"Research and conservation of whale sharks and fish spawning aggregations in Belize"

Final Report

Prepared by:

Prof. Callum M. Roberts
and Dr. Rachel T. Graham

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Acronyms

BBR..... Belize Barrier Reef
CBD ..... Convention on Biological Diversity
CITES ..... Convention on International Trade in Endangered Species of Flora and Fauna
DoF ..... Department of Fisheries
FGBNMS ..... Flower Garden Banks National Marine Sanctuary
FoN ..... Friends of Nature
GSSCMR ..... Gladden Spit and Silk Cayes Marine Reserve
MBRS ..... Mesoamerican Barrier Reef System
NGO ..... Non-Governmental Association
RA ..... Research Assistant
SI ..... Smithsonian Institution
TIDE ..... Toledo Institute for Development and Environment
TNC..... The Nature Conservancy
WCS ..... Wildlife Conservation Society

Darwin Initiative for the Survival of Species

Final Report

1. Darwin Project Information

Project title	Research and conservation of whale sharks and fish spawning aggregations in Belize
Country	Belize
Contractor	University of York
Project Reference No.	09/005
Grant Value	£129,220
Staring/Finishing dates	April 2000-June 2003

2. Project Background/Rationale

The UK Darwin Initiative whale shark and fish spawning aggregation project, in association with local stakeholders aimed to provide new information on the population dynamics and behaviour of the highly charismatic whale shark. The need for the project became apparent during research undertaken in Belize in 1998 and 1999 by the RA(1) in collaboration with Governmental and Non-Governmental (NGO) partner organisations. A hitherto unknown, large seasonal concentration of whale sharks (*Rhincodon typus*) was discovered at an offshore promontory on the Belize Barrier Reef called Gladden Spit. The whale sharks were feeding on the eggs produced by snapper (Lutjanidae) spawning aggregations. The whale shark is one of the few marine species listed on the World Conservation Union's Red List of Threatened Species, and is highly at risk from overexploitation and destruction of its food sources. No comprehensive study on whale shark populations or behaviour had previously been conducted in the Atlantic or Caribbean, which are regions undergoing rapid tourism development. The whale shark aggregation at Gladden Spit provided a predictable venue at which to study these usually elusive sharks and also an opportunity to investigate the spawning behaviour of species targetted by Belizean fisheries.

This project therefore established baseline information for whale sharks both at the regional and global levels. We also assessed the impact of exploitation on the last commercially fished spawning aggregation in Belize and the relationship between the snapper fishery and whale shark abundance. The project highlighted the need to develop special management for migratory species, including how to best design marine reserves for their benefit.

The main focus of work was Gladden Spit and Silk Cayes Marine Reserve and its five stakeholder communities (Figure 1 and 2). Although, with the addition of

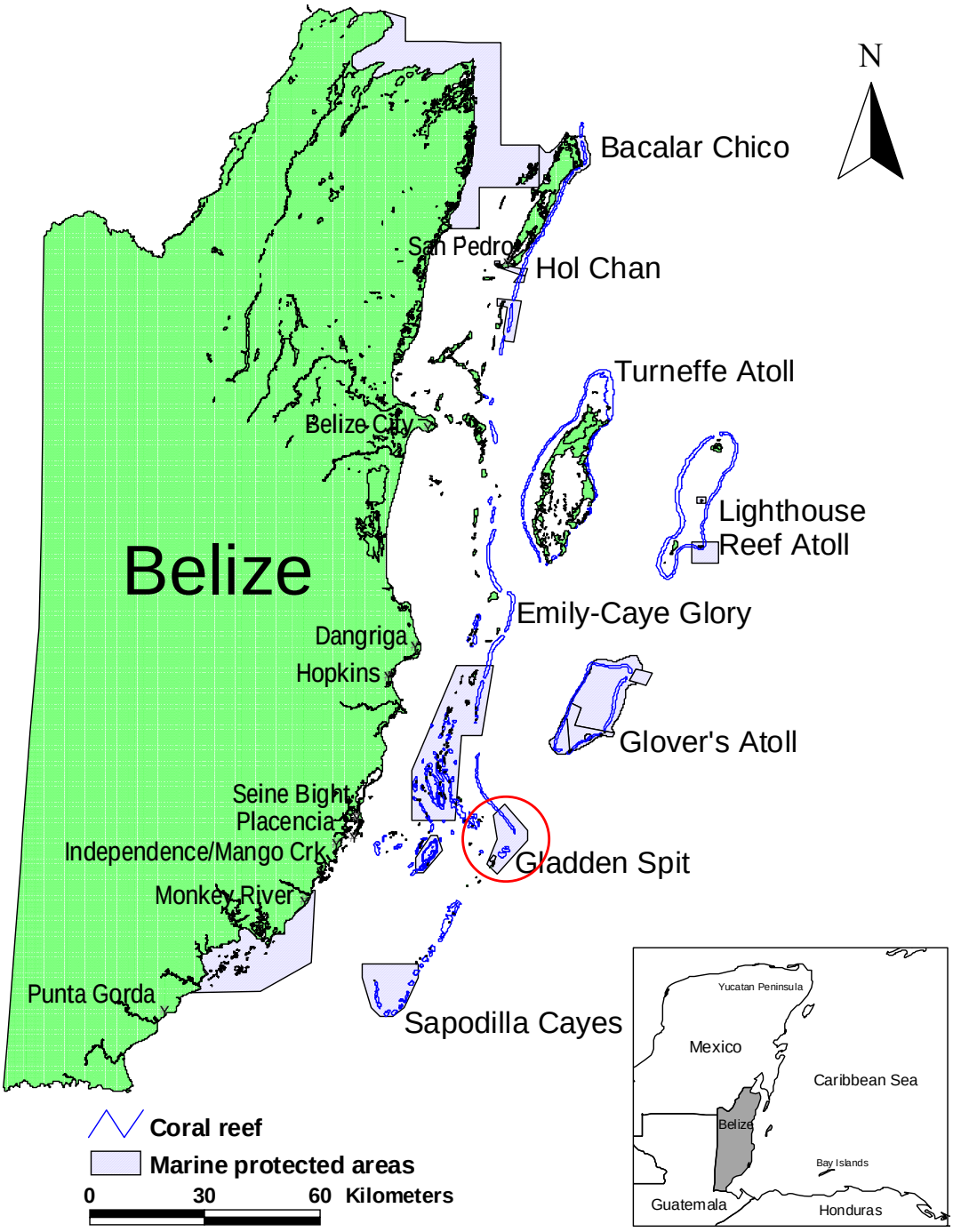

Figure 1: The Belize Barrier Reef and marine reserves with locator map. The research site at the tip of Gladden Spit is located approximately 48 km offshore from Placencia. The marine reserve's five stakeholder communities include Monkey River, Placencia, Seine bight, Independence/Mango Creek and Hopkins. (Base map of Belize courtesy of Coastal Zone Management Authority).

