Darwin Plus:
Overseas Territories Environment and Climate Fund

Final Report

Important note *To be completed with reference to the Reporting Guidance Notes for Project Leaders: it is expected that this report will be a maximum of 20 pages in length, excluding annexes*

Darwin Project Information

Project Ref Number	DPLUS036
Project Title	**Sustainable management of threatened keystone predators to enhance reef resilience**
Territory(ies)	Cayman Islands
Contract Holder Institution	Marine Conservation International
Partner Institutions	Cayman Islands Dept. of Environment, Guy Harvey Ocean Foundation, Nova SE University, Bangor University
Grant Value	Darwin Plus £173,439; Total Grant £288,640
Start/end date of project	01/04/2015 – 31/03/2017
Project Leader Name	Dr. Mauvis Gore
Project website/Twitter/Blog etc.	www.marineconservationinternational.org; http://www.doe.ky/
Report author(s) and date	Dr. Mauvis Gore, 30/04/2016, Rupert Ormond, Gina Ebanks-Petrie, Tim Austin, Guy Harvey, Mahmood Shivji, John Turner

1 Project Overview

The project is located in the Cayman Islands which is a UK overseas territory in the north-west Caribbean Sea. There are three Cayman Islands: Grand Cayman, Little Cayman and Cayman Brac, the locations and extent of which are shown in the maps (Fig. 1a & 1b). Work was undertaken in close cooperation with the Cayman Islands Department of the Environment (DoE) which provided office space, accommodation, vehicles and diving facilities and whose staff skippered the small boats used in survey and tagging work. For ecological and cost-effectiveness reasons the work under the present grant focused, as planned, on Grand Cayman and Little Cayman.

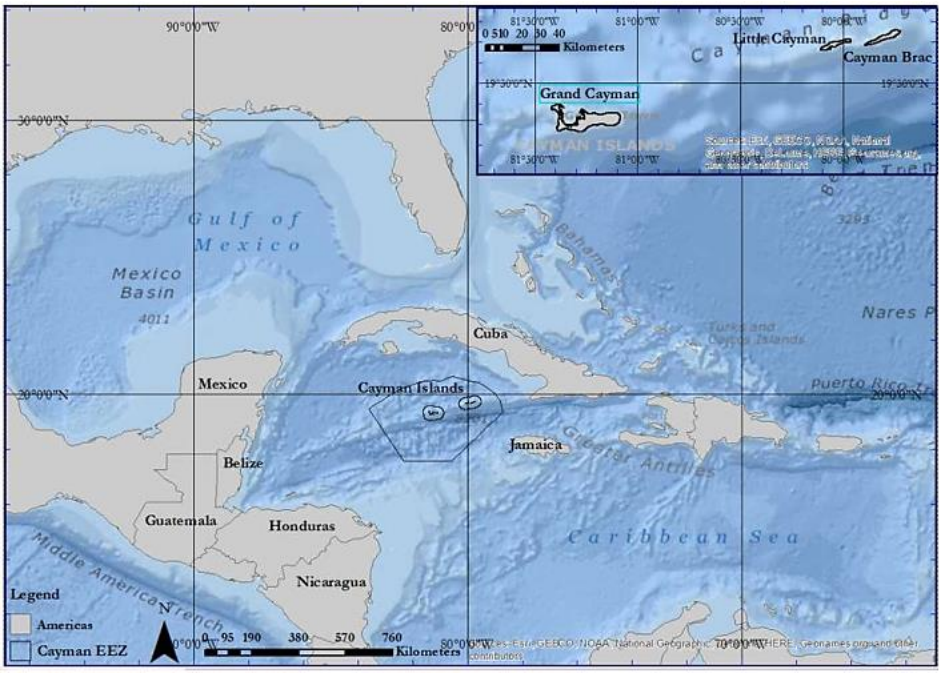


Figure 1a. Map showing the location of the three Cayman Islands and (inset) their positions in relation to each other in the north-west Caribbean Sea. The lines surrounding the islands indicate the extent of territorial waters (inner) and of the exclusive economic zone (outer). Map source: DoE GIS layers.

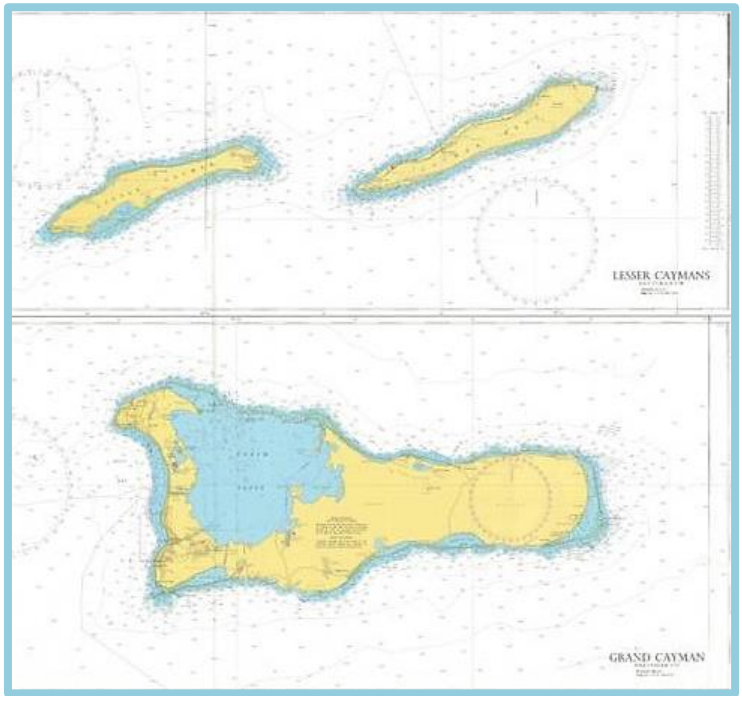


Figure 1b. Charts showing detail of the three Cayman Islands: (top) the Sister Islands - Little Cayman (left) and Cayman Brac (right) - and (bottom) Grand Cayman.

Thanks to a network of Marine Protected Areas (MPAs) established over 25 years ago (Fig. 2), coral reefs in the Cayman Islands have fared better than those in most other Caribbean areas. Nevertheless, due to climate change and other impacts, the abundance of living corals in Cayman is now only around a third of that originally present prior to human impact [Jackson et al. 2014]. Similarly, while globally the abundance on reefs of top predators, especially sharks, has collapsed, our previous OTEP funded project showed that in Cayman various large

predatory sharks, grouper and snapper were still present, although their relative abundances appeared much lower than would have been the case on pristine reefs. The proper management of these large marine predators was considered urgent, not only to secure the conservation of the most threatened species, but because increasing evidence suggested that large predators may play a keystone role in maintaining the balance of trophic cascades, so preventing excessive algal growth outcompeting corals and so enhancing reef resilience.

While MPAs have been found to be an effective tool for managing many reef fish populations, early acoustic tagging studies (by ourselves and one or two other researchers) suggested that large reef sharks, such as the Caribbean reef shark, may range over areas considerably larger than any one of the Cayman Island MPAs. Such preliminary data provided support for the case, also being made following a study of algae-coral-herbivore interactions by a sister project (Darwin project: PI Turner), for major extensions in size to the existing Cayman Island MPAs. The present project was planned to investigate in more detail the relative and absolute abundances of keystone predators, gain information about their reproductive rates, determine whether large threatened shark species should be given full protection through all or part of the Cayman Islands, and produce and implement Biodiversity Action Plans (term used in the Cayman Islands) to help manage their populations. It was also intended to gather comparable data on selected grouper and snapper species to inform the sustainable management of those species subject to fishing. The project was thus intended to support the Cayman government's commitment to "Ensure the protection and restoration of key habitats and species".

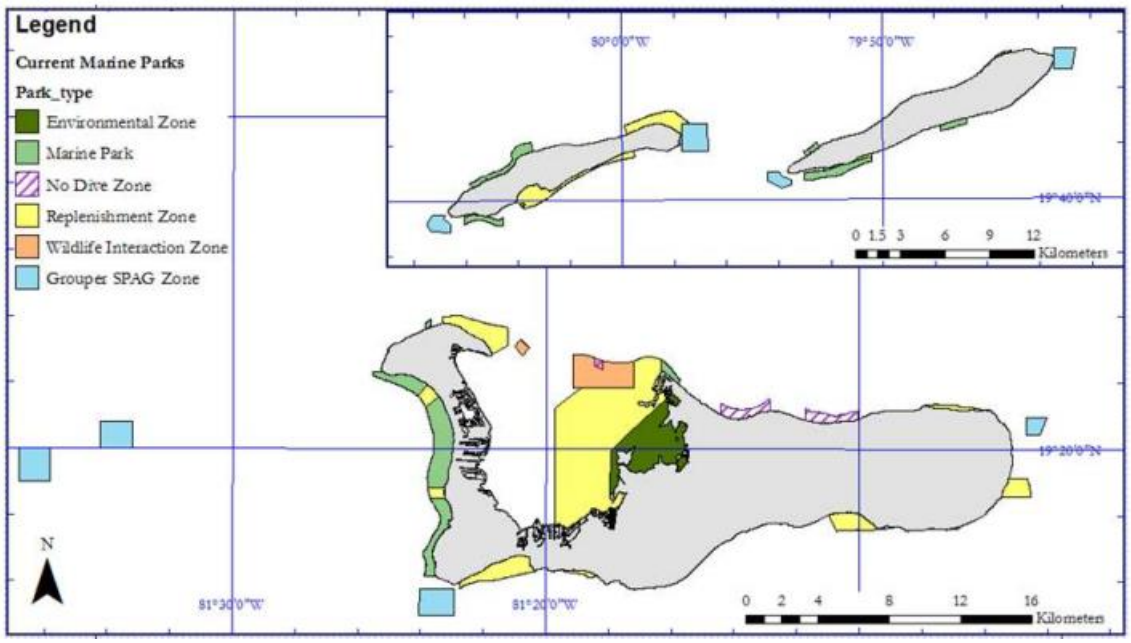


Figure 2. Map showing the extent of different types of Marine Protected Area (MPA) on each of the three Cayman Islands, Grand Cayman (main map), and Little Cayman and Cayman Brac (inset). Map source: DoE GIS layers.

