UNDERWATER TURTLE VISUAL CENSUS METHODOLOGY

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1. MAIN OBJECTIVES

The main objective of this Underwater Turtle Visual Census Protocol is:

- to provide a practical and standardised method for monitoring turtles using SCUBA diving for the purpose of evaluating population and health status trends aligned with previously used methods in Tobago.

2. TEAM

Each team must include four divers: a PADI Divemaster-certified dive leader, a scientific leader (who may also be the dive leader), and two or three (community-based) field technicians (CBFT); for definitions see below. The approved turtle monitoring process must be taught to all team members, including boat captains, to ensure they understand the data collection and diving procedures and are well versed in species identification.

Roles

DIVE LEADER (DL)

The dive leader must be a currently certified dive – master with at least 150 dives, have a track record of organising dives under similar conditions like the survey sites, be first aid certified, and be familiar with the survey sites.

The dive leader shall be accountable for the safety of the divers. They shall ascertain whether the water conditions, including swells, visibility, current, and egress, are conducive for the survey. In addition, they, along with the scientific leader (SL), are responsible for coordinating the recruitment of CBFTs, reserving dive boats, and setting up dive and emergency equipment. The dive leader will lead the dive path and is also responsible for initiating and directing the emergency procedure in accordance with the guidelines specified in ERIC's Dive Safety and Emergency Procedure. The dive leader shall ultimately have authority over the dive.

SCIENTIFIC LEADER (SL)

The scientific leader must have demonstrable experience in recording, validating, and analysing scientific data, have ideally a BSc in natural sciences; in addition, they must be certified on advance level diving, have at least 50 logged dives, and be first aid certified.

The scientific leader shall validate and verify the information gathered by the dive team. Except in cases where both positions are occupied by the same individual, the SL shall collaborate with the DL to organise CBFT recruitment and dive boat reservations. In addition, the SL is responsible for ensuring the readiness of all scientific materials and apparatus, such as slates and pencils. In consultation with the DL, they are also accountable for directing the dive pattern (spacing) of divers and ensuring that they capture the necessary data in a safe manner. A reliable DL may be designated by the SL to validate data in the event that their absence is unavoidable. In this instance, it is the responsibility of the SL to ensure that the DL has a comprehensive understanding of the data and directives used to operate the CBFTs. In the event that the SL differs from the DL, the SL are required to adhere to the DL's instructions regarding dive and diver safety, particularly in adverse conditions. Additionally, the SL are required to provide support in the execution of any emergency protocols as instructed by the DL.

COMMUNITY-BASED FIELD TECHNICIANS (CBFT)

CBFTs must be certified on advance level diving, have at least 50 logged dives, and be first aid certified.
The community-based field technicians shall collect data under the guidance and instructions of the DL and SL. They are required to aid the DL in the assembly and disassembly of dive and emergency equipment. Their responsibilities commence upon arrival, with gear assembly and boat loading and conclude with equipment stowage. Unless the DL grants an exception, all equipment must be thoroughly cleaned and stowed before duties are deemed fully performed. They must additionally ensure that the SL receives and verifies their data which includes slates and cameras. They are required to provide support in the execution of any emergency protocols as instructed by the DL.

BOAT CAPTAIN

The boat captain shall transport divers to and from the dive sites. They are required to communicate with the DL and/or SL to facilitate punctual meetings with the dive team. In addition, they are required to consult with the leaders regarding weather and sea conditions, providing guidance on the safety of the divers and the boats, particularly in hazardous weather or sea conditions. Additionally, they are responsible for facilitating a secure descent into the water and re-entry onto the vessel. It is imperative for the boat captain to follow the dive team at a safe distance and consistently monitor for diver emergencies or surface threats, with the dive team's position denoted by a surface marker buoy.

3. EQUIPMENT AND MATERIALS

The following equipment and materials are required for each survey dive:

- One complete set of dive gear per diver including surface marker buoy (SMB), dive computers and underwater and surface signalling device,
- One set of spare dive gear and one spare tank,
- One tank per diver per dive, one spare tank for the group
- Emergency oxygen,
- Surface marker buoy,
- First aid kit,
- Prepared Rite in the Rain Notebook,
- One prepared slate and pencil per diver,
- One camera per buddy pair,
- Underwater compass,
- Measuring tape, and
- GPS/ FishFinder.

4. SURVEY METHOD

Surface

Upon arrival at the site, the SL/ DL must enter the following data in the Rite in the Rain notebook:

- Date,

- Time,
- Weather conditions,
- Sea conditions,
- Number of boats/ yachts within 1km radius of survey site,
- Presence of effluence,
- Presence of debris

To minimise any potential bias related to the time of day, it is advisable to schedule dives to occur at approximately the same time.

The DL/ SL will designate buddy pairs (team), supply a camera to each team and slates to all divers. Using their discretion, the DL/ SL will assign the divers with better air consumption to survey at deeper depths. Less proficient divers (if any) should be partnered with an experienced diver, preferably a divemaster (if possible).

