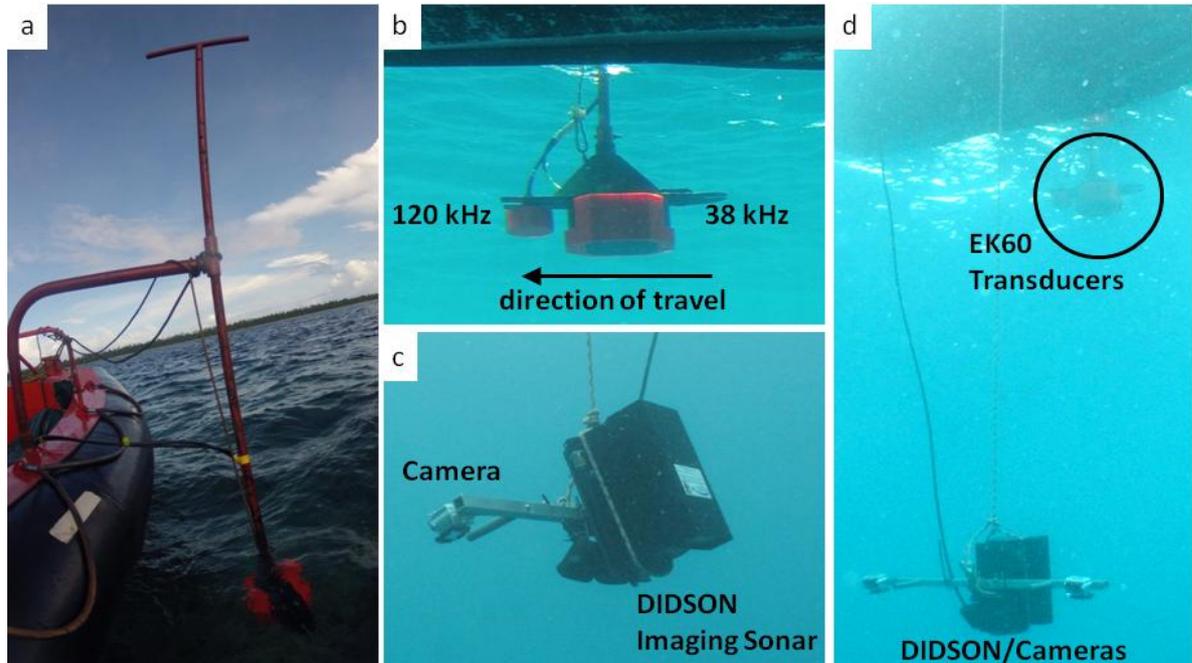


Figure 3: Acoustic equipment employed during the pelagic expedition. a) Pole assembly for EK60 transducers; b) EK60 transducer arrangement; c) DIDSON imaging sonar with attached camera rig; d) Configuration during combined EK60/DIDSON/video surveys.

