ESTABLISHMENT OF A BASE LINE INFORMATION FOR *TUSRSIOPS TRUNCATUS* FOR A MONITORING PROGRAM IN THE MARINE RESERVE OF PUERTO HONDURAS, BELIZE

By

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1. Introduction

This project emerged from the urgent need of the NGO Toledo Institute for Development and Environment (TIDE), located in Punta Gorda, Belize, for information of the use of hábitat by dolphins in the Port Honduras Marine Reserve (PHMR), which is managed by TIDE. This urgency is due to the pressure from the oil industry to find oil deposits within the reserve, which has pushed TIDE to seek scientific and ecological foundations to highlight the importance of conservation of flora and fauna living within the PHMR .

Previously to this study there was anecdotal information on the presence of dolphins but this information was not systematized. This project aims to establish base line information and dolphin monitoring methodologies adapted to TIDE's available resources that can be executed by the organization in the future.

This report contains an explanation of the problem, a brief theoretical framework that explains the importance of base lines and monitoring programs, and a brief contextualization of the latest research of dolphins in Belize followed by a methodology, that can be followed by TIDE staff for the continuation of a dolphin monitoring program. The results, are presented in a quantitative manner and include baseline information as well as a catalog of 52 photo-identified dolphins. The discussion that follows aims to analyze, in a qualitative way, the importance of establishing a monitoring program and its possible implications for a future management program for dolphins. Finally, the conclusions and recommendations are intended to guide further actions in the monitoring program for dolphins.

2. Problem

While bottlenose (*Tursiops truncatus*) dolphins are one of the most studied cetaceans in the world (Wells and Scott, 1999) and yet its condition of conservation is not well defined. The IUCN Red List classifies it as a low concern, identifying that the main threats they face are hunting, being caught by fishing nets, and destruction and degradation of habitat (IUCN 2012). It has also been reported by that these organisms are killed to avoid competition with fishermen. It also has been identified that oil exploration activities involving high power sonars can directly and indirectly affect these organisms (Gordon et al. 2001). The loss of these organisms can have a cascading effect on the rest of the trophic levels that destabilize the food chain and marine ecosystems, having ecological and economic effects that may be irreversible.

PHMR, located near the town of Punta Gorda, Toledo District, Belize, is administered by TIDE. This organization is dedicated to the study and monitoring of natural resources in Belize, as well as assisting in the planning and management of Natural Protected Areas and development of responsible tourism and other economic activities through training and assistance to local communities.

An essential requirement for management programs in response to threats to dolphins in PHMR, is the knowledge of the main characteristics of the groups that live within the boundaries of the protected area (Bassos-Hull et al. 1994). The population structure, the number of individuals in groups, estimates of birth rates, mortality and migration and immigration of groups are basic characteristics that describe a given population and therefore yield key information for conservation.

To find this information, it is essential to systematize the available information about where and when these species are within the marine reserve. Through the photo identification of organisms and their recapture it is possible to analyze associations between organisms (Slooten et al. 1993), understand the social structure of the population, their reproductive rates, their use of habitat or their movements in and outside groups within the marine reserve and whether they are residents or visitors. Currently, in PHMR no information about these characteristics

of dolphin groups is available. The scientific staff working at TIDE is aware of the presence of dolphins through anecdotal information, however, there is no systematic information about them.

In this sense it is important to begin a baseline of information in order to establish a long-term dolphin monitoring program. It is argued that this monitoring program could be similar to the Manatees and Dolphins in Belize program operated in Drowned Cayes in Belize by the Sirenian International Inc. in partnership with the Earth Watch Institute (Sirenian International 2012). With this information specific management programs could be created for this species which could result in recommendations on their management. Furthermore, this information could inform estimates of the extent of ecological impact that could occur if the establishment of a potencially harmfull development, such as oil exploration, were to take place.

Currently TIDE is developing the program "Ridge to Reef Expeditions", which aims to strengthen and expand the monitoring currently performed in the terrestrial and marine ANP administered with the help of volunteers interested in contributing to scientific research in Belize . Said program start operating as soon as possible and it is contemplated that volunteer groups are present for a period of 6 to 10 weeks. Will try to hold the program permanently throughout the year to enlist the help of volunteers permanently. It is suggested that dolphins monitoring program is part of "Ridge to Reef" from the start as an activity within the scheduled.

2.1. Providence Energy Group

Oil exploitation in PHMR, if materialized, could destabilize in a transcendental way both economic and ecological dynamics of the region (personal communication TIDE). Providence Energy Group Company has obtained permission to explore 854 km2 in southern Belize where it is believed that there are leaks of oil and natural gas (Providence Energy Group, 2013). The company aims to establish sixteen lines and seismic exploration wells crossing PHMR where they propose to conduct 2D seismic surveys (personal communication TIDE) that generate energy waves that cross the Earth's crust to identify the type of soil that exists below the

earth's surface (Energy in action, 2010). Many studies have shown these techniques to be very harmful to marine mammals and their impacts are evident on numorous levels (Gordon et al. 2001). To reduce the impacts associated with these activities the company is required to conduct environmental impact studies. Within the parameters to be evaluated in this study, they consider different aspects of the flora and fauna of the PHMR. In this sense, if there is no systematic information on the preference and habitat use of marine mammals that inhabit PHMR, the oil company can't take into account the impacts of these activities on existing populations.

On this premise, it is essential to generate basic information that can be used for the establishment of a monitoring program of marine mammals in PHMR, intended to generate information on population and migration of dolphins in the area, which can in turn inform decisions over oil development.

2.2. Principle of precaution

While ideally all conservation plans and associated actions are based on complete and adequate scientific data, there are times when specific actions for conservation should wait for evidence of scientific confirmation. Often, in order to avoid a delay to prevent these types of action's, it is necessary to take actions immediately while the necessary information is collected. This is called the "precautionary principle" (SEC, 2007). The application of this principle should be carefully considered and properly justified.

In the case of PHMR a clear need for information as soon as possible on dolphin populations that inhabit the area is needed. Existing studies have been conducted on dolphin populations in Belize and can act as a framework (Grigg and Markowitz, 1997, Campbell et al., 2002, Kerr et. Al 2005; Dick and Hines, 2011). However it is important to understand local populations dynamics to justify a management strategy against a short term threat such as oil exploration. However, due to the urgency to respond to this threat, TIDE is forced to conduct a monitoring program as soon as possible to give some immediate evidence of the existence of dolphins

to take a position on the possible impact the activities oil exploration can have on local populations.

3. State of Knowledge

The following chapter breifly describe the current knowledge about the information baselines , monitoring programs , the available information on similar research in Belize and a brief description of TIDE .

3.1. Base line information programs

Baselines provide information databases for conservation plans comprising both basic information as the key species of human activities required to implement scientifically supported management actions and to establish whether the reserve is functioning effectively. In particular it:

• Provides data to determine whether management actions are necessary and can be viable, and to assign priorities where necessary.

• Sets the reference level to allow monitoring and trend analysis and thus provide a feedback mechanism to determine the effectiveness of the conservation plan by determining whether adjustments are needed to the original plan.

The establishment of this information is needed for scientific reference to inform conservation action. However this is only the first step to implementing effective management that results in the conservation of a target species. Once this goal is achieved, monitoring needs to be seen as an integral and essential part of management programs (Donovan, 2005).