In summary the environmental/climate change goals of the project were:

1. To secure key information about the abundance, movement and reproductive behaviour in the Cayman Islands of three threatened shark species (Caribbean reef shark (*Carcharhinus perezi*), tiger shark (*Galeocerdo cuvier*) and oceanic whitetip shark (*C. longimanus*) so as to inform decisions on:
    a. Whether the species should be given full protection through part or all of Cayman Island waters.
    b. Whether the size of existing MPAs should be significantly enlarged to provide greater protection for these species.
2. To produce and begin to implement Biodiversity Action Plans that would help to secure the conservation of these threatened species.
3. To collect comparable information on two other species of predatory teleost fish (e.g. grouper, snapper) that were subject to commercial or recreational fishing in order to:
    a. Assess their population status
    b. Provide advice on measures that should be taken to secure their sustainable management.

1.1.1 Initially tiger grouper (*Mycteroperca tigris*) and grey snapper (*Lutjanus griseus*) were selected for this work, but, following a request from the Cayman Islands Dept. of Environment, research on tiger grouper was halted in favour of data collection on mutton snapper.

4. To collect data that would help elucidate the extent to which the abundance of top predators might be influencing the abundance of other trophic groups, including in particular fish herbivores, and so enhance reef resilience by regulating algal growth.

The project thus intended to carry out research focussing on five focal species: oceanic white tip shark and grey snapper (both considered by IUCN to be vulnerable, with grey snapper being reported by local fishers as becoming increasingly scarce), tiger and Caribbean reef sharks (both considered by IUCN to be near-threatened), and mutton snapper (*L. analis)*, reported by local fishers and divers as becoming less common).

Specifically it was proposed to:
1. determine population abundance of the five focal species through a) High-definition Baited Remote Underwater Video Stations (BRUVS), allowing photo-identification of most individuals, b) diver-based distance sampling, a method yielding estimates of absolute abundance, c) application of mark-recapture methodology to derive area population estimates.

2. quantify local patterns of movement for foraging and reproduction in relation to existing and potential MPA boundaries through a) acoustic tagging a total of 60 individuals and logging their movements using the established network of acoustic receivers around the islands, b) comparing abundances at different locations between seasons, and c) recording locations where identifiable individuals are re-recorded.

3. investigate the reproductive biology of local populations through such activities as sampling gonads, monitoring suspected spawning sites and surveying potential nursery areas.

4. assess the extent of population exchange with other Caribbean areas (and hence reliance of local populations on reproduction elsewhere) by a) DNA sequencing of mitochondrial genes in Caribbean reef sharks, tiger grouper and grey snapper, to compare with samples from other parts of the Caribbean and b) satellite tagging a total of 15 oceanic white-tip and tiger shark to quantify the extent of adult movement between the Cayman Islands and other Caribbean areas.

5. investigate the functional significance of top predators to the health of reefs by a) investigating the diets of selected species and b) testing respective datasets for relationships between abundance and diversity of top predators and those of other reef fauna and flora.

6. prepare for the five focal species Biodiversity Action Plans that would also consider, so far as practicable, closely related species.

7. establish formal liaison groups with artisanal and recreational fishers, who would assist by sharing samples and knowledge and be assisted through the input of fisheries management advice.

8. secure improved conservation and management through: a) directed liaison with artisanal and recreational fishers, b) ongoing patrolling and enforcement activities and c) public awareness campaigns directed at both fishers and general public.

2 Project Achievements

2.1 Outcome

Outcome:	Baseline	Change by 2017	Source of evidence
1. Knowledge of local population size of each focal species of large marine predator	Indicative data on relative abundance of sharks from preceding project, but no estimates of regional population size for any species	From BRUVS, long-line and diver surveys, more precise estimates of relative abundance have been obtained for Caribbean reef, blacktip and nurse sharks and mutton snapper. Shark abundance varied between islands, habitat and year, with downward trend and then upward during the study period (Fig. 3a). Caribbean reef sharks were about three times as abundant on Little Cayman as on Grand Cayman (Fig. 3b) or Cayman Brac, probably due to differences in fishing pressure and prey abundance. Reef sharks are more abundant in the Cayman Islands than at many Caribbean locations, but less common than in large protected reef areas in Belize, or on relatively pristine reefs in the Indo-Pacific. There were relatively few recaptures or re-sightings of fin-tagged or other individually identifiable sharks (54 re-sightings and 5 recaptures compared to 166 dorsal tags deployed), limiting the confidence of any absolute population estimates. Also the large-scale movements observed in all the large shark species (see below) indicated that the effective populations were mixing over a) very or b) extremely large areas (tens of thousands to hundreds of thousands of km^2). Order of magnitude estimates suggest the numbers of individuals in Cayman waters to be approximately: Caribbean reef sharks – 1000, oceanic whitetip sharks – 100, tiger sharks – 10, grey snapper – 1000, mutton snapper – 1000. Oceanic whitetip sharks were found to be relatively few and largely adult of both sexes. Protection by the legislation may have begun to result in a more stable population of Caribbean reef shark.	Shark Project Report Ormond et al (in press): ms
2. Knowledge of movement patterns of large marine predators	Some movement data for Caribbean reef shark. None for snapper species.	75 sharks, including 56 Caribbean reef sharks, have been tagged with acoustic transmitters. The Caribbean reef sharks showed considerable variation in ranging behaviour (Fig. 4). Some individuals showed long distance movements of 130 km or more (in one case incorporating visits to all three islands) through water >1500 m deep, usually in late summer and probably linked to biennial pupping and mating patterns. Seven tiger sharks and 18 oceanic whitetip sharks were tagged with SPOT satellite tags (Harvey), revealing in both species migrations of up to 1000 km or more. Tiger sharks appeared to visit mainly Grand Cayman and seasonally in winter and between times ranging over much of the western Caribbean (Fig. 5a, b). Oceanic whitetips, mostly adult, were caught offshore of Grand Cayman in spring and subsequently moved widely through the western Caribbean and Gulf of Mexico, and in one case along the Atlantic coast of Florida. Grey snapper tagged at daytime aggregation sites identified in North Sound, Grand Cayman, were observed to disperse at night to forage over the sound, with larger individuals migrating to the outer part of the adjacent northern fringing reef during the period of the new moon, presumably to spawn (Fig. 6). Mutton snapper by contrast occur in small groups in most reef areas but were observed by drop camera during the July full moon to have migrated to one of the traditional grouper and snapper spawning sites (SPAGS) off the east end of Grand Cayman.	Shark Project Report Snapper Project Report Ormond et al (in press): ms

3. Knowledge of reproductive biology of large marine predators in Cayman	Information available only by inference from some other parts of Caribbean. Some local knowledge.	Spawning movements of grey snapper were observed around the new moon and of mutton snapper around the full moon, both in early summer. Specimens collected at this time revealed mature gonads in adults and immature gonads in smaller individuals. Evidence from movement patterns of Caribbean reef, blacktip and nurse sharks suggest these species pup during mid-summer, the first two species in shallow fringing reef areas, the latter within shallow coastal sounds. Juvenile tiger sharks were recorded on BRUVS suggesting that some tiger sharks may pup during visits. Significant proportions of young of the year (13.7%) and sub-adult (59.5%) sharks were recorded from sharks caught during the project period, suggesting local populations are currently reproducing successfully.	Snapper Project Report Shark Project Report
4. Knowledge of population exchange with adjacent Caribbean	Few shark and no snapper tissue samples available from Cayman Islands.	Genetic analysis (Shivji) has shown that Caribbean reef shark from the Cayman Islands constitute part of a genetic population cluster extending across the Caribbean Sea and in to the western North Atlantic, implying a degree of population mixing over this area. Analysis of grey snapper genetic samples by Dr David.Portnoy who has kindly agreed to undertake following the retirement of Dr. John Gold.	Bernard et al (in press): ms Snapper Project Report
5. Knowledge of functional interactions with other trophic groups	Some comparable studies of gut contents from other Caribbean locations.	Stomach contents from grey and mutton snapper show crustacean to be the main prey of both species. Shark species were not sampled given the need to conserve all local species and the fact that their diets are relatively well established. Data analysis to relate shark abundance to abundances of other reef fish has revealed an unexpected negative correlation between shark abundance and that of each other trophic group (Fig. 7).	Snapper Project Report Shark Project Report
6. Biodiversity Action Plans (SAPs) for 5 large marine predators	Cayman Island BAPs published for only 3 other marine taxa.	Draft Biodiversity Action Plans (BAPs) and a Shark and Ray Conservation Plan have been completed covering all shark species plus the two focal snappers and are being reviewed by the Cayman Islands DoE before approval by the Cayman Islands National Conservation Council and subsequent publication and implementation.	Shark & Ray Conservation Plan & 5 BAPs
7. Establishment of Fisher Liaison Groups to assist with data collection and stock management	Divers & fishers have been surveyed in previous work, but no formal network.	A significant portion (45) of known professional and recreational fishers were contacted and interviewed. Many assisted with information and sample collection, though there was little enthusiasm for the establishment of a formal group. In contrast a network of experienced regular divers has been established who are participating in a shark recording (shark-logger) scheme. Over 878 dives have been logged and over 328 shark sightings reported in the first year running.	Snapper Project Report Ormond et al (in press): ms
8. Enhanced protection and stabilisation or recovery of target species	No steps taken to protect species whose populations appeared to be in decline.	Based on project findings it was argued that full protection of all sharks and their relatives (elasmobranchs) throughout the Cayman EEZ be included in the new National Conservation Law. This provision became effective April 2015 and as a result it is an offence to harm or possess any shark or ray or its parts, while sharks caught as by-catch when fishing for other species are required to be released unharmed. The size of existing MPAs will also be greatly increased and an extra Conservation Officer and patrol boat funded to control illegal fishing.	Cayman Islands National Conservation Law