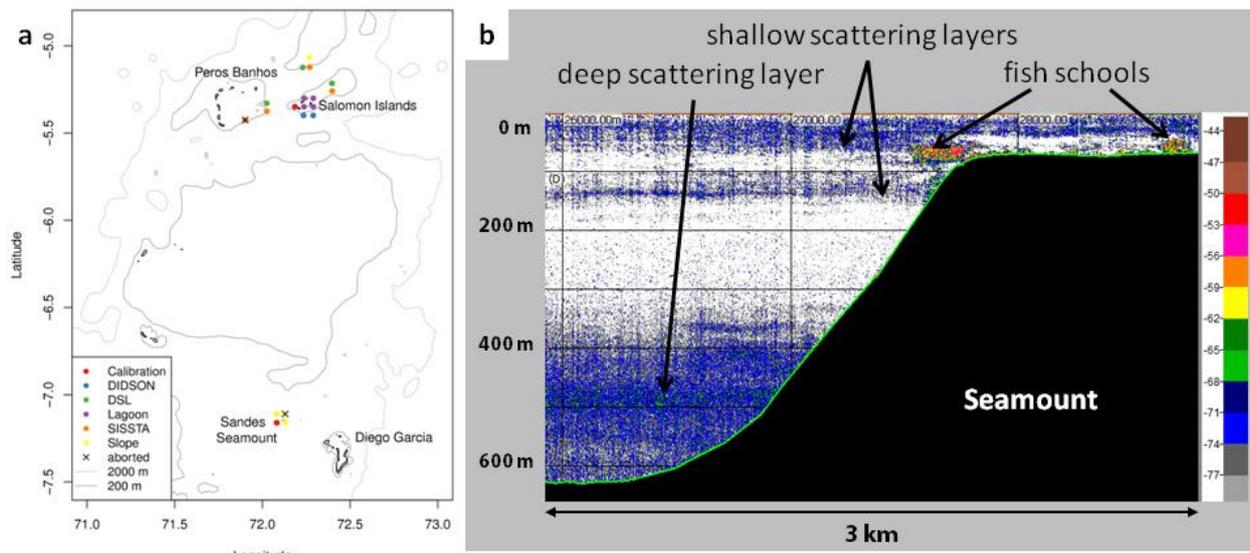


Figure 4: Outcomes of the acoustic surveys. a) Acoustic surveys conducted during the November 2012 expedition; b) Example echogram from Sandes Seamount showing biological features typically encountered during acoustic surveys.

Surveys over the coral reef inside Salomon Islands lagoon demonstrated a near-bottom depletion of zooplankton over the seabed and a previously undescribed phenomenon: extensive zooplankton-depleted zones around coral knolls. The relationship between fish predators and zooplankton distribution will be investigated using the concurrently collected video and sonar footage.

Recommendations

For future fisheries acoustics surveys we recommend:

1. **A fully waterproofed instrumentation housing** for any acoustic surveys conducted from an FRC. This would reduce daily set-up times and enable both higher survey speeds and surveys in less favourable weather conditions.
2. **The deployment of echosounders from the Pacific Marlin:** FRC operations were limited to daylight hours and to spatial scales in the order of 1-10 km. The installation of a transducer pole on the *Pacific Marlin* would enable the archipelago-scale collection of acoustic data and 24 hours a day.

For the future development of the Pacific Marlin as a dual-purpose enforcement and research platform we recommend:

3. **The long-term deployment of fisheries echosounders:** A robust transducer mount on the *Pacific Marlin* would enable deployments of fisheries echosounders between scientific expeditions or even permanently. Once installed fisheries echo-sounders are low-maintenance and operational settings can be controlled remotely. This would yield valuable ecological data at minimal additional costs and without interfering with patrol duties.
4. Operational planning during the expedition was at times hindered by a lack of reliable charts. A **bathymetry plotting system** connected to the ship's hydrographic echosounder would be extremely useful to gather and store bathymetry data for operational use and future survey planning.

References

^[1]Genin 2004 J Mar Syst 50:3–20; ^[2]Morato et al. 2010 PLoS ONE 5:e14453; ^[3]Morato et al. 2008 MEPS 357:23–32; ^[4]Morato et al. 2010 PNAS 107:9707; ^[5]Rowden et al. 2010 Mar Ecol 31:226–241; ^[6]Kloser et al. 2009 ICES JMS 66:998-1006; ^[7]Kaartvedt et al 2012 MEPS 456:1-6; ^[8]Sheppard et al. 2012 Aquat Conservat 22:232-261; ^[9]Morato et al. 2010 PNAS 107:9707.

4. Oceanographic characterisation of water masses

Lewis Fasolo

Background

Investigating the oceanographic characteristics of the BIOT Marine Reserve in relation to the region's mid-water fish assemblages will provide insight into the region's productivity. The integration of oceanographic data with data generated from the SISSTAs and acoustic activities will allow for a deeper understanding of the ecology of the BIOT Marine Reserve, and thus contribute to the reserve's management. This study was the first to collect basic oceanographic data at the scales of cross-archipelago transects and localised measurements associated with shallow seamounts (<100m) and lagoons.

Objectives

Objectives were to investigate oceanographic characteristics at localised scales within the BIOT Marine Reserve, specifically focusing on variation associated with relatively long transects across the archipelago, and the conditions associated with shallow seamounts and lagoons. Particular focus was directed at vertical and spatial profiling with respect to temperature, salinity, and fluorescence as a surrogate for chlorophyll-a, and a measure of primary productivity.

