Standard Operating Procedure for Fisheries Independent Surveys and Habitat Assessments

CNMI Division of Fish and Wildlife Technical Report

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1 Introduction

The Commonwealth of the Northern Mariana Islands (CNMI) Division of Fish and Wildlife (DFW) has the responsibility of managing natural resources and enforcing conservation laws. The Fisheries Research Section (FRS), housed within DFW, monitors fisheries and essential fish habitat to inform management, enforcement, and policy development.

This document will serve as a reference and training resource for the FRS's Fisheries Independent Survey and Habitat Assessment (FISHA) program. It will also provide transparency for scientists, resource agencies, and members of the public who are interested in our methodological approach. These methods are designed to fill a variety of monitoring needs, including short and long-term monitoring. Standardizing methodological approaches to gather data relevant to different research questions decreases staff training time and material costs, ultimately enabling better assessment of marine resources in the CNMI.

Two major underwater visual census (UVC) techniques have been used by FRS in the past to monitor fisheries independent resources. The first, a Stationary Point Count (SPC), focused on larger roving species while the second, a modified Belt Transect (BLT), focused on small, sedentary, and cryptic species. In recent years, the BLT was modified to collect additional photoquadrat and fish habitat data. Separating these types of data collection allowed divers to specialize in different parts of the survey but made coordination of field logistics challenging since staff were not cross-trained in all tasks. Data aggregation, standardization, and monitoring of long-term trends also proved difficult since SPC and BLT surveys presented two halves from separate locations that could not be easily combined ex-situ.

Moving forward, our goal is to create a more cohesive data stream in which each diver will collect all data targets using a modified dual SPC methodology that is closely adapted from NOAA's Rapid Ecological Assessment Standard Operating Procedure (SOP) (Ayotte et al., 2015). Both NOAA and DFW data streams may be combined in the future to increase the total amount of information available to model the CNMI's marine resources.

The updated methodology synthesizes data collected from DFW's past survey methods into one cohesive protocol. A visualized "survey cylinder" is used to standardize the SPC, and two divers will collect fish count data at each site instead of one. Benthic habitat information will be collected following the SPC, and invertebrate counts will be taken along the transect line within a 4 meter BLT. Lastly, 30 photoquadrats will be taken at 1 meter intervals along the transect line to collect finer resolution benthic habitat information for analysis with tools like CoralNet.

2 Survey Design

2.1 Site Allocation

Site allocation is dependent on the needs of the survey being conducted although this methodology has been applied to a habitat-stratified random sample design in the past. The site-selection method may vary depending on survey questions. For surveys in Saipan's lagoon area, for instance, sites may be chosen within five dominant habitats of Halodule Seagrass, Enhalus Seagrass, Sand, and Coral/Rubble in proportion to their area (Trianni et al., 2018; Figure 2). In addition, there may be some cases, such as when conducting surveys in small, highly-variable areas, where sampling proportional to each strata's variance is appropriate to avoid biasing results when applying parametric modeling techniques. In locations where habitat information is limited, such as the Northern Islands of the CNMI, surveys can also be stratified along depth contours as opposed to habitat type. Following site selection, each site should be assigned a unique ID and compiled into a site metadata database.

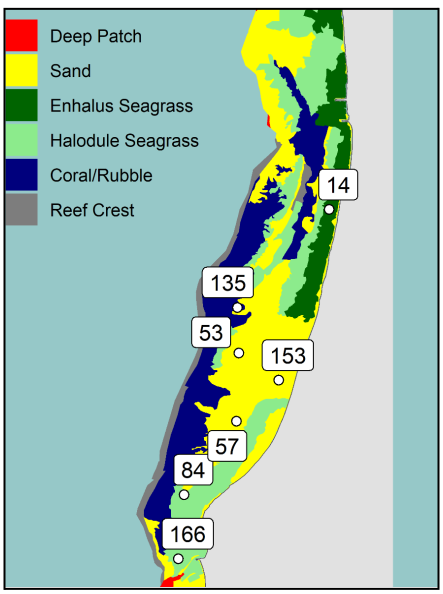


Figure 2: Example of Survey Day Saipan Lagoon Habitat Map. Habitat classification scheme adapted from Trianni et. al. 2018. Numbered points represent randomly generated survey sites.

2.2 Survey Site Generation

Many of DFW's large-scale survey projects will include more sites than can be surveyed in a single day or even over several days. To help account for temporal differences between survey dates, DFW employs a random snapshot survey design (Figure 2).

To generate a random snapshot, sites are randomly sampled without replacement from a pool of all unsurveyed sites using an R script before the survey begins (Appendix 4). This script generates a map of the day's survey points with habitat information included (Figure 2).

If necessary, site selection can be further filtered based on tide, weather, and logistical constraints. During the FY23 Lagoon Survey, for instance, the study region was divided into southern and central areas. This aids site selection and survey planning because the shallow southern lagoon must be surveyed at high tide.

Once a plan is finalized, the captain of the boat is consulted to confirm the survey’s viability. If approved, a waterproof map of the day’s survey is printed as a reference, all equipment is prepped, and a final checklist is completed to ensure all necessary materials are on board (Appendix 1).

3 Survey Set Up

Prior to embarking on a survey day, both captain and crew conduct pre-survey readiness checks. The captain and crew are responsible for maintaining shared equipment and ensuring the boat is fueled and well-maintained, and each diver is responsible for their own dive and survey equipment. At all times, the captain is responsible for the sea-worthiness of the vessel, adherence to Coast Guard regulations, and any other measure to ensure safety on or in transit to the water. The crew is responsible for ensuring all survey materials and equipment are packed and ready. They should utilize an equipment checklist to ensure everything is packed and secured before leaving the Fisheries Warehouse (Appendix 1).

Once on the water, the survey team navigates to preselected sites with a preloaded Garmin GPS Map79s. Other GPS units can be utilized as long as they have a high degree of accuracy. For sites primarily consisting of sand, pavement, and other non-sensitive substrate, the survey area can be marked with a weighted throw float. In areas with coral or other sensitive substrates, divers will carefully place weights to avoid damaging habitat.

For surveys in areas too shallow for the boat to navigate, a float with GPS strapped to the top can be utilized as the survey crew swims to the survey area. A traditional compass or the electronic compass included on a dive computer can also be used for navigation. Supplementally, we developed a QField cloud project application that contains survey points, habitat polygons, 1 m bathymetry, and base map layers. This adds additional information that is useful for identifying site areas, obtaining accurate GPS locations, and setting compass headings.

While still on the boat, divers record date, time, their initials, and site ID. Water temperature, pH, and conductivity are collected on board using a YSI 1030 sonde cable assembly. The divers communicate with one another to confirm that the site ID and date are accurately recorded prior to entering the ocean.

During snorkel surveys, entry is simple. After the survey area is marked by the surface float, the boat is moved greater than 50 meters away and the surveyors are free to swim their equipment to the site. Dive survey entry is more challenging, complicated by cumbersome equipment and limited time in areas where anchoring would cause damage to habitat. In most cases, a throw float will be utilized to mark the survey site prior to diver entry. At sites where anchoring and/or dropping a marker buoy is not feasible, divers will synchronize entry upon arriving at the site and manually place the float to designate the survey zone. This requires coordination between the captain and divers to ensure safe conditions for entry. The boat engine is of particular concern and should never be in gear while divers are in the water nearby. Entry communication between captain and divers will occur as follows:

DIVERS: “Ready?” (as the boat nears the site coordinates)

CAPTAIN: “Ready” (upon reaching survey point)

DIVERS: “Neutral?” (To ensure the engine is in neutral)

CAPTAIN: “Neutral” (After confirming engine is in neutral)

DIVERS: “Diving” (Seeking permission to enter the water)

CAPTAIN: “Dive on” (Final confirmation that it is safe to enter water)

As soon as divers enter the water, the captain will keep the engine in neutral and monitor diver position by watching for bubbles and monitoring the surface buoy. It should be noted that the position of the buoy relative to the divers is influenced by wind direction and current. The captain will allow the boat to drift away from the divers and will not put the engine in gear until they have reached an area greater than 50 meters away from the surface float. If an imminent danger requires movement of the boat within 50 meters of the surface float, the captain will only put the boat in gear after confirming both divers' positions by visualizing their bubbles. The boat should always stay down-current of the survey zone.

While the boat safely drifts away from the survey zone, the dive team will execute a controlled descent with a weight and reel attached to a surface marker buoy. The diver controlling the descent of the weight will descend ahead of the diver with the line to avoid entanglement. After the weight is securely placed, the line attached to the surface marker can be connected.

Once descent is complete, the buddy team will unfurl two 15 m transect lines that have been premarked in 7.5 m intervals with flagging tape to help visualize the survey area (Figure 3). These lines are clipped to loops on the central weight which holds the surface marker in place. The transect line should be laid along the survey area’s depth contour or into the direction of the current during snorkel surveys.

After divers have laid the 30 m transect line, they collect visibility data with a modified horizontal Secchi disk. The first diver will hold a modified Secchi disk at the end of their transect line (typically a printed piece of paper with the Secchi pattern showing on their clipboard) while the other swims towards them. When the second diver can see the Secchi disk, they signal to the other diver and note the distance at which the disk became visible on their datasheets. SCUBA divers must be able to maintain visual contact throughout the survey. If visibility is less than the 15 m needed to meet this requirement, the dive is aborted and the survey is moved to an alternate location. If the survey is shallow and can be accessed by snorkel (e.g. in a lagoon area), then it may proceed even in low visibility because participants can still communicate above the surface. If the visibility is less than 7.5 meters, the recorded visibility becomes the size of the survey cylinder (if the visibility is 5 meters, the diameter of the survey cylinder becomes 5 meters). Snorkelers should not, even when assessing for cryptic species, move beyond the bounds of their survey cylinder.