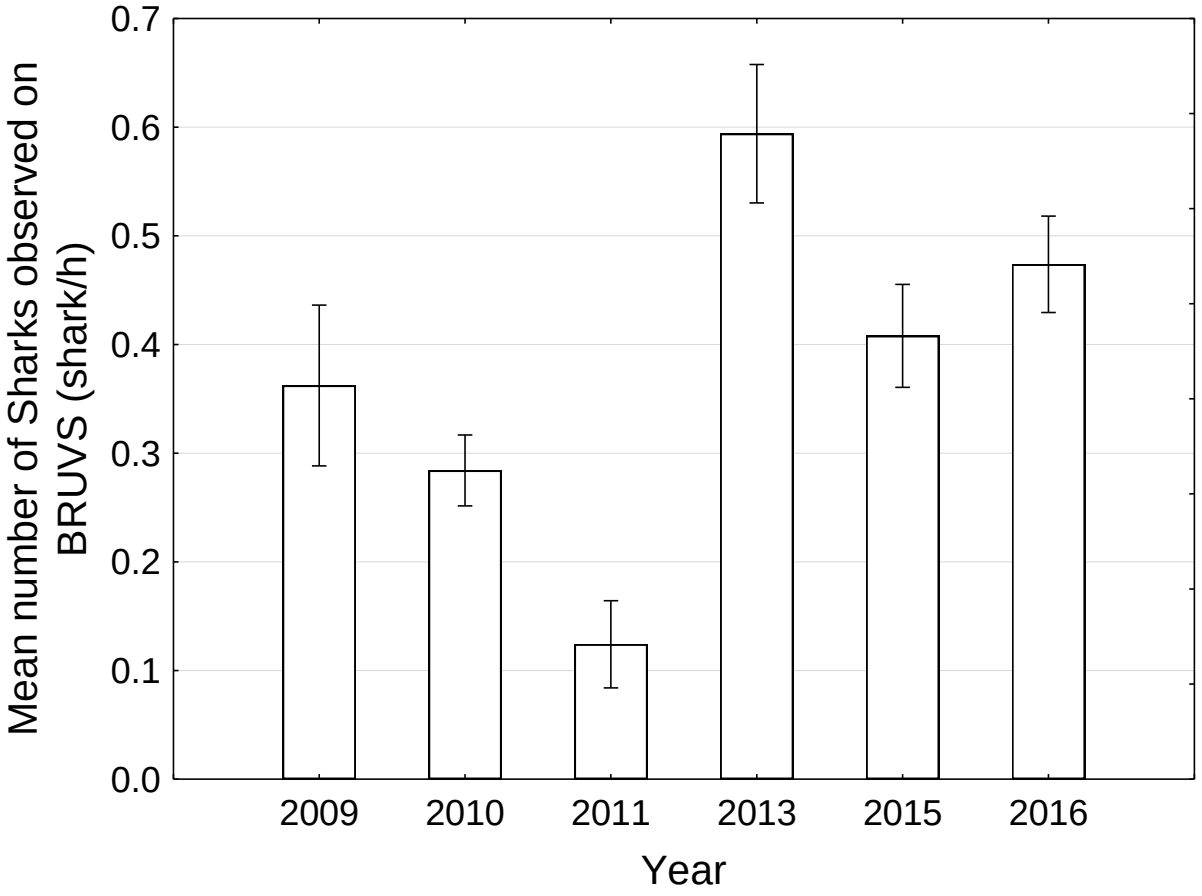
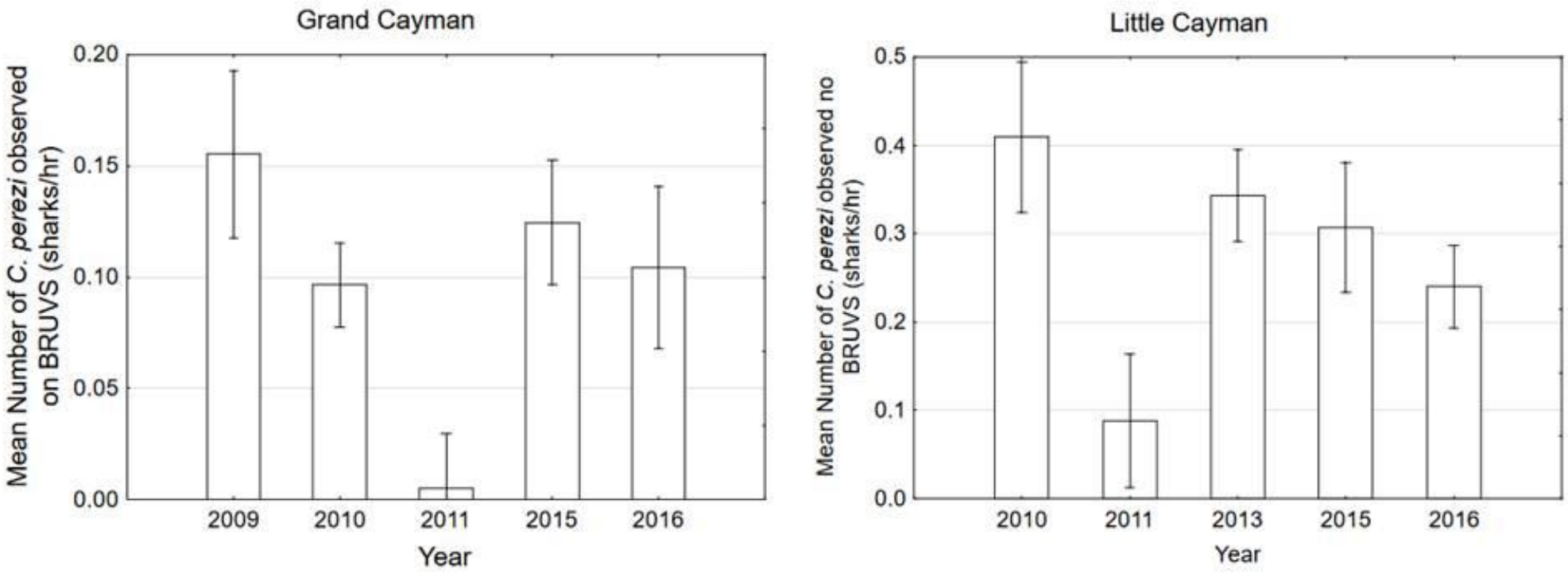


Fig. 3. The mean (± Std. Err.) number of sharks per hour against year derived from BRUVS data. Note no data for 2012 or 2014.
a. All shark species.



b. Caribbean reef sharks (*C. perezi*) per hour against year for Grand and Little Cayman.