Information requirements for an effective monitoring program should address two main points (SEC, 2007):

1. Monitoring of population characteristics and habitat

2. The monitoring of human activities

In both cases it is necessary to prioritize monitoring activities according to their usefulness and feasibility. The monitoring plan should take into account specific conservation objectives established for the different attributes that are defined in this case as the population genetic structure, distribution and habitat use, and prey abundance (SEC, 2007). In this case, this monitoring program will focus on the distribution and habitat use. The practicality of monitoring tools (including data collection and analysis) to detect changes in the population is a key element that will guide the construction of this monitoring program given the lack of baseline information, time and human and financial resources available.

For the collection of baseline data and monitoring information it is important to consider the synergies between data collection and sampling methods (SEC, 2007). Certain aspects are repeated in both. This is an important aspect to consider when trying to prioritize specific actions.

The wide range of distribution of *T. truncatus*, plus the fact that they spend their entire lives underwater make estimations of the main characteristics of a population difficult (Wilson et al. 1999). The ability to recognize and identify individuals over time through photo identification provides opportunities to estimate abundance, assess immigration or emigration of organisms, females in reproductive status, new births, and to identify the population structure and the carcasses of dead animals. (Bassos-Hull et al. 1994).

Spatial and temporal monitoring to identify population trends on dolphins can be made from a wide range of techniques, including air surveys, on land or in small boats or through the use of telemetry and acoustic instruments (Berrow, 2012).

Generally it is advisable to conduct monitoring over several years to determine populations over all seasons of the year to accurately represent the population dynamics (Grigg and Markowitz, 1997, Campbell et al., 2002, Kerr et. Al 2005; Dick

and Hines, 2011, Fury, 2009). However, this is not always posible due to financial constraints or lack of human resources capable of driving permanent monitoring. There are two posible strategies to address this problem.

On the one hand, low-level monitoring can provide crucial information on the short-term large-scale changes in population abundances of groups of dolphins. With this information one can make timely decisions to determine whether changes are needed in the management programs of Marine Reserves (Bassos-Hull et al. 1994). This type of monitoring has been conducted in Florida (Bassos et al. 1994) from previously identified information on a specific time of year where dolphin's populations use this territory for breeding.

Bottlenose dolphins have long life cycles, generally with low reproductive rates,, therefore to detect trends in population growth it is necessary to conduct extensive monitoring periods (Wells 1991). This type of monitoring allows having a more detailed picture of the behavior of resident and visiting populations, however, the long-term programs monitoring can represent an investment of time and resources and require careful consideration in its operation. This requires having a budget that could cover the costs over the entire sample.

Detecting trends in abundance of a species depends on the power statistics (LaCommare et al. 2012) and an effective monitoring program should generate data that could be statistically analyzed to detect trends. Both the accuracy of population rates as the sampling structure, number of transects, sample rate, number of years sampled affect the ability to detect changes in the abundance of the population. Statistical power, through simulation, is the process used to determine these trends. These simulations can be performed from an individual accumulation curve, the addition of new individuals to the inventory is related to some measure of sampling effort. The higher the effort, the greater the number of species collected (Jiménez-Valverde and Hortal J., 2001).

3.2. Dolphins in Belice

Dolphin populations are not necessarily permanent residents of a particular site. It is possible that some populations have home ranges that cover distances that are outside of the study area. The reuse of the habitat or the return of the organisms, the site fidelity in ecological terms (Greenwood 1980), may occur at different levels depending on whether organisms are resident or semi-resident (Weller and Würsig, 2004). The availability of food resources, individual and group movements and dietary patterns of populations (Shane et al., 1986, Wells et al., 1980) are factors that must be taken into account when estimating the fidelity habitat of a population.

Although this species has been extensively studied worldwide, in Belize there is little research on the population characteristics of Tursiops truncatus. Such research has been conducted in the north of the country mainly in the areas of Turneffe Atolls and Drowned Cayes (Grigg and Markowitz, 1997, Campbell et al., 2002, Kerr et. Al 2005; Dick and Hines, 2011) in periods ranging from two to four years. This monitoring has focused on studying the habitat fidelity, group size and population abundance using transect sampling with small boats to photo identify observed organisms. These studies provide baseline scientific information on dolphin populations closer to PHMR.

Campbell et al. (2002) reported 81 individuals photo identified at Turneffe Atoll in a period of four years. He mentioned 150 samples were needed to identify the 81% (n = 66) of individuals in the area. The rest were photo identified remaining 33 months of the study, indicating that 30% of the photo-identified organisms are residents of this area. Also he reported an abundance of 86 individuals counting the young. Kerr et al. (2005) reported 115 photo-identified individuals in Drowned Cayes located at 16 miles from Turneffe Atoll. They report that it took 90 samples to identify 66% of the population (n = 76). In this case, the authors estimate that 30% of individuals in this region are considered residents and reported an abundance of 122 individuals. The abundances obtained in these studies were obtained from the closed model of Chao (1992) to capture probabilities in variation

with time and individual. Dick and Hines (2011) reported 97 observed individuals and he estimated the abundance of 216 individuals with a density of 0.749 dolphins/km2. For the study of Dick and Hines (2011), they used two methods to estimate abundance: an analysis of conventional and survey distance and a covariate analysis that allows multiple different variables include the distance. Because these two types of models of abundance, their results differ markedly from that proposed by Campbell et al. (2002) and Kerr et al. (2005) (Dick and Hines, 2011).

These investigations concluded that both the area and in Drowned Cayes Turneffe exists a relatively low population and dolphin habitat fidelity is also low so that populations do not use much habitat in this region. This may be due to the low density of prey for dolphins, although it is possible that may be due to factors such as pressure and overexploitation of fishery resources. It could even be that because of this exploitation has taken place for centuries, now can be currently observed ecological collapse of the ecosystem.

Furthermore, they compared the catalogs of photo agencies identified among all studies and there was no recurrence agencies in both areas and at different times of each study, so it can be inferred that they are people who are not permanent residents of the area.

3.3. Use of hábitats of dolphins in Belize

It is reported that in Belize represent certain types of habitat that is a quality habitat for the dolphins so that's where to be found. For example, in the study of Grigg and Markowitz (1997) they found that dolphins were seen more frequently in some areas associated with coral strips surrounding Turneffe where it has been registered that there are large fish biomass near Keys of mangroves. It seems that also can be found in patches of corals where strong tidal movements exist that present opportunities for dolphins to feed (Grigg and Markowitz 1997) so apparently this is a prime habitat for the populations present in Belize (Dudzinski et al., 1995; Hansen, 1990). Also, it is known that sea grass beds and mangrove

coastal areas are important habitats that serve as breeding sites for fish so there is usually a significant amount of biomass available for feeding dolphins (Sedberry & Carter, 1993). He also found that the mullet (Mugil cephalopus), often located as a food of special interest by Tursiops coast are frequently found in small groups in the sandbanks of bays and estuaries during high tides and gather in larger groups when the tide begins to recede so that Tursiops may be found in these areas (Würsig and Würsig, 1979).

