CONVENTION ON INTERNATIONAL TRADE IN ENDANGERED SPECIES
OF WILD FAUNA AND FLORA

_____

Twenty-fifth meeting of the Animals Committee
Geneva (Switzerland), 18-22 July 2011

Solomon Islands Dolphin Project

PROGRESS REPORT ON DATA COLLECTION AND ANALYSES

The attached information document has been submitted by the Secretariat at the request of the IUCN/SSC Cetacean Specialist Group in relation to agenda item 9.5.*

* *The geographical designations employed in this document do not imply the expression of any opinion whatsoever on the part of the CITES Secretariat or the United Nations Environment Programme concerning the legal status of any country, territory, or area, or concerning the delimitation of its frontiers or boundaries. The responsibility for the contents of the document rests exclusively with its author.*

Solomon Islands Dolphin Project

_____

Progress report on data collection and analyses

M. Oremus, Principal Investigator
with J. Leqata, J. Hurutarau, S. Taei, M. Donoghue, K. Thompson, and C.S. Baker

Revised Draft: 24 June, 2011
[originally submitted on April 2011]

EXECUTIVE SUMMARY

- In 2009, a MoU was developed and a collaborative project was initiated between the South Pacific Whale Research Consortium, the Solomon Islands Ministry of Fisheries and Marine Resources and the Solomon Islands Ministry of Environment, Climate Change, Disaster Management and Meteorology with the aim of providing scientific advice to help in management decisions involving the removal of dolphins from wild populations (captive trade and traditional take) in Solomon Islands.
- This project was developed specifically to investigate conservation issues related to the live-capture of Indo-Pacific bottlenose dolphins and the traditional drive-hunt of small cetaceans combining demographic and molecular tools.
- Thanks to support from the MFMR, MECDM and the Pew Environment Group (PEG), small boat surveys were conducted in November 2009 and November 2010, with a total research effort of 2442 nautical miles in the area of Guadalcanal, Florida Islands, Santa Isabel and Malaita.
- A total of 82 groups of marine mammals, representing nine different species were encountered during these surveys. Biopsy samples were collected from 64 individuals of five species for the purposes of genetic analysis.
- Photographs were obtained from most encountered groups and a particular effort was made to document groups of *T. aduncus* (28 groups were photographed). Dolphin exporters were also approached to collect skin samples and photographs from captive dolphins.
- To identify species taken in traditional drive-hunts, dolphin teeth were collected from local markets, shops and communities (n = 242).
- Photographs of *T. aduncus* identified 184 unique individuals in the wild. Nine individuals were re-sighted within the same year while 23 individuals were first sighted in 2009 and re-sighted in 2010. All resighting were within one of the study sites indicating some degree of site fidelity and suggesting a potential demographic closure between the study sites.
- High rates of between-years resighting is suggestive of small population sizes but further analyses are needed before drawing conclusions.
- None of the captive dolphins released between the two surveys were found among the photographs collected in the wild in November 2010, and therefore the fate of these animals is unknown.
- Preliminary genetic analysis provided molecular species identification, sexing and information on mitochondrial diversity.
- A third field survey is planned in July 2011 which should assist in the collection of sufficient data to answer initial research questions developed for the project.
- Further funding is urgently required to insure the completion of data analyses and report writing. This needs to include funding for visits to museums known to house historical samples from traditional drive hunts.

INTRODUCTION

Top predators such as marine mammals have a fundamental influence on the biological structure and function of marine communities (Heithaus et al. 2008). In the South Pacific, these species also play an important cultural role. The consequences of their removal by hunting or incidental mortality can vary, but an increasing number of studies show evidence of large-scale deleterious cascading effects (e.g., Myers et al. 2007). It is therefore critical for marine ecosystems to assess and ensure the sustainability of any kind of top predator removals through by-catch, direct kill or live-capture.

The Solomon Islands have a long history of hunting dolphins by driving groups ashore (Dawbin 1966, Takekawa 1996). Several villages, especially on the island of Malaita, have been engaged in traditional drive-hunts for several decades or longer. The hunt provides teeth, which are used as bride price, traditional currency, and adornments, and meat, which is consumed or sold locally. The cultural significance of the hunt is widely recognized and the traditional methods changed little over time. However, there are various reasons to be concerned for the conservation status of dolphin populations in the area. First, the species and numbers taken are poorly documented, but may involve several hundred small individuals a year (Takekawa 1996, Kahn 2006). These appear to be mainly spotted and spinner dolphins. Second, the dynamics of the hunt seem to have varied dramatically through time, with a marked increase in the scale of the hunt in the 60's. This is thought to have resulted in the local disappearance of the melon-headed whale, *Peponocephala electra,* the teeth of which were the most highly-prized (Dawbin 1966, Takekawa 1996).

The need for biological assessment of the drive kill has long been recognised (Dawbin 1966, Reeves et al. 1999) but curiously, little attention has been given to marine mammal conservation management in the Solomon Islands, until recently. This changed in 2003, with the live capture of dolphins, which were then held locally in captivity for the purpose of being sold and exported overseas for public display. This new enterprise received large media coverage followed by numerous critisisms from activists, environmental agencies and foreigh governments. Concern has also been expressed by major intergovernmental groups, including CITES the CMS and IUCN, about the potential conservation implications of dolphin removals in the Solomon Islands (Reeves & Brownell Jr. 2009). An assessment of dolphin removals has also been recognized as a priority under the SPREP (South Pacific Regional Environment Program) Whale and Dolphin Action Plan 2008-2012 and the CMS Pacific Cetacean MoU. Yet, political comments and international agreements have failed to find a solution to these problems (Parsons et al. 2010) and therefore, an independent scientific project appears to be the only way to overcome the relative *statu quo* surrounding the use and associated conservation and management issues for dolphin populations in the Solomon Islands.

The Government of Solomon Islands currently permits up to 40 dolphins to be exported per year for display purposes. So far, exports have only involved *Tursiops aduncus*. The current state of knowledge of Indo-Pacific bottlenose dolphins throughout their range suggests that this level of removal is unlikely to be sustainable (Reeves & Brownell Jr. 2009). Furthermore, there is still no regulation or monitoring program for the traditional drive-hunt in Solomon Islands. The implementation of scientific studies to identify and assess the population status of the targeted species is thus long overdue.

In response to these two urgent conservation issues (live-capture and traditional drive-hunt), a scientific program was initiated in 2009 by the South Pacific Whale Research Consortium (SPWRC), in collaboration with the Solomon Islands' Ministry of Fisheries and Marine Resources (MFMR) and Ministry of Environment, Climate Change, Disaster Management and Meteorology (MECDM). The main objectives of this project are:

1. To gain an improved understanding of the population status and dynamics of Indo-Pacific bottlenose dolphins (*Tursiops aduncus*) in the Solomon Islands and to contribute to a robust science-based assessment of the sustainability of current authorised levels of live-capture removal;
2. To determine the species of dolphins taken by traditional drive-hunts in the Solomon Islands and to investigate the population status of these species using molecular tools; and
3. To provide, through objectives 1 and 2, the Government of Solomon Islands with scientific advice, based on robust data, to help in management decisions involving the removal of dolphins from their wild populations.

Here, we report on the progress of this research program, describing the activities completed to date, the research effort, as well as some preliminary data analyses. Finally, we describe the future work to be carried in order to complete the project.

BACKGROUND of the PROJECT

In August 2008, a workshop held in Samoa by IUCN focused on the status and potential implications of *T. aduncus* removals from wild populations (Solomon Islands was a study case). This workshop was attented by dolphin experts from around the world, including four representatives from South Pacific Whale Research Consortium (M. Oremus, C. Garrigue, S. Taei and S. Childerhouse). Discussions focused on the status of *T. aduncus* populations and on how to conduct a research program that could provide decision makers with the robust data needed to help in management decisions involving the removal of dolphins from wild

populations. This workshop provided the opportunity to initiate communication between the SPWRC and representatives of the Solomon Islands Government. Following this initial contact, the Solomon Island Government was invited to attend the next SPWRC annual meeting in February 2009 to further discuss dolphin removal issues and potential for collaborative effort that could take advantage of the SPWRC expertise in the assessment of cetacean populations' status. This has resulted in the joint development of a research proposal between the SPWRC and the Government of Solomon Islands. This proposal has been based on recommendations made at the population assessment workshop organised by IUCN in August 2008 (Reeves and Brownell 2008).

In May 2009, a National Dolphin Technical Committee (NDTC) was formed by the Solomon Islands government to ensure the finalisation and endorsement of a National Dolphin Management Plan of the Solomon Islands. The Committee is composed of relevant government agencies and NGOs. One of the key objectives of the committee is to oversee the development and implementation of biological surveys to investigate the status of dolphin populations in the waters of Solomon Islands. In June 2009, a researcher from the SPWRC (M. Oremus) travelled to the Solomon Islands to meet decision makers and to further discuss the research proposal written in February 2009 and the feasibility of such biological surveys. This resulted on the development of a Memorandum of Understanding (MoU) with the objective of collecting robust scientific data to inform management decisions involving the conservation of dolphins in the Solomon Islands and, in particular, the impact of removals from their wild populations. The MoU was completed in November 2009 and signed in February 2010 by the SPWRC, the Solomon Islands MFMR and the Solomon Islands MECDM. The first biological surveys started in November 2009. A second survey was conducted in November 2010. One researcher (M. Oremus) from the SPWRC has led the surveys and work in direct collaboration with officers from the MFMR and MECDM. At least one more survey will be conducted in July 2011 with the objective on completing a final report by the end of the year, as stated in the MoU.