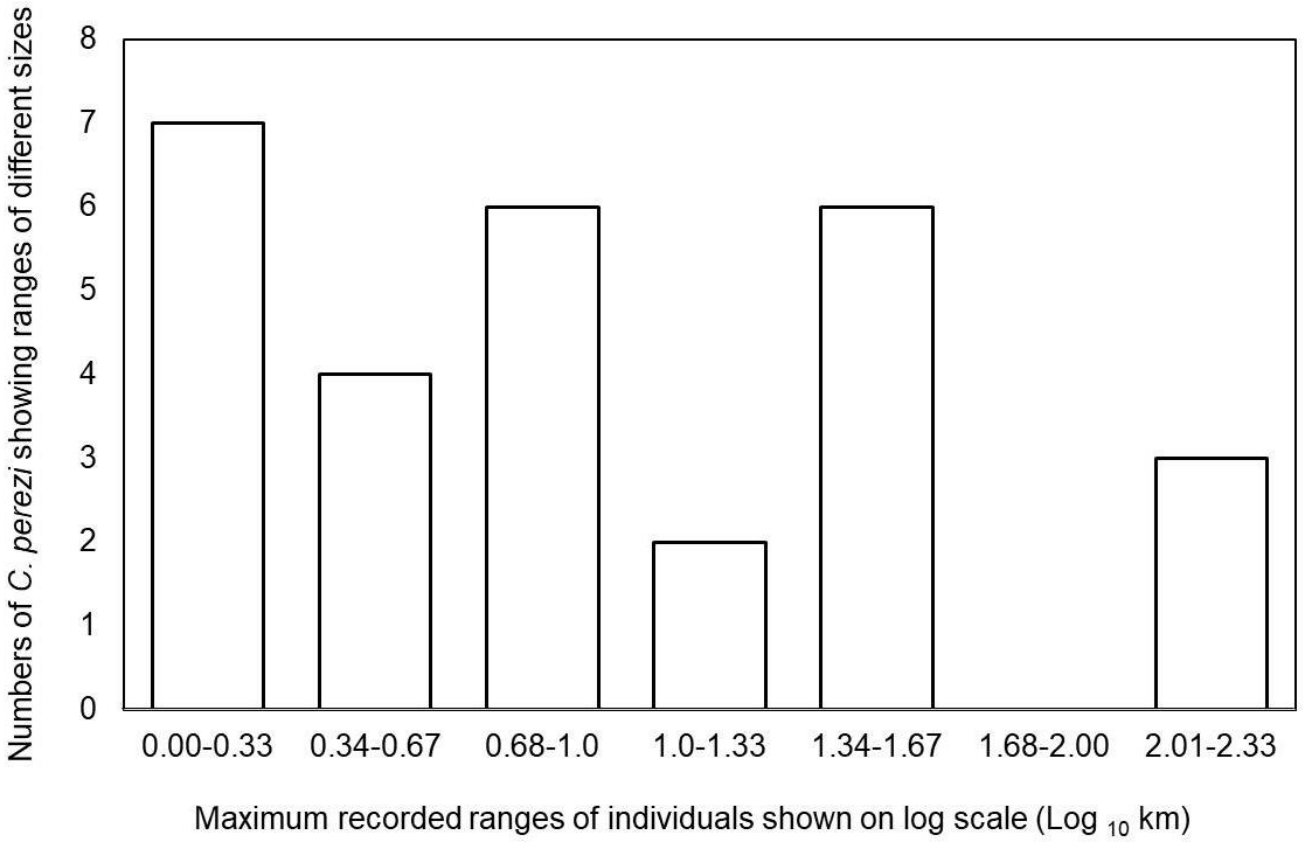


Fig. 4. The maximum ranges (expressed as Log_{10} km, i.e. 1=10km, 2=100km) travelled by individual Caribbean reef (*C. perezi*) sharks as recorded by acoustic receivers.

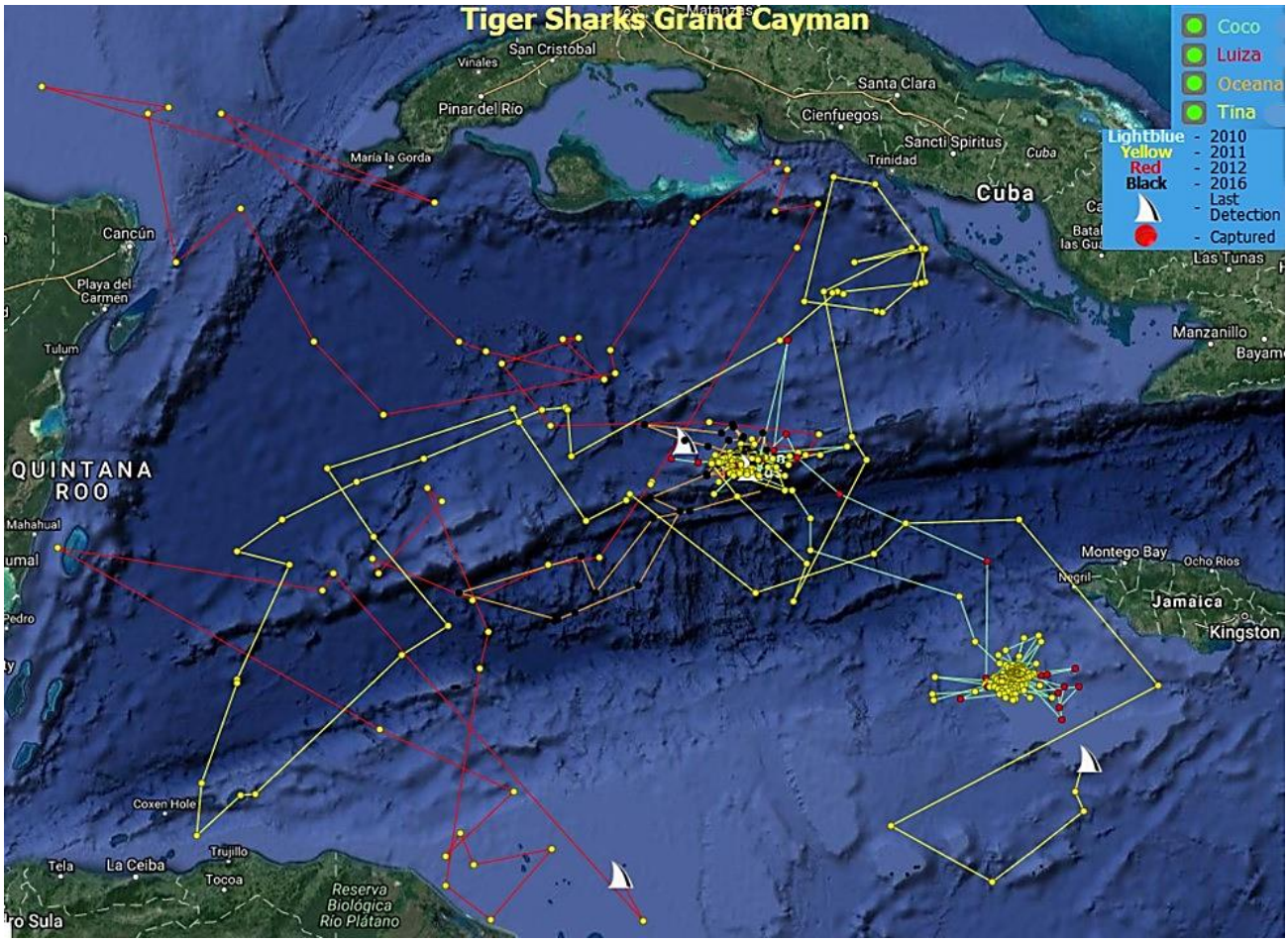


Fig. 5a. Tiger (*G. cuvier*) shark tracks recorded by satellite (SPOT) tags in the Caribbean area (Courtesy of http://cnso.nova.edu/sharktracking/). The key shows the individual sharks and years marked by different colours.

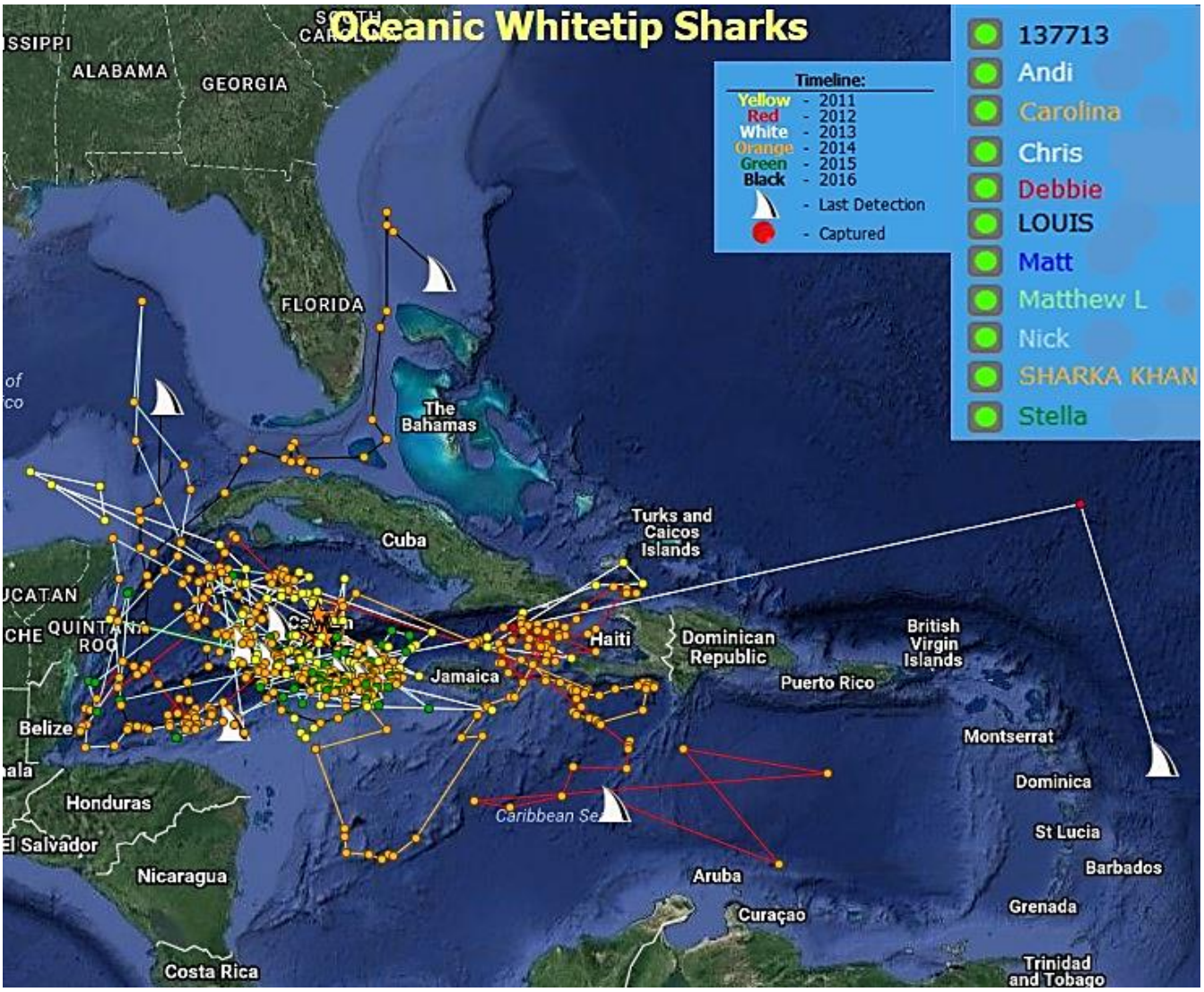


Fig. 5b. Oceanic whitetip (*C. longimanus*) shark tracks recorded by satellite (SPOT) tags in the Caribbean area (Courtesy of http://cnso.nova.edu/sharktracking/). The key shows the individual sharks and years marked by different colours.