3.4. TIDE

The Toledo Institute for Development and the Environment (TIDE) was created in 1997 as a response to illegal fishing and disorganized that developed in the area in the 90s PHMR . This organization is dedicated to the study and monitoring of natural resources in the Toledo District in Belize , assisting in the planning and management programs of Protected Areas , the development of responsible tourism and other economic exploitation activities through training and assistance to local communities (Fernandes and Tide , 2005) . In conjunction with the government of Belize, TIDE manages Paynes Creek National Park and PHMR . In the latter, the organization has developed various projects ranging from management plans, to scientific research projects .

Thus, through these projects and ventures with local and international experts , TIDE maintains a constant monitoring ecological aspects PHMR (Sommer , 2001, Foster, 2009) .

4. Objectives

The overall objective of this research is to establish base line information to systematize and demonstrate the presence of dolphins in the Port Honduras Marine Reserve in order to demonstrate its ecological and conservation importance against a threat of oil exploration. For practical purposes, this main objective can be divided into three sub-objectives:

• Generate a systematic database on Tursiops truncatus populations present in the period from May to October in the Port Honduras Marine Reserve.

• Identify the dolphin groups present and their patterns of residence in the period from May to October in the Port Honduras Marine Reserve.

• Establish a methodology for a long-term monitoring program of dolphin (Tursiops truncatus) based on information needs, budgetary and human resources of the Toledo Institute for Development and the Environment (TIDE).

• Identify and provide recommendations for mitigating the main threats to populations of dolphins in the Port Honduras Marine Reserve associated with oil exploration activities.

5. Methodology

This section presents the study area, the species, the design and sampling methods that were used in this investigation . This method is proposed as the most appropriate methods depending on the arrangement of TIDE's human resources, infrastructure, organizational and economical, so by itself is part of the results and recommendations to follow.

5.1. Study Area

The Marine Reserve of Puerto Honduras (PHMR) covers an area of approximately 414 km2. It stretches from the coast of Snake Cayes in the east to Monkey River in the northern limit to Rio Grande in the southern (Fernandes and TIDE, 2005). The reserve is divided into three main areas: general purpose area: area of conservation and preservation area, occupying 95%, 4% and 1% respectively of the territory (Map 1) (Foster, 2009). It is an inshore coastal environment with high fresh water input resulting from seven major basins where the rivers of Deep River, Golden Stream, Middle River, Monkey River, Punta Ycacos Lagoon and the Rio Grande (Heyman and Kjerfve 1999). Extensive seagrass meadows stretch across the shallow zone of the coast,surrounding an intricate network of ~138 islands covered with mangroves located within the PHMR. Also, thick mangroves border the coastline and estuaries of PHMR. A strip of coral extends offshore near the Snake Cayes, and coral patches and can be found throughout the reserve (Sullivan et al. 1995).

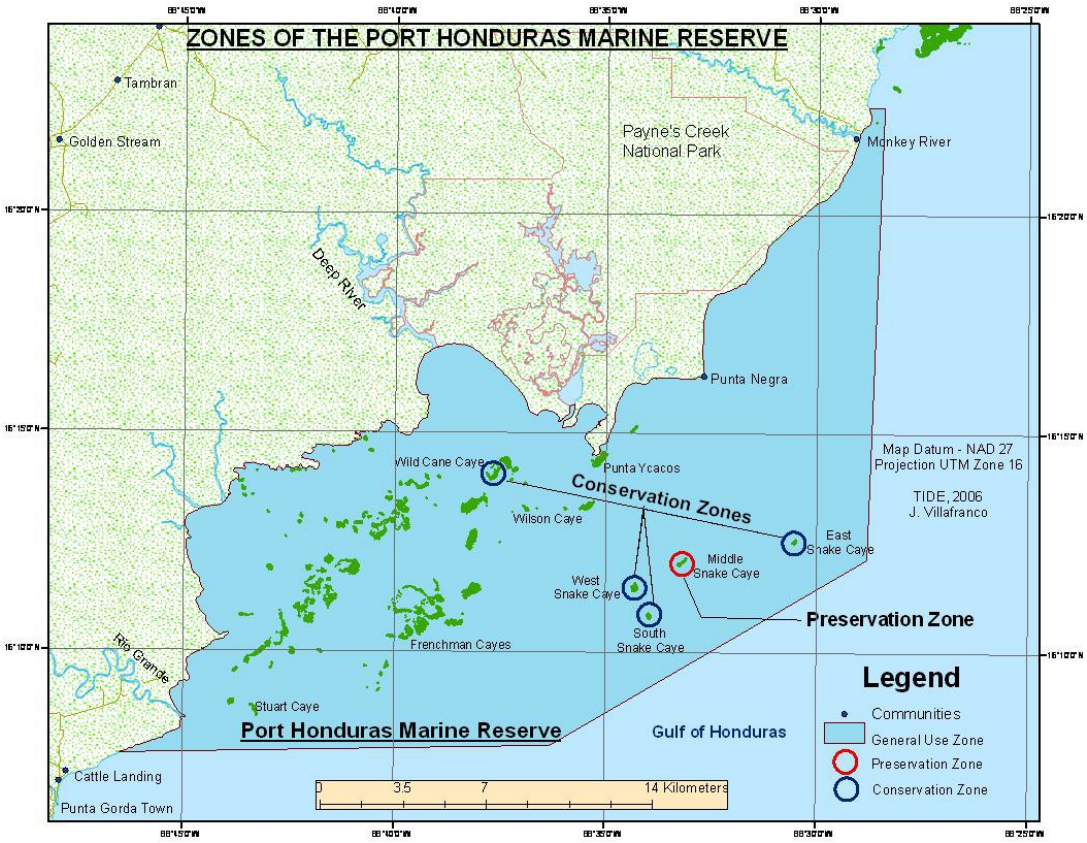
5.2. Study species

Bottlenose dolphins (Turciops truncatus) are cetaceans from the Odontoceti order and are the best known species of the family Delphinidae. They live their entire lives in the sea, they are highly adapted to different environments and are widely distributed in tropical and temperate oceans. They occupy a wide variety of habitats (Leatherwood and Reeves, 1983) absent only in polar regions (Grigg and Markowitz, 1997). They are predators that consume a broad variety of fish, cephalopods, small scratches or sometimes small sharks. Their dietary habits vary

by geographic location (Reynolds III, 2000) and also their feeding behavior and characteristics of each population (Wells & Scott, 1999).

Their social structure is based on long-term social groups. It has been reported that habitat characteristics and activity patterns (ie alimentation vs. socialization) are the main factors that determine the size of the group (Shane et al., 1986). In general, the size of these groups tends to increase in deep water, while in shallower water tend to be smaller with some individuals recorded to have been feeding alone. (Würsig & Würsig, 1979, Scott et al., 1990). The increase in the size of the groups in deeper waters may result from feeding strategies or protection from predators (Shane, et al., 1986). Habitats such as bays or nearshore areas may attract small resident populations or individuals (Wells et al. 1999) as is the case of PHMR. Generally, the size of the coastal groups of dolphins is between 2-15 animals (Shane et al. 1986) and it has been reported that groups of dolphins in the northern region of Belize, are the smallest registered, being on average 3.5 individuals per group observed (Connor et al. 2000).

Map 1. Port Honduras Marine Reserve . Excerpted from TIDE , 2009



5.3. Survey design methods

In the months of June to September 19 exploratory samplings were performed with the help of TIDE rangers. The sampling method was an adaptation and modification of the method of linear transect distances (Buckland et al. , 2011) that consists of traversing the linear transect as an observer scans the area in search of the organisms recording the distances at which each animal is detected. The distance was estimated empirically based on the experience of the rangers, so should be considered an error range of + / - 5m.