After setting up the survey area and assessing visibility, divers proceed to the center of their survey cylinders at 7.5 and 22.5 meters respectively. Upon arriving, they record the depth at the center of their cylinder and the compass heading between them and their partner. Each diver can then conduct surveys based around this central reference point with a 7.5 m radius, ultimately forming an imaginary survey cylinder that extends from the sea floor to the surface (Figure 3). After the survey is completed, the divers gather equipment and meet at the center of the site. Upon surfacing, the divers will signal the boat for pick up. Pickup of the dive team should only begin once both divers have surfaced and are accounted for in the water. When the boat arrives, it will record the location of the buoy as a new GPS position. The updated GPS coordinates and the compass heading recorded by the divers will allow DFW to precisely geolocate the survey data using bathymetric data.

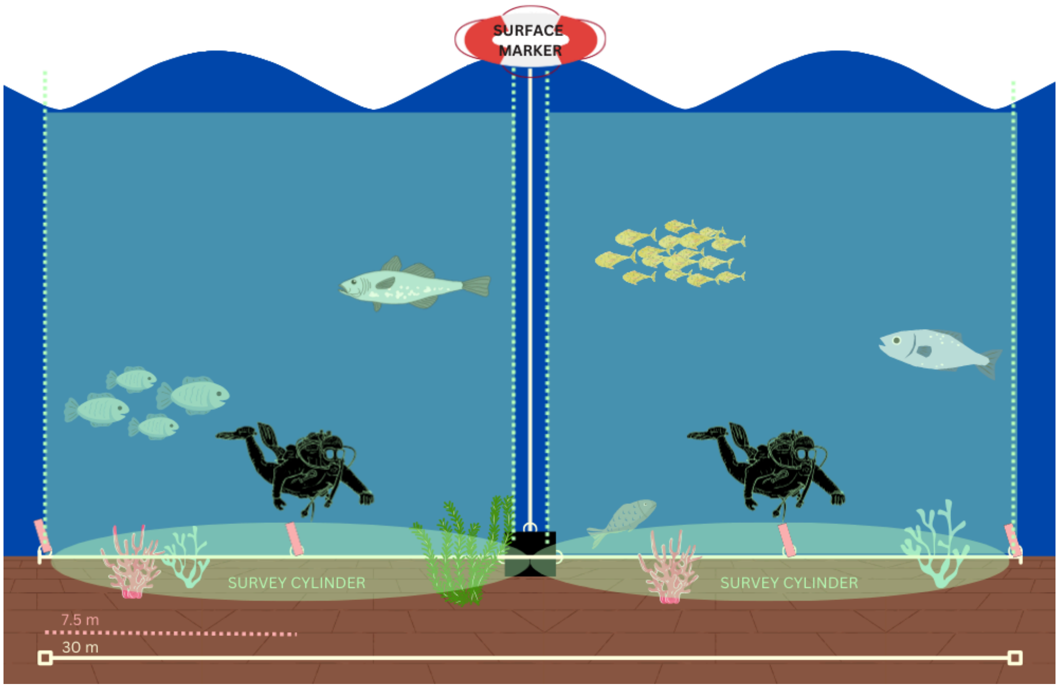


Figure 3: Illustrated Diagram of the Dual Cylinder SPC Method. Flagging tape marks the center and edges of cylinder areas.

4 Fish Data Collection

The primary method for fish data collection in this procedure is an updated SPC based on the NOAA Rapid Ecological Assessment (REA) SOP (Ayotte, et al. 2015). The following methodology matches this method almost exactly, with emphasis on certain points to better suit DFW's existing programs. One small change, for example, is the use of fork length rather than total length for visual estimation. The REA dual SPC method, when paired with a random stratified survey design, produces standardized estimates of abundance, biomass, and relative diversity.

In some cases, the BLT method used by DFW in the past may still be useful, such as during nighttime surveys or in low visibility areas (e.g. < 4m). It may be employed to generate counts of sessile, slow moving, and camouflaged creatures such as benthic-associated fish species. The BLT method may also be used as a direct comparison to historic surveys. Nevertheless, the majority of FRS surveys regarding the collection of fisheries independent data will employ the modified NOAA REA method for fisheries independent data collection. Fish survey methods do not vary between snorkel and scuba surveys.

4.1 Stationary Point Count

4.11 Method Overview

The modified NOAA REA dual-SPC method consists of two components:

1) **5-minute listing period**

2) **Variably timed tallying period**

During the 5-minute listing period, each SPC observer makes a list of all the species present in or moving through their survey cylinder. After the five minutes have concluded, the tallying period begins. During this period, the diver goes back through the list and systematically adds count and length data for each species. The tallying period is dependent on the abundance of fish in the survey area and may be as short as 5 minutes or as long as necessary to complete tallying of listed species.

Species IDs are recorded using the 4-letter species code. Many of these codes come from NOAA, although there are several that have been compiled by DFW over the years as well. These codes are generally formed by taking the first two letters from the genus and species names of fish although there are some exceptions (e.g. *Cheilinus undulatus* = CHUD) (Figure 5). An entire library of practice materials and a readme file has been provided in the fishID training materials folder for reference.

Count data can be recorded as tally marks, written numbers, or a combination of both. Lengths are recorded as estimates of fork length by measuring from the tip of the jaw or snout (with closed mouth) to the center of the fork in the tail to the nearest cm (Figure 4).

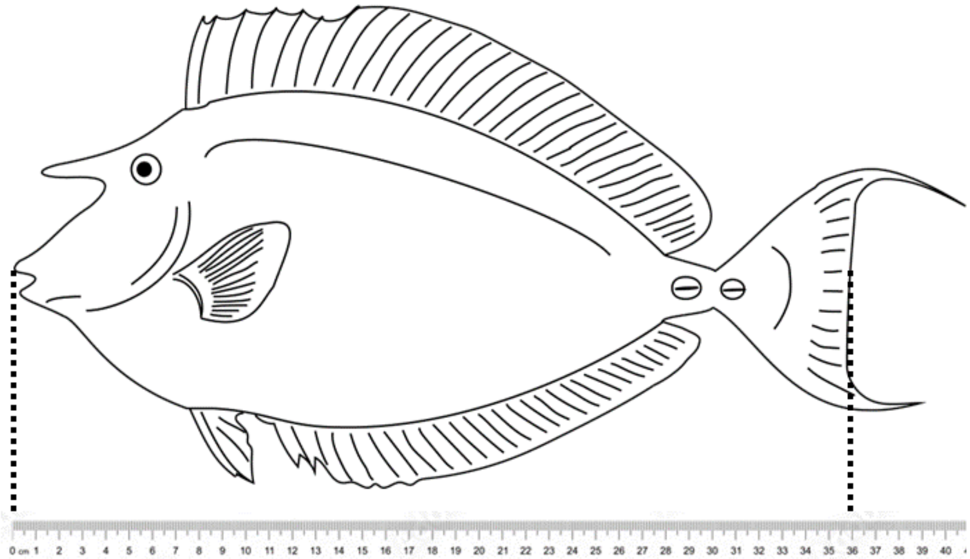


Figure 4: Example of Fork Length Measurement Using *Naso unicornis.* Drawing credit: Brett Tayler.

Count and length data should always be distinguished from one another by enclosing parentheses or other distinguishing features (e.g. brackets, horizontal dashes, underlining, etc.) (Figure 6).

Throughout the survey, each SCUBA diver must maintain visual contact with their buddy. Hand signals between divers should be exchanged at each 5-minute interval to ensure that everyone is OK and that the survey progresses on schedule. During shallow snorkel surveys, verbal signals may also be used.

Figure 5: Four Letter Species Code Example Using *Chaetodon auriga.* Photo credit: Nicholas Robie. Figure adapted from Ayotte et al., 2015.

4.12 Listing Period

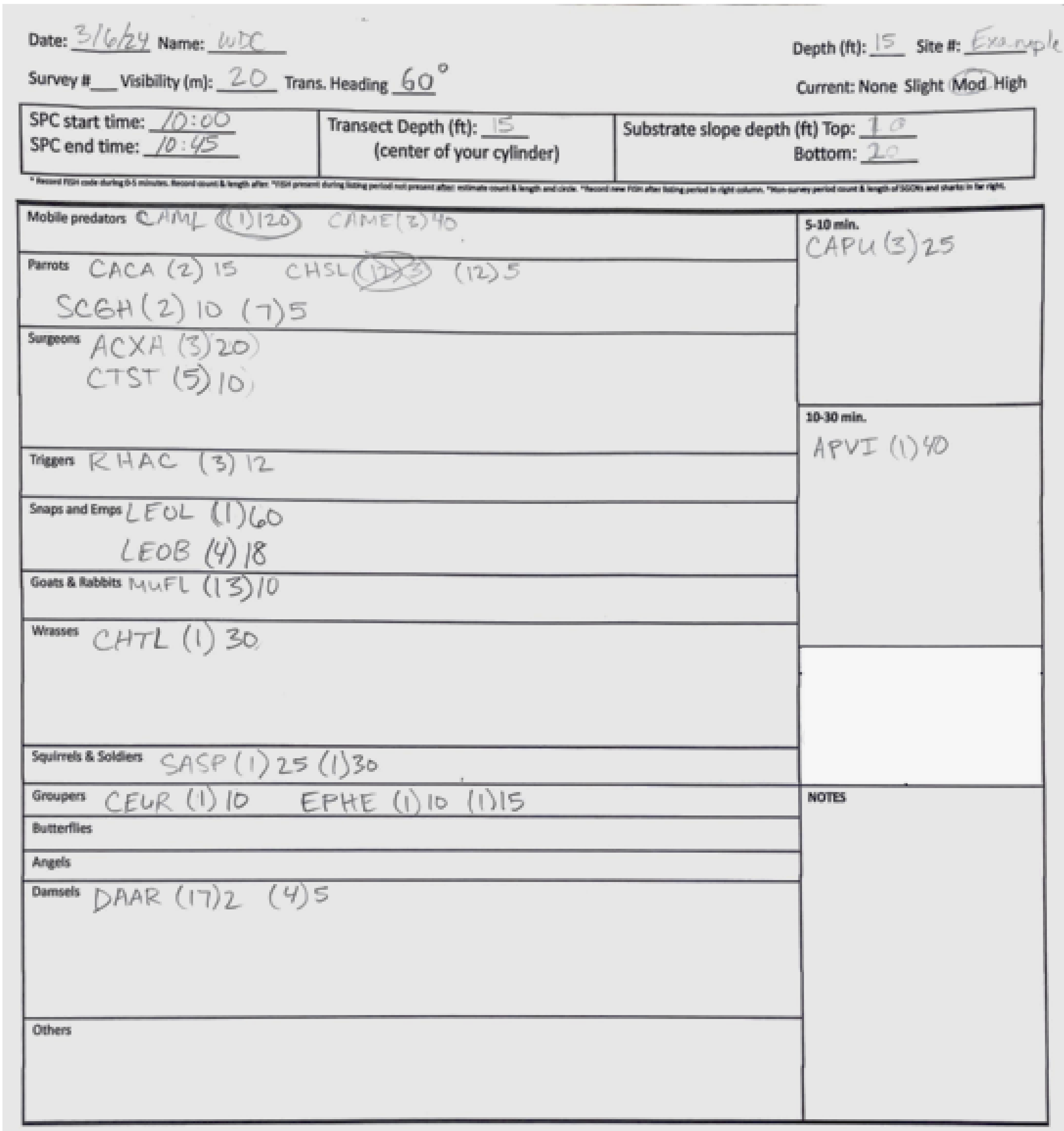
During the listing period, the diver only records species presence in their survey cylinder. No count or size information is collected. Time is enforced using the countdown timer function on a dive computer. The timer will beep after 5 minutes have expired, keeping effort during this portion of the survey standardized. The species list is developed following a standardized procedure in which the diver follows the datasheet from top to bottom (Figure 6).