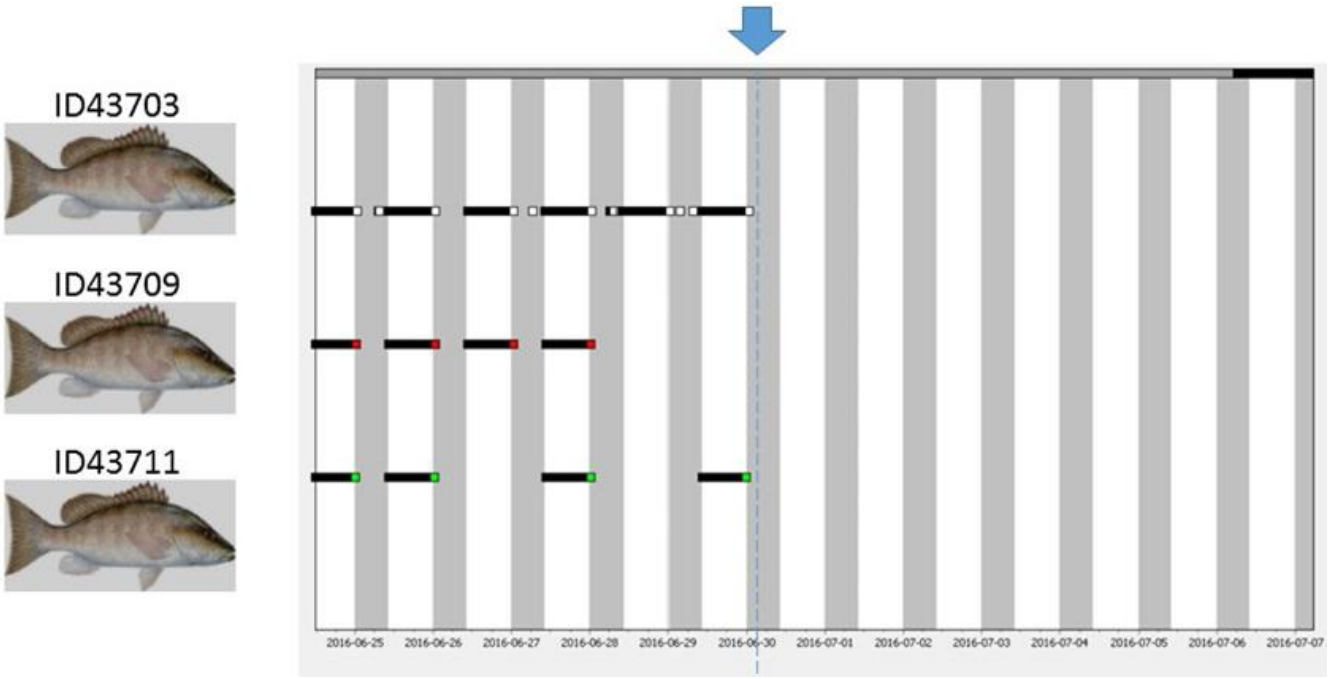


Fig. 6. Movement of three grey snapper (*L. griseus*) from their roost over a new moon period in Jun - Jul 2015, North Sound in Grand Cayman, derived from acoustic transmitters. The ID gives the number for each snapper. Grey bands: night time, white bands: day time. Black horizontal line and small white, green or blue squares: presence detected at the site. Blue arrow indicates the timing of last detections of any of the three fishes during this period.

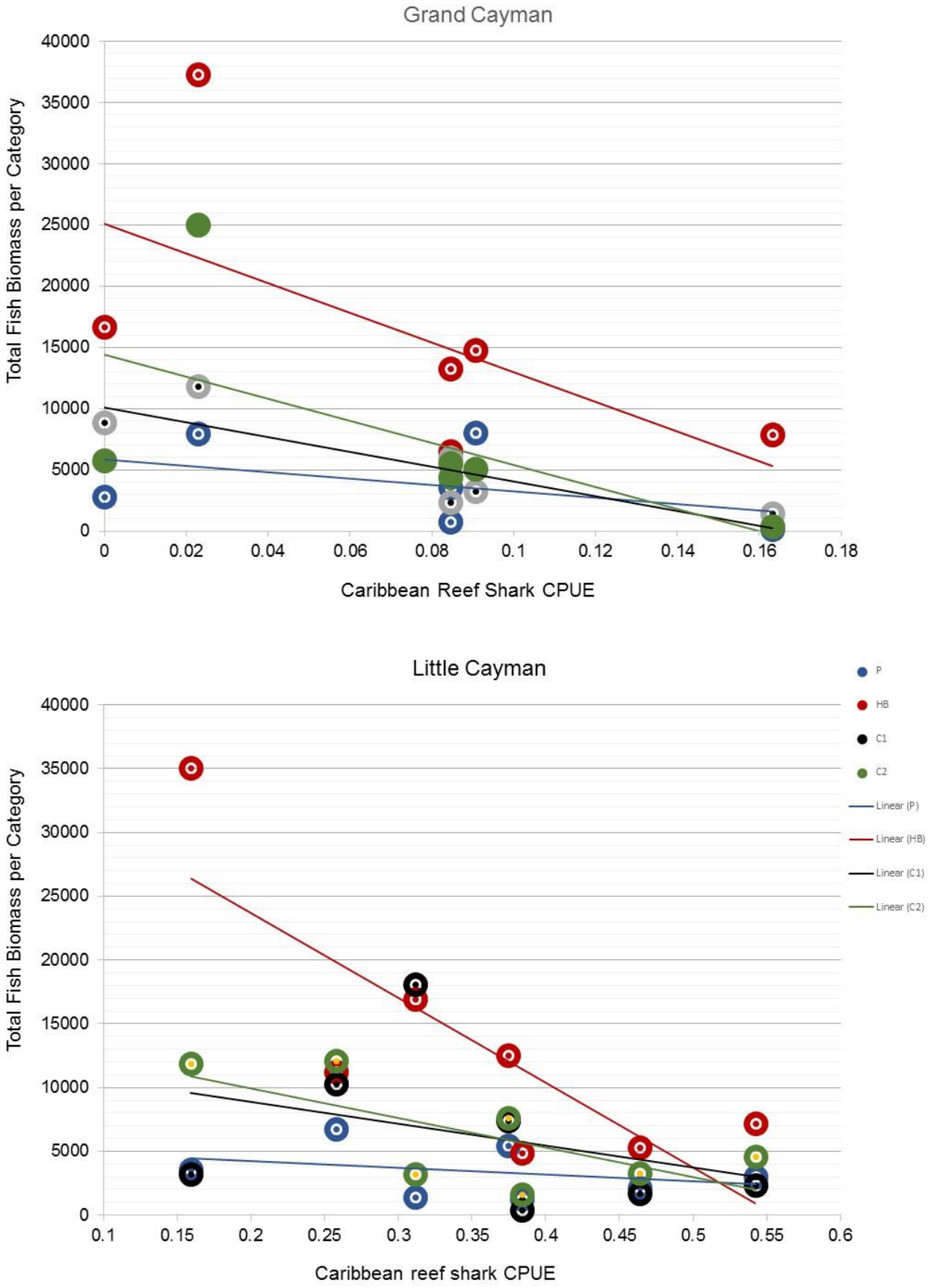


Fig. 7. The relationship between Caribbean reef sharks (*C. perezi*) abundance (BRUVS CPUE: sharks/h) and the total biomass (g) of piscivorous (blue dots), carnivorous (black and green dots) and herbivorous (red dot) reef fish in the same areas, showing the respective regression lines. Top figure: Grand Cayman, bottom figure: Little Cayman

The project's major achievement was the securing of full legal protection for all sharks and other elasmobranchs throughout Cayman waters. Also of very great scientific interest were the contrasting large-scale movement patterns of the Caribbean reef, tiger and oceanic whitetip sharks revealed by the tagging programme. Tagging and counts of grey snapper also neatly contrasted their daily night-time foraging excursions with seasonal migration to spawn on adjacent outer reefs, while drop-cam footage revealed seasonal spawning of mutton snappers at reef-end grouper and snapper spawning aggregation (SPAG) sites.