Survey Accomplishments

A CTD (conductivity, temperature and depth) water sampler with attached fluorometer was deployed at a total of 81 stations. In addition, 14 water samples were taken to measure chlorophyll-a to calibrate fluorescence measures. Single casts were taken at each sampling station with the distribution of these stations as follows:

1. Five long transects when the vessel was transitioning from one site to another with a total of 36 casts.
2. On and off seamounts to draw a comparison of oceanographic features (n=12 casts) and a short transect over a seamount to give a high-resolution picture of the changing oceanographic parameters (n=23 casts)
3. Within a lagoon (Salomons) to determine the effects of tidal variation (n= 10 casts).

Preliminary results

Figure 5 is a typical water column profile for samples at locations exceeding 500 m in water depth, with our sampling limited to the surface 250 m. The water column is characterised by a strong thermocline from 50-150m with a spike in fluorescence and a decrease in oxygen concentration occurring with the start of this thermocline. The mixed surface layer over the top 45m is indicated by the steady temperature, salinity, fluorescence and oxygen values.

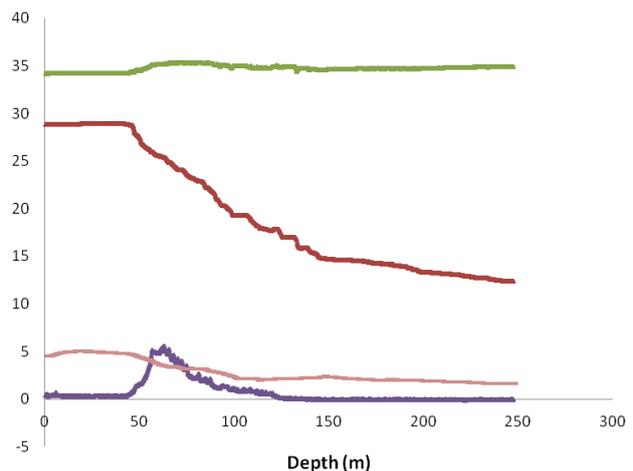


Figure 5. Depth profiles of temperature (red), salinity (green), fluorescence (purple) and oxygen (pink) from a typical sampling station.

Recommendations

Should further CTDs be deployed on another voyage, we would recommend that a more powerful winch is acquired and installed, with capacity to sample to 1000 m. This would allow the deeper water masses to be characterised.

5. Pelagic ornithological surveys

Peter Carr

Background

The BIOT Marine Reserve and the central Indian Ocean in general has had very little “sea birds at sea” monitoring undertaken to date. Extremely little is known about the feeding and foraging ranges of the internationally important breeding sea bird colonies within the marine reserve and, virtually nothing is known of the importance of the marine reserve to transient or sea bird populations that use the area when not breeding. Further, studies elsewhere have demonstrated sea bird associations with cetaceans and predatory fish such as tuna and, with oceanic features such as sea mounts. No such research has been conducted in the marine reserve. To conserve the sea birds using the marine reserve a thorough scientific understanding of how they use the open ocean area of the marine reserve is essential. From this “science for conservation” approach, management plans for the preservation and protection of habitats required by sea bird populations can be drawn up.

Objectives

The specific objective of the ornithological surveys was to provide scientifically robust and repeatable censuses of sea birds at sea in the marine reserve, that when combined with the results from other scientific disciplines operating on the expedition, would reveal insights in to how the ecosystems’ of the open oceans operate above and below the ocean’s surface.

Survey accomplishments

Twenty-one species of sea bird were recorded during 118 transects, with additional records coming from six point counts of chumming episodes and twenty counts of feeding aggregations, some associated with cetaceans and tuna.

Preliminary results

Preliminary analysis indicates there is a definite division between how sea bird communities forage and feed throughout the seas of the marine reserve. There appear to be generalists that forage and feed throughout the waters of the marine reserve and, specific communities that utilise certain areas of the marine reserve and it is likely that these areas have features such as sea mounts or banks that create conditions conducive to feeding sea birds (and most likely cetaceans and predatory fish).

Specific findings include:

- (1) The discovery of a healthy population of Matsudaira’s storm petrel (74 sightings; Figure 6) that may be spending the northern hemisphere winter in the MPA. This is an IUCN red-listed (Data Deficient) species and these sightings constitute the first confirmed records ever for this species in the central Indian Ocean.
- (2) The gathering of data that when thoroughly analysed may prove that areas of the marine reserve are used by communities of mixed-taxon organisms and, that these areas deserve recognition (as Marine Important Bird Areas) and continued protection.
- (3) The sighting and photographing of a Tahiti petrel (Figure 6). This Pacific Ocean species has had an increasing number of sightings in the Indian Ocean over the past decade and this record is the first from the central Indian Ocean.