The datasheet has been structured so that highly mobile fish (e.g. sharks, rays, mobile predators, etc.), likely to move in and out of the survey area, appear at the top. Roving herbivores and mesopredators fill in the middle portion of the sheet, while sedentary, cryptic, and benthic-associated fish are at the bottom. This organization helps ensure that all fish present are accounted for by prioritizing initial attention on roving fish that are more likely to move during the survey.

4.13 Tallying Period

After species are initially listed, count and length observations are made by a series of "rapid visual sweeps" of the survey cylinder to capture a snapshot of which fish are in the survey area instantaneously. The diver will again work through their list from top to bottom. In some cases, a "rapid visual sweep" will be for a single species (e.g. *Naso lituratus*). At sites with low abundance, it may be possible to lump several species together into a single sweep (e.g. unicornfishes). This will depend on abundance and is left to the diver's discretion.

Tallying continues until counts and lengths are completed for each species from the initial list. If a species was listed but is no longer within the survey cylinder during the tallying period, the diver should estimate count and length data from their memory of the listing period and circle the entry. Circled entries indicate that the species was not a part of the instantaneous sweep but is a recollection from the initial listing period. For some highly mobile fish (e.g. sharks, rays, jacks, milkfish, etc.), it may be more practical to simply collect the length and count data during the listing period. The diver can circle the data to proactively mark it as non-instantaneous. If the species returns to the cylinder during the tallying period, the diver can cross out the circled entry and write in the new instantaneous count and length.



Date: 3/6/24 Name: WDC
Depth (ft): 15 Site #: Example
Survey #___ Visibility (m): 20 Trans. Heading 60°
Current: None Slight Mod High

SPC start time: 10:00 SPC end time: 10:45	Transect Depth (ft): 15 (center of your cylinder)	Substrate slope depth (ft) Top: 10 Bottom: 20

Mobile predators CAML (1)120 CAME(3)40	5-10 min. CAPU (3)25
Parrots CACA (2) 15 CHSL (12)3 (12)5 SCGH (2) 10 (7)5	
Surgeons ACXA (3)20 CTST (5)10	
Triggers RHAC (3) 12	10-30 min. APVI (1)40
Snaps and Emps LEOL (1)60 LEOB (4) 18	
Goats & Rabbits MUFL (13)10	
Wrasses CHTL (1) 30	
Squirrels & Soldiers SASP (1) 25 (1)30	
Groupers CEUR (1) 10 EPHE (1)10 (1)15	NOTES
Butterflies	
Angels	
Damsels DAAR (17)2 (4)5	
Others	

Figure 6: Fish Data Collection Sheet Example. The datasheet is organized from top to bottom with more mobile/priority fish at the top of the sheet. In the parrotfish row is an example of a fish (CHSL) spotted in the initial 5-minute listing period, recorded and circled as non-instantaneous because it was no longer visible, then crossed out and sized/counted during the tallying period because it swam back through the survey area. Other cases of non-instantaneous fish are noted throughout the datasheet (i.e. CAML). Species not initially listed, but encountered later during the survey are noted on the right-hand-side of the datasheet in either the 5-10min (i.e. CAPU), or 10-30min (i.e. APVI) boxes. This Datasheet and figure are adapted from Ayotte et al., 2015.

4.14 Additional Tips and Rules

1. Do not add, count, or size additional already-listed species during the tallying period.

Never amend or adjust already-listed species during the tallying period. Doing so will nullify the instantaneous nature of the data. For example, if you already counted and sized six SIAR (*Siganus argentus*), do not amend that list if a new individual swims into the cylinder after completion of the 5-minute listing period. Simply ignore that fish and focus on the remaining species in your list.

2. Record count and length of species **not** included during the initial listing period on the right side of the data sheet.

If a fish that was not initially listed (i.e. a new species) swims into the diver's cylinder during the tallying period, the diver can record that fish with count and length data on the right side of the datasheet in either the "5-10 min" or "10-30 min" box. This information will not be used in instantaneous biomass estimates but can be used for analysis of species presence, diversity, and length structure.

3. Record species of special interest outside of the survey time or area using the "Site Pres…" box at the bottom of the data sheet or the "notes" box (Appendix 3).

These boxes can be used for species of interest that are seen outside of the survey area at any time during the survey. This allows divers to record presence/absence information on species that rarely enter the survey cylinder (e.g. Napoleon wrasse, giant grouper, gray reef sharks, etc.)

4. Record cryptic fish during the tallying period as instantaneous if there is confidence that the species was present but hidden within the cylinder and did not move into the cylinder after the initial listing period.

Try to remain at the center of your cylinder and focus attention on roving species as much as possible during the 5-minute listing period. If a diver feels they were not able to adequately capture all sedentary and cryptic species during the initial 5-minute listing period and have finished tallying their list, they can use part of their remaining time to search their cylinder for cryptic species. If the diver believes fish found during this time were present, but hidden, they can be entered as instantaneous. Examples of species for which this may be useful include groupers (Serranidae), squirrel fishes (Holocentrinae), soldier fishes (Myripristinae), and certain species of cave dwelling snappers (ex. *Lutjanus kasmira* or *Lutjanus fulvus*).

5. Prioritize food fish and species of special importance if necessary.

Other cryptic and sedentary species found during this time may include gobies, blennies, and cardinal fishes. While these fish are interesting in terms of relative diversity and presence/absence, they represent only a small portion of overall biomass. Moreover, such fish are not usually targeted by the fishery and are a lower survey priority compared to exploited and indicator species. SGCN fish should also be prioritized (Appendix 1). Divers must always be mindful of time, depth, and no decompression limits and ensure that enough time and air will be left to complete the benthic data collection portion of the survey.

5 Benthic Data Collection

After completing fish surveys, the buddy pair begins benthic data collection. This portion of the survey is structured similarly to the NOAA Rapid Ecological Assessment protocol although it differs in many ways (Ayotte et al., 2015). Each surveyor begins by recording a general habitat description and a visually estimated benthic cover percentage within the cylinder area. After these estimations are complete, one diver will take 30 photoquadrats (Section 8) while the other counts invertebrates, including sea cucumbers, sea urchins, species of greatest conservation need (SGCN), and Endangered Species Act (ESA) listed species, present along a 4m belt transect (2m on each side of the transect line). Collection of these species' density provides important information on both habitat and population health. Information regarding fish habitat and benthic dwelling species can be found at the bottom of the datasheet (Figure 7).

Habitat Description		**Benthic Cover**	**Cyl. Dens. Hard Coral**	**Site Pres. SGCN/ESA/ETC.**	**4M BELT TRANSECT INVERTEBRATE DENSITY. PICTURE FOR ID.**	
		Hard Coral %	Staghorn ___%	Hawksbill __#	**BOAR**	**Others**
Fore Reef	Reef Rubble			Green Turtle ___#		
		Uprt Mac Al. %	*A. globiceps* ___#	Spin. Dolphin ___#	**HOAT**	
				Squid ___#		
Back Reef	Sand	CCA %	*A. retusa* ___#	Day Oct. ___#	**HOHI**	
		Bare %	*S. aculeata* ___#	**SGCN FISH & SHARKS**	**STCH**	
Reef Crest	Upr. Mac. Al	*Enhalus* %	**Coral Health Notes**		**SYMA**	
Patch Reef	*Enhalus sp.*	*Halodule* . %			**TRIDAC.**	
		Other %			**TROCHUS**	
Pavemnt	*Halodule sp.*				**LILA**	
		TOTAL 100%				

Figure 7: Benthic Habitat Table Located at the Bottom of MRA24 Data Sheet. Surveyor should circle the component in **Hab. Descrip.** column that matches the site. Cover percentages within the survey cylinder should be estimated in the listed categories under the **Benthic Cover** column. The **Cyl. Dens. Hard Coral** column should be used to record the relative percentages of CNMI SGCN corals as well as make notes on coral health at the site. The **Site Pres. SGCN/ESA/ETC.** is for recording presence data for the species listed, any SGCN fish, and any species of shark. The final column, **4M BELT TRANSECT INVERTEBRATE DENSITY** column is for recording species counts along the belt transect. The most commonly found invertebrates are listed. Pictures of unidentified invertebrates should be taken.

5.1 Habitat Description

The function of the habitat description parameter is dependent on survey design. For habitat-stratified survey designs, the habitat description area serves as a way to generalize habitat types into broad categories for modeling. It can also be a useful way to record unexpected findings that contradict prior habitat classifications. Some sites surveyed during the FY23 season were classified as seagrass in prior studies, although our work found that they had become entirely sand. In this case, we recorded the contradiction so that we maintained up-to-date records of benthic habitat.