The modification of the method is related to the planning and monitoring of routes during the tours, which did not follow a previous planification in order of a rigorous sampling design. Due to the difficulty of having a boat available exclusively for sampling dolphins, we chose to accompany the rangers patrols in the entire reserve. Initially this possibility was discarded because of the opposition betwen

the patrol and the scientific objectives. The objectives of the patrols are to control and monitor illegal fishing within the PHMR so the presence of a researcher on these trips was not empathetic for the patrolling rangers coordinator. However, in mid- June, the coordinator ceded in his position given the backwardness that research showed that time. Later it was possible to access two or three times a week to ranger patrols. His travels are poorly planned and are mandated to travel all the PHMR área. However there is no doubt that these trips represented the best option to spend time at sea as initially planned tours accompany TIDE science team when performing monthly monitoring water quality. These trips were quickly discarded due to the rapidity with which the captain of the boat is moved from one sampling point to another and given the priority value that has the water quality sampling over dolphins sampling.

Sampling was conducted in the period from June 25 to September 7 in a boat of 7.6 m long and with a 100 hp Yamaha engine. Most trips were made in optimal weather conditions for dolphin watching, however, under the premise to exploit all possible trips, two samplings were performed with slightly agitated sea. It was not posible to take the tracks followed in each patrol due to technical problems. Instead, every time the boat changed direction, a georeferenced point was took and then these were converted into a polyline in ArcView GIS 3.4. to have a route as nearly as possible from reality. The patrols were generally made by two person minimum and maximum four who during the course remained alert to any sighting of dolphins. Since the main purpose of travel was patrolling, every time there was a fisherman we approached the vessels to conduct routine patrol activities (data collection of the fisherman, screening of cargo, etc.). In this way the dolphin observamientos were performed only when there wasn't a fisherman in sight, because if this occurred, the patrol had priority even if a dolphin sighting ocurr.

A dolphin sighting was defined as a group of dolphins that were seen moving in the same direction and developing similar activities. Calves were classified as animals that are light colored and measure one third the size of an adult dolphin (Morteo et al. 2004). When a sighting happened, we proceeded to slow boat to come alongside the dolphins and take photographs of their dorsal fins and perform a

counting on group size. Each persono n boat performed a count of individuals observed and eventually we arrived to an estimate of a central value. We attempted to take pictures of both sides of the fins to have a complete profile of the dorsal fin of each individual, however it was not always possible. Efforts were oriented to conduct the vesel parallel to the group of dolphins so to avoid to take pictures against backlight for a clear shot of the dorsal fin. We used a Nikon D3200 camera with a 55-200 mm lens. When the photographer thought he had taken all the photographs or when the rangers decided it was enough, we left the group and went back in the originally direction to continue the patrol.

It was georeferentiated each location where dolphins were observed and some basic environmental data was collected like the sea state at the time, the type of bottom, when possible, the number of individuals observed, the number of calves, time of start and end of the observation and general notes on group behavior .

5.4. Photo-Id catalogue

The photographs that were not focused, that were blurry or in bad angle were discarded to preserve only the photos that came out sharp, with the dorsal fin perpendicular to the plane of the photograph and the fin clear enough to identify the possible marks, spots , wounds, etc. of the dorsal fin. The photo identification was performed with the help of photo editing software Adobe Lightroom 5.0. This software allows to catalog, analyze, compare, and edit pictures in high quality format. Photographic catalog was adapted to the characteristics of the program so that it can be easily accessed.

The cataloging of dolphins was carried out based on a percentage of 95% confidence. This means that for an individual to be scored, the photo in question must be clear enough to show individual features 100 % notable to leave no room for doubt that it is a particular individual. We reviewed intensively each album sighting and proceeded to identify organisms from the profile of each dorsal fin. Contour drawings were made of the dorsal fin with the help of Photoshop CS6 software to have a clear profile of the dorsal fin in a monochrome image. The

identification was made by comparing the photograph of the dorsal fin in question with the catalog of previously identified individuals. If this did not match any pictures of the catalog it was assigned a personal key that contains the name of the organization, the consecutive number within the database, the date of first identification and the specie. Subsequently, a folder with the personnel information that includes the first observation and recaptures, the best photographs of the individual, a profile drawing of the dorsal fin and finally a map showing the location of your sightings in JPG format was generated.

5.5. Sistematization of local knowledge

Two meetings were held with staff of TIDE (park rangers and scientific staff) to incorporate the sightings they have witnessed into the database. For this porpuse they were asked to identified the places they had spotted at least a dolphin within PHMR using Google Earth 7.1 software. Data on the dates and the number of individuals sighted was not accurate so in the map it is just presented the sites of sightings.

5.6. Effectiveness of the survey methods

Una forma de evaluar la efectividad de los programas de monitoreos es a través del uso de “statistical power calculations” (Gerrodette, 1987). Esto puede ayudar a enfocar cuestiones prácticas relacionadas con el enfoque, el tamaño de muestra, la longitud del programa y los recursos requeridos (Taylor and Gerrodette 1993) al identificar los mínimos de muestra requeridos para alcanzar la totalidad de las especies muestreadas, que en este caso serán individuos presentes en la PHMR. Esto se realizará mediante la obtención de la ecuación de Clench en donde las especies serán sustituidas por el número de nuevos organismos identificados. La curva será realizada con el programa EstimateS 9.0 siguiendo la metodología propuesta por Jiménez-Valverde y Hortal (2001).

One way of evaluating the effectiveness of monitoring programs is through the use of "statistical power calculations" (Gerrodette , 1987). This can help focus practical

issues related to the approach, the sample size, the length of the program and the resources required (Taylor and Gerrodette 1993) to identify the minimum sample required to survey all the species, which in this case are the dolphins present in the PHMR. This will be done by obtaining Clench equation where species are replaced by the number of new dolphins identified. The curve will be performed with the program EstimateS 9.0 following the methodology proposed by Jiménez- Valverde and Hortal (2001).

It was also made with th Arc View 3.4 software an iteration analysis between the routes to identify the most visited áreas areas during the samplings.

6. Results

17 surveys were conducted in the period from June 25 to September 7 with an average duration of 2 hours for each sample. All samples were performed in the range from 9:00 am to 16:00 pm. The total number of hours of sampling was 44 hours and 9 minutes, of wich 8 hours with 53 minutes were of direct observation of dolphins (18.37 % of the time). There were 11 events of dolphins sightings (Map 2) from which 8 were made during the course of sampling, 2 were sightings from the TIDE rangers station in Abalone Caye and one was made while conducting foreign research sampling.

During the workshops with the rangers and the scientific crew it were located a total of 45 sightings during patrols monitoring programs conducted monthly by the TIDE scientist staff over a period of one year prior to the investigation. These information is approximate and do not indlude the standard data of this study, ie , it must be regarded as an exercise in systematizing anecdotal information from the presence of dolphins within and outside the PHMR (Map 2).