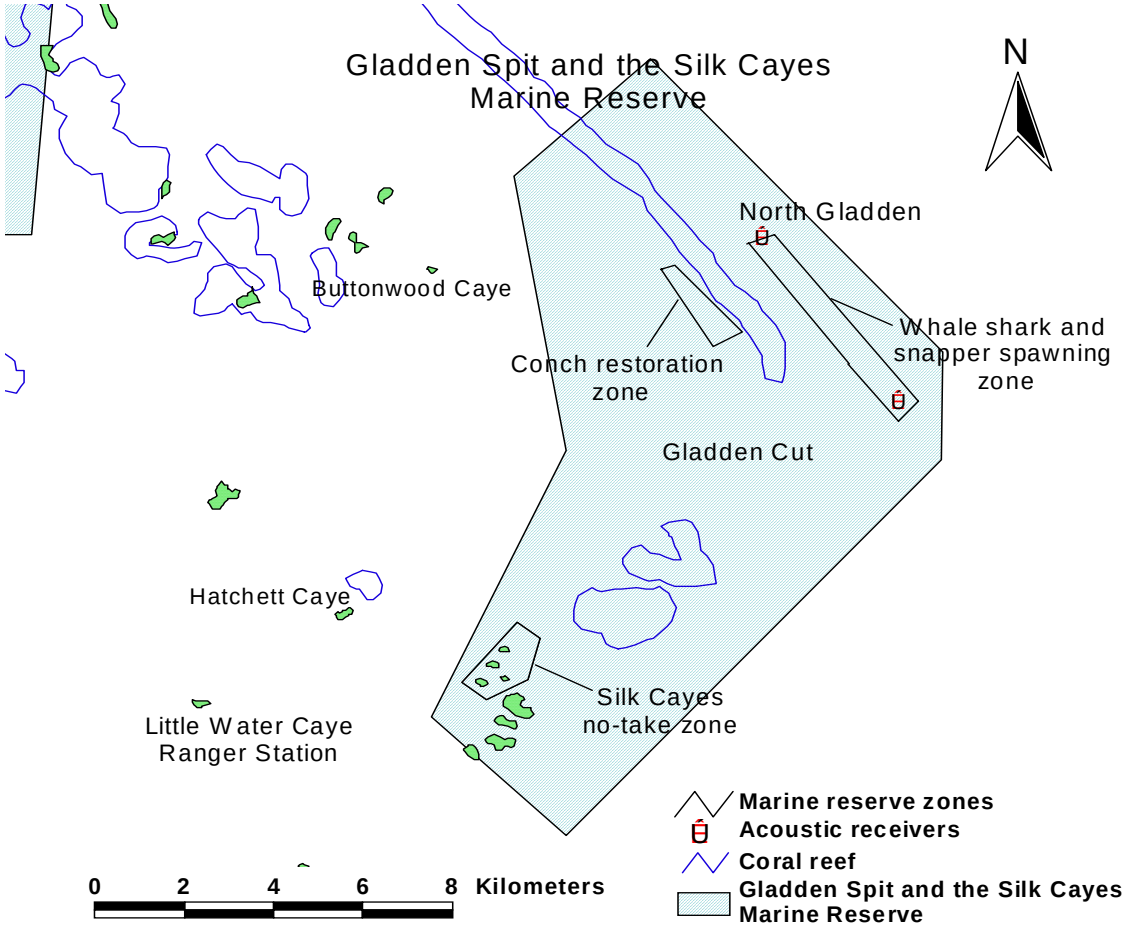

Figure 2: Gladden Spit and the Silk Cayes Marine Reserve (GSSCMR). Zone boundaries defined by GPS points provided in the GSSCMR management plan. The reserve has three special zones that will eventually be no-take marine reserve zones and include the “conch restoration zone”, the “whale shark and snapper spawning zone” and the three “Silk Cayes no-take zones”. Red stars denote the location of two acoustic receivers used to determine the presence versus absence of whale sharks in relation to fish spawning events. The current snapper spawning area is located ~ 1 km from the eastern boundary of the reserve. (Base map courtesy of Coastal Zone Management Authority).

Three months after implementation of the Darwin project, fieldwork was expanded to seven additional sites along the Belize Barrier Reef using additional funds from the Natural Environment Research Council. This expansion permitted comparisons between fish spawning aggregation sites, and helped to better track the timing of whale shark movements along the barrier reef and their relation to spawning fish.

The rapid increase in tourist and academic interest at Gladden Spit over the past five years, indicates that the project was very timely. Given the multiple demands currently affecting the site it would now be difficult to repeat the work that we have done. Project results have been used to promote additional research and formulate management decisions and regulations pertaining to whale sharks in Belize, Mexico, and the Seychelles. This research has also provided Friends of Nature, the local NGO managing the Gladden Spit and Silk Cayes Marine Reserve (GSSCMR), with much of the rationale and background evidence for raising over a half million dollars to protect the site and its fauna.

3. Project Summary

The primary purpose of the Darwin whale shark project was to characterise the population and behaviour of a recently discovered whale shark aggregation at Gladden Spit in relation to fish spawning aggregations and tourism and to provide information for its management and conservation.

The four key project objectives were to:

(1) Increase global knowledge of the natural history of the little known whale shark, with a focus on elucidating the population dynamics and migratory behaviour of the seasonally, or annually-based Belizean population.

We successfully accomplished this objective by establishing that the population of whale sharks is transient and seasonal, and consists predominantly of juvenile males. At least 106 individuals were catalogued through photo identification. Outside of the peak snapper spawning periods of March through June, whale sharks ranged throughout the Belizean Barrier Reef (BBR) and beyond with a brief return visit to Gladden Spit in August/September. Whale sharks tagged at Gladden Spit displayed rapid large-scale movements beyond political borders to the east of the Bay Islands of Honduras (~210 km) and to the tip of the Yucatan Peninsula of Mexico (~550 km). Results suggest that the visiting whale sharks feed only on the spawn of cubera and dog snappers (*Lutjanus cyanopterus* and *L. jocu*) and not on the spawn of mutton snapper (*L. analis*) or several species of grouper found at the site (*Epinephelus* and *Mycteroperca* spp.). It was important to assess what species eggs the whale sharks were eating since local fishers exploiting the mutton snapper aggregation believed whale sharks were directly competing with them for the same resource.

(2) Determine the costs and benefits of whale shark tourism as a local economic alternative to commercial fishing through an environmental economic analysis of whale shark tourism.

The artisanal fishery exploiting the mutton snapper spawning aggregation led to a decrease in the number and size of fish based on catch per unit effort and landings data.

The fishery yielded a total income of US$35,000 in 2002. By comparison, scuba diving revenue from Gladden Spit Marine Reserve and whale shark tourism yielded US$1.35 million in 2002. This represents 39 times more worth than the local fishery and provided for a greater number of beneficiaries. However, cultural incompatibility with tourists prevents many of the older fishers in diverting from fishing. In 2002 we determined that the average tourist was willing to pay a daily fee of US$ 9.60 to visit the Gladden Spit and Silk Cayes Marine Reserve, and that their willingness to pay was related to the presence of whale sharks and satisfaction with their trip to the reserve.

(3) Determine the impacts of tourism and fishing on whale sharks and the optimum size of a marine reserve capable of providing protection to whale sharks at the aggregation site.

We did not perceive quantifiable impacts from tourists on whale sharks. However the number of tour operators offering whale shark encounters has risen by 900% since 1997, from 2 to 18, and will continue to increase in 2004. Consequently, boat congestion has increased and there have been reports of boats inflicting injuries to whale sharks. Of 17 sharks seen with gross scarring, several individuals displayed fresh scars attributed to propeller cuts. In 2002 and 2003, following increased diving pressure, we observed diver-induced changes in the aggregating and spawning behaviour of cubera snapper whose spawn the whale sharks feed on. Further research is required to quantify and more fully characterise these impacts. Our research indicates that the current boundaries of the Gladden Spit and Silk Cayes Marine Reserve (GSSCMR) encompass the main activities of spawning fish and feeding whale sharks. However, we did recommend that the eastern boundary of the reserve should be extended offshore by a minimum of 5 km to protect whale sharks feeding on tuna from being hit by the area's heavy shipping traffic which passes close to Gladden Spit.

(4) Assist local and national organisations in the development of guidelines to protect migratory species such as the whale shark.