For survey designs that do not rely on habitat stratification or for surveys in areas where benthic zones have not yet been delineated, habitat types can be recorded in the habitat description box to stratify the survey zone in situ. In this circumstance, the most appropriate habitat type should be chosen from a predetermined list, although notes on habitat may still be taken. Table 1 includes some suggested habitat types that may be used for surveys, although this can be adjusted with survey needs.

Table 1: Suggested Habitat Descriptions for Surveys. Surveys should circle the category that most matches the site.

Suggested Habitat Types	
Fore Reef	Reef Rubble
Back Reef	Sand
Reef Crest	Upright Macroalgae
Patch Reef	*Enhalus* Seagrass
Pavement	*Halodule Seagrass*

5.2 Benthic Cover Estimates

Divers are tasked with conducting visual estimates of benthic cover in seven categories: hard coral, upright macroalgae (Uprt. Mac. Algae), *Halodule* seagrass (*H.* seagrass), *Enhalus* seagrass (*E.* seagrass), coralline algae (CA), bare, and other (Table 2). Generally, the top layer of substrate is the one identified. Macroalgae growing on top of sand, for instance, should be estimated as macroalgae. In the case that categories are lightly speckled with sand, the organism underneath should be the one identified. If CA is covered in a thin dusting of sand, it should still be identified as CA. Categories are further described below.

Table 2: Benthic Cover Categories for Visual Estimation. Total benthic cover should sum to 100%.

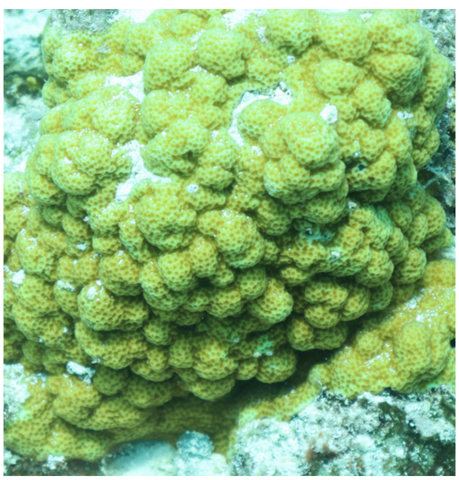
Hard Coral ____%	CA ____%
Uprt. Mac. Algae ____%	Sand ____%

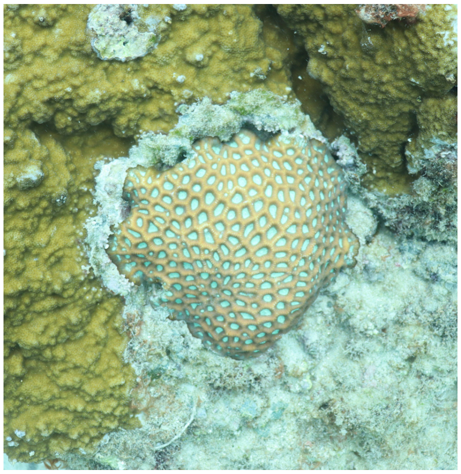
H. Seagrass ____%	Other ____%
E. Seagrass ____%	TOTAL 100%

5.21 Hard Coral

Hard corals are Scleractinian coral colonies that are at least partially covered in living tissue (Table 3). Tissue appears colored because of the presence of Symbiodiniaceae, a symbiotic dinoflagellate. Hard corals can present in different colors and as different structures, including branching, plating, corymbose, encrusting, and massive growth forms.

Table 3: Examples of Scleractinia Habitat and Morphological Variation Between Species in the CNMI. Note that color and morphology can vary between and even within species. Photo credit: Nicholas Robie

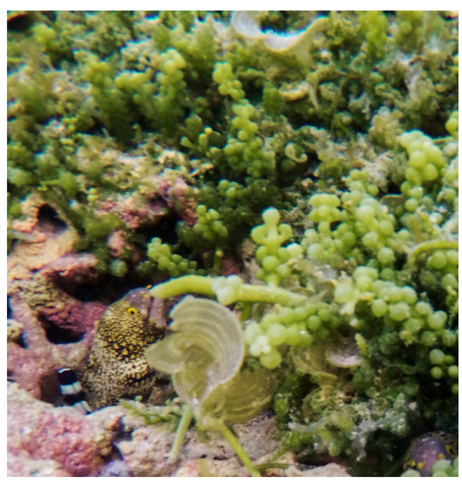
	

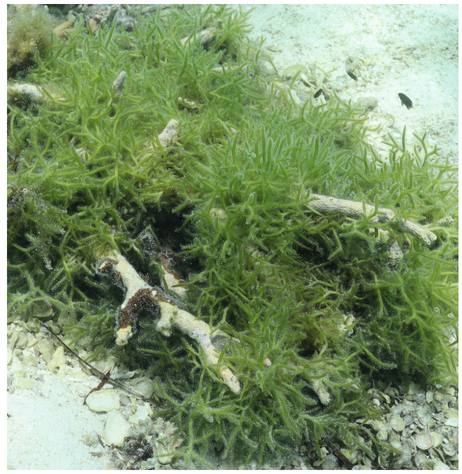
	
	
	

5.22 Upright Macroalgae

The upright macroalgae category for DFW surveys consists of algae that is > 1 cm from the substrate (Table 4). They include representatives from multiple groups including Rhodophyta, Chlorophyta, and Phaeophyceae. Algae may be calcareous, filamentous, or exhibit complex structure. It does not include calcareous encrusting or branching coralline algae in the family Rhodophyta.

Table 4: Examples of Upright Macroalgae Habitat in the CNMI. Photo credit: Nicholas Robie

5.23 *Enhalus* Seagrass

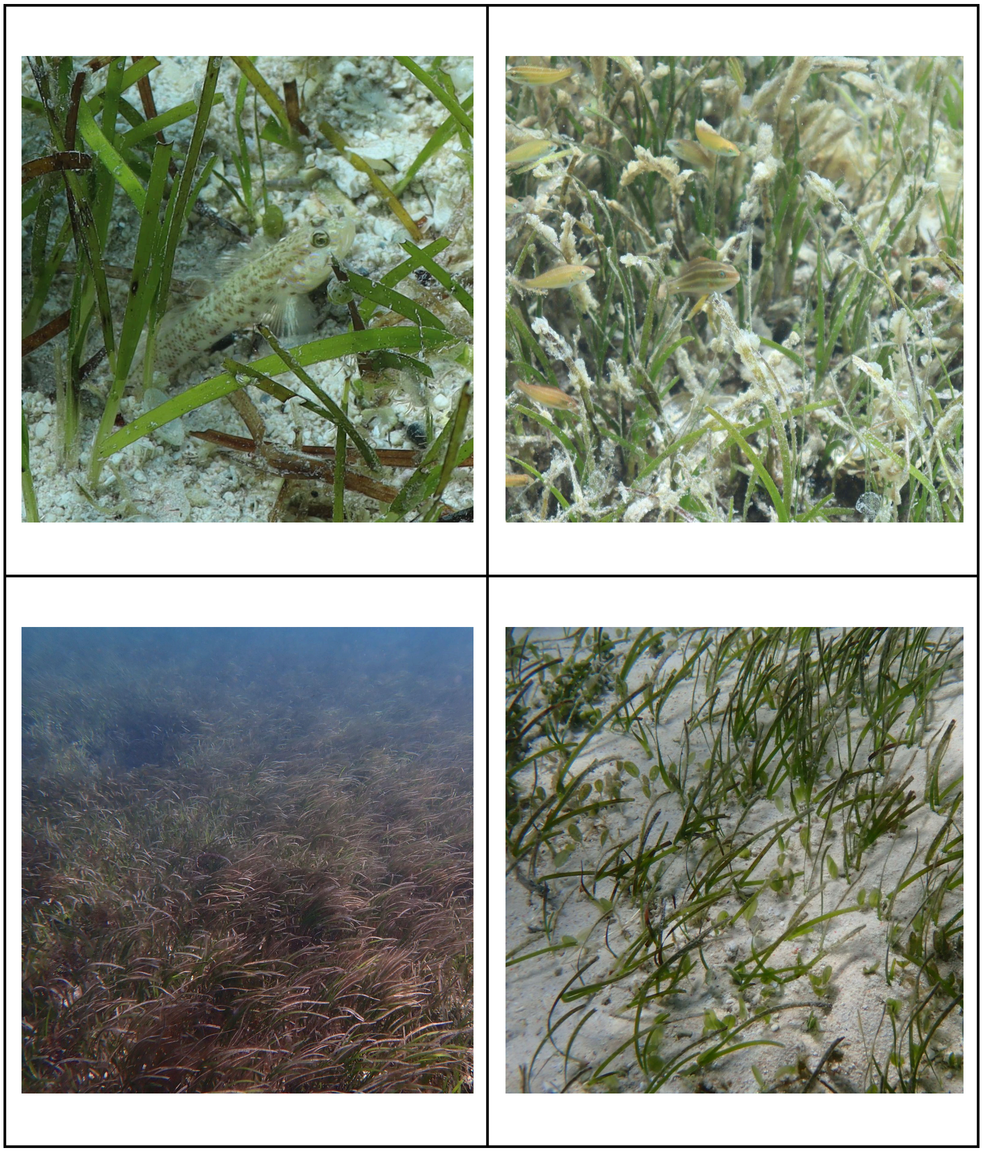
Enhalus acoroides, commonly known as tape seagrass, is the sole member of its monotypic genus (Table 5). This species is commonly found in shallow lagoons near areas of freshwater discharge. The blades of tape seagrass are wide and waxy, and the plants typically grow much larger and wider than other seagrass species.