The surveys undertaken so far were conducted thanks to financial support from the Solomon Islands MFMR (research vessel and 2009 survey), the Solomon Islands MECDM (2010 survey) and the Pew Environment Group (SPWRC expenses and preliminary data analyses).

Dolphin holding facilities

The two dolphin facilities active in 2009 were visited during the surveys. At Honiara facility, 19 dolphins, all *T. aduncus* , were held in captivity in November 2009 (Figure 1). We were told that all of the dolphins were captured on the north coast of Guadalcanal, nearby Honiara. Two of the 19 dolphins had more captive training than the others and these were supposed to be exported very soon to the Philippines. The facility at Gavutu Island was also visited in November 2009 (Figure 1), where there were 27 *T. aduncus* held in captivity, with

different level of training. Seven dolphins were supposed to be exported soon, jointly with the two dolphins from Honiara's facility. Here again, we were told that all the dolphins in Gavutu were captured along the coast of Guadalcanal and then brought by boat at Gavutu. A trainer told us about an attempt years ago to keep and train some pantropical spotted dolphins, *Stenella attenuata*, captured around Malaita by local fishermen involved in drive-hunting. This attempt was not successful and many dolphins died during the experiment.

Figure 1: Solomon Islands dolphin holding facilities in Honiara, Guadalcanal (top) and Gavutu, Florida Islands (bottom).

In November 2010, a further visit to the Honiara facility was conducted. Only eight dolphins were left, including six males and two females, according to the trainer. Apparently, three dolphins were exported in December 2009. The owner told us that around July 2010, he started releasing some dolphins two by two, simply by opening their pens to the ocean. Although the reasons given were unclear, it seems that keeping all the dolphins in captivity was too expensive considering the uncertainty in selling them overseas. Considering that 19 dolphins were in the facility in November 2009 and that three of them were exported in December 2009, it seems a minimum of 8 dolphins must have been released. Between November 2009 and November 2010, the facility at Honiara was re-built, with the

construction of a sea wall to secure the pens (work was not finished in November 2010). The effects of noise disturbance on the dolphins due to the construction work are unknown.

We also went back to Gavutu in November 2010 but the facility was then closed with no dolphins in the pens. A security guard on site told us that 7 dolphins were exported in December 2009 (along with the three dolphins from Honiara facility). The business was later closed for unknown reason. We were told that the dolphins were released simply by opening the pens in Gavutu. The security guard told us that three dolphins died in the process of being released. These were buried somewhere on Gavutu island. Therefore, as many as 17 dolphins previously held in captivity at Gavutu Island could have been released in the waters of the Florida Islands.

During November 2010, we also tried to visit new facilities belonging to a third entrepreneur and located near Gavutu, Florida Islands. Unfortunately, we were not granted access. We later met the entrepreneur in Honiara, who told us that there were currently no dolphins held in this facility but that he was planning on having some dolphins captured on the coast of Malaita within the next year. According to entrepreneur, the future captures are not meant to be exported but used for local display and breeding program.

METHODS

Study area and boat surveys

Two series of small-boat surveys (n = 39) were conducted, the first in November 2009 (n = 19) and the second in November 2010 (n = 20). The research vessel (6m) was purchased by the MFMR specifically for this project (Figure 3). In order to answer our research questions, it was decided that the effort will primarily focus on four main islands or group of islands of the eastern part of Solomon Islands: Santa Isabel, Malaita, Guadalcanal and the Florida Islands (Figure 2). The choice for this area was made on the basis that most dolphin removals, past and present, happened around or near these islands. Indeed, captures of *T. aduncus* were primarily made on the North Coast of Guadalcanal and possibly around Malaita, while traditional drive-hunt occur exclusively around Malaita (although it also occurred around the island of Makira in the past). Effort was mainly concentrated in coastal habitat, looking for *T. aduncus*. Here, coastal habitat is arbitrarily defined as the stretch of water extending from the coastline to 1NM offshore. Substantial search effort was also made offshore, including multiple crossing between islands.

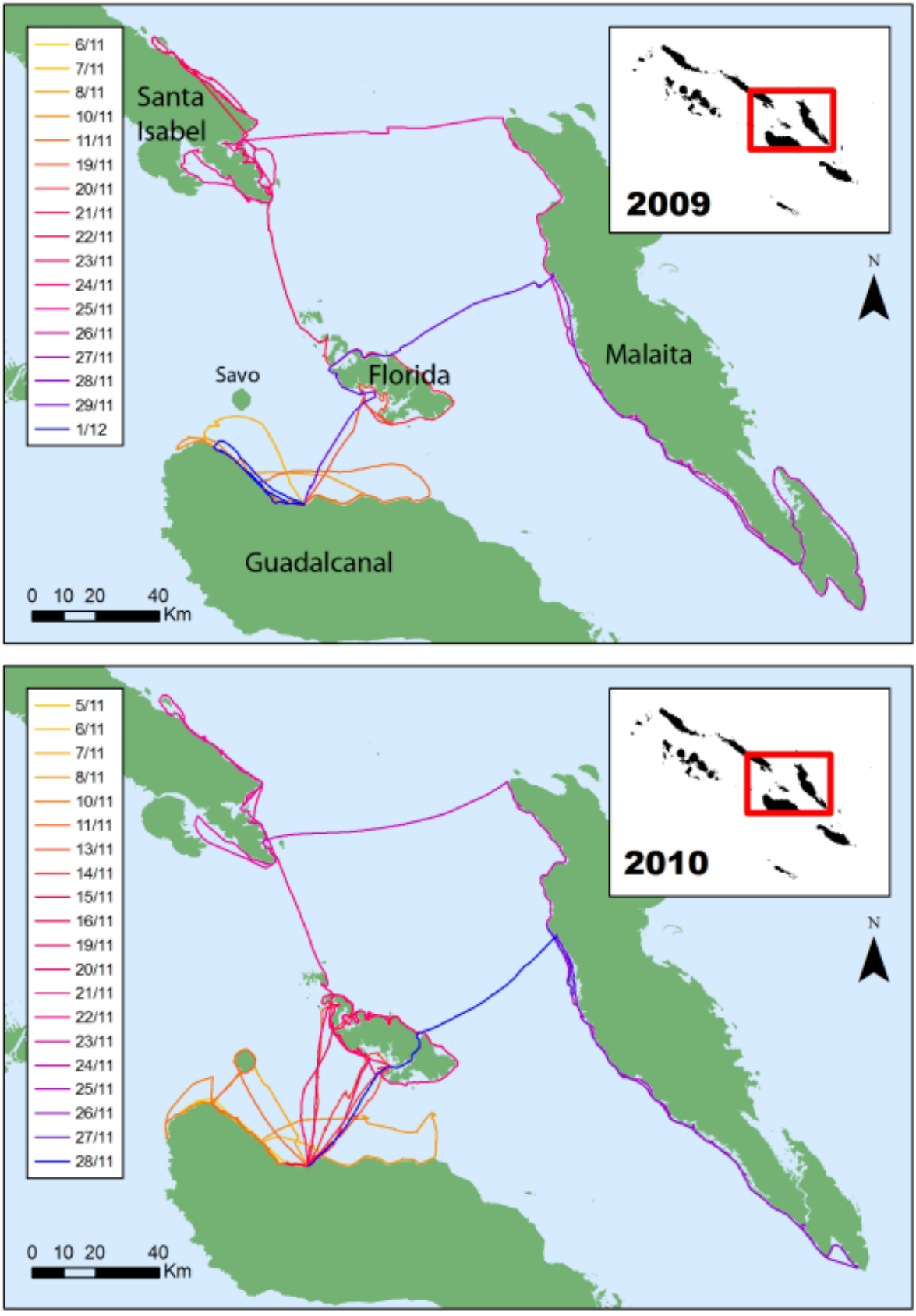


Figure 2: Surveyed area and research effort to date

Figure 3: Research vessel for dolphin surveys in Solomon Islands

In this study, a "group" is defined as a spatial aggregation of animals that appears to be involved in a similar activity (e.g., foraging, socialising, resting or travelling, Shane et al. 1986). During each encounter with a marine mammal group (cetacean or dugong), the species was identified visually, GPS positions was recorded, group size was estimated by visual counts and general behaviour was noted. Group encounter rate was calculated for the most frequently sighted species (*Tursiops aduncus* and *Stenella longirostris*). It was estimated as the number of groups encountered for every 100NM of effort. When possible, photographs and/or biopsy samples were taken to confirm species identify. For dolphins, *T. aduncus* in particular, dorsal fin photographs were taken of as many individuals as possible using a digital SLR camera equipped with a 300 mm lens.

Figure 4: Paxarms biopsy system

The Paxarms system© was employed to collect biopsy samples (Krützen et al. 2002). It uses a small biopsy dart fired from a modified 22-caliber veterinary rifle equipped with a variable pressure valve (Figure 4). This system was especially developed to assure minimal impact on small cetaceans. Biopsies were only collected on individuals presumed to be mature. Samples were preserved in 70% ethanol and stored at -20°C for subsequent analyses.

Market surveys and captive dolphins

In addition to the data collected during boat surveys, local markets, shops and communities were visited to purchase dolphin teeth from the traditional drive-hunt. The teeth were bought loose or on jewelleries, including hearings, necklaces and headbands (Figure 5).