We worked with Friends of Nature, the Belize Department of Fisheries and representatives of stakeholder communities to develop tourism guidelines for whale sharks. As part of this effort, 43 local fishermen and tour guides were trained in two Whale Shark Tourism and Conservation courses. Although the tourism regulations were gazetted into law, they have not yet been enforced. Attempts to gain Government-supported protection for whale sharks in territorial waters, have so far been unsuccessful.

(5) Strengthen the organisational, collaborative and management capacities of local institutions responsible for managing marine reserves and migratory species.

Our former international partner, The Nature Conservancy, undertook most of the capacity strengthening work with the local institutions Friends of Nature and Toledo Institute for Development and Environment (TIDE). Their financial support and planning training enabled both NGOs to undertake strategic planning and to better manage their marine reserves. Six individuals used skills acquired during project training to help them organise and implement fieldwork and marine conservation.

Modifications to the project's operational plan were necessary following The Nature Conservancy's (TNC) departure from the project and an unexpected yet substantial rise

(>30%) in petrol and boat/captain hire costs. Without being able to share the costs of fieldwork with TNC, we had to scale down our fieldwork activities. Consequently we focused efforts on the peak whale shark and snapper spawning season (March to June) and made shorter field visits to other research sites to monitor presence/absence of sharks. Limited funds also meant that consultations and stakeholder meetings often took place in Placencia/Seine Bight as opposed to in all of the five stakeholder communities. Futhermore, on 8 October 2001, Hurricane Iris destroyed a significant proportion of four key stakeholder communities (Monkey River, Placencia, parts of Independence and Seine Bight), and so diverted local priorities away from conservation and research for over a year. The Darwin Secretariat gave their approval for these operational changes.

This project has helped Belize to work towards meeting several of its obligations under the Convention on Biological Diversity pertaining to Articles 7, 8, 12, 13, and 14 (see Appendix 1 for details on the articles). Research and training are the most important obligations addressed by the Darwin Project and we have made great achievements in both. We produced new information on the poorly known whale shark and about fish spawning behaviour, while training local students, fishers and guides in fish research and monitoring techniques.

In summary, the project achieved virtually all of its objectives apart from one section of no. 5, which was met by our former project partner TNC. We were unable to undertake stakeholder meetings to discuss fishery regulations in the marine reserve, particularly those pertaining to spawning aggregation fisheries as this issue is highly contentious and Friends of Nature who manage the reserve felt unable to tackle it. However, Friends of Nature was very supportive of stakeholder meetings to discuss whale shark tourism regulations and organised three of these during which project results were presented.

Project research was instrumental in aiding the declaration of the Gladden Spit and Silk Cayes Marine Reserve in May 2000, and in the listing of whale sharks on Appendix II of the Convention on International Trade in Endangered Species of Flora and Fauna (CITES) in November 2002. CITES listing requires that international trade in whale shark products will be monitored and regulated.

4. Scientific, Training, and Technical Assessment

A lack of reliable data on whale shark abundance and its migratory patterns has constrained understanding of this species' ecology and hampered efforts to manage it. Monitoring visiting whale shark population abundance, and their patterns of revisitation to Gladden Spit is key to whale shark conservation in the Mesoamerican region. It also underpins local tourism focused on whale shark interactions with people. Patterns of movement and low abundances of the visiting whale shark population recorded in this study support this species' recent Appendix II listing in CITES.

Project research consisted of three main sections: 1. whale shark population and patterns of movement and site fidelity; 2. status of the mutton snapper spawning aggregation fishery; 3. whale shark tourism and the tradeoffs with spawning aggregation fisheries. Each will be addressed in turn. The project was overseen by Prof. Callum Roberts and field work was conducted by Dr. Rachel Graham (UK staff) with key support from the following Belizean staff: Eloy Cuevas, Alfred Williams, Dan Castellanos Jr., Dan Castellanos Sr., Julie Berry, Shayne Pech, Jason Williams, Tamba Nicholas, Jill Hepp and Nia Cherrett. Dr. Will Heyman participated in project activities until 2001.

1. Whale shark population and patterns of movement and site fidelity

This element of the study was divided into: 1) population structure and abundance and 2) patterns of site fidelity and movement. Both approaches used whale shark tagging to yield results. To estimate and characterise the visiting population of whale sharks at Gladden Spit we deployed 70 conventional visual marker tags over three years. Conventional tags enabled the rapid determination of presence versus absence of sharks within and between years and their large-scale movements along the reef. Because of tag breakage and fouling over time, we used photo identification as a backup mechanism to estimate population size. Shark sizes were estimated above water by running a 7.5 m boat alongside the animal. Underwater we estimated shark size by comparing it to an adjacent diver of a known size. During periods of fieldwork, we recorded in-water or near-boat encounters (within 20 m) with sharks on a daily, seasonal and yearly basis. Originally we hoped to use the Jolly-Seber population model to estimate the area's overall population. However, this method was abandoned after the first year when results indicated that due to a strong bias of juvenile males the Gladden population was unrepresentative of the larger population.

Using a combination of data on encounters, photo identification and conventional marker tagging, 106 individual whale sharks were identified as transient visitors to Gladden Spit between 1998 and 2003. A minimum of 521 encounters with whale sharks was recorded during the same period. Results indicate that the fish spawning site is a preferred site for feeding by male juvenile whale sharks. The majority of sharks encountered (60.3%, n = 314) had a mean total length (TL) of 6.3 m ± 1.7 m SD (range: 3.0 m to 12.7 m; error of ± 0.50 m). Thirty one percent of encountered sharks were sexed, revealing that 86% were juvenile males. Seventy sharks were tagged with conventional marker tags between 1999 and 2002. Mean length of measured and tagged sharks (n = 63) was 6.0 m ± 1.6 m SD (range 3.0 m to 9.7 m). Of these, 41% of tagged individuals were sexed with 83% recorded as juvenile males. Only 14 mature males, and eight females (two mature and six juveniles) were sighted from 1998 to 2003. Nine sharks were recorded with a total length over 9 m, which qualifies them as mature. The skewed population and predominance of juvenile whale shark is similar to that encountered in the Seychelles (Graham, unpublished data) and at Ningaloo Reef in Western Australia (Colman, 1997).

Patterns of site fidelity

Patterns of movement and feeding behaviour of whale sharks at a multi-species reef fish spawning site at Gladden Spit, Belize, were characterized in relation to the seasonal spawning of large aggregations of cubera and dog snappers. We used a submersed passive acoustic receiver (Vemco VR1) moored at the spawning site that recorded patterns of diel, intra- and inter-annual visitation from April 2000 to July 2002 for 22 whale sharks tagged with externally attached acoustic tags. Whale sharks showed strong diel and intra-annual (n = 17), and inter-annual (n = 10) site-fidelity to Gladden Spit. These data indicate that snapper spawn is an attractive food source for whale sharks. The sharks altered their behaviour during the snapper spawning season by remaining primarily in the upper water column and reducing the frequency of deep dives as determined by satellite pop-off tag results. A preliminary $\delta^{15}N$ analysis of whale shark tissues sampled after two fish spawning moons suggests that sharks displayed a prey preference for zooplankton rather than spawn. Site fidelity results indicate that the design of the marine reserve at Gladden Spit encompasses the sharks' key aggregation areas, and

so provides them with important protection during vulnerable periods of surface feeding. A 5km extension of the reserve's eastern boundary would provide a greater buffer for vulnerable surface-feeding whale sharks from nearby cargo boat traffic. Acoustic and observational data suggested that whale sharks do not reside year-round in the Gladden Spit and Silk Cayes Marine Reserve, indicating that the marine reserve may primarily protect juvenile male whale sharks during vulnerable yet limited periods of their life.