Table 5: Examples of *Enhalus acoroides* Habitat in the CNMI. Photo credit: Nicholas Robie


5.24 *Halodule* Seagrass

Halodule uninervis is the most common seagrass found in the CNMI (Table 6). They are common in shallow lagoon areas between the shore and back reef. *Halodule* seagrass serves as both habitat and sustenance in the ecosystem, particularly for juvenile parrotfish and wrasses. These grasses can be threatened by macroalgae overgrowth in nutrient rich environments because fast growing macroalgae outcompetes seagrass for light.

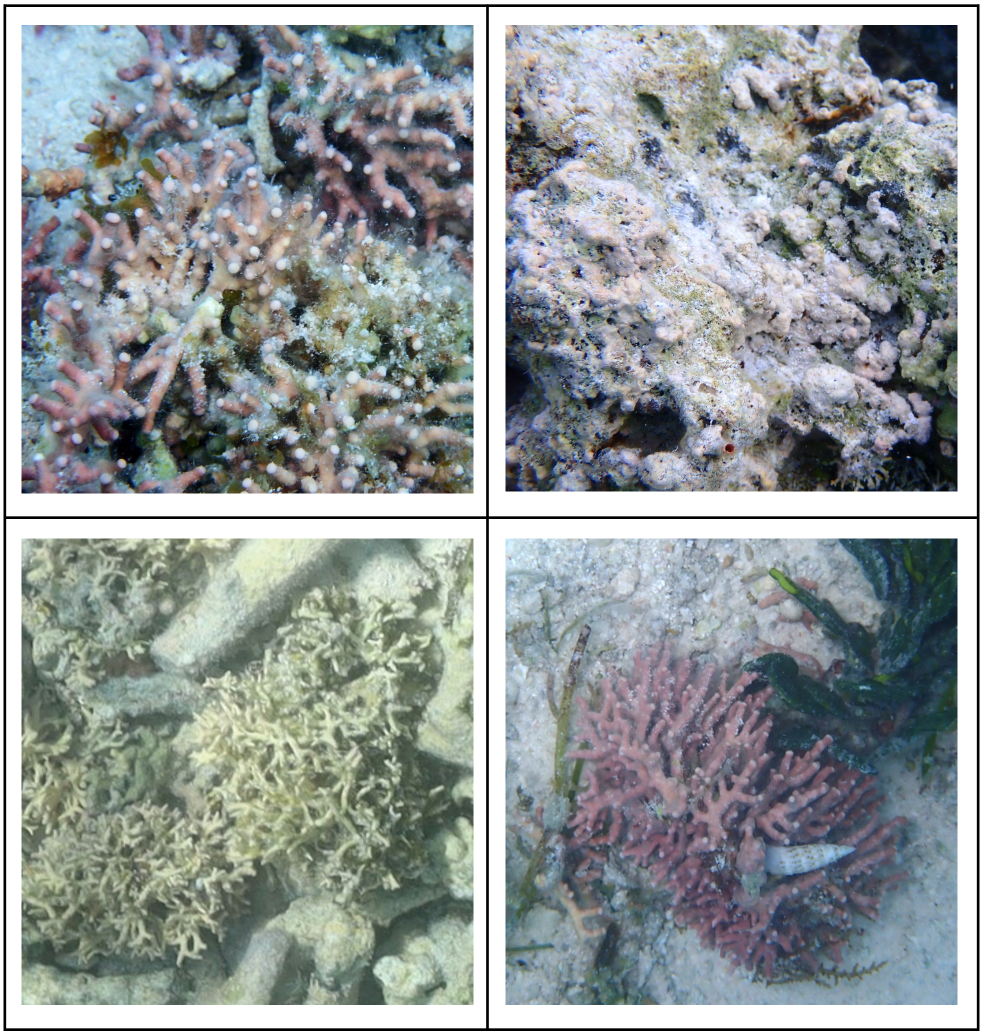
Table 6: Examples of *Halodule uninervis* habitat in the CNMI. Photo credit: Nicholas Robie



5.25 Coralline Algae

Coralline algae (CA) is a type of calcareous red algae that forms on substrate and dead coral (Table 7). Crustose coralline algae (CCA) form encrusting layers on substrate while branching coralline algae (BCA) forms upright structures on the benthos. CCA is notable for its role in reef calcification and its promotion of coral larval settlement in many species. Though they commonly form an encrusting layer, CA can also develop three dimensional structures.

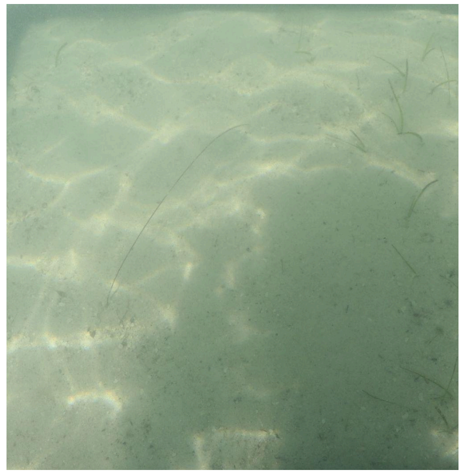
Table 7: Examples of Crustose Coralline Algae Habitat in the CNMI. Photo credit: Nicholas Robie



5.26 Bare

The bare category includes sand, pavement, and not yet colonized calcareous substrate resulting from death of organisms that generate skeletons (Table 8). Sand includes both inorganic and organic sediments. The texture and size of these sediments can vary, although sand areas should be > 1 cm deep.

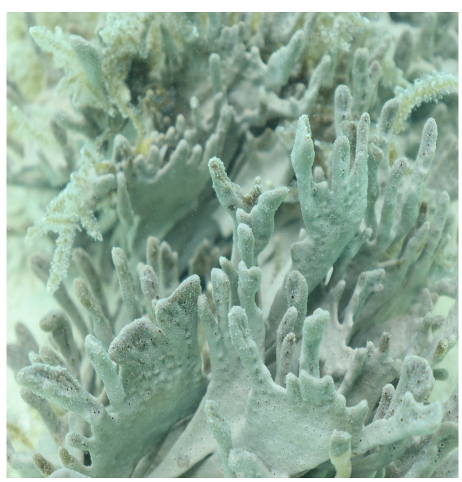
Table 8: Examples of Bare Habitat in the CNMI. Photo credit: Nicholas Robie

5.27 Other

Other habitat areas include areas of the benthos not consisting of hard coral, upright macroalgae, CA, seagrass, or bare habitat (Table 9). This may include anemones, sponges, dead corals, soft corals, cyanobacteria, turf algae, sea squirts, etc., but it does not include mobile animals like sea cucumbers or sea urchins.

Table 9: Examples of Other Benthic Cover in the CNMI. Photo credit: Nicholas Robie

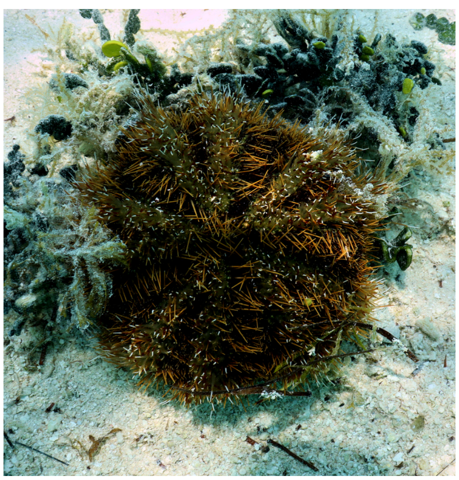
5.3 Cylinder Density of SGCN Hard Coral & Coral Health Notes

The next section of the benthic table concerns SGCN hard corals. Hard corals listed in the 2015 SWAP are *Acropora globiceps, Acropora retussa, Seriatopora aculeata*, and all species that can be classified as staghorn corals. *Acropora globiceps* is the only coral species in this group currently ESA-listed as threatened in the Mariana Islands. A percentage of the survey cylinder consisting of Staghorn coral should be estimated and the number of colonies of the other listed corals should be counted. In addition, coral health notes on disease, bleaching, etc. should also be recorded.

5.4 Site Presence of SGCN/ESA/ETC.

The fourth column from the right on the benthic portion of the data sheet is for recording site-wide presence of species of special importance. These include SGCN's, ESA-listed species, and any shark species (Table 10). Presence of these species can be recorded at any time around the site area.

Table 10: Examples of Species to SGCN/ESA/Species of Interest. Counts of these species can be recorded to estimate density.

6 Four Meter Belt Transect Invertebrate Density Count

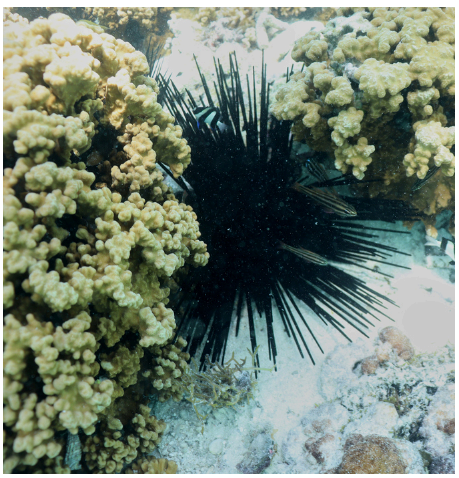
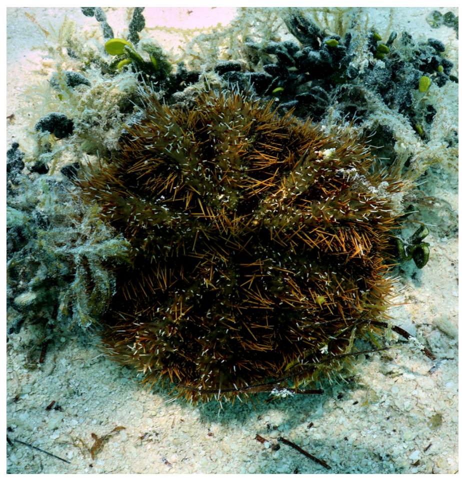
2015 SGCN's include giant *Tridacna* clams, spiny lobster, the collector urchin, and several species of coral and molluscs (Appendix 1). The priority actions for these species are primarily to determine basic ecological information like abundance, distribution, and habitat association. Sea cucumbers and sea urchins, although not designated as SGCN's, have also been identified to have potential for fishery importance in the future. Beyond that, they fill important ecological roles that affect broader ecosystem function. Gathering information for invertebrates fills critical knowledge gaps defined in the 2015 State Wildlife Action Plan (Liske-Clarke, 2015).