Figure 5: Earrings made of dolphin teeth for sale in an hotel of Honiara, Solomon Islands

Contact was also initiated with the dolphin exporters holding *T. aduncus* in captivity in their facilities at Honiara (Guadalcanal) and Gavutu (Florida Islands). On request, they agreed to provide skin-swabbing samples from their captive dolphins. Equipment, including 5mL tubes filled with 70% ethanol and sterilized nylon scrub pads, was provided for the trainers to collect the samples. Unfortunately, it was not possible to attend and supervise the sampling and most samples turned out to be of poor quality for genetic analyses.

Figure 6: Typical posture of captive Indo-Pacific bottlenose dolphins at Gavutu holding facility

Photographs of dorsal fins were also taken from as many captive dolphins as possible. Not all the dolphins could be photographed as many individuals stay still at the surface with the top of their head out of water and never showing their dorsal fin (Figure 6). Otherwise, the

methods were similar to the photographs taken in the wild (see below). These were taken to compare dolphins within the same facility between two years, but also to compare captive and wild dolphins to detect new captures or potential releases.

T.aduncus *photographs analyses*

Individuals within each group were identified using notches on the dorsal fin, shape of the dorsal fin, scarring and skin pigmentation. For every individual within each group, the best left- and right-side photographs were selected and graded for quality using five parameters: focus, size of the dorsal fin on the image, exposure, orientation and percentage visible. For each criterion, the photographs were assigned a grade from 1 (bad) to 5 (excellent). The final quality score of each dorsal fin was calculated as the average grade over the five criteria (Oremus 2008). Each individual was given a distinctiveness rating, based on marks on the dorsal fin visible from either left- or right-side. Rating was as followed: (1) not distinctive, (2) slightly distinctive, (3) distinctive, and (4) very distinctive.

Every individual showing distinctive marks (rated (2) to (4)) were compared to each other, searching for re-sightings. A catalogue of unique individuals was created and re-sighting events were classified as “within” or “between” islands and “within” or “between” years. In complement to group encounter rates, we provide relative abundance indices (RAI) for *T. aduncus*, estimated in terms of number of dolphins photographically identified per 100nm of coastal effort. Indices are given in order to compare relative abundance between 2009 and 2010 but also to compare relative abundance between study sites.

Genetic analyses

Total DNA was isolated from the 2009 biopsy samples as well as from the *T. aduncus* skin samples available (including skin swabbing from exporters) by digestion with proteinase K followed by a standard phenol: chloroform extraction method (Sambrook et al. 1989) as modified for small samples by Baker et al. (1994). A fragment of the 5’ end of the mtDNA control region (d-loop) was amplified via PCR using the primers light-strand, tPro-whale M13-Dlp-1.5 (5'-TCACCCAAAGCTGRATTCTA-3', Dalebout et al. 1998), and heavy strand, Dlp-8G (5'-GGAGTACTATGTCCTGTAACCA-3', designed by G. Lento as reported in Dalebout et al. 2005). PCR reactions and sequencing were conducted as reported in Oremus et al. (2007). Sex of DNA samples was identified by co-amplification of the male-specific *sry* gene and the ZFX positive control gene, as described by Gilson et al. (1998). These analyses were conducted at the School of Biological Sciences, University of Auckland.

Mitochondrial control region sequences were aligned using the program *Geneious* (Drummond et al. 2009) and edited manually. Variable sites and unique haplotypes were identified and confirmed by visual inspection of peak heights with *Geneious*. For *T. aduncus*

samples, the software *Arlequin* was used to estimate standard indices of genetic variation, i.e., nucleotide diversity, π, and haplotype diversity, *h*. Finally, sequences of the mitochondrial (mt) DNA from all biopsy samples were used to confirm species identity using the web-based program DNA-Surveillance (Ross et al. 2003).

RESULTS

A total of 39 small-boat surveys were conducted across the study area, in November 2009 (n = 19) and November 2010 (n = 20). Effort was similar between the two series of surveys, representing a total of 2442 nm covered, including 1707nm of coastal effort and 735nm of offshore effort (Table 1). The same areas were covered in 2009 and 2010 (Figure 2), with the inclusion of the island of Savo during the 2010 surveys (included in the Guadalcanal surveys). Furthermore, effort on the coast of Florida Islands was substantially increased in 2010 (Table 1). The largest effort was employed on the northern coast of Guadalcanal where captures of *T. aduncus* have been reported. Overall, weather conditions were good for the two surveys. Daily expeditions were only undertaken at Beaufort Sea State (BSS) less than four. Search effort was resumed when BSS reached four but this occurred only rarely.

Table 1: Summary of research effort and group encounter with marine mammals in Solomon Islands

SITE	# surveys		Coastal effort (NM)			# grp cetaceans	
	2009	2010	all	2009	2010	2009	2010
Guadalcanal	7	7	449	189	260	15	18
Florida Islands	3	5	384	116	268	6	16
Santa Isabel	5	4	388	207	181	10	5
Malaita	4	4	486	251	235	8	3
Total	19	20	1707	763	944	39	42

Over the two years, a total of 82 groups of marine mammals were encountered (Figure 7). These were represented by 9 different species, including 8 cetacean species and one sirenian species (Table 2). Two species were encountered much more frequently than the others: *S. longirostris* (n = 35) and *T. aduncus* (n = 30). The third most commonly encountered species was the pantropical spotted dolphin, *Stenella attenuata*, with four encounters. *S. longirostris* and *T. aduncus* were almost exclusively encountered in coastal habitat (less than 1nm from coastline). Other cetacean species were typically encountered more offshore with the exception of a baleen whale species, *Balenoptera sp.*, which was observed close to the coast on three occasions. Although the species was not conclusively identified, total estimated length (ranging from 6 to 10m), and photographs of the rostrum and back of the animals suggest that these were Omura's whales (*Balenoptera omurai*). No obvious ridges were seen

on the rostrum of the animals (Figure 8). On the 14th of November 2010, two of these whales were seen feeding within the Sandfly passage at Florida Islands. Dugongs were encountered at Guadalcanal and Florida Islands; they were close to the coast as expect for this species, which depends on seagrass and thus, shallow habitats.

Table 2: List of marine mammals encountered in Solomon Islands in November 2009 and November 2010, including number of groups and biopsy and average group size.

Latin name	Common name	Order	Sub-Order	# grp encountered		# biopsies	Average grp size
				2009	2010		
Dugong dugon	Dugong	Sirenian	-	0	3	0	1
Balenoptera sp.	-	Cetacean	Mysticete	1	2	0	1-2
Globicephala macrorhynchus	Short-finned pilot whale	Cetacean	Odontocete	2	1	3	30-40
Grampus griseus	Risso's dolphin	Cetacean	Odontocete	1	1	0	2-5
Pseudorca crassidens	False killer whale	Cetacean	Odontocete	0	1	0	8-10
Stenella attenuata	Pantropical spotted dolphin	Cetacean	Odontocete	1	3	19	75-100
Stenella longirostris	Spinner dolphin	Cetacean	Odontocete	17	18	34	50-75
Tursiops aduncus	Indo-Pacific bottlenose dolphin	Cetacean	Odontocete	14	16	1	7-9
Tursiops truncatus	Common bottlenose dolphin	Cetacean	Odontocete	2	0	7	50-70

Average group size was the largest for *S. longirostris* and *S. attenuata* (Table 2). *T. aduncus* were found in smaller group sizes, ranging from 1 to 30 individuals. Mixed species sighting included *S. longirostris* with *T. aduncus* and short-finned pilot whales, *Globicephala macrorhynchus,* with common bottlenose dolphin, *Tursiops truncatus*. In November 2009 at Guadalcanal, we observed a juvenile *S. longirostris* swimming with a *T. aduncus* on two instances, one day apart (Figure 8). On both encounters, the juvenile was the only *S. longirostris* in the group and on both encounters it was seen swimming with the same *T. aduncus*, as shown by distinctive marks on its dorsal fin. This particular *T. aduncus* was seen again in November 2010, with another counterpart of the same species but mixed with a larger group of *S. longirostris*. The juvenile *S. longirostris* observed in November 2009 showed no distinctive marks and therefore, it is unknown if it was present again in November 2010.