Patterns of horizontal and vertical movement

We studied the patterns of movement of whale sharks along the Mesoamerican Barrier Reef using a combination of 11 satellite pop-off tags deployed on 9 sharks and marker tags applied to 70 whale sharks. Coded acoustic transmitters deployed on 22 whale sharks coupled with passive receivers moored at 23 locations throughout the Belize Barrier Reef provided additional information on site presence versus absence, large-scale movements and timing of movement. The importance of fish spawning aggregations in whale shark foraging behaviour was investigated with eight acoustic receivers sited in areas hosting multi-species spawning aggregations. Results indicated that whale sharks ranged throughout the entire Mesoamerican Barrier Reef and seven of Belize's 12 marine reserves. All 22 acoustically-tagged whale sharks displayed different patterns of movement and residency, with sharks demonstrating a mixed strategy of individual and group foraging. No diel home ranges could be determined for whale sharks in this study but several sharks display meso-scale residency to the Gulf of Honduras. On the Belize Barrier Reef, site fidelity is highest at Gladden Spit where sharks timed their arrival and departure in accordance to the availability of a patchy and ephemeral food. This was the eggs released by large snapper spawning aggregations. Tagged whale sharks did not show similar site attachment to any other spawning aggregations investigated along the Belize Barrier Reef. Similar seasonal site fidelity is witnessed in whale sharks aggregating at Ningaloo Reef, Western Australia (Taylor, 1996; Colman, 1997), the Seychelles (Graham, unpublished data), Baja California (Clark & Nelson, 1997) and the Yucatan Peninsula (M.C Garcia, personal communication).

Whale sharks are proving more physiologically robust and closer to marine mammals in their diving behaviour than was previously thought. We investigated the diving patterns of whale sharks over different time scales and in relation to a predictable food source, the seasonal spawn of aggregating snappers, using satellite pop-off archival tags. Satellite tags deployed over periods of 14 to 206 days provided dive data on four male whale sharks. All four sharks performed dives of over 1000 m to depths with temperatures of less than 8.5^0C. One shark (S4) withstood ambient water temperatures below 4.35^0C and possibly dived below 1500 m. All sharks displayed diel oscillatory diving behaviour, with shallow diving taking place at night and deeper dives taking place during the day. This behaviour is similar to that described for the megamouth shark (*Megachasma pelagios*) (Nelson *et al.*, 1997), and is thought to mimic the diel vertical movement of the sharks' key zooplankton prey. Like marine mammals, whale sharks make significantly faster ascents than descents during directed dives over 500 m. The recovery of a satellite tag from a shark (S4) with 206 days of archived data on depth and temperature logged every 60 seconds provided unprecedented fine-scale dive data for a shark. Dive data from S4 displayed clear periodicities at 45 minutes, 8 hours, 24 hours and 29 days indicating the possible existence of free-running endogenous ultradian, circadian and circalunar rhythms.

2. Status of the mutton snapper spawning aggregation fishery.

The predictable sites and timing of reef fish spawning aggregations have made them an easy target for fisheries worldwide. More recently conservationists have focused on the need for their protection. Scientific information on the decline of reef fish spawning aggregations, particularly of snappers in tropical countries is sparse. In Belize, fishers once fished thirteen seasonal spawning aggregations, primarily for groupers. Following extirpation of most of these, the mutton snapper spawning aggregation fishery at Gladden Spit is the last to be commercially fished in Belize. We analysed inter-seasonal catch (n = 5155), effort and yield of this small-scale fishery and found a significant 58.5% decline in catch per unit effort (CPUE) and a decrease of 22% in mean landings per fisher between 2000 and 2002. Over the same period the mean number of fishers increased by 27% and boats by 25% and these were accompanied by a significant 34% increase in the mean time spent fishing. Mean mutton snapper fork-length in catches decreased by 4.2%. Fishers believed that whale sharks feeding on mutton snapper spawn were responsible for the decline in catches. Our results indicate that the small-scale artisanal fishery is responsible. These findings mirror trends noted in numerous historical extirpations of other spawning aggregations in Belize and worldwide (Bohnsack, 1989; Sadovy, 1994; Aguilar Perera & Aguilar Davila, 1996; Domeier & Colin, 1997; Johannes *et al.*, 1999; Sala *et al.*, 2001). As such, we have recommended that the precautionary principle be applied, whereby this and other spawning aggregations need to be fully protected to ensure the health and survival of fish stocks.

3. Whale shark tourism and the tradeoffs with spawning aggregation fisheries.

Whale shark encounter tourism is growing rapidly worldwide, and particularly in Belize where sightings are seasonally predictable. Located on the Belize Barrier Reef, the Gladden Spit and Silk Cayes Marine Reserve forms the primary site for this wildlife tourism where whale sharks congregate in large numbers to feed on the eggs from snapper spawning aggregations. To provide information for management of this growing niche tourism we undertook visitor counts to the Gladden Spit and Silk Cayes marine reserve from 2000-2002 and conducted questionnaire surveys in 2001 and 2002. Operators offering whale shark tours increased in number from 2 to 18 between 1997 and 2002 and tourists at the whale shark aggregation site increased by 64% between 2001 and 2002. Daily visitation fees have been adopted as a means of covering the reserve's operational and management costs. Surveys showed that visitors believed 8 people to be the optimal number of snorkelers or divers present during a whale shark encounter. Visitors were on average willing to pay a daily fee of US$9.60 to visit the reserve, and this was related to the presence of whale sharks and their overall trip satisfaction. By 2002 tourists spent a mean of US$2,218 ± SD 1,804 during their trip to Belize. The reserve's five stakeholder communities captured 36% of this expenditure in 2002 with mean visitor expenditure at US$812 ± SD 999. Whale shark tourism at the reserve is worth US$3.7 million for a six-week operating period with US$1.35 million captured locally in 2002. Whale shark tourism at Gladden is worth 39 times more than the spawning aggregation fishery that takes place at the same time of year. Careful management of Gladden Spit is required to ensure the sustainability of whale shark tourism and the reef fish spawning aggregations that form the basis for predictable shark visitation.

Results from this research were presented at six international conferences over the duration of the project and are currently being prepared for submission to peer-reviewed scientific journals (see below for the titles of eight papers in preparation and currently submitted). Many of the final results such as the fisheries statistics were only available recently due to the need to create a time-series of data before analysis. Much of this research also formed the basis of Rachel Graham's doctorate, which was examined by Dr. David Sims, a specialist in shark behaviour – notably of basking sharks. He considered the results to represent excellent findings and novel contributions to the field.

Graham R. T., Roberts C. M., and J. Smart (in prep.) Diving behaviour of whale sharks in relation to a seasonally abundant food source.

Graham R. T., Roberts C. M., Castellanos D., and W. D. Heyman (in prep.) Patterns of whale shark site fidelity at a multi-species reef fish spawning aggregation site in Belize.

Graham R. T. and C. M. Roberts (in prep.) Patterns of whale shark movement along the Mesoamerican Barrier Reef.

Graham R. T. and C. M. Roberts (in prep.) Structure and dynamics of the seasonal population of whale sharks on the Belize Barrier Reef.

Graham R. T., Roberts C. M., Carcamo R., and W. D. Heyman (in prep.) The decline of a snapper spawning aggregation fishery in Belize

Graham R. T. and R. Scarpa (in prep) Whale shark tourism in Belize: an alternative to unsustainable fishing practices?