Before each dive, the boat captain and DL/ SL must evaluate the water conditions to determine if it is safe to proceed with the dive. Prior to every dive, the DL will deliver a dive briefing to review underwater safety, signals, survey pattern, dive conditions and emergency procedures.

Survey sites must be georeferenced by taking GPS coordinates at the beginning and end of each survey. Once the divers have entered the water, descended and established the survey formation, the DL/ SL will give a strong pull to the surface marker buoy to alert the boat captain that the survey has commenced and to mark the first waypoint as close as possible to the SMB. At the end of the survey, the DL/ SL will designate a CBFT to signal the boat captain using a strong pull on the SMB (or release a second SMB if wave conditions require) that the survey has ended and to log the ending waypoint.

Underwater

POSITIONING

The pair of teams will enter the water and descend at a controlled rate, paying close attention to visibility, current and diver proximity. The teams should descend to the substrate which should be at an average depth of 10m. The dive depth will be contingent upon the reef's bathymetry; however, regardless of the location, the dive depth must not exceed 18m, to ensure safety and sufficient air for the deep team to complete the dive. The two teams will align themselves perpendicular to the survey direction and depth contour. At sites where there is a shallow reef crest, the shallow team will position themselves slightly below the crest at a depth of approximately 7m. If a reef crest is absent, the shallow team will position themselves at a depth of 7-12m.

The deep team will station themselves as far as visibility allows while maintaining visual contact with the outermost person in the shallow team, and vice versa. Members of each team should not be more than 5m apart from each other. The maximum allowable depth for the deep team is 18m. The divers will align in a linear formation so that when they turn their heads, they can see the head of the next diver parallel to them. If a diver can see other divers ahead, this indicates that the diver is lagging behind and should make an effort to catch up with the teams. If a diver does not observe anyone to their left or right when turning their head, this means that the diver has swum too far ahead and should decrease their speed to re-align with the survey formation. The dive leader should signal to divers to maintain their position, if they deviate from the formation. The height above the reef should be equal for all divers and consistent across dives as far as possible

UNDERWATER VISUAL CENSUS

Before beginning and at the end of the survey, the team should estimate the horizontal visibility. Once the teams have assumed their positions, the SL/ DL will record the survey start time and the bearing of the survey route. The survey team should swim at a moderate pace and at 1.5 – 2m above the substrate. The team members should diligently observe the bottom and water column, periodically directing their attention to the surface, to detect any turtles. Large plate corals, small caves or sufficiently large surfaces for a resting turtle, should all be closely monitored. There is no visual limit for the survey, therefore, once a team member sights a turtle, they must signal to the remaining divers. The buddy team that has spotted the turtle shall document all the following details on a pre-written slate:

- Time,
- Species – Hawksbill, Green, Loggerhead, Olive Ridley, Leatherback,
- Juvenile, sub-adult, adult
- Sex – adult male, suspected adult female, or unknown,
- Estimated straight carapace length – in standard 15 cm intervals (20-35, 35-50, 50-65, 65-80, 80-95, 95-110, 110-125; dive team should be trained in size estimation using proxies),
- Distinct markings on carapace, head, flippers etc e.g. barnacle pattern, scars, etc,
- Tags and tag numbers where possible
- Estimated depth of turtle – m,
- Location in water – surface, water column, bottom (Maitz, n.d.; Smith, n.d.),
- Behaviour – resting (remaining stationary on the seabed without foraging), assisted resting (remaining stationary under a structure such as plate corals, caves, etc), foraging (ingesting prey), swimming (movement in water column without ingesting prey) (Houghton, Callow, and Hays 2003)
- Condition – alive, injured, dead, fibropapilloma growths (Smith, n.d.), and
- Predominant substrate – hard coral, soft coral, rock, sand, sponge, mixed (coral and macroalgae), other (e.g. wreck)

To differentiate between immature and mature turtles, the divers should use a combination of shell size estimations and secondary sexual features, such as tail length in adult males (Ballorain et al. 2010). Some shell size estimations of mature turtles for the different species are provided below. It should be noted that size at sexual maturity reported in the literature is highly variable between and within populations, and size is therefore not reliable as an indicator of maturity (Meylan et al 2011). Sex cannot be verified in large individuals with short tails without additional data such as laparoscopic examination or observation of the turtle on a nesting beach, due to the variability of size at sexual maturity (Meylan et al 2011). Therefore the SCL estimates provided should only be used as a guide and definitive assessments of maturity can only made in the case of adult males where elongated tails are apparent, or very large individuals.

Table 1. Straight carapace length (SCL) estimates at first maturity

Species	**Estimated shell length at maturity (SCL)**
Leatherback	135cm (Zug and Parham 1996)
Hawksbill	67cm (Meylan et al 2011)
Green	77cm (Meylan et al 2011)
Loggerhead	82cm (TEWG 2009)
Olive Ridley	62.5cm (daSilva et al 2007)

To determine the turtle's depth, depth estimation should be used at the discretion of the diver since exact depth when first observed is not a critical parameter.