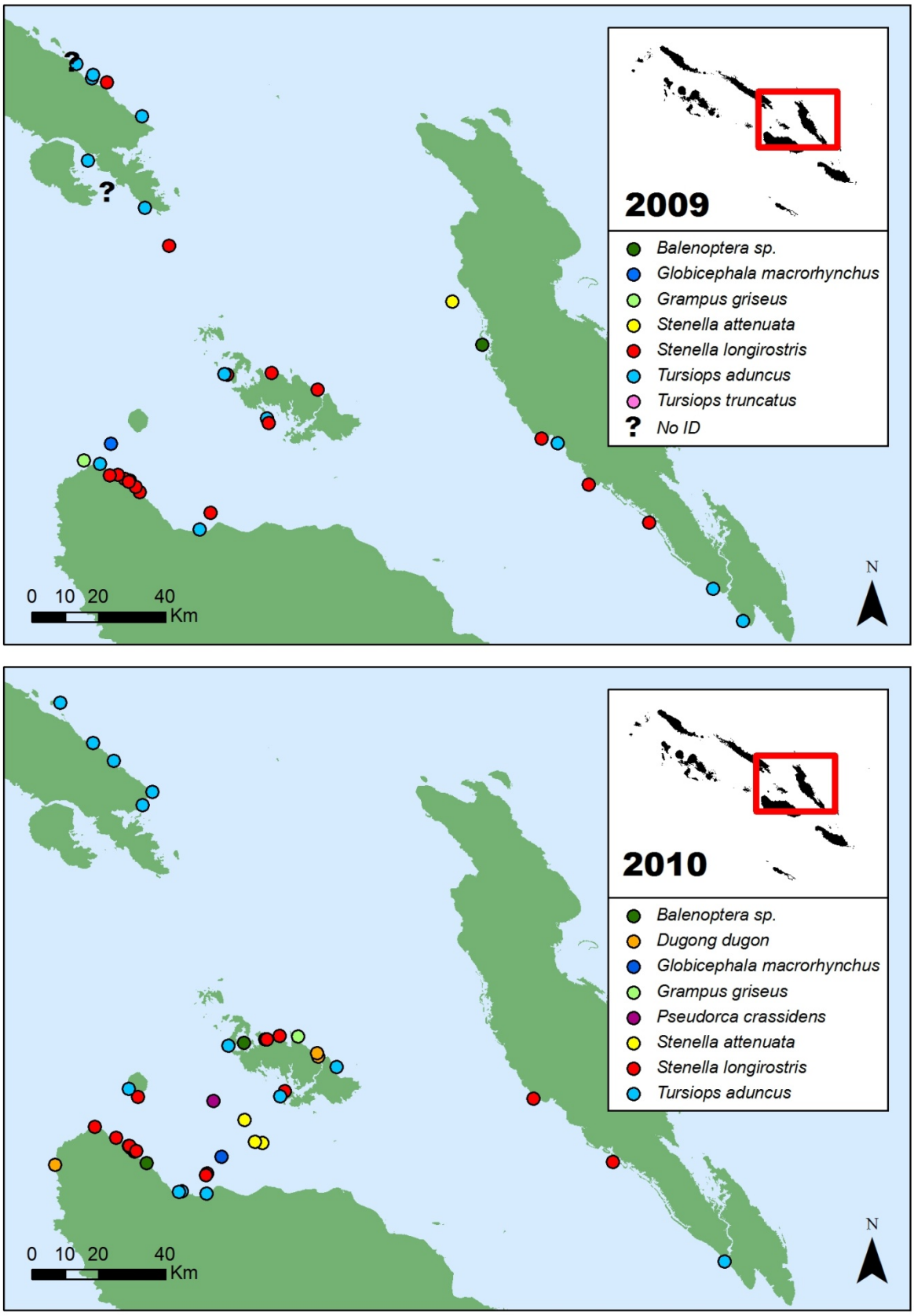


Figure 2: Geographic positions of marine mammal encounters in Solomon Islands

Figure 8: *Balenoptera* sp. sighted on the coast of Florida Islands, November 2010

Figure 9: Juvenile of *Stenella longirostris* accompanying an adult *Tursiops aduncus* at Guadalcanal

S. longirostris and *T. aduncus* were observed at each of the four study sites. The group encounters rates for the *S. longirostris* and *T. aduncus* at each study sites were roughly similar between the two surveys (Table 3). On the other hand, this pattern shows much variation between study sites and between species (Table 3). Groups of *S. longirostris* were more frequent at Guadalcanal and Florida Islands. Sightings were less frequent in Malaita, while they were rare at Santa Isabel. On the other hand, Santa Isabel is the study site where most *T. aduncus* were encountered. This was confirmed by the RAI around this island (Table 3). The number of groups encountered was fairly similar at Guadalcanal and Florida Islands. However, estimates of RAI suggest that many fewer dolphins were seen in the former, indicating that larger groups were found at Florida Islands. In fact, RAI at Guadalcanal was the smallest of all study sites despite group encounter rate being lower at Malaita. This indicates that fewer groups of *T. aduncus* are found at Malaita but that these groups were larger than in Guadalcanal.

Table 3: Number of group encountered and encounter rate at different study sites for *Tursiops aduncus* (a) and *Stenella longirostris* (b). Number of individuals photographically identified (ID) and relative abundance indices are also given for *T. aduncus* only.

(a) *Tursiops aduncus*

SITE	# grp		# grp/100nm			# ID			RAI*		
	2009	2010	all	2009	2010	all	2009	2010	all	2009	2010
Guadalcanal	2	5	**1.6**	1.1	1.9	**29**	8	21	**6.5**	4.2	8.1
Florida Islands	2	5	**1.8**	1.7	1.9	**79**	27	52	**20.6**	23.3	19.4
Santa Isabel	6	5	**2.8**	2.9	2.8	**116**	68	48	**29.9**	32.9	26.5
Malaita	3	1	**0.8**	1.2	0.4	**35**	28	7	**7.2**	11.2	3.0
Total	13	16				**259**	131	128	**15.2**	17.2	13.6

* Relative Abundance Indices, i.e., number of dolphins photographically identified per 100NM of coastal effort

(b) *Stenella longirostris*

SITE	# grp		# grp/100nm		
	2009	2010	all	2009	2010
Guadalcanal	8	9	**3.8**	4.2	3.5
Florida Islands	4	7	**2.9**	3.4	2.6
Santa Isabel	1	0	**0.3**	0.5	0.0
Malaita	3	2	**1.0**	1.2	0.9
Total	16	18			

A total of 64 biopsy samples were collected over the two years (32 in 2009 and 32 in 2010; Table 2). Most of these come from two species: *S. longirostris* (n = 34) and *S. attenuata* (n = 19). Unfortunately, we managed to collect only one biopsy sample of *T. aduncus* despite being the species with which we spent most time so far (25h 11min with *T. aduncus* compared to 16h 15min with *S. longirostris*).

Additional samples of *T. aduncus* were obtained from the facilities at Honiara (n = 16) and Gavutu (n = 17). Unfortunately, many of these samples were of poor quality and low quantity. Finally, a total of 242 teeth were collected at local markets and shops as well as in the drive-hunting village of Fanalei, in Malaita. These teeth seem to come mostly from *Stenella* sp.. However, based on the shape and size, at least five different species are represented in the dataset. According to fishermen from Fanalei, some of the teeth that they provided come from *Tursiops sp.* and false killer whale, *Pseudorca crassidens*. However, they indicated that these species were not hunted but found stranded.

Photo-identification

T. aduncus photographs were obtained from 13 groups in 2009 and 15 groups in 2010. A total of 259 individuals were photographically identified. Among these, 216 showed marks

distinctive enough to be useable for photographic matching (distinctiveness (2) to (4)). Most individuals were identified at Santa Isabel, followed by Florida Islands, Guadalcanal and Malaita (Table 4).

Table 4: Summary of photo-identification data and number of re-sighting at the four study sites

Site	# ID	# of unique individuals			# re-sightings within same year	# seen both years
		all	2009	2010		
Guadalcanal	28	20	6	18	4	4
Florida Islands	62	50	22	38	2	10
Santa Isabel	100	88	56	41	3	9
Malaita	26	26	23	3	0	0
Total	216	184	107	100	9	23

The matching of these 216 distinctive dorsal fins revealed that 184 unique individuals are represented in the dataset, with 32 re-sighting events (Table 4). Nine re-sightings were found within years (Table 5); four at Guadalcanal, three at Santa Isabel and two at Florida Islands. Two of the Guadalcanal re-sightings were in fact made between the North Coast of Guadalcanal and the Island of Savo, just 7nm to the north. Twenty-three individuals were first identified in November 2009 and re-sighted in November 2010 (Table 5). All these between-years re-sightings were found within the same study sites: four at Guadalcanal, nine at Santa Isabel and ten at Florida Islands. No dolphin was seen in two different study sites.

Table 5: Summary of overall re-sighting history between November 2009 and November 2010 (within year/between years)

Site	Guadalcanal	Florida Islands	Santa Isabel	Malaita
Guadalcanal	**4/4**	-	-	-
Florida Islands	0/0	**2/10**	-	-
Santa Isabel	0/0	0/0	**3/9**	-
Malaita	0/0	0/0	0/0	**0/0**

Photographs of captive dolphins taken in November 2009 resulted in the identification of 28 distinctive individuals, 14 at Honiara and 14 at Gavutu. These represent 74% and 52% of the dolphins held in captivity at the two facilities, respectively. In November 2010, a second visit to the Honiara facility allowed the identification of four of the 8 dolphins still in captivity. Two of these were previously photographed in November 2009 while the other two were unknown to us. Curiously, the two dolphins re-identified in 2010 were the two animals that had received more training as in November 2009. These were supposed to be exported first based on what we have been told in November 2009.

Despite the potential release of 8 dolphins from Honiara and 17 dolphins from Gavutu, we found no match between the photographs taken at the facilities in 2009 and the identifications made in the wild in November 2010.

Genetic analyses

DNA was successfully extracted from all the biopsy samples collected in 2009 (n = 32). The sequencing of the mtDNA control region and analyses using DNA-Surveillance confirmed the 5 species identification from field observations (Appendix 1): *S. longirostris*, *S. attenuata*, *T. truncatus*, *T. aduncus* and *G. macrorhynchus*. All individuals but two were successfully sexed using molecular tools.

DNA was also extracted for skin swabbing samples collected on captive dolphins at Honiara (n = 16) and Gavutu Island (n = 17). Molecular sexing was successful for 14 samples, indicating a surprising sex ratio of 12 males and 2 females. So far, sequences of the mtDNA control region could be obtained for 16 samples (546 base pairs). From these, six unique haplotypes were identified resulting in a surprisingly high haplotype diversity ($h = 0.867 \pm 0.05$). On the other hand, nucleotide diversity was relatively low, indicating little difference between haplotypes ($\pi = 0.508\ \% \pm 0.317\%$). Preliminary comparison with mtDNA sequences from *T. aduncus* sampled in New Caledonia shows no shared haplotypes with Solomon Islands.