Graham R. T. and D. Castellanos (submitted to Fishery Bulletin) Natural spawning behaviour recorded in the permit, *Trachinotus falcatus* in Belize, with notes on spawning behaviour in four other carangids.

Heyman, W.D, Kjerfve, B, Graham R.T., E. Cuevas, and K. L. Rhodes. (submitted to Journal of Fish Biology) Characterizing spawning aggregations of cubera snappers, *Lutjanus cyanopterus* (Pisces: Lutjanidae) on the Belize Barrier Reef.

Training was an integral part of the Darwin project, and took place on formal and informal levels. Over the course of three years, 12 Belizean students, 7 fishers, 2 volunteers and 2 guides were trained in a range of research techniques, several of which were useful to participants in procuring jobs following the end of their work with the project. The pool of potential candidates for any position or volunteer spot is very small in Belize. This is due to the small population in the country and the even smaller number of people who have experience or an interest in marine work. Our students came from the University of Belize and fishers were chosen on the basis of their captaining expertise, knowledge of Gladden Spit, known ability in the field and proffered interest in research activities. Guides involved in the research conformed to the same criteria except captaining expertise.

During the project, four students and two volunteers were trained in tourism survey design and implementation. Eight university students were trained in fishery survey techniques including landings sampling, macroscopic gonadal analysis and

limited data analysis. Two students, four fishers and two volunteers were taught how to prepare tags and tag sharks both above and underwater. One student was trained in video analysis for whale shark photo identification.

Formal training was provided by the whale shark tourism and conservation course, run jointly with the Friends of Nature in 2001 and repeated in 2003. It consisted of 1-2 days of theory, round-table discussions and on land practice and one day of fieldwork. The content of this course is appended. Certificates were issued to all who completed the course, and Friends of Nature will distribute formal accreditation in the form of whale shark tour guide licenses. As a result of these courses 43 guides were trained in conducting sustainable whale shark encounter tours.

The project also co-sponsored dive education for four open water divers with two divers advancing to the Rescue Diver level of the Professional Association of Diving Instructors (PADI). Friends of Nature subsequently funded three of these divers to become divemasters.. All four divers went on to work with the project as dive research assistants. The project gave each a full set of dive equipment.

5. Project Impacts

Information from this project on whale shark behaviour, whale shark tourism and spawning aggregation fisheries has had an impact at the local, national, regional and global levels. Whale shark diving behaviour and patterns of movement in relation to a predictable food source were previously unknown in the Atlantic and Caribbean and only poorly understood in the Pacific. These results indicate that whale sharks are able to feed and move in a range of environments and have a keen sense of orientation. Major impacts of the project that respond to Articles 7, 8, 12, 13, and 14 of the Convention on Biological Diversity are:

1) the creation of a marine reserve to protect feeding whale sharks and fish spawning aggregations,
2) cutting edge research providing novel information about a poorly known, rare and threatened marine species,
3) training spawning aggregation fishers in whale shark tourism guiding as an alternative means of livelihood to unsustainable fishing practices,
4) development of regulations to guide whale shark tourism at Gladden Spit.

The project also helped to "increase public awareness and knowledge about the value, conservation and sustainable use of coastal and marine biodiversity"[1]. Hence the project purpose, as it relates to conservation and management, was accomplished.

Project expertise has been sought to develop whale shark and spawning aggregation research or tourism education programmes in Seychelles, Mexico, Costa Rica, Mozambique and Cuba. However, publicity about Gladden Spit arising from the project has increased visitation. This has led to problems with boat congestion and too many divers present at fish spawning aggregations. The lucrative nature of whale shark tourism has led to several regulatory compromises that favour the tourism industry. These include:

1) an increase in acceptable boat size from a maximum of 42ft to 48 ft,
2) a maximum number of divers limited to 12 (as opposed to the recommended 8),

[1] Belize Biodiversity Action Plan, section 4.6B Education and public awareness – Fisheries, coastal and Marine Resources.

3) up to 6 boats allowed in the whale shark and fish spawning area during a particular 2 hour time slot,
4) an extended time cut-off for diving on the spawning aggregation site allowing for greater tourist contact with spawning fish.

In 2001 and 2001the project team participated in an effort led by GreenReef to monitor Belize's fish spawning aggregation sites. As a result 10 fish spawning aggregation sites have been identified in the country.

The project has improved local capacity to undertake marine biodiversity research and monitoring. Specifically the project helped to orient several students towards marine management work and several fishers and guides to work in marine research. Two of the students, have progressed to manage marine reserves, and another has become manager for the marine NGO Toledo Association for Sustainable Tourism and Environment (TASTE). A fourth student is now a fisheries officer with the Department of Fisheries. Three of the fishers have worked on research for Friends of Nature and one of the dive guides has managed the Friends of Nature spawning aggregation monitoring team for 6 months.

This project represents the first collaboration between Friends of Nature and a UK partner. Project research supported the need for active management and monitoring at Gladden Spit and therefore Friends of Nature's bid for co-management of the Gladden Spit Silk Cayes Marine Reserve. Additionally, research results such as whale shark population structure and patterns of movement, helped to bring together the Department of Fisheries, Friends of Nature and stakeholder communities, thus providing a basis for discussion on the development of tourism and fishery regulations.

The people who benefited most from this project were local tour-guides, students requiring field experience and fishers seeking to learn new skills and diversify into new economic activities. Evidence for the latter was clearly visible from the number of fishers who moved into whale shark guiding and working on research projects. Publicity about the project in a National Geographic article entitled "Feast of the Giant Sharks" helped increase tourism to the area.

The study of the mutton snapper spawning aggregation indicates that this fishery is declining and unsustainable even at current, relatively low levels of exploitation. Based on rapid extirpation of spawning aggregations elsewhere, this fishery should be halted. in the short term, doing so would negatively impact about 18-30 traditional fishers at Gladden Spit, although they would benefit from maintained stocks of mutton snappers over the long-term. Fisher surveys indicate that the majority of these fishers are not willing to retrain as whale shark tour guides due to their age and lack of desire to participate in the tourism/service industry. Several management options were considered for the spawning aggregation fishery. However, by default, fishing pressure will reduce as fish numbers decline and gasoline prices increase beyond fishers' ability to break even on their catches.

6. Project Outputs

The majority of project outputs were achieved, and some were slightly modified. Other organisations implemented specific activities such as the institutional capacity building activities (see Appendix II for details). The output schedule was delayed in 2001 due to the loss of partner TNC and the use of its equipment (diving, video, boat, etc.) and the advent of Hurricane Iris. This delay led to our request for a 3-month extension until the

end of June 2003 to complete project activities and capitalise on one last full snapper spawning-season before closing the project. Following field trials, or because of insufficient funds, some aspects of the research that had to be altered or dropped. These included, tracking whale shark movements using GPS (very difficult due to field conditions at Gladden), monthly visits to Gladden Spit for three full years (>30% rise in gas and boat hire costs made this impossible), and the quantification of whale shark behaviour in relation to divers and boats (little to quantify and difficult to achieve tagging and monitoring at exactly the same time). Instead, we set up an array of acoustic receivers throughout the reef to provide a picture of shark movement and timing. We focused the majority of field time at Gladden on the months of March-June, and looked at diver impact on fish spawning aggregations as an alternative piece of research. We began to quantify fish behaviour using underwater video in 2003.

One of the projects initial aims was to establish the appropriate size of a marine reserve at Gladden. However, tagging and resighting results did not provide sufficient data. Instead, we looked at whether the current marine reserve boundaries adequately encompassed the activities of whale sharks and spawning fish during the peak snapper spawning aggregation season (March-June). We also undertook the majority of tourism, guiding and fisher survey work during this time due to increased fieldwork costs.