Only in two minor regards was the project unable to fulfil its objectives. Because of the unexpectedly very large ranges occupied by the sharks and the consequent low proportion of recaptures and re-sightings, absolute population sizes could not be estimated with any confidence. Also the request part way through the project to replace tiger grouper with mutton snapper as a focal species meant that not only have fewer data been gathered on this species, but it has not yet been possible to find a molecular geneticist interested to collaborate in a regional analysis of DNA samples taken from it.

2.2 Long-term strategic outcome(s)

The project has provided extensive new data on key species of large marine predator about which little was previously known in the Cayman Islands.

Considerable effort was made in increasing public awareness of the ecological and economic significance of sharks in the Cayman Islands. Successive public awareness initiatives addressed these issues and did much to change the negative attitudes that previously existed towards sharks. The campaign has been so successful that both the media and members of the public now frequently speak much more positively about sharks and the need to protect them both in the Cayman Islands and globally.

These outcomes have enabled the DoE and Cayman Islands Government to move forward with their conservation and management by:

a) enacting legislation giving full protection to all sharks and other elasmobranchs
b) significantly increasing the size of existing MPAs
c) publishing a shark and ray conservation plan
d) having a dedicated data file for public-reported shark sightings
e) providing more funding to allow increased patrolling against illegal fishing

The inclusion of sharks, rays and other elasmobranchs in the National Conservation Law and the extension of the MPA network will both have significant implications for the management of fishing, the regulation of coastal development and the control of other harmful impacts.

2.3 Outputs

Indicator	Baseline	Change recorded by 2017	Source of evidence	Comments (if necessary)
Output 1:	Knowledge of local population size of each focal species of apex predator			
Survey and mark-recapture (sight-re-sight) data collected and analysed	843 BRUVS & 222 longlines were completed up to the end of the OTEP project in 2013	Now completed 1126 BRUVS deployments, 275 longlines and 61 survey dives. 52 Caribbean reef sharks re-sightings/recaptured. Preliminary assessment complete.	Shark Project Report	Detailed analysis of BRUVS data completed, revealing significant variation

Output 2:	Knowledge of movement patterns of apex predators			
Acoustic & re-sightings data collected and analysed & movement patterns mapped	45 acoustic tags were deployed up to the end of the OTEP project in 2013	A total of 73 sharks have now been tagged with acoustic tags, including 56 Caribbean reef sharks, of which 29 (51.8%) individuals have been detected on receivers. 26 snapper were tagged with acoustic tags of which 14 (54%) were detected on the receivers. Basic analysis of movement data complete.	Ormond et al (in press) ms. Shark Project Report	Distances travelled by reef sharks revealed to be greater than previously assumed and new annual patterns of migration demonstrated.
Output 3:	Knowledge of reproductive biology of apex predators in Cayman			
Data for spawning areas of snapper, and of pupping & nursery areas for sharks	No information	Data indicate Caribbean reef sharks, blacktip sharks and tiger sharks pup locally in shallow reef areas; mutton snapper spawn at SPAG sites at ends of islands, grey snapper on fringing reef adjacent to North South	Snapper Project Report Shark Project Report	Shark information based on BRUVS sightings, snapper information from acoustic transmitters and drop-cam data
Output 4:	Knowledge of population exchange with adjacent Caribbean			
Samples collected and DNA sequenced; satellite tag data downloaded	Some DNA samples of Caribbean reef shark available	Tracks obtained from all save 2 of 18 oceanic whitetip sharks and 7 tiger sharks satellite tags. Caribbean reef shark DNA samples analysed. Snapper DNA samples collected, grey snapper samples awaiting sequencing.	Ormond et al (in press) ms. Shark Project Report Bernard et al (in press) ms.	Grey snapper samples will be sequenced by Portnoy (Texas A&M) when samples available from other regions.
Output 5:	Knowledge of functional interactions with other trophic groups			
Gut samples inspected; statistical comparisons of abundance data completed	Limited information available from literature	Annual reef fish counts completed at 67 dive sites and shark abundance data collected via BRUVS at 25 stations. Co-analysis in hand revealing unexpected trends.	Shark Project Report	Given protected status resulted in no bycatch of sharks that could be used for stomach content analysis.
Output 6:	Biodiversity Action Plans (BAPs = UK Species Actions Plans) for 5 marine apex predators			

Draft and final Biodiversity Action Plans (BAPS) prepared for each focal species	Cayman BAPs available for only 3 other marine species or groups	5 species specific BAPS and a more general Shark & Ray Conservation Plan submitted and being reviewed by DoE	Draft Shark & Ray Conservation Plan and 5 draft BAPs	Plans require approval by National Conservation Council and public consultation
Output 7:	Establishment of Fisher Liaison Groups to assist with data collection			
Fishers liaison groups established, workshops held, data & samples obtained	Only informal contacts with few fishers	Detailed interview with 45 local fishers and required samples obtained. SCUBA diver network established to develop shark-logger project.	Snapper Project Report Shark Project Report	Fishers unsupportive of formal liaison group(s) but many provided great assistance.
Output 8:	Enhanced protection and stabilisation or recovery of target species			
Monitoring indicates stable or recovering populations; reduced illegal fishing	Limited data for pre-project period	Populations of reef sharks no longer declining. Increased enforcement efforts suggests only limited intentional mortality.	Ormond et al (in press) ms.	Increasing numbers of juvenile sharks suggests potential population recovery

2.4 Sustainability and Legacy

The main project achievements expected to endure are that legislation has now been enacted to protect sharks and other elasmobranchs, the network of MPAs is to be extended, and the additional funding has been secured to enhance fishing related enforcement patrols.

Six DoE staff who participated in a wide range of field and desk-based work will remain in post and continue oversight of shark and ray conservation matters.

Using DoE and independent resources (including Caybrew, see below), one of the project students (Johanna Kohler) will continue to be based full-time (for the next three years) in the DoE and with MCI as the Shark Project Officer on the Cayman Shark Project; she is also now registered as a PhD student at Heriot-Watt University, Edinburgh, with Gore as Supervisor.

Kohler will continue with the following project related activities:

i. Assisting acoustic tagging of additional sharks and regular downloading of data from the acoustic receiver network.
ii. BRUVS surveys biannually at established sites.
iii. Promoting and analysing data from the shark-logger project as part of which over 3000 dives have now been completed with frequency of shark sightings being recorded as catch per unit effort.
iv. Promoting awareness of the Shark and Ray Conservation Plan and related Shark and Ray Conservation legislation, as well as the need for shark conservation more generally.

Our partnership with the local brewing company Caybrew will continue and Caybrew will provide a regular income from the sale of our shark conservation beer, Whitetip Lager, (the first shark conservation beer globally), to fund the continuation of the Cayman shark project.

An agreement has also been made with the Central Caribbean Marine Institute (CCMI) in Little Cayman for their Education officer (Tom Sparke) to adopt the use of BRUVS methodology at selected sites for use by annual visiting student groups. Furthermore, collaboration between CCMI and the Cayman Shark Project has been agreed for a programme of surveying reefs on Little Cayman.

The MCI project leader (Gore) has also agreed to continue leading the Cayman Shark Project and visit for fieldwork on at least a biannual basis for a further three years to ensure project sustainability.

3 Project Stakeholders/Partners

The proximate stakeholder in the Cayman Islands has been the Department of Environment (DoE). DoE staff have been involved in project activities on an almost daily basis during the two to three fieldwork periods per year. Senior DoE staff (Ebanks-Petrie, Austin, Bothwell) have been involved in project planning and decision making on an at least weekly basis during fieldwork periods in Cayman, and at least monthly at other times. UK based project staff have only the highest regard for the commitment and support of DoE collaborators.

The ultimate stakeholders are the present and future generations of Caymanians, pre-eminently those involved in the tourism and fisheries sectors. These are increasingly familiar with and supportive of the shark and fisheries related work of the DoE project, as a result of public awareness initiatives including media appearances, presentations at major dive centres and other shark related events and working with local fishers.

4 Lessons learned

In broad terms we believe the project could not easily have been more successful or better managed. Relations with and support from the Cayman DoE proved excellent. Management links worked well as in general did informal links with collaborating specialists.

Two marginal difficulties have prevented full achievement of all objectives:

a) Because the DoE was hosting a greater number of projects than in previous years, and prevailing sea conditions during some fieldwork periods were markedly less favourable than in previous years, there was at times, especially on good weather days, a shortage of boats and skippers; as a result planned fieldwork was sometimes delayed, especially during the first year.
b) The request almost half-way through the project to change a focal species, combined with the retirement of the original researcher (Gold) through whom it was intended to undertake genetic analysis of snapper species, has limited the work we have been able to complete on mutton snapper - the replacement species.

In addition, although the Cayman Islands are small and communities tight-knit, we found fishers reluctant to come together formally. Nevertheless we met with 45 fishers many of whom were eager to assist with project work.

4.1 Monitoring and evaluation

As indicated above, a change to one of the five focal species did limit slightly what could be achieved with the replacement species. This change, made at the request of the Cayman Islands DoE was approved by the Darwin Initiative office.

Given the quality and frequency of liaison with DoE staff and with collaborating specialists there has been little need for formal Monitoring & Evaluation (M&E), those involved in reviewing draft manuscripts being in this instance able to add little to discussions of project planning and direction.

Presentations to the Caymans Island National Conservation Council have been useful both for obtaining feedback about political opinions and identifying extra sources of local knowledge.