There were found two diferent species (*Tursiops truncatus* and *Stenella frontalis*) from which it were achieved to photo identified 29 and 24 respectively. The average dolphin per sighting event was 10.27 dolphins. The percentage of calves was for *T. truncatus* 3.4% (n = 1), while for *S. frontalis* was 29.1 % (n = 7). Of the total number of dolphins observed, 37 were recorded only once, ten dolphins in two

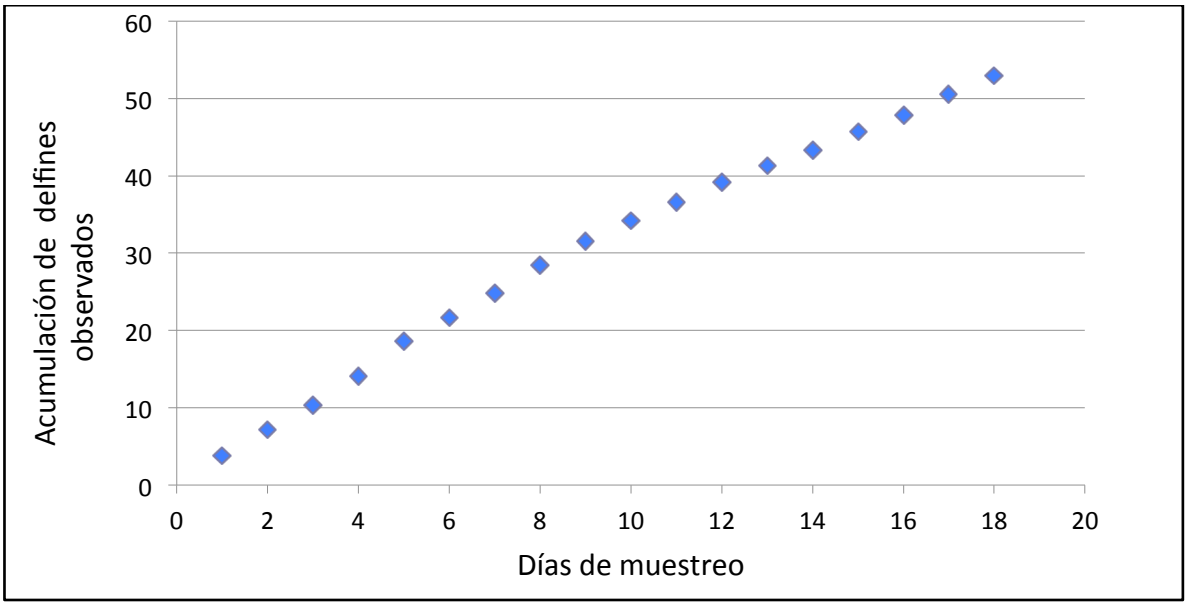
ocasión, three in three ocasion and three on four occasions. From the 6 organisms that were recorded more tan twice, 5 were recorded consecutively in less than a week , and only one was seen three times in a period of a month .

It can be assume that there are at least two distinct groups of dolphins were observed during the sampling period . A group of about 16 individuals of the species *T. truncatus*, and a larger one about 25 individuals of the species *S frontalis.*

In relation to the places the most visited by the routes followed during patrols, the results indicate the percentage of times that the route passed within the PHMR areas (Map 3). The busiest area is the zone 2 with 100% of visits in 17 times, followed by the zone 3 with a 76.4 % equivalent to 13 trips that happened within this area. Zone 4 and 1 were visited the same number of times (11, 64.7 %) and less frequented area is zone 5 with only 6 views equivalent to a percentage of 35.3 %.

Figure 1 shows the results of statistical analysis of the equation performed by the program Clench Estimates. The curve describes the accumulation of new registered dolphins regarding sampling effort that is represented in this case by sampling days. The asymptote of the curve , which is obtained to predict the number of samples required to sample 80 % of dolphins present in the study area could not be estimated due to lack of statistical program " Statistica ". However, from the analysis made with "Estimates" software, it was obtained a value of the total number of dolphins in the study area , which is 148 dolphins.

Figure 1. Accumulation of dolphins in relation to sampling effort.



6.1. Data base

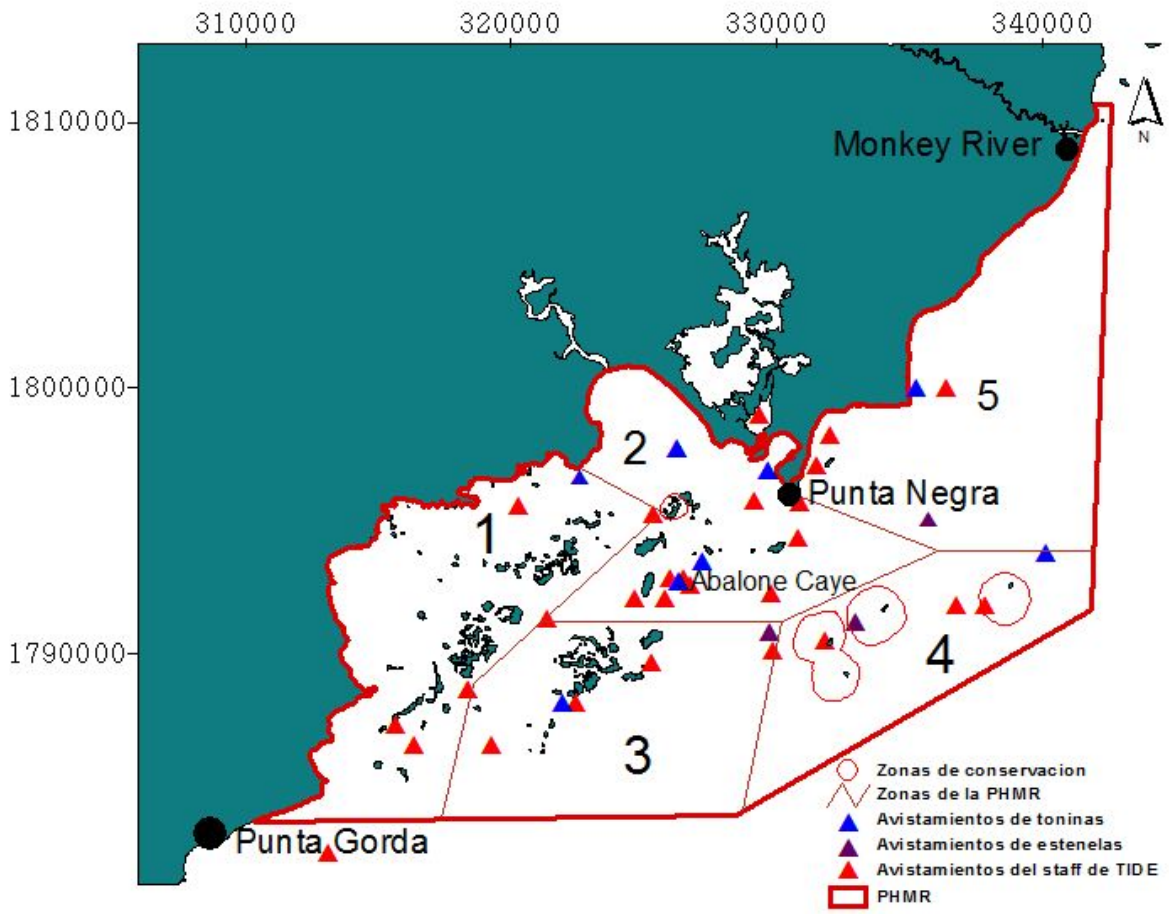
Nine photographic albums were obtained, with an absolute total of 2,324 photographs of which 1,202 were effective and useful for photo identification and they are now part of the new TIDE photographic collection of dolphins. The remaining material was discarded because of its low value for photo identification.