Information has been disseminated via a dedicated project web site, two newsletters (one in prep), a brochure, two laminated informational sheets and soon through a poster (in prep) summarising whale shark biology and project results. We produced an annual report of research methods and results for the Department of Fisheries from 2000 onwards. Since Rachel Graham expects to continue the research in Belize and at other sites, she will continue to disseminate information and possibly the newsletter as part of her affiliation with Friends of Nature. Cost of further dissemination of information will be born by the University of York (web page hosted by York), Rachel Graham and Friends of Nature.

7. Project Expenditure

Budget Item	Budget line	2000/01	2001/02	2002/03	Total	Actual spend

8. Project Operation and Partnerships

Originally we had planned to work with only two partners but then expanded our collaborative base once the project was underway. The expansion was catalysed by the Natural Environment Research Council funded acoustic receiver project that led to an expansion of fieldwork to nine additional monitoring sites along the Belize Barrier Reef. We therefore had six local partners and two international partners. The local NGOs were: GreenReef, TIDE, Friends of Nature, Belize Audubon Society, University of Belize and the Department of Fisheries and the international partners were: Wildlife Conservation Society (WCS), The Nature Conservancy (TNC) and the Smithsonian Institution (SI). WCS collaborated on the acoustics array by establishing a compatible array around Glover's Reef Atoll and sharing their data on whale shark movements. SI provided research facilities during field trips to the northern stretch of the Belizean Barrier reef. TNC were primarily involved in the fish spawning aggregation research. All local NGO partners are involved in marine biodiversity conservation and advocacy and have recently branched out to include a larger research component in their operational strategies. Particularly active partners were the Department of Fisheries with whom we collected fisheries data over three years, GreenReef and the University of Belize who provided us with a dedicated volunteer and student help. Following the strengthening of Friends of Nature in late 2001, and its development into a staffed NGO, we worked closely with two of their biologists and their rangers on fish spawning aggregations and whale shark monitoring activities.

No collaborative efforts with other like projects existed, as this project was the only one of its kind in Belize. Consultation with the Biodiversity Strategy office was made prior to the start of the project and again in 2002 to determine whether whale sharks would become protected in Belize's territorial waters. Such legislation has not yet occurred.

Additional international collaboration occurred with the US Peace Corps who provided us with volunteer help between April and June in 2001 and 2002. Collaborations with the Wildlife Conservation Society, Scripps Oceanographic Institution and the Flower Gardens Banks National Marine Sanctuary (FGBNMS) helped further the acoustic array on the barrier reef and aided video research on the impact of people on spawning fish. Additionally, FGBNMS formed part of an informal network of Governmental and NGO whale shark collaborators who alerted us to shark sightings and provided images for identification matching.

Aided by project activities, local NGOs have been successful at addressing several strategic recommendations outlined in the Belize Biodiversity Strategy. These include:

1. Development and enactment of new regulations protecting fish spawning aggregations.

2. Development and implementation of tourism regulations to mitigate impacts on marine life, including whale sharks.

3. Creation of several new marine reserves, including the Gladden Spit and Silk Cayes Marine Reserve that form part of a countrywide network of reserves.

4. Implementation or support for management-oriented research (e.g. Darwin Project);

5. Fostering collaborations and dissemination of lessons learned in biodiversity

conservation between organisations and countries through joint projects and exchanges.

Local partnerships are continuing since the Darwin Project has ended. New initiatives currently underway include the use of satellite location tags on whale sharks and a project on the movement and site fidelity patterns of bull sharks (*Carcharhinus leucas*). Particularly, support from Frineds of Nature for this research remains strong.

9. Monitoring and Evaluation, Lesson learning

Our strategy for monitoring and evaluation of this project was based on the production of tangible research results and their translation into management practices and policy. During the project we collected scientific, social and economic information. Scientific data included: whale shark movement, abundance and population dynamics through tagging, presence versus absence of whale sharks at snapper spawning aggregations, and abundance and behavioural observations for all spawning fish species at Gladden Spit. We used fisheries landings data (size, weight, gonadal state and catch per unit effort) to determine impacts of fishing on the mutton snapper spawning aggregation. We also gathered socio-economic data on fishermen and tourguides and tourists visiting the Gladden Spit and Silk Cayes Marine Reserve.

Results indicated that the visiting population of whale sharks was limited (a total of 106 individuals identified using photo identification) and did not vary significantly in size between 2000 and 2001. In 2002, a decrease in sightings followed a change in the behaviour of spawning snappers. This may have been caused by the rapid increase in tourists and boat numbers visiting the spawning site. Whale sharks time their arrival at Gladden Spit to coincide with the onset of fish spawning activity and range up and down the barrier reef in between these episodes. We demonstrated that tagged whale sharks leaving Gladden Spit move as far north as the northern point of the Yucatan Peninsula and beyond the Bay Islands of Honduras to the south. Fisheries research results indicated that the open-access exploitation, even at the artisanal level, is impacting mutton snapper stocks. We recorded a significant decline in the catch per unit effort and mean snapper size on the spawning ground between 2000 and 2002. Tourism surveys revealed that visitors are willing to pay to visit the Gladden Spit Marine Reserve and that locals captured US$1.35 million of tourist revenue in 2002. Revenues from local whale shark tourism represented 39 times the amount generated by the mutton snapper fishery at Gladden Spit. Both these economic activities occur simultaneously. However, whale shark tourism is an imperfect economic and cultural substitute for the fishery, because it is closed access and requires a large capital expenditure in the start-up phase. Specialised training for whale shark tourism is also required and many older fishers perceive it as an unacceptable occupation.

We continuously monitored the success of our data collection and made appropriate modifications wherever this was necessary. Few adjustments to original methodologies were actually required as most had already been tried and tested before the project began. An internal evaluation was planned for the end of the project but Rachel Graham was unable to carry this out due to her pregnancy.

A key lesson from this project was the need to be flexible with the operational plan. In taking this approach we were able to adjust to the departure of a partner organization, the initial lack of a functional local partner, the destruction caused to the local communities by Hurricane Iris and the substantial rise in operational costs. We also learned how to use the Darwin project to lever additional funding. This was necessary to

cover shortfalls of cost and to provide the project with much needed equipment.

10. Darwin Identity

The project benefited from a high profile locally and internationally. Locally, talks and courses on whale shark and fish spawning aggregation biology at The University of Belize and in the Placencia Community Center helped to raise the profile of project activities and the role of the UK Darwin Initiative in promoting research on these topics in Belize. Two national and 3 local articles were published in Belize and in the UK, the project benefited from 5 local, two national and 3 international web-based articles outlining research and results. The Darwin Logo was used in all talks and affixed on all published and presented materials that have been disseminated locally and internationally. Internationally the Darwin Initiative was highlighted as the project funder during five presentations given on project research results. We designed and disseminated a colour informational brochure, two laminated informational sheets, and a whale shark T-shirt, hat and mask strap given to local project participants. The Darwin logo was featured predominantly on all of these, and they were distributed widely to national and international partners. Darwin was identified on the whale shark tourism and conservation course video, and as a funder for the National Geographic Explorer article entitled "Feast of the Giant Sharks". This profiled our research project plus local fishermen in the context of the whale sharks and fish spawning aggregations. Research results were also included in a BBC TV programme entitled "Smart Sharks" and we had three radios spots in the UK.