4.2 Actions taken in response to annual report reviews

We found official feedback on our first year annual project report unhelpful. This we attribute in part to the rather restrictive yet repetitive format adopted for the annual report form, with resulting comments appearing to mainly concern a lack of information which there had been insufficient space to include. At the same time the benefit of limiting the length of report required is much appreciated.

The reviewer was correct in pointing out that because of poor weather during the first year the relatively low number of sharks caught and tagged could result in difficulty in deriving reliable population estimates from mark-recapture data. During the second year the planned tagging quota was fulfilled, but the unexpected continued low rates of recapture or re-sighting of recognisable individuals nevertheless made it impossible to derive precise population estimates. These low rates of re-sighting and recapture are almost certainly linked to the previously unknown very large distances over which we have found many sharks range.

5 Darwin Identity

The Darwin Initiative has been very generous in helping to study and understand biodiversity and conservation needs in the Overseas Territories and we have been very happy to promote them. We have badged our media, presentations, Citizen Science programmes, posters, events, flyers, leaflets and booklets with the Darwin logo. The project has been the Darwin Initiatives with MCI and DoE as the main partners and Darwin Initiative is understood in the Cayman Islands to be a keen supporter of the type of work that this project has undertaken. For details on badging, please see table below and Annex 2 (printed material).

Date	Media	Topic	Link
27/05/2015	DoE FB site	supporting sharks	
25/06/2015	Project FB site	supporting sharks	
25/06/2015	CIGTV News Update	project launch	https://www.youtube.com/watch?v=fI4BD7Q11Fk
26/06/2015	Cayman News	project launch	https://caymannewsservice.com/2015/06/funding-secured-to-protect-local-sharks/
26/06/2015	Ieyenews	project launch	http://caribbeanictnews.com/cayman-islands-ict-news.html
26/06/2015	CaymanNewsService	project launch	https://caymannewsservice.com/2015/06/funding-secured-to-protect-local-sharks/
29/06/2015	CICT News	project launch	http://caribbeanictnews.com/cayman-islands-ict-news.html
08/10/2015	Cayman 27 - Daybreak TV	shark numbers and value of sharks	
22/10/2015	Press release	shark numbers and value of sharks	
22/10/2015	Radio Cayman	shark numbers and value of sharks	http://www.radiocayman.gov.ky/cayman-shark-numbers-may-be-reduced-but-their-worth-is-high&h=1
23/10/2015	Cayman News	shark numbers and value of sharks	https://caymannewsservice.com/2015/10/local-shark-numbers-declining-warns-doe/
09/02/2016	Cayman 27 - Daybreak TV	Citizen Science #SpotThatCayFish	http://www.cayman27.ky/blog/2016/02/environment-break-spot-cay-fish/
09/02/2016	Cayman 27 - Daybreak TV	Importance of Sharks on Reef	http://www.cayman27.ky/blog/2016/02/environment-break-citizen-scientist-programme/
09/02/2016	Cayman 27 - Daybreak TV	Study methods (Tag, beads, photo ID)	http://www.cayman27.ky/blog/2016/02/environment-break-tools-research/
12/02/2016	Press release	Citizen Science #SpotThatCayFish	
22/02/2016	Cayman news service	#SpotThatCayFish	https://caymannewsservice.com/2016/02/doe-calls-for-photos-of-caymans-ocean-predators/
25/02/2016	Cayman Compass news	#SpotThatCayFish	https://www.caymancompass.com/2016/02/25/marine-research-project-seeks-volunteer-photographers/
04/03/2016	Cayman 27 - Daybreak TV	Importance of top predators - tagging program	http://cayman27.ky/2016/03/environment-break-putting-a-focus-on-top-marine-predators/

04/03/2016	Cayman 27 - Daybreak TV	Fisher call for information, fish samples	http://cayman27.ky/2016/03/environment-break-collecting-data-on-fish/
13/03/2016	Press release	CayBrew Funding	
16/03/2016	Cayman 27 - Daybreak TV	CayBrew Funding	http://cayman27.ky/2016/03/environment-break-caybrew-support-shark-survey/
05/04/2016	Talk today - Cayman radio	SharKY Fest	
08/04/2016	Cayman Radio	Shark research, #SpotThatCayFish, SharKY Fest	
19/04/2016	Press release	Fisher call for information, fish samples	
26/04/2016	DoE Website	SharKY Poster Competition	http://www.doe.ky/sharky/
27/04/2016	Facebook	SharKY Fest	
27/04/2016	Facebook	SharKY Poster Competition	
27/04/2016	CS Messages	SharKY Poster Competition	
27/04/2016	Email schools	SharKY Poster Competition	
28/04/2016	Radio Cayman	SharKY Poster Competition	
23/05/2016	DoE Website	SharKY Fest	http://www.doe.ky/sharky-fest-4-june-2016/
25/05/2016	CS Messages	SharKY Fest	
25/05/2016	Press release	SharKY Fest	
25/05/2016	Cayman Compass	SharKY Fest	https://www.caymancompass.com/2016/05/25/sharks-to-be-celebrated-at-june-4-festival/
30/05/2016	Cayman 27 - Daybreak TV	SharKY Fest	https://cayman27.ky/category/shows/daybreak/
30/05/2016	Flyers, posters - Georgetown	SharKY Fest	
30/05/2016	CS Messages	SharKY Fest	
30/05/2016	Talk today - Cayman radio	SharKY Fest	
30/05/2016	Daybreak in studio	SharKY Fest	http://cayman27.ky/2016/05/sharky-fest/
31/05/2016	Cayman Radio	SharKY Fest	.WAV file
01/06/2016	2nd wave of flyers - WB	SharKY Fest	
01/06/2016	CS Messages	SharKY Fest	
02/06/2016	2nd wave of flyers in EE	SharKY Fest	
03/06/2016	Talk today - Cayman radio	SharKY Fest	
04/06/2016	Cayman 27	SharKY Fest	http://cayman27.ky/2016/06/saving-the-sharks/

06/06/2016	Cayman Compass	SharKY Fest	https://www.caymancompass.com/2016/06/06/sharks-celebrated-at-west-bay-festival/
06/06/2016	Daybreak pTV	SharKY Fest	http://cayman27.ky/2016/06/environment-break-5/
07/06/2016	Press release	SharKY Fest	
07/06/2016	newspaper article	SharKY Fest	https://www.caymancompass.com/2016/06/06/sharks-celebrated-at-west-bay-festival/
31/06/2016	Advert at Radio Cayman	SharKY Fest	
31/06/2016	Advert at Breeze FM	SharKY Fest	
Apr 2016	Presentation	Cayman's Sharks	West Bay, Grand Cayman
Jun 2016	Presentation	Cayman's Sharks	Gulf & Caribbean Fisheries Institute Conference, Georgetown, Grand Cayman
Nov 2016	Presentation	Cayman's Sharks	Georgetown, Grand Cayman
Nov 2016	Presentation	Cayman's Sharks	East End, Grand Cayman
Nov 2016	Presentation	Cayman's Sharks	Central Caribbean Marine Institute, Little Cayman
26/05/- 04/06/2016	Facebook	SharKY Fest	

6 Finance and administration

6.1 Project expenditure

Project spend (indicative) since last annual report	2016/17 Grant (£)	2016/17 Total actual Darwin Costs (£)	Variance %	Comments (please explain significant variances)
Staff costs				
Consultancy costs				
Overhead Costs				
Travel and subsistence				Some airfares were paid from co-funding stream.
Operating Costs				
Capital items				
Others				Includes Final Audit
TOTAL	67235	67240.94		

Staff employed (Name and position)	Cost (£)
Dr. Mauvis Gore	
TOTAL	**36,000**

Consultancy – description of breakdown of costs	Other items – cost (£)
TOTAL	0

Capital items – description	Capital items – cost (£)
TOTAL	0

Other items – description	Other items – cost (£)
Final Audit Survey gear, fishing gear for sharks & snappers, batteries for gear, night fishing gear, cameras, boat gear, consumables	
TOTAL	5127.11

6.2 Additional funds or in-kind contributions secured

Source of funding for project lifetime	Total (£)
Guy Harvey Ocean Foundation	
Greenlight	
CayBrew	
SharKY Fest	
TOTAL	**34,500**

Source of funding for additional work after project lifetime	Total (£)
CayBrew	
TOTAL	**30,000**

6.3 Value for Money

The project has been widely seen as providing exceptional value for money in that:

i. A very experienced project officer (Gore) was employed on only a 75% basis.
ii. Quality UK based MSc level interns were recruited to assist with the fieldwork rather than paid research assistants.
iii. 6 Cayman DoE staff also assisted with the fieldwork, data analysis, policy development and liaison with fishers as required.
iv. Living accommodation, boats, vehicles, fuel, diving and office facilities were provided free-of-charge by the Cayman DoE.
v. Minimal overheads were charged towards the UK office costs.
vi. Highly experienced professorial level staff from several Universities and organisations have given their time unsalaried for specific aspects of the research: Ormond (Heriot-Watt University), Turner (University of Bangor), Shivji (Nova SE University, Florida), as well as Harvey (Guy Harvey Ocean Foundation) and Roberts (University of York).
vii. Local divers have been recruited to a citizen science project, assisting with effort-based data collection on frequency of shark sightings during routine dives.
viii. Local fishers have also become involved by fishing for specimens and contributing their expertise.
ix. Caybrew (the Cayman Islands brewery) has been sponsoring the project through a levy on our conservation beer “White-Tip Lager”.
x. The Guy Harvey Ocean Foundation has also funded and deployed a series of SPOT satellite tags.
xi. The project has employed a number of novel or cutting edge techniques: modern population genetics, SPOT satellite tags, the application of individual photo-identification to Baited Remote Underwater Video stations (BRUVS) and an effort-based Citizen Science programme.
xii. The considerable effort in the project’s public awareness campaign on the presence of sharks and issues related to sharks in Cayman waters has been highly successful in changing predominant negative attitudes and opinions towards sharks both in Cayman and in the wider field.
xiii. The project has also provided an unusual opportunity (because of the extent of data collected by different local projects) to relate the abundance of large marine predators to the health of other reef fish.