The last section of the bottom portion of the data sheet will record data on invertebrates, including SGCN, ESA-listed species, and species of interest for management purposes (Appendix 5, Table 11). Invertebrate counts should be conducted in tandem with benthic photoquadrats (Section 8). The diver responsible for the BLT will move down the transect line from end to end. First, they will focus on tallying invertebrates on the right side, 2 meters perpendicular to the transect line. Then, they will continue tallying on the opposite side of the line. The sweeps for invertebrates should be conducted as many times as necessary to generate an accurate measure of species abundance and diversity. The counts collected from this survey should be recorded at the bottom of the data sheet (Figure 7).

Table 11: Examples of Invertebrates Found During Surveys in the CNMI



7 Benthic Photoquadrats, CoralNet, and Future Directions

7.1 Benthic Photo Protocol

The use of benthic photos taken at regular intervals along the thirty meter transect line is recommended by the NOAA Rapid Ecological Assessment Program methodology (Ayotte et al., 2015). After fishery independent data collection is complete, photographs of the survey area and benthos can begin together with the BLT invertebrate counts detailed in Section 7. One diver is responsible for doing the invertebrate counts along a 4 m belt transect, and the other is responsible for taking a total of 30 photoquadrats at 1 m intervals. The camera of choice for this procedure is an Olympus Tough TG-6. Divers taking images should first use their slate or an 18% gray card to correct the white balance at depth. Achieving correct white balance is critical for deep learning automation with CoralNet. After the correct white balance is confirmed, the diver will take at least four reference images of the site in underwater snapshot mode. Site photos should be reflective of the general habitat, so that they can be used during data processing to reference sites.

The buddy pair will then move down the right side of the transect line. The diver with the camera will take pictures at 1 m intervals at a fixed height of 1 m above the substrate while the other conducts the BLT transect invertebrate count. The lens of the camera should be parallel to the subject of the photograph and the diver with the camera should ensure that images collected are not blurry and that the camera is fully "zoomed" out, i.e. the lens is at its widest possible angle. The camera will be mounted on a one meter long PVC pipe ("monopod") to ensure that the height and angle of photo capture remains constant. Any images that are not taken satisfactorily (crooked monopod, blurry, incorrect zoom) should be immediately deleted and retaken. A total of 30 photos will be captured, encompassing the full transect length.

7.2 Camera Equipment, Photo Analysis, and Archival

Following the completion of the day's field exercises and the proper cleaning and storage of the camera equipment, images should be uploaded into a folder designated specifically for that survey project's images.

7.21 Naming Images

All titles of items in the shared drive should be lowercase. The directory structure within the hard drive will be simple. Primary folders titled by their project_name will hold two subfolders: **photo_quads** and **reference_photos**. The photo_quad folder will hold all images taken of benthic habitat along the transect scaled with monopod as described above. Photo quadrats should be renamed according to the date and 24-hour time they were taken and the site number they are associated with using the template:

<sitenum>_<Year-month-day>_<24hour-minute-second>

Reference photos, the first four images taken after white balancing the camera, should be named:

<sitenum>_<Year-month-day>_<24hour-minute-second>_ref

Fish or other taxon ID photos of quality should be named:

<sitenum>_<Year-month-day>_<24hour-minute-second>_id

This archive system makes metadata accessible and sorting easy. The downsides of this naming structure are a reliance on the accuracy of file names.

7.211 Examples of Naming System

Example. Photoquadrat taken on January 15, 2023 at 4:35:12 PM at survey site 1:

site01_2023-01-15_16-35-12

Example. Reference photo taken by Nicholas Robie on January 21, 2024 at 9:12:12 AM at survey site 183:

Site183_2024-01-21_09-12-12_ref

Example. Fish identification of *Naso unicornis* taken by Nicholas Robie on January 21, 2024 at 9:13:16 AM at survey site 183:

site183_2024-01-21_09-13-16_id

7.22 Batch Renaming

Many software programs are available to batch rename large quantities of photographs quickly using the metadata stored in image files, however in-house programs written in python or R are preferred. Automating the renaming process will increase efficiency of data organization and storage. Upon upload of a survey trip's SD card, select, rename and transfer all 30 photoquadrats first to the photo_quads folder within the appropriate project's folder. Then, select, rename, and transfer the minimum of four reference photos. Follow the exact file naming structure detailed in this guide.

7.23 Analysis of Photoquadrats with CoralNet

After photoquadrats have been properly named and organized, analysis should be completed using CoralNet. CoralNet is a web-based resource for coral identification and benthic analysis. It makes use of a deep learning system which can be trained to assist human identifiers with benthic identification. NOAA's procedure for CoralNet should be used to ensure that there is data reciprocity with their program (Lamirand, 2022).

CoralNet has not been used by DFW before, and its use may change depending on program needs and capacity. CoralNet is the most feasible option for in-house benthic analysis at this time. Proper naming and file organization will enable its use.

8 Data Entry and Database Management

Best practices for data entry include entering data as close to collection date as possible, double checking each value entered, and maintaining a high degree of organization.

The database used to organize the data collected from fisheries independent surveys at DFW is organized into different google sheets files by fiscal year. Each year's spreadsheet holds all data from the surveys collected during that time. A rough template of this file can be found at the following link:

> https://docs.google.com/spreadsheets/d/1TqLxVlo-IjWMFX-PDbBbYzxLddkYyJF_LaN52P-IXRY/edit#gid=0

Within the broader google sheet, organized by project, there are ten different sub-sheets that help streamline the data. These sheets are often interconnected, helping to autofill information to make data entry more efficient. The "NOAA Codes" sub-sheet, for instance, provides a list of different codes that can be used to easily identify, study, and record fish in the field. It also includes the relevant information to auto-populate the data sheets with useful data fields like family or species name. The "id" field, in which the site number surveyed is inputted, is critical because it links all the sub-sheets to one another. This field can then be used to filter and analyze data across sub-sheets.

After data is entered into the correct survey database, the survey sheet should be marked with the date entered and the person who entered it. It should then be placed in the correct folder for completed and entered data to maintain a paper trail in case of technological issues.

8 Training

8.1 Survey Training

DFW professional staff are trained in the above survey methods using several learning resources. Flashcards and powerpoints of commonly encountered fish species are provided and continually refined to support fish identification. In addition, flashcards of Species of Greatest Conservation Need (SGCN) are available. Four-letter codes for these species are used to increase efficiency by reducing writing time. Quizzes on relevant fish ID are also given twice a month before and during the survey season to assess and maintain staff proficiency. Staff should be proficient in identifying food fish and common non-harvested fish before conducting surveys.

Divers are also trained with fork length calibration surveys given before and during the survey season. During a calibration survey, divers affix wooden fish cutouts of fixed length to the substrate at various distances from the center of the SPC cylinder (Figure 1). Divers then record their fork length estimations on a new datasheet. These calibration tests serve two purposes. First, they provide opportunities to evaluate and correct fork length estimations. Second, if team members record measurements that are consistently short or long, off by a certain percentage, or some combination of these two errors, a correction model can be generated to improve the accuracy of the full data set.

Training should be conducted with the appropriate frequency to ensure that DFW staff are able to perform their field duties. Prior to survey season, it is recommended for staff to study for fish ID quizzes, given in at least bi-weekly intervals. During survey season, the frequency of fish ID quizzes can decrease, but the frequency of length calibration surveys should increase. While length calibrations can be conducted sparingly in the pre-survey period, they should be conducted at least monthly during the survey season to recognize and correct staff patterns and biases.

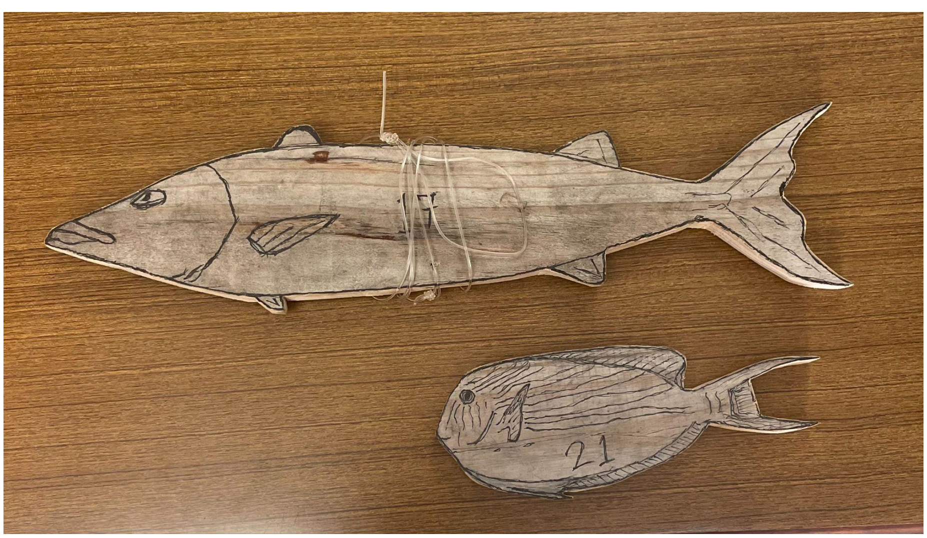


Figure 7: Examples of Wooden Fish Cutouts Used to Test Length Estimation. In-water, cutouts are affixed to the substrate using a weight and fishing line.

8.2 Dive and Safety Training

Safety during surveys is a fundamental priority. All team members must be trained and hold current certifications in cardiopulmonary resuscitation (CPR) and emergency oxygen administration. In addition, all dive personnel should be certified to the rescue diver level, although exceptions may be made in certain extraordinary circumstances. “Check dives,” where regular dive skills, rescue scenarios, and survey techniques are practiced, occur at regular intervals to maintain field readiness. The DFW Dive Manual details the requirements of the dive program and is scheduled to be updated in the near future.