A photographic catalog of dolphins observed in the sampling period was made. It contains the basic information of the first capture and recaptures, a map of where they have been observed, a profile of the dorsal fin and the best photographs used for identification (Appendix 1).

40 "shape" files were generated about the sightings and the routes followed during surveys of dolphins that are now part of the geographic TIDE database of dolphins and it have the characteristic that they can be analyzed and modified using a GIS software.

In addition, all individual information of each individual is, cataloged, organized and stored in digital form for the science team TIDE to dispose of it in future monitoring and analysis outputs.

Map 2. Sightings of dolphins. The blue and purple triangles sightings were made during this investigation. The red triangles are the sightings by park rangers and TIDE scientific team in a period of approximately 1 year.

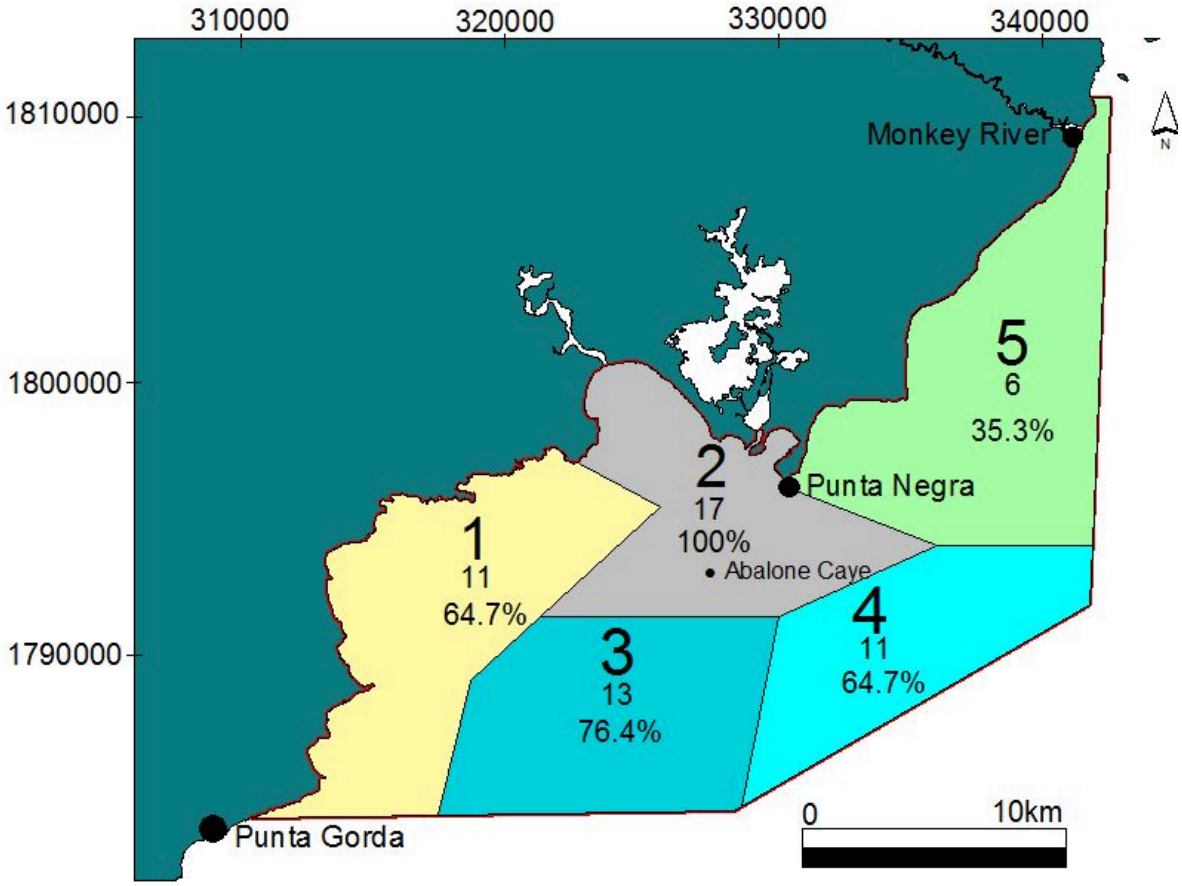


6.1. Training the rangers in the survey methods

During the collection of data for this study worked closely with TIDE Rangers. They were able to observe closely the methodology of taking pictures of dorsal fins throughout the study. Subsequently explained in a brief workshop given to the two Rangers in the personal opinion of the writer of this report, are best suited to

perform this monitoring, the camera operation and the main techniques to take quality pictures and useful for monitoring of dolphins.

Map 3. Frequency of visits to PHMR areas. The value is shown in the number of times that the area was visited and in the percentage of the total number of samples (n = 17).



7. Discusions

7.1. Effectiveness of the technique used.

Photo- identification of organisms was not altered by the fact of not having specific sampling for dolphins. During the trips made with the rangers, there was enough time to take pictures of dolphins fins. Würsig and Jefferson (1990) consider that to photo- identify correctly 80% of the group it is necessary to have at least 3 photos per dolphin and the more photographs are taken, the photo - identification will be

more accurate. This research has an average of 3 photographs per individual so we can asume the groups are well identified.

7.2. Residence

Regarding residence patterns of dolphins little can be said in this research due to the short sampling period (3 months). 69% of the dolphins identified was observed only once, from the 6 individuals that were recorded more than two occasions, 5 were registered consecutively in less than a week and only one was seen three times in a longer period of time, one month. So it is necessary to have more data over time to be able to give a realistic estimate of the residence patterns of groups of dolphins. However, the literature mentions that the coastal variation of *T. truncatus* are usually residents.

7.3. Structure of groups

The low percentage of bottlenose calves may be due to the fact of the peaks are in the spring and fall and the sampling period was in summer. Also there is a possibility that the inhability to identify calves may be due to limited training observers to distinguish adults. Even if they have a singular behaviour and their size is a reference at the time of observation is difficult to make distinctions. The high percentage of calves estenelas, may be because they are easier to identify because they do not have as dense motting as adults and their behavior is extremely curious, approaching the boat repeatedly.

7.4. Distribution

The homogeneity of the distribution of sightings was affected by sampling effort by area and patrol methods. The most affected area was the number five, which was visited 35.3 % of cases. This is reflected in the number of sightings in this area during this study and also in those conducted throughout the year by the TIDE team (n = 6) (Map 2) where the most were in areas of the central área of PHMR (zones 1-4). This occurs because the rangers give more importance to the central

areas because of its importance as source of fishery resources for fishermen and due to illegal activities are more frequent in these areas. Also one of the mandates they have is monitoring of conservation areas, which also are found in the rest of areas .

8. Conclusions and recommendations

The establishment of the necessary background information as a scientific reference for conservation action is only the first step in effective actions that result in the conservation of the target species. The results of this investigation are the first scientific data on dolphins in the PHMR and establishing the base line information for the a monitoring program of dolphins will be routinely operated by TIDE. Once this first objective is reached, Donnovan (2005) says, monitoring needs to be seen as an integral and essential part of management programs. Undoubtedly, the systematized evidence of the presence of dolphins provide the foundation needed to continue this work in the future and to establish specific management programs for the target species and so on provide evidence to support its preservation against a potential threat as oil activities.