Annex 1 Standard Measures

Code	Description	Totals (plus additional detail as required)
Training Measures *Dear Darwin Initiative: please note that the document Standard Measures 2017 uses a different coding system to the one in this form.*		
1	Number of (i) students from the UKOTs; and (ii) other students to receive training (including PhD, masters and other training and receiving a qualification or certificate)	(ii) Non-UKOT: 1 PhD student (ongoing), 7 MSc student (1 ongoing)
2	Number of (i) people in UKOTs; and (ii) other people receiving other forms of long-term (>1yr) training not leading to formal qualification	
3a	Number of (i) people in UKOTs; and (ii) other people receiving other forms of short-term education/training (i.e. not categories 1-5 above)	(ii) Non-UKOT: 2
3b	Number of training weeks (i) in UKOTs; (ii) outside UKOTs not leading to formal qualification	(ii) UKOT: 70 day total for 8 DoE staff & 5 volunteers in longlining and BRUVS survey methods
4	Number of types of training materials produced. Were these materials made available for use by UKOTs?	
5	Number of UKOT citizens who have increased capacity to manage natural resources as a result of the project	
Research Measures		
9	Number of species/habitat management plans/ strategies (or action plans) produced for/by Governments, public authorities or other implementing agencies in the UKOTs	5 BAPs (=UK SAPs): *Carcharhinus longimanus, C. limbatus, C. perezi, Galeocerdo cuvier, Lutjanus analis, L. griseus* 1 Conservation Action Plan (CAP) for sharks and rays
10	Number of formal documents produced to assist work in UKOTs related to species identification, classification and recording.	
11a	Number of papers published or accepted for publication in peer reviewed journals written by (i) UKOT authors; and (ii) other authors	(ii) 3 peer reviewed scientific papers: Bernard et al. (in press) Genetic connectivity of a coral reef ecosystem predator: the population genetic structure and evolutionary history of the Caribbean reef shark (*Carcharhinus perezi*). Ormond et al. (in press) Protecting Cayman Island Sharks: Monitoring, Movement and Motive.

Code	Description	Totals (plus additional detail as required)
		Richards et al. (2015) Sharks and people: Insight into the global practices of tourism operators and their attitude to shark behaviour.
11b	Number of papers published or accepted for publication elsewhere written by (i) UKOT authors; and (ii) other authors	
12b	Number of computer-based databases enhanced (containing species/genetic information). Were these databases made available for use by UKOTs?	4: Baited Remote Underwater Video Stations (BRUVS), longlining, diver surveys, acoustic transmitter recordings
13a	Number of species reference collections established. Were these collections handed over to UKOTs?	
13b	Number of species reference collections enhanced. Were these collections handed over to UKOTs?	
Dissemination Measures		
14a	Number of conferences/seminars/workshops/stakeholder meetings organised to present/disseminate findings from UKOT's Darwin project work	3 conferences: International Coral Reef Symposium, Gulf and Caribbean Fisheries Institute Conference, European Elasmobranch Association Stakeholder meetings: 45 fisher, 250 diver, 500 members of the public at SharKY Fest, 300 at Cayman Sharks event.
14b	Number of conferences/seminars/ workshops/stakeholder meetings attended at which findings from the Darwin Plus project work will be presented/ disseminated	2
Physical Measures		
20	Estimated value (£s) of physical assets handed over to UKOT(s)	Ca. £8,807
21	Number of permanent educational/training/research facilities or organisation established in UKOTs	
22	Number of permanent field plots established in UKOTs	20 monitoring sites for sharks, 5 for snapper
23	Value of resources raised from other sources (e.g., in addition to Darwin funding) for project work	£34,500

Annex 2 Publications

Type * (e.g. journals, manual, CDs)	Detail (title, author, year)	Nationality of lead author	Nationality of institution of lead author	Gender of lead author	Publishers (name, city)	Available from (e.g. weblink, contact address, annex etc)
*Scientific journal	The genetic population structure, diversity, and evolutionary history of the Caribbean reef shark (*Carcharhinus perezi*). Bernard, A.M., Horn, R.L., Chapman, D.D. Feldheim, K.A., Brooks, E.J., Gore, M.A., Shivji, M.S.	Canadian	American	Female	Journal of Biogeography, Medford, MA, USA	Annex 4
*Scientific journal	Protecting Cayman Island Sharks: Monitoring, Movement and Motive. Ormond, R., Gore, M., Bladon, A., Dubock, O., Kohler, J., Millar, C.	British	British	Male	Gulf and Caribbean Fisheries Institute, Marathon, FL, USA	Annex 4
*Scientific journal	Sharks and people: Insight into the global practices of tourism operators and their attitudes to Shark behaviour. Richards, K., O'Leary, B., Roberts, C., Ormond, R., Gore, M., Hawkins, J.	British	British	Female	Marine Pollution Bulletin	Annex 4
*Report	Snapper Project Report Biology and Management of Grey Snapper (*Lutjanus griseus*) and Mutton Snapper (*L. analis*) in the Cayman Islands. Gore, M., Davies, P., Lewis, J. Ormond, R.	British	British	Female	MCI	Annex 4
*Report	Shark Project Report	British	British	Female	MCI	Annex 4

	Cayman Island Shark Survey and Monitoring Project 2009-2017: Species, Numbers, Movement. Gore, M., Ormond, R., Bladon, A., Kohler, J., Millar, C.					
*Booklet	Cayman's Sharks, MCI, 2016	British	British	Female	MCI	Annex 4
*Report	Shark & Ray Conservation Plan, MCI, 2016	British	British	Male	DoE	Annex 4
*Report	Biodiversity Action Plan: *Carcharhinus perezi* (Caribbean reef shark)					
*Report	Biodiversity Action Plan: *Galeocerdo cuvier* (tiger shark)					
*Report	Biodiversity Action Plan: *Carcharhinus longimanus* (oceanic whitetip shark)					
*Report	Biodiversity Action Plan: *Lutjanus griseus* (grey snapper)					
*Report	Biodiversity Action Plan: *Lutjanus analis* (mutton snapper)					
*Leaflet	Calling all Divers & Snorkelers, MCI, 2015	British	British	Female	MCI	Annex 4
*Leaflet	Calling all Fishers & Anglers, MCI, 2015	British	British	Female	MCI	Annex 4
*Leaflet	Top Marine Predators at Home, MCI, 2015	British	British	Female	MCI	Annex 4
*Poster	DoE No Harassment, DoE, 2016	Caymanian	Caymanian	Female	DoE	Annex 4
*Poster	SharKY Fest, MCI, 2016	Caymanian	British	Female	MCI	Annex 4
*Poster	SharKY Fest poster competition, MCI, 2016	Caymanian	British	Female	MCI	Annex 4
*Flyer	Talk at Ocean Frontiers, MCI, 2016	British	British	Male	MCI	Annex 4
*Flyer	Talk at Sunset House, MCI, 2016	British	British	Male	MCI	Annex 4
*Flyer	SharKY Fest, MCI, 2016	Caymanian	British	Female	MCI	Annex 4
*Postcard	SpotThatCayFish, MCI, 2015	Caymanian	British	Female	MCI	Annex 4

Annex 3 Darwin Contacts

Ref No	DPLUS036
Project Title	Sustainable Management of Threatened Keystone Predators to Enhance Reef Resilience
Project Leader Details	
Name	Dr. Mauvis Gore
Role within Darwin Project	Principal Investigator
Address	Marine Conservation International, 5 Lang Rigg, Unit 6, South Queensferry, Edinburgh EH30 9WN, UK
Phone	
Fax/Skype	
Email	
Partner 1	
Name	Prof. Rupert Ormond
Organisation	Marine Conservation International
Role within Darwin Project	Deputy PI, SAPs
Address	5 Lang Rigg, Unit 6, South Queensferry, Edinburgh EH30 9WN, UK
Fax/Skype	
Email	
Partner 2	
Name	Gina Ebanks-Petrie
Organisation	Director, Cayman Islands Department of Environment
Role within Darwin Project	Partner overseeing project, formal liaison groups of fishers
Address	Department of Environment, Cayman Islands Environment Centre, 580 North Sound Road, Grand Cayman
Fax/Skype	
Email	
Partner 3	
Name	Timothy Austin
Organisation	Co-Director, Cayman Islands Department of Environment
Role within Darwin Project	Partner overseeing project logistics, securing improved conservation measures
Address	Department of Environment, Cayman Islands Environment Centre, 580 North Sound Road, Grand Cayman
Fax/Skype	
Email	

Annex 4 See files, listed in Annex 2 above, sent with Darwin Final Report.