DISCUSSION

Information on the status of cetacean populations in Solomon Islands remains relatively scarce. The ongoing project on which we report here is certainly one of most intensive effort to date dedicated to gaining information on marine mammals of the region. Substantial work was also conducted in the past by Shimada and Pastene (1995) and Kahn (2006) which provides most of the information currently available on cetacean diversity, distribution and density in Solomon Islands. The main difference between our surveys and previous work rely in our substantial research effort in coastal habitat while previous studies mostly concentrated offshore. We note, however, that numerous surveys were conducted by R.H. Defran on the coast of Guadalcanal (Reeves & Brownell Jr. 2009); results from this research are not available yet.

All of the 9 marine mammal species encountered during our surveys were previously identified in Solomon Islands. In particular, we confirmed the presence of the two currently recognized species of the genus *Tursiops*: *T. truncatus* and *T. aduncus*. These two species were identified on the basis of morphological and molecular evidence. Three more species of delphinids were genetically identified using biopsy samples and sequences of the mtDNA

control region (Appendix 1). These data provide the first molecular information on Solomon Islands cetaceans apart from genetic work conducted to investigate the phylogeny and taxonomic status of *B. omurai* (Sasaki et al. 2006), based on samples collected during early scientific whaling by Japan.

The baleen whales encountered during our surveys were most likely *B. omurai*, although we cannot be certain of this identification. It is interesting to note that these whales were observed very close to shore (within a couple of hundred metres) and that in one instance they were seen feeding. All sightings of baleen whales reported by Shimada and Pastene (1995) were offshore and on the Pacific Ocean side of the islands.

As reported by Kahn (2006), *S. longirostris* was the most commonly encountered species during our surveys (43% of marine mammal encounters). However, we also commonly encountered *T. aduncus* (37% of encounters), which was not the case in previous surveys. Most sightings of these two species occurred along the coast. This confirms the coastal habitat of *T. aduncus* as observed in other populations worldwide (Wang & Yang 2009). *S. attenuata* was the third most commonly encountered species confirming Kahn's observation that this species in regularly encountered in the offshore waters of Solomon Islands.

Despite the presence of both species at each study site, the rates of encounter for *S. longirostris* and *T. aduncus* show interesting variations. The two species were common at Florida Islands and often seen in mixed species groups. At Santa Isabel, *T. aduncus* were common but *S. longirostris* were rarely seen. The opposite was seen at Guadalcanal where *S. longirostris* were common but *T. aduncus* much less frequent. At Malaita, both species were observed at a low rate comparatively to other sites. The causes of these differences are unknown. It could be due to habitat differences and/or anthropogenic pressures and further investigation is required. We note that Guadalcanal, where captures of *T. aduncus* have been reported, shows the lowest RAI. However the paucity of data suggests that it is too early to draw definitive conclusions on this.

The re-sighting of individuals *T. aduncus* at the same study sites over the two surveys, one year apart, indicates some level of site fidelity. No dolphins were re-sighted at Malaita but this could be due to the small number of identification obtained in 2010. A similar pattern is observed elsewhere for this species which usually constitute small resident populations limited to coastal habitat (Wang & Yang 2009). In agreement with this scenario, we found no evidence so far of movement between islands. The fairly high level of re-sighting at Guadalcanal, Florida Islands and Santa Isabel is suggestive of small population sizes. However, further data from the third field season will assist in investigating population abundance.

None of the captive dolphins identified at Honiara and Gavutu in November 2009 were re-sighted in the wild despite the potential release of 25 animals between the two. The fate of these animals is therefore unknown. We note that at least some of the dolphins that were released were in captivity for several months (and potentially much longer). Their health status and degree of habituation to captivity is unknown. Furthermore, the dolphins from Gavutu were released in an area different from where they were initially captured (Guadalcanal). All this is of concern for the welfare of these dolphins. None of the releases was attended by government people.

The level of mitochondrial diversity for the *T. aduncus* in captivity was higher than in New Caledonia, where only two mtDNA haplotypes were identified (Oremus et al. 2009). The fact that there were no shared haplotypes between these two regions suggests that there is no reproductive exchange. Further molecular analyses and sampling are required to confirm this.

The proposal developed for this project outlined 6 research questions to be addressed. Here, we briefly summarise the progress so far and future work needed to answer them:

a) How are local populations of T. aduncus structured or subdivided and what are the 'units to conserve' in the area of live capture?
Considerable progress has been achieved for this question on the basis of photo-identification. Additional photographs will collected in July 2011, which should bring further information on site fidelity and level of demographic exchange between study sites. Unfortunately, we have encountered significant difficulty in obtaining biopsy samples from wild *T. aduncus*. Dolphins from this species have proven very difficult to approach in comparison to other places (Oremus, pers. obs.). The reasons for that are unknown but could relate to previous human interactions (e.g., hunting or capture). Additional effort will be placed on biopsy collection from *T. aduncus* during the next field season. However, it seems unlikely that a sufficient number (20-30 samples) will be obtained from each study site. Further surveys will be required to complete this sampling and allow adequate genetic structure analyses to be conducted.

b) What is the abundance of the T. aduncus population(s) currently impacted or likely to be impacted in near future?
The use of photo-identification has proven very efficient to build a dataset of capture-recapture on *T. aduncus*. It is anticipated that by the end of the next field season sufficient data will be available to obtain population size estimates from at least three of the study sites.

c) Are the current authorised levels of removal sustainable for the local population(s)?

The answering to this question depends on the results from the first two research questions. It is therefore, anticipated that this question will be addressed by the end of the project using calculations such as Potential Biological Removal (PBR) or Population Viability Analysis (PVA).

d) What species are currently exploited by traditional drive-hunts and are they different from the species caught in past decades?

Over 200 dolphin teeth from recent drive-hunts have been collected so far. If further funding becomes available, these teeth will be used for molecular identification of species (DNA barcoding) to better describe the dynamics of traditional drive hunt. Contact has also initiated with the Museum of Sydney to request access to historical samples of teeth collected by Bill Dawbin. The Museum showed considerable interest in collaborating with this project. Other museums are known to held historical dolphin material from Solomon Islands.

e) What are the current levels of genetic diversity in the drive-hunted populations and have these varied through time?

This question will probably focus on the two species thought to be primarily targeted by traditional drive-hunt: *S. longirostris* and *S. attenuata*. A substantial number of contemporary samples have already been collected from wild populations during the first two surveys. Additional samples will be obtained from the teeth as well as during the next field season. As above, addressing this question will depend on funding available to collect and analyse museum samples.

f) Are the population limited in range to Solomon Islands or are they connected to populations from surrounding areas?

Sufficient number samples have already been collected from *S. longirostris*, *S. attenuata* and *T. aduncus* to address this question. Hopefully, more samples will be obtained from *T. truncatus* and *G. macrorhynchus* to include these species in the analyses. This ongoing work is expected to contribute to a large-scale collaborative study of genetic connectivity among insular dolphins of the South Pacific, referred to as 'a Pattern of Dolphins' (aPOD), funded in part by a Pew Marine Fellowship to one of the investigators (CSB).

CONCLUSIONS

To date, the collaborative project initiated between the SPWRC and the Government of Solomon Islands has achieved considerable success. Field surveys have resulted on efficient data collection. They also gave opportunity to provide some training in marine mammal surveys to fisheries and environment officers of the GSI. A third field season will be conducted in July 2011 that should provide enough data to address most of the research questions initially developed. However, the completion of the project is currently

jeopardised by the lack of funding for final data analyses and report writing, as well as for visits to museums for access historical samples.

ACKNOWLEDGEMENTS

We thank the Pew Environment Group for supporting this work and the production of this report. In Solomon Islands, we thank the MFMR and MECDM for providing financial support and field assistance. Thank to all fisheries and environment officers that helped during field surveys. Thanks to Mr Joe Horokou (MECDM) and Dr Chris Ramofafia (MFMR) for their support.

REFERENCES

Baker C.S., Slade R.W., Bannister J.L., Abernethy R.B., Weinrich M.T., Lien J., Urban-R. J., Corkeron P., Calambokidis J., Vasquez O., Palumbi S.R. (1994) Hierarchical structure of mitochondrial DNA gene flow among humpback whales, *Megaptera novaeangliae*, world-wide. Mol. Ecol. 3:313-327

Dalebout M.L., Robertson K.M., Frantzis A., Engelhaupt D., Mignucci-Giannoni A.A., Rosario-Delestre R.J., Baker C.S. (2005) Worldwide structure of mtDNA diversity among Cuvier's beaked whales (*Ziphius cavirostris*): implications for threatened populations. Mol. Ecol. 14:3353-3371

Dalebout M.L., Van Helden A., Van Waerebeek K., Baker C.S. (1998) Molecular genetic identification of Southern Hemisphere beaked whales (Cetacea: Ziphiidae). Mol. Ecol. 7:687-695

Dawbin W.H. (1966) Porpoises and porpoise hunting in Malaita. Aust. Nat. Hist. 15:207-211

Drummond A.J., Ashton B., Cheung M., Heled J., Kearse M., Moir R., Stones-Havas S., Thierer T., Wilson A. (2009) Geneious v4.8, Available from http://www.geneious.com/

Gilson A., Syvanen M., Levine K., Banks J. (1998) Deer gender determination by polymerase chain reaction: validation study and application to tissues, bloodstains, and hair forensic samples from California. Calif. Fish Game 84:159-169