While one diver documents the data, the second team member should cautiously approach the turtle (if possible) to photograph it. If the turtle is already in motion, approaching it may be impractical, requiring the need to quickly capture images. If feasible, photographs should aim to capture the entire dorsal side of the turtle, to aid in accurate species identification. Photographs of facial scutes on both sides of the head should also be taken where possible; photos for species ID should aim to capture the pre-frontal scales between the eyes and at least the front of the shell to see the relative position of the first lateral scute to the nuchal scute

When approaching the turtle for photos or to make observations, care should be taken to approach slowly and from the side where possible. Avoid approaching from in front or behind and no diver should block the turtle's access to the surface. Do not chase/pursue the turtle if it moves away quickly.

While the data is being collected, the second team should remain vigilant for any additional turtles that may be present. Data on each individual turtle must not be duplicated. After acquiring the data, the recording team should indicate their completion, and both teams must return to their positions and resume the survey until the next turtle is spotted.

There is no temporal limit to the survey, however, the dive should last between 45-60 minutes, depending on the prevailing conditions and air consumption rates. The survey will be considered complete when either the teams have reached the end of the dive site or the first diver reaches a tank pressure of 50bars or 750 psi. Several strong pulls on the SMB will signal the completion of the dive to the boat captain, who will record the GPS coordinates as close to the marker as possible while the DL/ SL records the time. The teams will slowly ascend to a depth of 5m for a three-minute safety stop before returning to the surface.

5. LOCATIONS – USING TOBAGO AS AN EXAMPLE

Locations should be identified in consultation with local fisherfolk and dive operators. The most important consideration must be diver safety: areas with strong currents, rapidly changing conditions, high boat traffic, risk of entanglement must be avoided. The average underwater visibility should nor be lower than 15m. Ease of boat or shore entry and exit must be ensured. Dive depth should not exceed 18m for the deepest diver.

There are eight surveys sites, four in the north-east region and four in the south-west of Tobago. The Turtle Village Trust initially selected these sites in the 2017 survey completed by ERIC, based on surveys done in 2009. ERIC revised the sites in 2017, considering factors such as accessibility and diver safety. The same sites were chosen for the 2024/25 survey to allow for data comparison.

Table 2. Approximate starting GPS coordinates of survey sites, based on ERIC 2017 underwater turtle visual census.

Region	Locality	Dive Site	Latitude	Longitude
Northeast	Man O-War Bay	Hermitage	11°19.573'	-60°34.510'
		Landslide	11°19.949'	-60°33.328'
	Speyside	Coral Garden/ Kelleston Drain	11°17.652'	-60°30.268'
		Japanese Garden/ Angel Reef	11°18.024'	-60°31.261'
Southwest	Cove	Cove Ledge	11°07.924'	-60°47.143'
	Crown Point	Flying Reef	11°08.084'	-60°49.848'
	Pigeon Point	Bopez	11°09.933'	-60°50.666'
	Mt. Irvine	Mt. Irvine SW Reef	11°12.005'	-60°47.958'

Frequency of surveys

Based on the advice of a turtle survey expert, the surveys effort should be evenly spread throughout the year. Patterns of movement of nesting/breeding turtles will become clear from the data collected, without any extra survey effort in the nesting season. Throughout the 12-month survey period, each site will be visited once per month (four dive days per month to visit the eight dive sites). The selection of days is contingent on the availability of human resources, and weather and sea conditions.

6. DATA ANALYSIS

The following is a list of different analyses that can be performed on the data collected from the underwater visual census.

1. *Turtle encounter rate – catch per unit effort* (Maitz, n.d.; Smith, n.d.; Cazabon-Mannette, 2017)

Rate of turtle encounters per dive and per hour – this will be comparable to data collected by Cazabon-Mannette (2017) and Turtle Village Trust and can be used to compare relative abundance across dive sites and over time, according to species and size if sufficient data is acquired.
Perform Kruskal-Wallis or Mann-Whitney U test as appropriate (Cazabon-Mannette 2017)

2. *Habitat preferences of each turtle species* (Ballorain et al. 2010, Cazabon-Mannette 2017)

Perform a Chi-Square (χ^2) test, Kruskal-Wallis or Mann-Whitney U test

3. *Frequency distribution of size estimations per site, per species*

Perform Kruskal-Wallis Test (Cazabon-Mannette 2017)

4. *Individual behaviour*

If photo ID of different individuals is successful, individual behaviour patterns can be examined (e.g., preferred habitat/distribution/residency/movement among sites).

5. *Population estimate using Capture-Mark Recapture*

If good, clear pictures are taken consistently for each encounter, with sufficient markings to identify specific and recurring individuals, the size of the total population may be estimated using capture-mark recapture models. We can assume that clearly identified recurring individuals are tagged and each newly identified individual is untagged. Calculations proposed by Mancini, Elsadek, and Madon (2015) may be used.

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