11. Leverage

To accomplish a wide range of objectives and to expand on the work that was initiated with Darwin funding, we successfully raised additional money from a wide range of sources. This included US$14,000 from Wildlife Computers for four additional satellite tags and £35,000 from NERC for acoustic tag and receiver based-research. PADI Project Aware Foundation gave us US$ 5,500 to pay for part of the costs of developing and implementing the first whale shark tourism and conservation course. Oak Foundation provided US$ 46,000 for underwater video equipment and satellite location-only tags, and US$ 35,000 for bull shark movement research at Gladden Spit. For travel the Royal Geographical Society gave £500 and the American Elasmobranch Society US$ 750. Mares/Discover Scuba provided US$ 18,000 for 8 full sets of SCUBA diving gear to the project. Five of these were distributed to fishermen who had trained as divers. REEF gave US$ 3,200 for 18 sets of marine wildlife identification guides which were distributed to all the marine reserves in Belize. Princeton Tech donated US$ 1,550 for underwater lights and safety strobes which we distributed to fishermen and divers who were working with the project and who will continue to work in marine conservation. The US National Oceanographic and Atmospheric Administration (NOAA) provided a researcher to assist with our video documentary of the grouper and snapper spawning aggregations at Gladden Spit. NGO staff were trained in various capacity building efforts including strategic planning and fundraising. This was co-funded by a range of international donors, and consequently Friends of Nature raised sufficient funds to purchase two islands. They developed their own management plan and covered their operational costs in 2002/03.

12. Sustainability and Legacy

The project's conclusions and results have been widely applied to shape management policy at the Gladden Spit Marine Reserve. Our research techniques have been used to study whale shark aggregations in the Seychelles and Mexico, and may be applied in Mozambique, Cuba and Costa Rica. Rachel Graham who lives in Belize will continue to provide information on project results for educational and management purposes. She has recently been affiliated to Friends of Nature as their shark researcher. Unfortunately there is still work to do. Whale sharks are not yet protected in Belize's territorial waters and the Government is currently selling whale sharks to US aquariums for substantial amounts of money.

The legacy of our work also lives on in the people we trained and the courses we developed. With respect to assets, the project gave a global positioning system (Garmin 12) to partner Friends of Nature, who also benefited from the use of project dive gear (dive gear, tanks and oxygen) for 12 months.

Much still remains to be learned about whale shark patterns of movement, behaviour and population dynamics and Rachel Graham is currently seeking funds for further work. She hopes to continue with photo identification and satellite tagging in Belize and to start a research project in Mozambique.

13. Post-Project Follow up Activities

The development of pattern recognition software for whale shark spot pattern images would enable rapid assessment of whale shark population dynamics, site fidelity and movement patterns. This system would also facilitate rapid matching between sites and years, thus establishing a cheap, non-invasive automated identification system precluding the need for further conventional tagging. The software could be developed with a specialist who has previously developed similar software for cataloguing whale populations for the International Fund for Animal Welfare (IFAW).

14. Value for money

This project represents very high value for money as we successfully completed globally significant research on whale sharks, often under difficult field conditions. We also determined that fishing impacts the mutton snapper spawning aggregation at Gladden Spit and highlighted the costs and opportunities of this economic activity compared to tourism. These results have helped to shape management and policy at the national (whale shark protected in Gladden Spit) and international levels (CITES declaration for whale sharks). We disseminated many of our results through the press and television and trained 43 local guides in whale shark biology and sustainable whale shark guiding.

Author(s) / Date

Callum M. Roberts

Rachel T. Graham

1st December 2003

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16. Appendix I: Project Contribution to Articles under the Convention on Biological Diversity (CBD)

Project Contribution to Articles under the Convention on Biological Diversity		
Article No./Title	**Project %**	**Article Description**
6. General Measures for Conservation & Sustainable Use		Develop national strategies which integrate conservation and sustainable use.
7. Identification and Monitoring	10	Identify and monitor components of biological diversity, particularly those requiring urgent conservation; identify processes and activities which have adverse effects; maintain and organise relevant data.
8. In-situ Conservation	10	Establish systems of protected areas with guidelines for selection and management; regulate biological resources, promote protection of habitats; manage areas adjacent to protected areas; restore degraded ecosystems and recovery of threatened species; control risks associated with organisms modified by biotechnology; control spread of alien species; ensure compatibility between sustainable use of resources and their conservation; protect traditional lifestyles and knowledge on biological resources.
9. Ex-situ Conservation		Adopt ex-situ measures to conserve and research components of biological diversity, preferably in country of origin; facilitate recovery of threatened species; regulate and manage collection of biological resources.
10. Sustainable Use of Components of Biological Diversity		Integrate conservation and sustainable use in national decisions; protect sustainable customary uses; support local populations to implement remedial actions; encourage co-operation between governments and the private sector.
11. Incentive Measures		Establish economically and socially sound incentives to conserve and promote sustainable use of biological diversity.
12. Research and Training	50	Establish programmes for scientific and technical education in identification, conservation and sustainable use of biodiversity components; promote research contributing to the conservation and sustainable use of biological diversity, particularly in developing countries (in accordance with SBSTTA recommendations).
13. Public Education and Awareness	25	Promote understanding of the importance of measures to conserve biological diversity and propagate these measures through the media; cooperate with other states and organisations in developing awareness programmes.

14. Impact Assessment and Minimizing Adverse Impacts	5	Introduce EIAs of appropriate projects and allow public participation; take into account environmental consequences of policies; exchange information on impacts beyond State boundaries and work to reduce hazards; promote emergency responses to hazards; examine mechanisms for re-dress of international damage.
15. Access to Genetic Resources		Whilst governments control access to their genetic resources they should also facilitate access of environmentally sound uses on mutually agreed terms; scientific research based on a country's genetic resources should ensure sharing in a fair and equitable way of results and benefits.
16. Access to and Transfer of Technology		Countries shall ensure access to technologies relevant to conservation and sustainable use of biodiversity under fair and most favourable terms to the source countries (subject to patents and intellectual property rights) and ensure the private sector facilitates such assess and joint development of technologies.
17. Exchange of Information		Countries shall facilitate information exchange and repatriation including technical scientific and socio-economic research, information on training and surveying programmes and local knowledge
19. Bio-safety Protocol		Countries shall take legislative, administrative or policy measures to provide for the effective participation in biotechnological research activities and to ensure all practicable measures to promote and advance priority access on a fair and equitable basis, especially where they provide the genetic resources for such research.
Total %	**100%**	**Check % = total 100**

17. Appendix II: Outputs

Code	Total to date (reduce box)	Detail (←expand box)
Training Outputs		
1a	Number of people to submit PhD thesis	
1b	Number of PhD qualifications obtained	1 – Rachel Graham received her doctorate based on the Gladden Spit whale shark and fish spawning aggregations work entitled "Behaviour and conservation of whale sharks on the Belize Barrier Reef".
2	Number of Masters qualifications obtained	
3	Number of other qualifications obtained	
4a	Number of undergraduate students receiving training	12* – undergraduates from the University of Belize, this represents 6 more students than noted in the original proposal.
4b	Number of training weeks provided to undergraduate students	24: 20 weeks were field based and 4 weeks were analysis.
4c	Number of postgraduate students receiving training (not 1-3 above)	
4d	Number of training weeks for postgraduate students	
5	Number of people receiving other forms of **long-term** (>1yr) training not leading to formal qualification (i.e. not categories 1-4 above)	10 – included local fishers, guides and volunteers.
6a	Number of people receiving other forms of **short-term** education/training (i.e not categories 1-5 above)	43 – fishers and guides who took the tourism and training conservation courses. Institutional strengthening was undertaken by TNC.
6b	Number of training weeks not leading to formal qualification	Minimum of 60 weeks of field based research training in the use of research methodologies, equipment use and data analysis.
7	Number of types of training materials produced for use by host country(s)	1* - Whale shark tourism and conservation course manual. Institutional strengthening was undertaken by NGO TNC in 2002.
Research Outputs		
8	Number of weeks spent by UK project staff on project work in host country(s)	Minimum of 140. Rachel Graham lived in Belize and worked full time on the project.
9	Number of species/habitat management plans (or action plans) produced for Governments, public authorities or other implementing agencies in the host country (s)	Assisted in establishing the set of recommendations to manage whale shark tourism (carrying capacity and protection of whale sharks) that were integrated in to the Gladden Spit Marine Reserve