Heithaus M.R., Frid A., Wirsing A.J., Worm B. (2008) Predicting ecological consequences of marine top predator declines. Trends Ecol. Evol. 23:202-210

Kahn B. (2006) Oceanic cetaceans and associated habitats. In: Green A, Lokani P, Atu W, Ramohia P, Thomas P, Almany J (eds) Solomon Islands Marine Assessment: Technical report of survey conducted May 13 to June 17, 2004. TNC Pacific Island Countries, Report No. 1/06

Krützen M., Barré L.M., Möller L.M., Heithaus M.R., Simmer C., Sherwin W.B. (2002) A biopsy system for small cetaceans: darting success and wound healing in *Tursiops* spp. Mar. Mamm. Sci. 18:863-878

Myers R.A., Baum J.K., Shepherd T.D., Powers S.P., Peterson C.H. (2007) Cascading effects of the loss of apex predatory sharks from a coastal ocean. Science 315:1846-1850

Oremus M. (2008) Genetic and demographic investigation of population structure and social system in four delphinid species. PhD thesis, The University of Auckland

Oremus M., Garrigue C., Schaffar A., Baker C.S. (2009) Fine-scale demographic and genetic structure in insular Indo-Pacific Bottlenose dolphins (*Tursiops aduncus*): implications for conservation of local populations. 18th Conference on the biology of marine mammals, Quebec, CA

Oremus M., Poole M.M., Steel D., Baker C.S. (2007) Isolation and interchange among insular spinner dolphin communities in the South Pacific revealed by individual identification and genetic diversity. Mar. Ecol. Prog. Ser. 336:275-289

Parsons E.C.M., Rose N.A., Telecky T.M. (2010) The trade in live Indo-Pacific bottlenose dolphins from Solomon Islands - A CITES decision implementation case study. Mar. Policy 34:384-388

Reeves R.R., Brownell Jr. R.L. (2009) Indo-Pacific bottlenose dolphin assessment workshop report: Solomon Islands case study of *Tursiops aduncus*:53

Reeves R.R., Leatherwood S., Stone G.S., Eldredge L.G. (1999) Marine mammals in the area served by the South Pacific Environment Programme (SPREP)

Ross H.A., Lento G.M., Dalebout M.L., Goode M., Ewing G., McLaren P., Rodrigo A.G., Lavery S., Baker C.S. (2003) DNA Surveillance: Web-based molecular identification of whales, dolphins and porpoises. J. Hered. 94:111-114

Sambrook J., Fritsch E.F., Maniatis T. (1989) Molecular cloning: A laboratory manual. Cold Spring Harbor Laboratory Press, New York

Sasaki T., Nikaido M., Wada S., Yamada T.K., Cao Y., Hasegawa M., Okada N. (2006) *Balaenoptera omurai* is a newly discovered baleen whale that represents an ancient evolutionary lineage. Molecular Phylogenetics and Evolution 41:40-52

Shane S., Wells R.S., Würsig B. (1986) Ecology, behavior and social organization of the bottlenose dolphin: a review. Mar. Mamm. Sci. 2:34-63

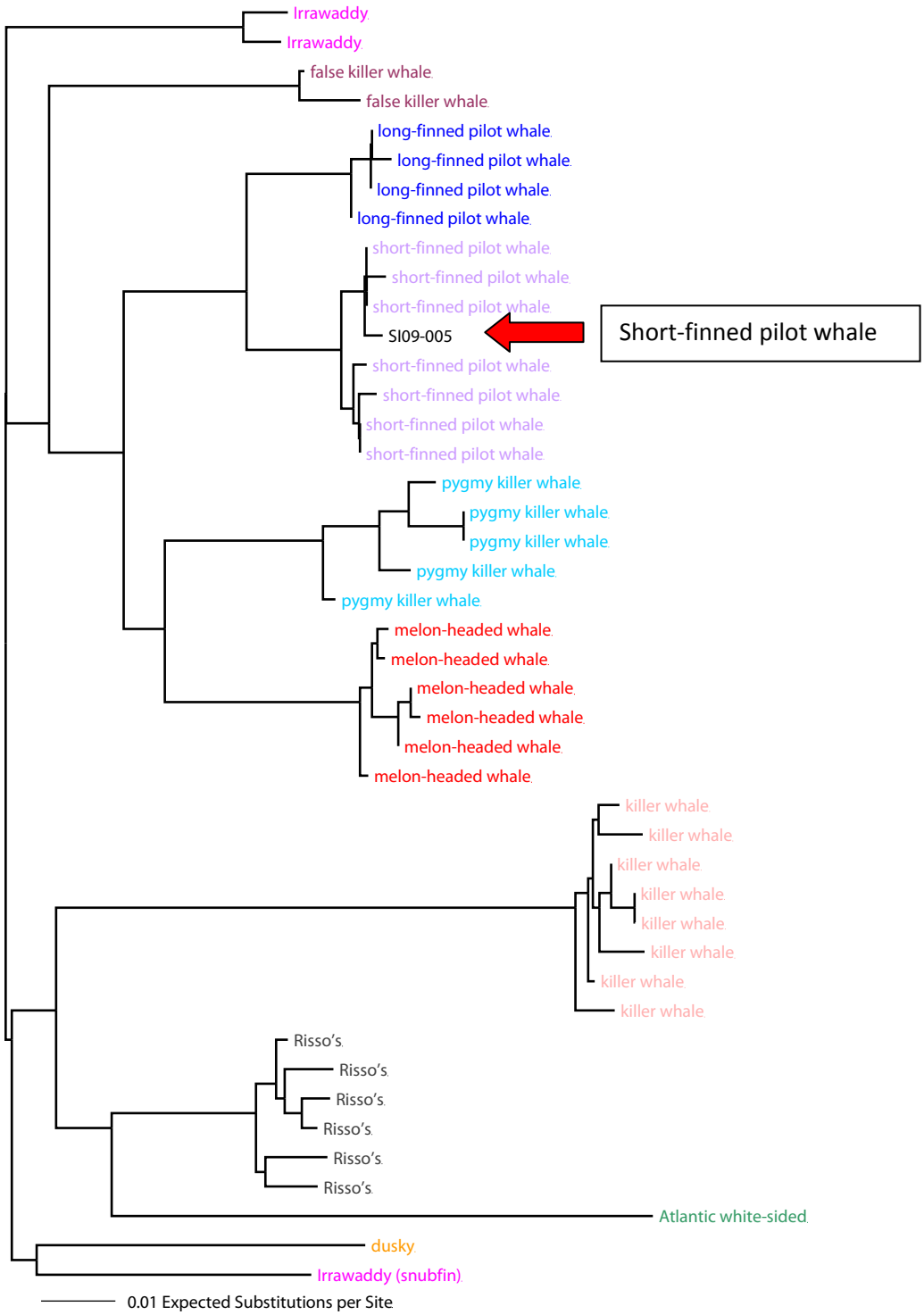
Shimada H., Pastene L.A. (1995) Report of a sighting survey off the Solomon Islands with comments on Bryde's whale distribution. Rep. Int. Whal. Comm. 45:413-418

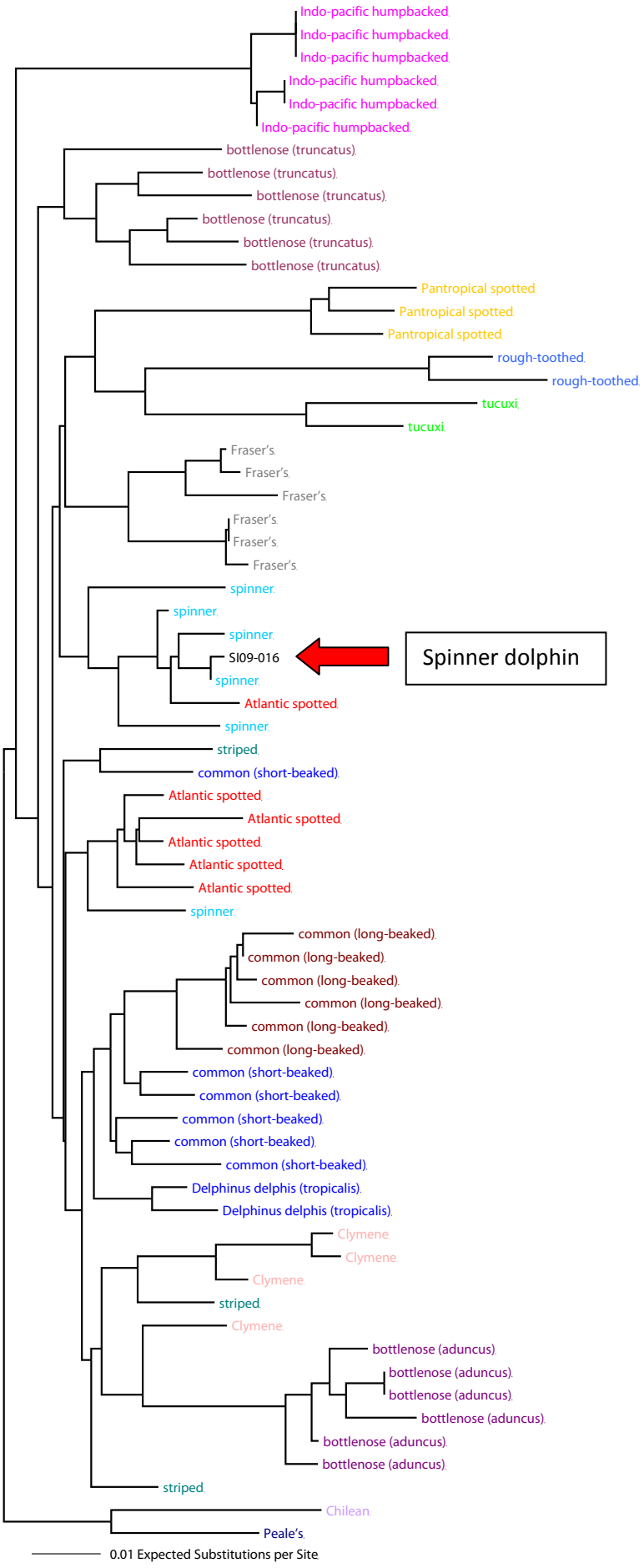
Takekawa D. (1996) The Method of Dolphin Hunting and Distribution of Teeth and Meat: Dolphin Hunting in the Solomon Islands 2. National Museum of Ethnology 42:67-80