9 Conclusion

Having a standard operating procedure to serve as a guide for DFW to evaluate the CNMI's marine resources is key to streamlining data collections and analysis. Building repositories of high quality data is critical for analyzing spatial and temporal trends in environmental health. Sharing our methodology and promoting data transparency is important to DFW FRS so that the proper contingencies can be accounted for during analysis. This methodology takes into consideration DFW survey procedures from the past and projects them into the future to promote a high quality fisheries-independent data stream that can be used to accomplish myriad agency goals. This document and methodology should be reviewed, and updated if necessary, each year with the goal of ensuring these methods are appropriate for DFW's needs.

References

Ayotte, P., McCoy, K., Heenan, A., Williams, I.D. (Ivor D., Zamzow, J.P., 2015. Coral reef ecosystem program standard operating procedures : data collection for rapid ecological assessment fish surveys. https://doi.org/10.7289/V5SN06ZT

Lamirand, M., 2022. Analysis of Benthic Survey Images via CoralNet: A Summary of Standard Operating Procedures and Guidelines (2022 update) Public Version. https://doi.org/10.25923/NHX2-6J45

Liske-Clarke, J., 2015. Wildlife Action Plan for the Commonwealth of the Northern Mariana Islands, 2015-2025. CNM DLNR-Division of Fish & Wildlife.

Trianni, M. S., Tenorio, M. C., McKagan, S. C., & Dunn, W. O. (2018). Evaluation of a Fishery Resource Response to a Net-Use Restriction in Saipan Lagoon, Commonwealth of the Northern Mariana Islands. *Pacific Science*, *72*(3), 291–306. https://doi.org/10.2984/72.3.1

Appendices

Appendix 1: Equipment Checklist

The following checklist should be used before leaving the Division and Fish and Wildlife building before surveys.

1. Survey Equipment
   - ☐ Global Positioning System loaded with that day's sites
   - ☐ Extra batteries for the GPS
   - ☐ Map of general survey area with site locations and numbers
   - ☐ 2 x 15 m transect line marked at 7.5 m intervals
   - ☐ Surface marker buoy attached to 50m line with weight
   - ☐ Secchi disk
   - ☐ Datasheet, slate, and rubber bands
   - ☐ Pencils
   - ☐ Dive watch with timer
2. Benthic Equipment
   - ☐ Pre-prepped camera with housing
   - ☐ Empty SD card
   - ☐ White balance card (dive surveys)
   - ☐ Charged battery
   - ☐ Lubricated O-rings
   - ☐ 1 m PVC stick marked at 10 cm increments
3. Dive Equipment
   - ☐ Fins and boots
   - ☐ Weights
   - ☐ BCD
   - ☐ Regulators
   - ☐ Mask
   - ☐ Snorkel
   - ☐ Correct number of **filled** tanks
   - ☐ Dive computer
   - ☐ Thermal protection
   - ☐ Oxygen analyzer (when diving with enriched air nitrox)
4. Safety Equipment
   - ☐ Audio signaling device (one per diver)
   - ☐ Surface marker buoy and dive reel (one per diver)
   - ☐ First aid kit
   - ☐ Oxygen kit (SCUBA dives)
   - ☐ USCG regulated safety equipment (Captain's responsibility)
5. Other
   - ☐ Sunscreen
   - ☐ Defog
   - ☐ Hat
   - ☐ Sunglasses
   - ☐ Water/Snacks/Lunch

Appendix 2: Step by Step Survey Procedure

Select survey sites

Check weather and tides to determine which areas are possible to survey

Set a survey goal (i.e. number of surveys to complete)

Run “Snapshot Survey” R script (Appendix 6) accounting for logistical constraints (i.e. weather, tides, etc.)

Confirm survey legitimacy with the boat captain and submit float plan to the shore contact

Print survey map and send electronic copies to the survey team

Prepare Necessary Equipment

Load boat or truck with the necessary survey equipment

Use the equipment checklist (Appendix 1) to double check equipment before departure

Navigate to the site

Navigate to site using handheld marine GPS

Throw marker float (if able) to mark the sites location

Move boat away from the site and prep to enter the water

Set up the survey area

Enter water and descend safely

Place central weight in survey area

Attach surface marker to weight

Attach reels to central weight

Attach other materials securely to weight

Extend transect lines along single heading roughly parallel to shore or depth contour

Note the compass heading of the transect line

Take visibility using Secchi disk along transect to the nearest meter

Divers set up at center of their cylinder, signal, and start fish data collection

Fish Data Collection

Record SPC start time

Record transect depth at center of cylinder

First five minutes: list every species in survey cylinder using series of rapid visual sweeps

Additional time: record count and length for listed and unlisted species as needed

Record SPC end time

Benthic Data Collection

Select habitat description

Estimate benthic cover in survey cylinder

Estimate number/percentage of SGCN corals per cylinder area + record coral health notes

Record site presence of SGCN/ESA listed species and sharks

Conduct 4m belt transect for invertebrates

Take 30 photos at 1 meter height at 1 meter intervals along right side of transect line

Finishing Survey

Roll up transect lines and pack survey equipment

Ascend safely and take safety stop

Appendix 3: List of Marine Species of Greatest Conservation in the CNMI.

2015 List of Marine Species of Greatest Conservation Need List for the CNMI. Far right column shows priority actions associated with each species, as defined by the 2015 CNMI State Wildlife Action Plan.

Scientific Name	Common Name	Chamorro/Carolinian Name	Priority Actions
Carcharhinus amblyrhynchos	Grey Reef Shark	Halu'u/Limwe	Determine specific abundance and distribution around Saipan, Tinian, and Aguiguan
Cheilinus undulatus	Napoleon Wrasse	Tanguisson/Maam	Measure abundance of juveniles in various habitats around Saipan
Chlorurus microrhinos	Steephead Parrotfish	Laggua/Igan-Wosh	Determine abundance and habitat associations around Saipan; plan additional actions as needed based on research and monitoring results
Leptoscarus vaigiensis	Seagrass Parrotfish	Kabara	Determine abundance and specific seagrass habitat associations around Saipan; plan additional actions as needed based on research and monitoring results
Multiple	Food Fish	Multiple	Plan actions based on research and monitoring results
Stenella longirostris	Spinner Dolphin	Toninos/Ghu	Plan actions as needed based on monitoring results
Eretmochelys imbricata bissa	Hawksbill Turtle	Haggan karai/Wong Maaw	Map foraging habitat
Chelonia mydas	Green Sea Turtle	Haggan/Wong Mool	Continue and expand outreach, education, and enforcement to reduce poaching; establish a community-based wildlife advisory board and implement appropriate management

Scientific Name	Common Name	Chamorro/Carolinian Name	Priority Actions
			recommendations; map and quantify the extent and quality of foraging areas around the southern islands; continue nest monitoring to track nesting success and deter poaching; work with DPL and regulatory agencies to maintain nesting beach suitability
Tripneustes gratilla	Collector Urchin	Laun/Larr	Determine abundance and specific habitat associations in areas accessible and inaccessible to harvest on Saipan
Panulirus spp.	Spiny Lobsters	Mahonggang/Yuurr	Determine abundance and distribution in areas accessible and inaccessible to harvest
Tridacna spp.	Native Giant Clams	Hima/Tto/Shafeshaf	Determine abundance and distribution in areas accessible and inaccessible to harvest
Gafrarium pectinatum	Pectinate Venus	Tapon/Amsun/Ai'mett/Ghatil	Determine abundance and specific habitat associations in areas accessible and inaccessible to harvest
Octopus cyanea	Day Octopus	Gamson/Ghuus	Determine abundance and specific habitat associations in areas accessible and inaccessible to harvest
Cassis cornuta	Horned helmet	Do'gas prensa/Mwe'ell	Determine abundance and specific habitat associations in areas accessible and inaccessible to harvest
Charonia tritonis tritonis	Triton's Trumpet	Kulu/Sa'wi	Determine abundance and specific habitat associations in areas accessible and inaccessible to harvest

Scientific Name	Common Name	Chamorro/Carolinian Name	Priority Actions
Lambis lambis	Common Spider Conch	Toro/Liyang	Determine abundance and specific habitat associations in areas accessible and inaccessible to harvest
Turbo spp.	Native Turban Snails	Aliling pulan/Lifott maram	Determine abundance and specific habitat associations in areas accessible and inaccessible to harvest
Chicoreus ramosus	Branched Murex	Do'gas/Abwel	Determine abundance and specific habitat associations in areas accessible and inaccessible to harvest
Acropora globiceps	Coral	Kuraling/Yeal	Determine distribution and abundance across the CNMI
Acropora retusa	Coral	Kuraling/Yeal	Determine distribution and abundance across the CNMI
Seriatopora aculeata	Coral	Kuraling/Yeal	Determine distribution and abundance across the CNMI
Acropora spp.	All Staghorn Coral	Kuraling/Yeal	Develop a coral propagation and reef restoration program; prioritize sites and implement appropriate conservation and management

Appendix 4: Example from FY23 Central and Southern Lagoon Survey

FRS completed a 172-point survey in Fiscal Year 2023 (FY23) using a snapshot random stratified design. The snorkel survey methods used included Stationary Point Count (SPC), Belt Transect (BLT), and Photo Quadrat Visual Estimates. Products from this effort included broad mappings of abundance, biomass, and relative diversity (Figure 8).