It is essential to conceive that continued monitoring will have the necessary ecological data, a prerequisite for testing statistics to highlight patterns in the population of dolphins present in the PHMR. Obviously assertiveness of management programs will depend largely on the continued monitoring over a wide time scale.

The proposed methodology for this research proved to be effective to obtain extremely valuable information which will set the monitoring program. Even taking into account some limitations and methodological weaknesses such as lack of rigor in planning routes, the relatively short duration of each sampling, or the eventual availability of rangers who clearly give priority to patrolling and monitoring dolphins its just sideline activity. This proposal methodology allows TIDE fully capable of

continuing the monitoring of dolphins and also strengthen the database to solve specific environmental problems over dolphins groups.

There is no doubt the robustness of the data is often related to the sampling effort and the variety of techniques used. Nonlinear analysis of the sampling effort demonstrates that there is still much work to be done to sample the total population of the PHMR dolphins. This objective will be achieved through the extension of the monitoring program and either in the analysis or during data collection.

On the other hand, in terms of threats to dolphin populations in PHMR associated with oil exploration, little can be said in this research in specific terms, because in order to assess threats to dolphins is essential first to have scientific evidence of their presence within the protected area and later to have estimates of the possible impacts. It is in this sense that this objective is addressed. By establishing the information base is now possible to have accurate data on the presence of cataloged dolphins to serve as a reference to compare temporal and spatial impacts of oil activities in future research.

These results provide potential for future scientific investigations in collaboration with NGOs and institutions of higher education and research as TIDE or Ecosur.

Also, another aspect that emerges from this research is concerning to the health of groups of PHMR dolphins. Thanks to the technique of photo-identification it was obtain evidence of at least 3 individuals who had some type of skin disease. This gives us an idea of the proportion of sick individuals and thus health status that can be studied in future research.

Finally, from this information an interesating arguing based on scientific facts will be able to positioned TIDE against the imposition of oil companies in PHMR. This lead to a reflection of the impact that this activity may have on groups of cetaceans that inhabit marine ecosystems the PHMR. The matter now rests with TIDE and there is no doubt that the use they will made of this information will be for the conservation of marine mammal groups in southern Belize .

Recomendations

The recommendations are organized in such a way that are divided into 3 main categories: management, infrastructure and future analysis.

Management

- The study can be continued for the PHMR Rangers in collaboration with the scientific team TIDE. For practical purposes it can be divided into two distinct tasks. The field data collection and analysis in cabinet.
- Being permanently in Caye Avalone station (see Map 2) , the rangers have the accessibility that is required to continue monitoring. They know the procedure of taking pictures when its find a pod of dolphins and they use a GPS for all patrols. They are also trained on taking pictures of dorsal fins.
- Once collected the photographs , they can be transferred to the database management during the meetings that are held every Tuesday at the offices of TIDE when the " rangers " change shifts. The photographs can be analyzed by the scientific team of TIDE .
- It is recommended the homogeneity in the patrols taking into consideration those unfrequented areas as zone 5 that was rarely visited.
- However, given recent cuts of human resources in the scientific department of TIDE and the long experience of working with volunteers, it is strongly recommended to seek for a specific volunteer in charge of the monitoring dolphin programe. Ther is no no doubt that the relation with ECOSUR would allow to offer this project to future generations of the master in International Ecology, however it is not guaranteed that students choose to come to Punta Gorda, so seeking for volunteers by other means is a viable and feasible way to continue monitoring.
- It is also recommended that the monitoring program of dolphins be continued by the group of volunteers of the " Ridge to Reef" operated by TIDE that will be released soon .

- It is recommended that volunteers bring their own photographic and computer equipment for the analysis of the photographs and statistical data.

Infraestructure recomendations

- TIDE currently has 1 EO5 DSLR Canon T2i and a tele 55-250mm lens. This equipment might be willing to monitor and given to the rangers or volunteers who would be responsible for use it. However, it availability is due to the different tasks of the communications department so that strainght can arise to dispose team indefinitely. It is recommended that if the equipment is required at all times by the department of communication, purchase a new camera and a tele 50- 300mm lens to take clearer pictures and not depend on communication department .

Recomendations for further analysis

- To analyze the use of habitat and preferred areas for dolphins within the PHMR, it is recommended to follow the methodology of spatial analysis by Wilson et al. (1997). This author proposes an analysis based on a harmonic model generating means isolines around dolphin sightings and thus have an idea of the areas preferred by the groups present in the study area. More information on using isolines to identify areas of interest in dolphins can be found in Simon and Rogan (2002) .
- Also, once ther ir several years of consecutive data, it could be applied ANOVA testings among individuals registered and the PHMR areas to see if there are relationships between them.
- Similarly, it could be use this statistical analysis to see the association between dolphins already identified and their dates of occurrence. This analysis aims to determine individual faithfulness of dolphins in the groups observed .

- To analyze abundance Berrow et al. (2012) used the Mark and CAPTURE software to generate a closed model that incorporates heterogeneity in capture probability based on the Chao's model. Castrillón Posada (2006) made an estimate of abundance from capture - recapture and the generation of a closed model populations. This analysis may be useful to efficiently estimate the size of the population.
- The distance sampling method can also be used to get an estimate of the abundance of organisms. This method can be viewed at Dick and Hines (2011).
- For photographic analysis is recommended Lightroom software training 5 .

9. Bibliography

BALLANCE, L.T. 1990. Residense patterns, group organization, and surfacing associations of bottlenose dolphins in Kino Bay, Gulf of California, p.267-283. En: S. LEATHERWOOD & R.R. REEVES (Eds). The Bottlenose Dolphin. San Diego, Academic Press Inc., 653p.

Barros, N. B. & Odell, D. K. 1990. Food Habits of Bottlenose Dolphins in the Southeastern United States. En: The Bottlenose Dolphin, S. Leatherwood & R.R. Reeves, (eds.) Academic Press, San Diego. pp. 309-328.

Bassos Hull K., Wells R. S., Urian K. W. 1994. Low level monitoring of bottlenose dolphins, (Turciops truncatus), in Charlotte Harbor, Florida.

Berrow S., O'Brien J., Groth L., Foley A. y Voigt K. 2012. Abundance Estimate of Bottlenose Dolphins (Tursiops truncatus) in the Lower River Shannon candidate Special Area of Conservation, Ireland. Aquatic Mammals 2012, 38(2), 136-144.

Bigg, M. (1982) An assessment of killer whale (Orcinus orca) stocks off Vancouver Island, British Columbia. Rep. Int. Whal. Commn.32: 655-666.

Bowen W. D. 1997. Role of marine mammals in aquatic ecosystems. Marine Ecology Progress Series. 158: 267-274. 1997.

Campbell G.S., Bilgre B.A., Defran R. H. 2002. Bottlenose dolphins (*Tursiops truncatus*) in Turneffe Atoll, Belize : occurrence, side fidelity, group size, and abundance. Aquatic Mammals 2002, 28:2, 170-180.