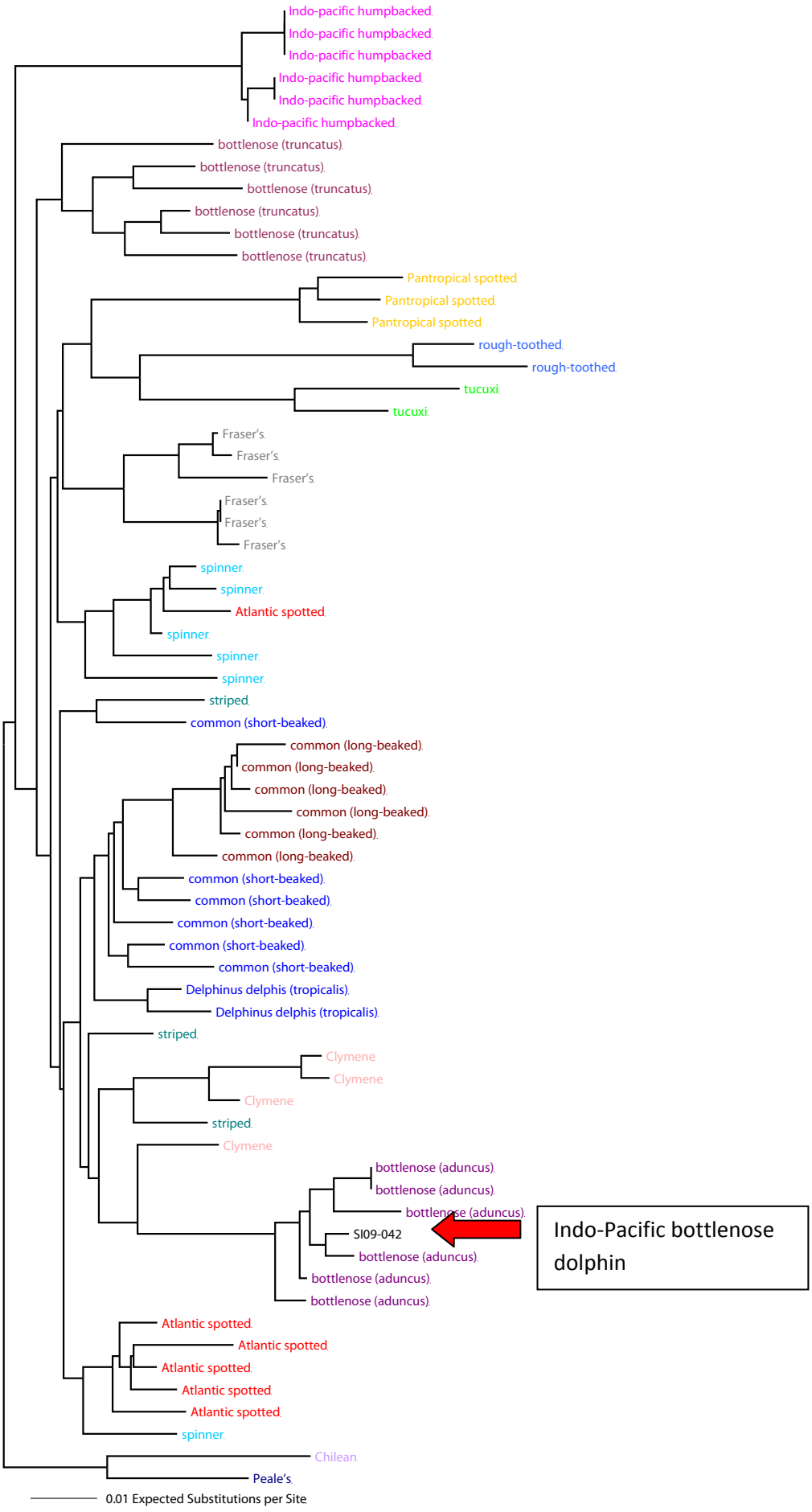
Wang J.Y., Yang J.-C. (2009) Indo-Pacific bottlenose dolphin, *Tursiops aduncus*. In: Perrin WF, Würsig B, Thewissen JGM (eds) Encyclopedia of Marine Mammals, Elsevier, Inc., San Diego, California