Code	Total to date (reduce box)	Detail (←expand box)
		Management Plan. TNC provided the marine reserve dimensions.
10	Number of formal documents produced to assist work related to species identification, classification and recording.	
11a	Number of papers published or accepted for publication in peer reviewed journals	8 in preparation
11b	Number of papers published or accepted for publication elsewhere	
12a	Number of computer-based databases established (containing species/generic information) and handed over to host country	Database still being compiled.
12b	Number of computer-based databases enhanced (containing species/genetic information) and handed over to host country	
13a	Number of species reference collections established and handed over to host country(s)	
13b	Number of species reference collections enhanced and handed over to host country(s)	
14a	Number of conferences/seminars/workshops organised to present/disseminate findings from Darwin project work	6*– held three additional seminars compared to the original proposal but was unable to hold the half day national seminar due to Rachel Graham's pregnancy (coincided with the end of the project).
14b	Number of conferences/seminars/ workshops **attended** at which findings from Darwin project work will be presented/ disseminated.	* Results presented in 6 international conferences. These all represent an addition to original proposal.
15a	Number of national press releases or publicity articles in host country(s)	2 - in the Belize Times (May 28, 2000) and in the Amandala (November 24, 2002). 1 is in preparation for publication with final project results.
15b	Number of local press releases or publicity articles in host country(s)	3 – Articles on whale sharks, tourism courses and fish spawning aggregations for the Placencia Breeze
15c	Number of national press releases or publicity articles in UK	2 – Sunday Telegraph and Daily Mail 3* - articles on international web pages (Discovery Channel, BBC and CNN)
15d	Number of local press releases or publicity articles in UK	5* – 2 articles in the Yorkshire Evening Post Landscapes for DEFRA University of York Magazine
16a	Number of issues of newsletters produced in the host country(s)	2 – second newsletter is in press and both available on the project web site 1 – brochure produced and 500 copies distributed. Also on the project web site.

Code	Total to date (reduce box)	Detail (←expand box)
		2* – informational leaflets produced in laminated hardcopy (250 copies each)
16b	Estimated circulation of each newsletter in the host country(s)	Difficult to estimate since on the web as well
16c	Estimated circulation of each newsletter in the UK	Difficult to estimate since on the web as well
17a	Number of dissemination networks established	1 web page established
17b	Number of dissemination networks enhanced or extended	
18a	Number of national TV programmes/features in host country(s)	1* – Half-hour profile of research, sharks and local fishers on Channel 5 TV.
18b	Number of national TV programme/features in the UK	2 * – "Feast of the Giant Sharks" on National Geographic Explorer and "Smart Sharks" on BBC1
18c	Number of local TV programme/features in host country	
18d	Number of local TV programme features in the UK	
19a	Number of national radio interviews/features in host country(s)	
19b	Number of national radio interviews/features in the UK	1*– 15 minute interview about the research for London Radio, broadcast internationally
19c	Number of local radio interviews/features in host country (s)	
19d	Number of local radio interviews/features in the UK	2 * – 5 minute interviews by BBC radio about the research and results
Physical Outputs		
20	Estimated value (£s) of physical assets handed over to host country(s)	£100 – one GPS given to Friends of Nature, the second continues to be used for project work with FoN. £9,688 * of equipment handed over to local partners from the funds raised in addition to Darwin funds (see notes under "Section 11 – Leverage" for details).
21	Number of permanent educational/training/research facilities or organisation established	
22	Number of permanent field plots established	
23	Value of additional resources raised for project	£112,813 *– this sum includes funding that the project leveraged and equipment handed over to local partners. The sum further represents an expansion of the UK Darwin funded whale shark and fish spawning aggregation research.

18. Appendix III: Publications

Provide full details of all publications and material produced over the last year that can be publicly accessed. Details will be recorded on the Darwin Monitoring Website Publications Database.

Mark (*) all publications and other material that you have included with this report

Type * *(e.g. journal paper, book, manual, CD)*	Detail *(e.g. title, authors, journal, year, pages)*	Publishers *(name, city)*	Available from *(e.g. contact address, email address, website)*	Cost £
PhD	*Behaviour and conservation of whale sharks on the Belize Barrier Reef, R. Graham, 2003, 430 pp*	*University of York, York*	*University of York Library, YO10 5DD, York, UK*	*?*
*Newsletter 1**	*Rachel Graham 2001, 6 pp*		*rtg@btl.net or www.york.ac.uk/environment/darwin*	*Free on web*
Newsletter 2	*Rachel Graham 2003, 8 pp (in prep)*		*rtg@btl.net or www.york.ac.uk/environment/darwin*	*Free on web*
Poster	*Rachel Graham, 2003 (in prep)*		*rtg@btl.net or www.york.ac.uk/environment/darwin*	*Free on web*
*Informational brochure**	*Rachel Graham, 2000*		*rtg@btl.net or www.york.ac.uk/environment/darwin*	*Free on web*
*Laminated guide**	*Whale research and conservation on the Belize Barrier Reef R. Graham, 2000 2pp, updated in 2002*		*rtg@btl.net or www.york.ac.uk/environment/darwin*	*Free on web*
*Laminated guide**	*Guide to whale shark tourism on the Belize Barrier Reef R. Graham, 2000 2pp Updated in 2002*		*rtg@btl.net or www.york.ac.uk/environment/darwin*	*Free on web*
*Manual**	*Whale shark tourism and conservation course*		*rtg@btl.net and Friends of Nature*	*TBD*
Report	*Technical report of research results to the Belize Department of Fisheries, Rachel Graham, 2001*		*Department of Fisheries, Belize City, Belize*	*?*
Report	*Technical report of research results to the Belize Department of Fisheries, Rachel Graham, 2002*		*Department of Fisheries, Belize City, Belize*	*?*

Report	*Technical report of research results to the Belize Department of Fisheries, Rachel Graham, 2003 (in prep)*	*Department of Fisheries, Belize City, Belize*	*?*

* = represents an additional output or additional outputs within a category

19. Appendix IV: Darwin Contacts

To assist us with future evaluation work and feedback on your report, please provide contact details below.

Project Title	Research and conservation of whale sharks and fish spawning aggregations in Belize
Ref. No.	**09/005**
UK Leader Details	
Name	Prof. Callum M. Roberts
Role within Darwin Project	Principal Investigator
Address	Environment Dept., University of York, York YO10 5DD
Phone	
Fax	
Email	
Other UK Contact (if relevant)	
Name	Dr. Rachel T. Graham
Role within Darwin Project	Research Associate 1
Address	61 Front Street, Punta Gorda, Belize
Phone	
Fax	
Email	
Partner 1	
Name	Mr. Lindsay Garbutt, Executive Director
Organisation	Friends of Nature
Website address	
Role within Darwin Project	Local NGO partner
Address	Placencia, Stann Creek District, Belize
Fax	
Email	
Partner 2 (if relevant)	
Name	Ms. Beverly Wade, Administrator
Organisation	Department of Fisheries
Role within Darwin Project	Government partner
Address	Princess Margaret Drive, Belize City, Belize
Fax	
Email	