Castrillón Posadas J. 2006. Tesis de licenciatura. Population size of bottlenose dolphins (*T.* truncatus) in Cardigan Bay (special area of conservation) Whales. POTIFICIA UNIVERSIDAD JAVERIANA, FACULTAD DE CIENCIAS. Bogotá, Colombia. 2006. Pp. 49.

Connor, R. C., R. S. Wells, J. Mann, and A. J. Read. 2000. The bottlenose dolphin: social relationships in a fission-fusion society. In Cetacean societies: field studies of dolphins and whales, ed. J. Mann, R. C. Connor, P. L. Tyack, and H. Whitehead, 91-126. Chicago and London: The University of Chicago Press.

Dick, D. M., Hines, E. M. 2011. Using distance sampling techniques to estimate bottlenose dolphins (*Tursiops truncatus*) abundance at Turneffe Atoll, Belize. Marine Mammal Science, 27(3), 606-621

Energy in action. 2010. Two dimensional (2D) seismic survey. Fact sheet. Disponible en : http://www.agk.com.au/hunter/assets/pdf/AGL-Hunter-2D-Seismic-Fact-Sheet.pdf. Consultado el 21 de marzo de 2013.

Fury, CA 2009, 'Abundance, behaviour and habitat use patterns of Indo-Pacific bottlenose dolphins (Tursiops aduncus) in the Clarence and Richmond River estuaries in northern New South Wales, Australia', PhD thesis, Southern Cross University, Lismore, NSW. Copyright CA Fury 2008

Gordon J. Gillespie D., Potter J., Frantzis A., Simmonds M., Swift R., Thompson D. 2001. A review of the effects of Seismic Surveys on Marine Mammals. Marine Technology Society Journal. 2001, **37**. 16-34.

Grigg E., Markowitz H. 1997. Habitat use by bottlenose dolphins (Tursiops truncatus) at Turneffe Atoll, Belize. *Aquatic Mammals* 1997, **23.3,** 163-170

Hammond, P.S. 1986. Estimating the size of naturally marked whale populations using capture-recapture techniques. Rep. Int. Whal. Commn. (Special Issue 8): 253-282.

Harzen, S. 1995. Behaviour and social ecology of the bottlenose dolphin, *Tursiops truncatus*, in the Sado Estuary, Portugal. Ph.D. thesis, University of Bielefeld, Germany.

IUCN 2012. IUCN Red List of Threatened Species. Version 2012.2. <www.iucnredlist.org>. Descargado el 24 de Marzo de 2013.

Jiménez-Valverde y Hortal J., 2001. Las curvas de acumulación de especies y la necesidad de evaluar la calidad de los inventarios biológicos. Revista Ibérica de Aracnología. Vol 8. 151-161.

Kerr, K. A., Defran, R. H., Campbell, G.S., 2005. Bottlenose dolphins (Tursiops truncatus) in the Drowned Cayes, Belize: Group size, site fidelity and abundance. Caribbean journal of science, 41(1), 172-177.

LaCommare, K. S., S. Brault, C. Self-−Sullivan, and E. M. Hines. 2012. Trend detection in a boat-−based method for monitoring sirenians: Antillean manatee case study. Biological Conservation 152:169-−177

Leatherwood, S., and R. R. Reeves. 1983. The Sierra Club handbookof whales and dolphins. Sierra Club Books, San Francisco, California, USA.

Lockyer, C.H. and Morris, R.J. 1990. Some observations on wound healing and persistence of scars in Tursiops truncatus. Rept. Int. Whal. Commn. (Special Issue 12): 113-118.

Morteo E., Heckel G., Defran R. H., Schramm. Distribución, movimientos y tamaño de grupo del tursión (Tursiops truncatus) al sur de Bahía San Quintín, Baja California, México. Ciencias Marinas (2004), 30(1A): 35–46

Providence Energy Group 2013. Large block garanted in south Belize. Disponible en: http://providenceenergygroup.com/featured-1/. Consultado el 24 de marzo de 2013

Reynolds J. E., Wells R. S., Eide S. D. 2000. The Bottlenose Dolphin. Biology and Conservation. University Press of Florida. Estados Unidos. Pp. 105.

Rossbach, K. A., and D. L. Herzing. 1999. Inshore and offshore bottlenose dolphin (*Tursiops truncatus*) communities distinguished by association patterns near Grand Bahamas Island, Bahamas. *Can. J. Zoo- log.* 77:581-592.

Shane, S. H., Wells, R. S. & Würsig, B. (1986) Ecology, behavior, and social organization of the bottlenose dolphin: a review. *Marine Mammal Science* **2**(1), 34–63.

Simon N. Ingram, Emer Rogan 2001. Identifying critical areas and habitat preferences of bottlenose dolphins Tursiops truncatus. Marine Ecology Progress Series. Vol. 244: 247-255.

Sirenian International 2012. Manatees and dolphins in Belize. Disponible en : http://www.kintera.org/atf/cf/%7BBD9A05BF-0860-451E-AA86-7FBF37574C00%7D/selfsullivan_briefing.pdf. Consultado el 24 de marzo de 2013.

Shane, S. 1990a. Behavior and ecology of the bottlenose dolphin at Sanibel Island,

Florida. In The bottlenose dolphin. Edited by S. Leatherwood and R.R. Reeves. Academic Press, San Diego. pp. 245–265.

Slooten, E., Dawson, S.M. and Whitehead, H. 1993. Associations among photographically identified Hector's dolphins. Can. J. Zool. 71: 2311-2318.

Sociedad Española de Cetáceos (SEC) 2007. Monitoring Plan for the bottlenose dolphin (Tursiops truncatus) in Andalucía and Murcia. "Conservation Plan for the bottlenose dolphin (Tursiops truncatus) in Andalucía and Murcia". First phase 2007 -2010

Taylor, B.L., & Gerrodette, T., 1993. The uses of statistical power in conservation biology – the vaquita and northern spotted owl. Conservation Biology, 7:489-500.

Verme V. y Iannacone, J. 2011. Catálogo de foto-identificación del Delfín Naríz de Botella (Tursiops Truncatus) en las Islas Canarias, España: una línea de base de información para su conservación. Biologist, ene./jun. 2011, vol.9, no.1, p.105-119. ISSN 1994-9073

Weller, D.W., & Würsig, B. 2004. Bottlenose dolphins of Aransas Pass, Texas: annual and seasonal patterns of occurrence, site fidelity, and behavior. U.S. Fish. Bull. In press.

Wells, R.S., & Scott, M.D. 1999. Bottlenose dolphin – Tursiops truncatus (Montagu, 1821) In: Handbook of Marine Mammals (Ridgway S.H., & Harrison S.R., eds.) Vol. 6: The second book of dolphins and porpoises. pp. 137-182.

Wilson B., Thompson P.M., Hammond P.S. (1997) Habitat use by bottlenose dolphins : seasonal distribution and stratified movements patterns in the Maray Firth, Scotland. Journal of Applied Ecology. **34** 1365 : 1374

Wilson B., Hammond Philip S., Thompson Paul M. 1999. Estimating Size and Assessing Trends in a Coastal Bottlenose Dolphin Population. Ecological Applications, Vol. 9, No. 1 (Feb., 1999), pp. 288-300

WÜRSIG, B. & M. WÜRSIG. 1977. The photographic determination of group size, composition, and stability of coastal porpoises (Tursiops truncatus). Science 198: 755.