Figure 6 – Matsudaira's storm petrel (left) and Tahiti petrel (right) © Peter Carr

Recommendations

That the same format of pelagic sampling be conducted in the marine reserve at different times of the year. Without doubt, the sea birds present and how they interact with the open oceans will change according to the time of year.

6. OUTREACH REPORT

Rudy Pothin

Background

A large part of ZSL's mission is to facilitate capacity building both at home and abroad, and enhance people's appreciation of wildlife. To help connect Chagossians with their wildlife heritage, the Chagos Environment Outreach Project is working towards increasing environmental awareness and capacity within all Chagossian communities that will contribute practically to the conservation of the natural environment and issues affecting the Chagos archipelago.

Objectives

My objectives were to take part in all of the research conducted during this expedition and to capture it on camera. I was to learn the roles of the scientists and the work they are doing in BIOT so I can simplify and convey this information to the Chagossian community. Through the pictures I took and the blog updates that I translated into Creole, a first step has been taken to having the community understand and be part of these expeditions. I also plan to do some drawings/paintings of the expedition which is another way to communicate and engage the Chagossian community, and create awareness among the general public.

Accomplishments

As the outreach assistant I was able to do all the work that I had planned. For me, working in BIOT with the scientists on their research is an unimaginable accomplishment. Being on the Pacific Marlin doing transects through hot sunny days to rain and crashing waves was just amazing. Equipped with three different cameras from the normal to underwater camera, I was able to capture everything through all weather. Working directly with the UK-based Chagossian community and having been able to experience BIOT means I am now more confident and able to do my work with more passion and determination. I also felt really privileged to have been part of such an amazing expedition and I certainly learned a lot from the scientists. I believe my most important contribution to science and the BIOT marine reserve was covering the expedition with my daily pictures which the scientists were very happy about.



Figure 7. Photos of the expedition taken by the author.

Preliminary results

Upon my return from the expedition I did an evening talk in Crawley with the Chagossian community and it was an honour just to be able to tell them about the expedition and show some of the pictures I took. The look on their faces made me realise I had accomplished my objective.

Recommendations

If I get the opportunity to do the work again it would be good to send pictures for the blog during the expedition. I would certainly bring more camera equipment for specific needs. I would also like to be SCUBA qualified so as to further discover the incredible realm of the underwater world beyond snorkelling.

SUMMARY:

There were a number of lessons learned from this trip. In addition to the research specific recommendations in sections 1-6, these include:

- (1) Pelagic expeditions are not compatible with dive focused expeditions as, from a health and safety perspective, the Pacific Marlin needs to be in close proximity to divers working from small ribs, rather than moving offshore for pelagic work.
- (2) Weather conditions need to be more closely assessed for pelagic work as this research expands. Advice from the Captain, Chief Engineer and SFPO was that April is quite reliable generally.
- (3) For some pelagic research activities, consideration should be given to targeting fronts where larger schools of pelagic fish species are known to occur. This would require real-time information on the formation of such fronts. This would also facilitate remote tracking of drifting scientific equipment.
- (4) Communication around medical (and possibly other) stores needs to be improved. We arrived to find that the inventoried medical supplies from February 2012 had disappeared, including both drugs and kit. We were fortunate that the US Medical Officer supplied their emergency response kit and the forward party was able to coordinate replacement of medications. These are now stored on the Pacific Marlin.
- (5) Consideration should be given to establishing formal contracts for scientific support services between the FCO and contractors on Diego Garcia.
- (6) As the scale, diversity and complexity of research activities from the Pacific Marlin increases,
 - a. careful pre-expedition discussion between the expedition leader and the Marlin is required;
 - b. a formal approach to health and safety is required, including daily debrief/ planning sessions and 'toolbox' meetings that include expedition members and Marlin crew as identified by the Master;
 - c. a qualified medical personnel is required, recognising where diving is not involved, this may require supporting incurred costs (i.e. travel) for the individual even as they volunteer their time.