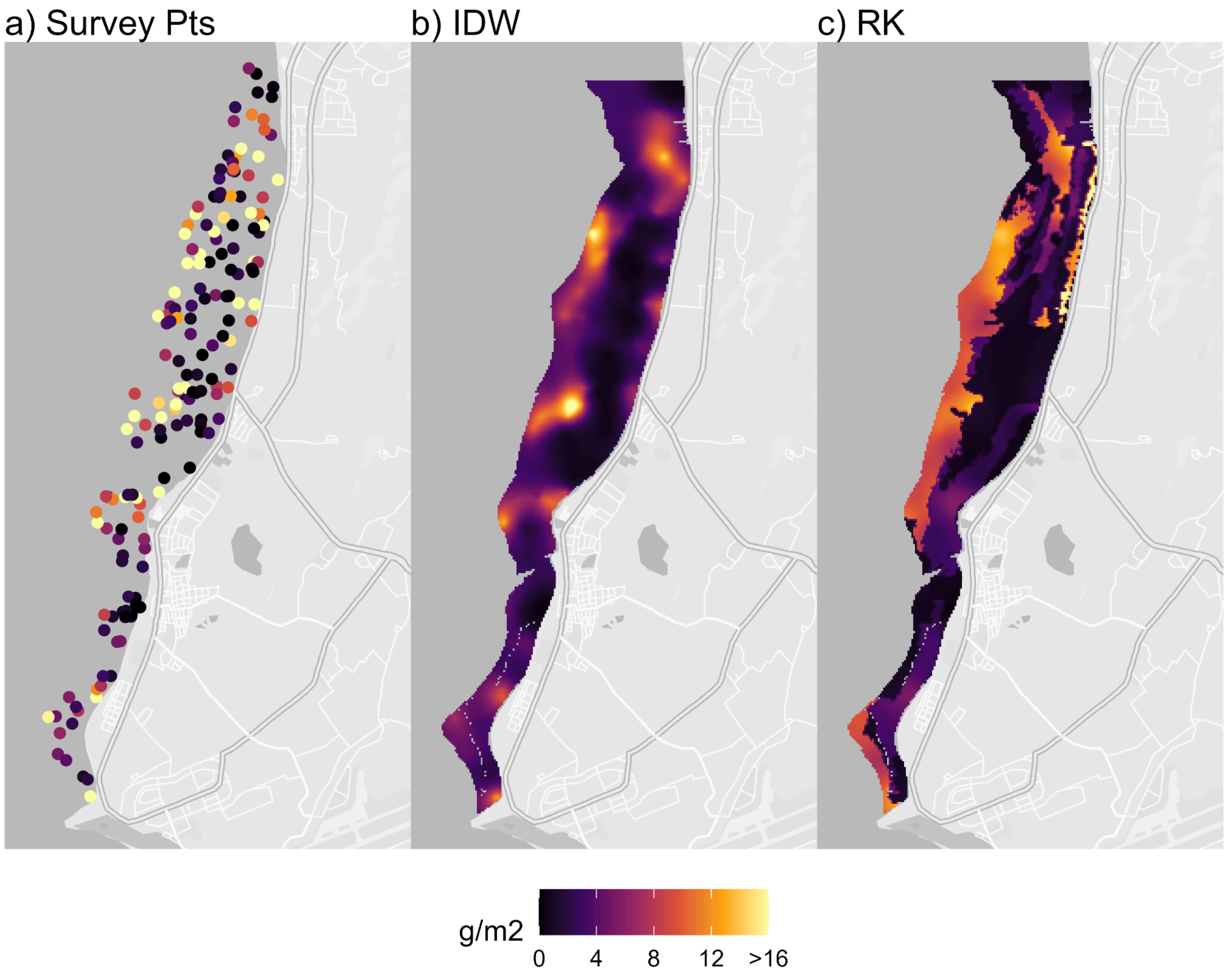


Figure 8: Fish biomass (g/m^2) Heatmap Generated from the FY23 MRA Survey of Saipan's Southern and Central Lagoon (Van Ee, 2023). Panel a) Calculated total biomass at each individual site surveyed during FY23. Panel b) Total biomass extrapolated to the entire survey area using an inverse distance weighting technique (IDW). Panel c) Modelled total biomass while accounting for habitat and spatial autocorrelation using regression kriging (RK).

Products from FY23 were derived almost exclusively from an updated SPC technique similar to what is outlined in this document. The BLT methods may be used at a later date to compare to historic surveys. The project revealed the powerful modeling applications of the updated SPC method and underscored a need to update standard operating procedures and standardize staff training.

As DFW continues these types of snapshot surveys and the database increases in size, we hope to include finer-resolution models of fish families, functional fish groups, or even individual species. This will help inform management decisions and provide an alternate data source to be referenced beyond the fishery-dependent Creel and Commercial Receipt Book Program datasets. Repeat samplings across years will eventually allow for trend analysis. However, the quality of these products will depend on the quality and consistency of the data collected by the MRA and FHS programs. Standardization of methodology and staff training are integral to the success of these programs.

Appendix 5: FY24 Data Sheet

Date: _________ Name: _________ Depth (ft): ____ Site #: _______

Survey #___ Visibility (m): _______ Trans. Heading _____ Current: None Slight Mod High

SPC start time: _________ SPC end time: __________	Transect Depth (ft): _____ (center of your cylinder)

* Record FISH code during 0-5 minutes. Record count & length after. *FISH present during listing period not present after: estimate count & length and circle. *Record new FISH after listing period in right column. *Non-survey period count & length of SGCNs and sharks in far right.

Mobile predators	**5-10 min.**
Parrots	
Surgeons	
Triggers	**10-30 min.**
Snaps and Emps	
Goats & Rabbits	
Wrasses	**NOTES**
Squirrels & Soldiers	
Groupers	
Butterflies	
Angels	
Damsels	
Others	

*Density counts are within the survey cylinder. Presence. counts are total site encounters by species. Record invertebrates along 4m BLT transect. Use photos for ID.

Habitat Description		**Benthic Cover**	**Cyl. Dens. Hard Coral**	**Site Pres. SGCN/ESA/ETC.**	**4M BELT TRANSECT INVERTEBRATE DENSITY. PICTURE FOR ID.**	
		Hard Coral %	Staghorn ___%	Hawksbill __#	**BOAR**	**Others**
Fore Reef	Reef Rubble			Green Turtle __#		
		Uprt Mac Al. %	*A. globiceps* ___#	Spin. Dolphin __#	**HOAT**	
				Squid __#		
Back Reef	Sand	CCA %	*A. retusa* ___#	Day Oct. __#	**HOHI**	
		Sand %	*S. aculeata* ___#	**SGCN FISH & SHARKS**	**STCH**	
Reef Crest	Upr. Mac. Al	*Enhalus* %	**Coral Health Notes**		**SYMA**	
Patch Reef	*Enhalus sp.*	*Halodule* . %			**TRIDAC.**	
		Other %			**TROCHUS**	
Pavemnt	*Halodule sp.*					
		TOTAL 100%			**LILA**	

Appendix 6: FY24 Snapshot Survey Generator R Script

```
##### SNAPSHOT SURVEY GENERATOR #####
# R Script written by Nathan Van Ee

### Load Packages and Data -------------------------
# Load Packages
library(sf)
library(tidyverse)

# Load lagoon map
lagoon_shp <- read_rds("E:\\FY23_LagoonSurvey\\saipan_lagoon_shp_nve.RDS")

# Load more Saipan spatial data
saipan_shp <-
st_read("E:\\DFW_GIS_Data\\Benthic_Habitats_CNMI\\Shapefiles\\saipan_habitat.shp")

# Filter to just the Saipan Land to get the shoreline outline
saipan_land <- saipan_shp %>% filter(D_STRUCT == "Land")

# Load up the survey points
library(googlesheets4)
# This will require an email authentication
FY24_survey_points <- read_sheet(
"https://docs.google.com/spreadsheets/d/1zczxobJKCG3kpBv0kNNkaHX1e85HOWo0WnVSiE
wW34A/edit#gid=445574687",
sheet = "meta_data"
)

### -----------------------------------------------

### Create a Random Survey -------------------------

# Enter the number of surveys you hope to accomplish today
goal <- 7

# Use the "#" to turn filters on or off depending on survey logistics

# Set a random seed for the survey
set.seed(2024)

# generate your list of survey points
survey_1 <- FY24_survey_points %>%
  # Consider only sites that have not been surveyed
```

```
  filter(survey_completed != 1) %>%
  # This filter removes sites that require SCUBA
  filter(trianni_cluster != "Deep Patch") %>%
  # Surveys conducted from the boat or from shore
  #filter(survey_type == "Shore-based") %>%
  slice_sample(n = goal, replace = FALSE) %>%
  mutate(sample_num = 1:goal)

### ------------------------------------------------

### Plot the survey map-----------------------------

# Match color scheme from Trianni et al., 2018
my_colors <- c(
  "red",
  "yellow",
  "darkgreen",
  "lightgreen",
  "navyblue",
  "grey50"
)

# Create space around edges of the map
adj <- 400

ggplot() +
  # add lagoon habitat map layer
  geom_sf(data = lagoon_shp, aes(fill = trianni_cluster), col = NA) +
  # add survey point data
  geom_point(data = survey_1, aes(long_UTM_55N, lat_UTM_55N), size = 3, fill = "white",
shape = 21, col = "black") +
  # add Saipan land outline layer
  geom_sf(data = saipan_land, fill = "grey90") +
  # create labels for the survey sites and make sure they don't overlap eachother
  ggrepel::geom_label_repel(data = survey_1, aes(long_UTM_55N, lat_UTM_55N, label = id)) +
  # add the custom color palette
  scale_fill_manual(values = my_colors) +
  # set theme
  theme_void() +
  # add labels
  labs(
    title = "FY24 Snapshot Survey Map",
    # Auto generate the date at the top of the map
    subtitle = paste0(Sys.Date()),
    fill = "",
    caption = "Habitat classification scheme from Trianni et al. 2018"
```

```
  ) +
  # Set limits of the map (in UTM Zone 55N)
  scale_y_continuous(limits = c(1681824-adj, 1688500+adj)) +
  scale_x_continuous(limits = c(360000-adj, 370000+adj)) +
  # Place legend and make other theme adjustments
  theme(legend.position = c(.75, .25),
        plot.caption = element_text(face = "italic", hjust = 0.5),
        plot.background = element_rect(fill = "#99CCCC", colour = NA))

# Save the survey map
ggsave(paste0(Sys.Date()," Survey Points.png"),
       dpi = 600)

# Save the survey metadata as a reference
write_csv(survey_1, paste0(Sys.Date()," Survey Points.csv"))

###-------------------------------------------------
End Script
```