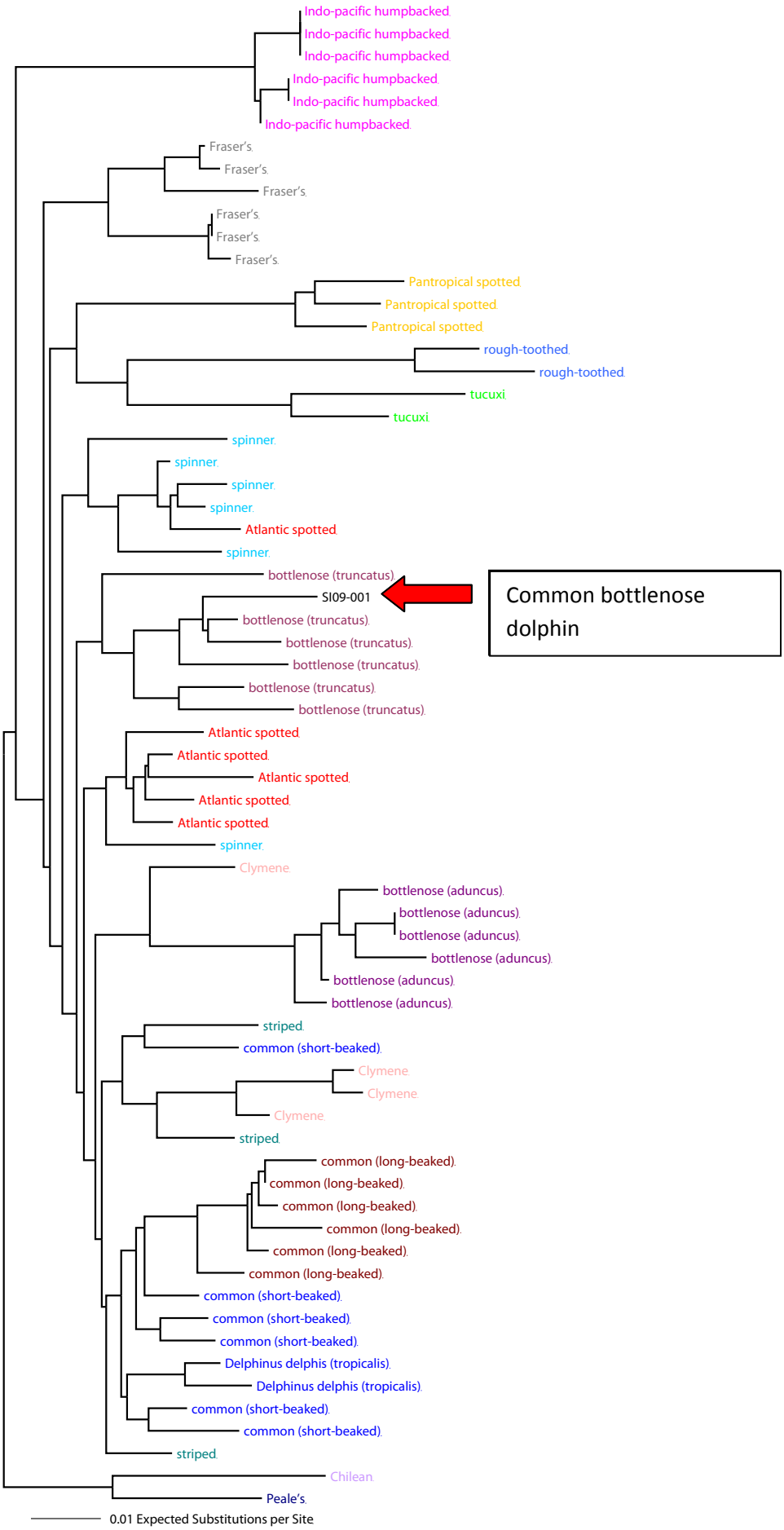
APPENDICES

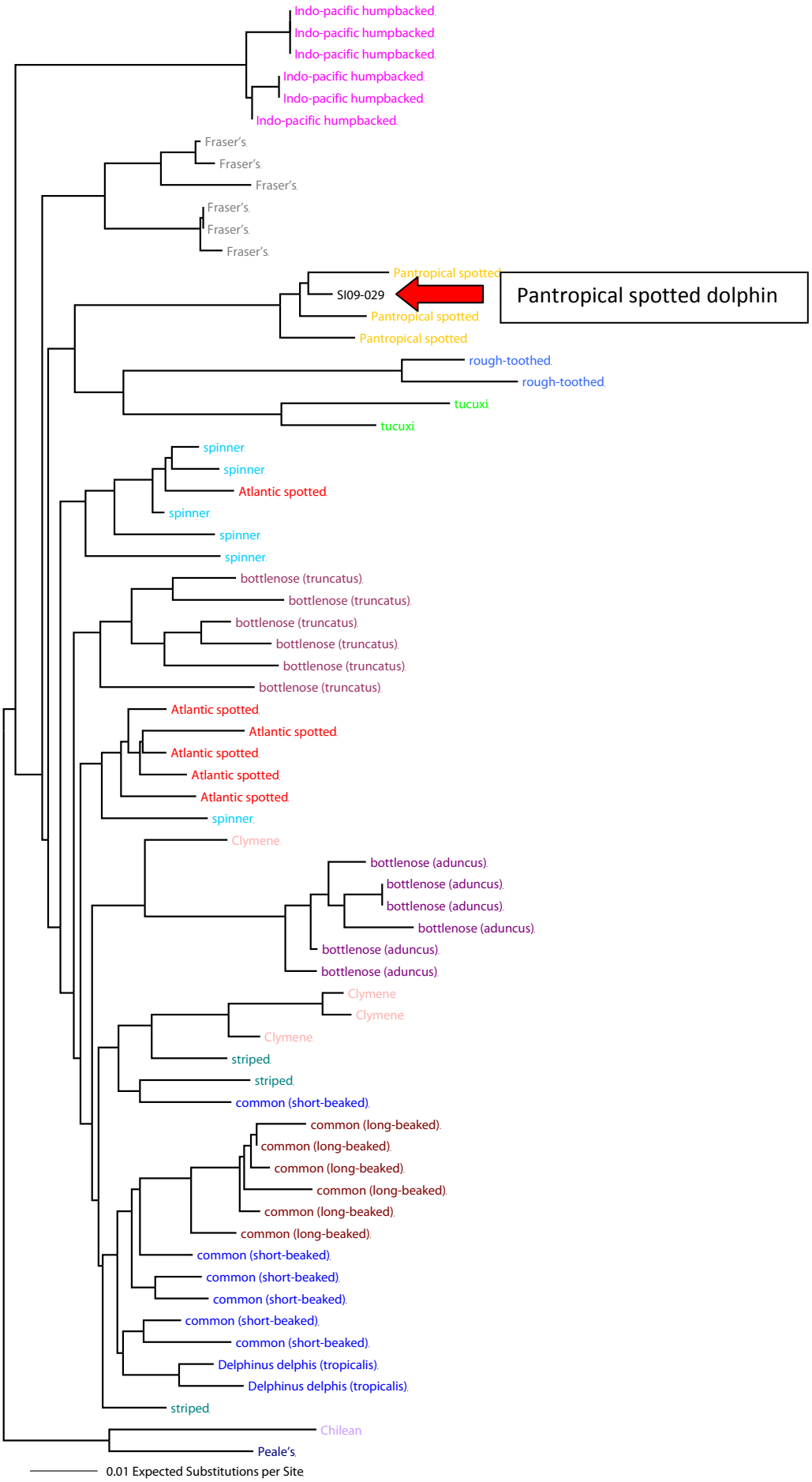
Appendix 1: Molecular identification of the five species biopsied during this study through phylogenetic reconstruction of mtDNA sequences, using the web-based program *DNA-Surveillance*.




Indo-pacific humpbacked
Indo-pacific humpbacked
Indo-pacific humpbacked
Indo-pacific humpbacked
Indo-pacific humpbacked
Indo-pacific humpbacked
bottlenose (truncatus)
bottlenose (truncatus)
bottlenose (truncatus)
bottlenose (truncatus)
bottlenose (truncatus)
bottlenose (truncatus)
Pantropical spotted
Pantropical spotted
Pantropical spotted
rough-toothed
rough-toothed
tucuxi
tucuxi
Fraser's
Fraser's
Fraser's
Fraser's
Fraser's
Fraser's
spinner
spinner
spinner
SI09-016
spinner
Spinner dolphin
Atlantic spotted
spinner
striped
common (short-beaked)
Atlantic spotted
Atlantic spotted
Atlantic spotted
Atlantic spotted
Atlantic spotted
spinner
common (long-beaked)
common (long-beaked)
common (long-beaked)
common (long-beaked)
common (long-beaked)
common (long-beaked)
common (short-beaked)
common (short-beaked)
common (short-beaked)
common (short-beaked)
common (short-beaked)
Delphinus delphis (tropicalis)
Delphinus delphis (tropicalis)
Clymene
Clymene
Clymene
striped
Clymene
bottlenose (aduncus)
bottlenose (aduncus)
bottlenose (aduncus)
bottlenose (aduncus)
bottlenose (aduncus)
bottlenose (aduncus)
striped
Chilean
Peale's
0.01 Expected Substitutions per Site


Indo-pacific humpbacked
Indo-pacific humpbacked
Indo-pacific humpbacked
Indo-pacific humpbacked
Indo-pacific humpbacked
Indo-pacific humpbacked
bottlenose (truncatus)
bottlenose (truncatus)
bottlenose (truncatus)
bottlenose (truncatus)
bottlenose (truncatus)
bottlenose (truncatus)
Pantropical spotted
Pantropical spotted
Pantropical spotted
rough-toothed
rough-toothed
tucuxi
tucuxi
Fraser's
Fraser's
Fraser's
Fraser's
Fraser's
Fraser's
spinner
spinner
Atlantic spotted
spinner
spinner
spinner
striped
common (short-beaked)
common (long-beaked)
common (long-beaked)
common (long-beaked)
common (long-beaked)
common (long-beaked)
common (long-beaked)
common (short-beaked)
common (short-beaked)
common (short-beaked)
common (short-beaked)
common (short-beaked)
Delphinus delphis (tropicalis)
Delphinus delphis (tropicalis)
striped
Clymene
Clymene
Clymene
striped
Clymene
bottlenose (aduncus)
bottlenose (aduncus)
bottlenose (aduncus)
SI09-042
bottlenose (aduncus)
bottlenose (aduncus)
bottlenose (aduncus)
Atlantic spotted
Atlantic spotted
Atlantic spotted
Atlantic spotted
Atlantic spotted
spinner
Chilean
Peale's
0.01 Expected Substitutions per Site
Indo-Pacific bottlenose dolphin


Indo-pacific humpbacked
Indo-pacific humpbacked
Indo-pacific humpbacked
Indo-pacific humpbacked
Indo-pacific humpbacked
Indo-pacific humpbacked
Fraser's
Fraser's
Fraser's
Fraser's
Fraser's
Fraser's
Pantropical spotted
Pantropical spotted
Pantropical spotted
rough-toothed
rough-toothed
tucuxi
tucuxi
spinner
spinner
spinner
spinner
Atlantic spotted
spinner
bottlenose (truncatus)
SI09-001
bottlenose (truncatus)
bottlenose (truncatus)
bottlenose (truncatus)
bottlenose (truncatus)
bottlenose (truncatus)
Atlantic spotted
Atlantic spotted
Atlantic spotted
Atlantic spotted
Atlantic spotted
spinner
Clymene
bottlenose (aduncus)
bottlenose (aduncus)
bottlenose (aduncus)
bottlenose (aduncus)
bottlenose (aduncus)
bottlenose (aduncus)
striped
common (short-beaked)
Clymene
Clymene
Clymene
striped
common (long-beaked)
common (long-beaked)
common (long-beaked)
common (long-beaked)
common (long-beaked)
common (long-beaked)
common (short-beaked)
common (short-beaked)
common (short-beaked)
Delphinus delphis (tropicalis)
Delphinus delphis (tropicalis)
common (short-beaked)
common (short-beaked)
striped
Chilean
Peale's
0.01 Expected Substitutions per Site
Common bottlenose dolphin


Indo-pacific humpbacked
Indo-pacific humpbacked
Indo-pacific humpbacked
Indo-pacific humpbacked
Indo-pacific humpbacked
Indo-pacific humpbacked
Fraser's
Fraser's
Fraser's
Fraser's
Fraser's
Fraser's
Pantropical spotted
SI09-029
Pantropical spotted
Pantropical spotted
Pantropical spotted dolphin
rough-toothed
rough-toothed
tucuxi
tucuxi
spinner
spinner
Atlantic spotted
spinner
spinner
spinner
bottlenose (truncatus)
bottlenose (truncatus)
bottlenose (truncatus)
bottlenose (truncatus)
bottlenose (truncatus)
bottlenose (truncatus)
Atlantic spotted
Atlantic spotted
Atlantic spotted
Atlantic spotted
Atlantic spotted
spinner
Clymene
bottlenose (aduncus)
bottlenose (aduncus)
bottlenose (aduncus)
bottlenose (aduncus)
bottlenose (aduncus)
bottlenose (aduncus)
Clymene
Clymene
Clymene
striped
striped
common (short-beaked)
common (long-beaked)
common (long-beaked)
common (long-beaked)
common (long-beaked)
common (long-beaked)
common (long-beaked)
common (short-beaked)
common (short-beaked)
common (short-beaked)
common (short-beaked)
common (short-beaked)
Delphinus delphis (tropicalis)
Delphinus delphis (tropicalis)
striped
Chilean
Peale's
0.01 Expected Substitutions per Site