

# Reef Visual Census (RVC) Fish Survey Protocol for Atlantic, U.S. Caribbean and Gulf of Mexico

National Coral Reef Monitoring Program (NCRMP)

Coral Reef Conservation Program (CRCP), National Oceanic and Atmospheric Administration

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## Introduction

The National Coral Reef Monitoring Program (NCRMP) is a broad-spatial snapshot for reef condition (*i.e.*, fish species composition/density/size, benthic cover, and coral density/size/condition) to provide context for local-scale studies of tropical reef ecosystems. Data collection will occur at stratified random sites where the sampling domain for each region (*e.g.*, Puerto Rico, U.S. Virgin Islands (USVI), Flower Garden Banks and Florida) is partitioned by habitat type and depth, sub-regional location (*e.g.*, along-shelf position) and management zone. NCRMP is intended to supplement local monitoring efforts by providing large-scale data on reef fishes and the benthos.

NCRMP fish surveys conducted in the US Caribbean/Gulf of Mexico region (Puerto Rico, USVI, Flower Garden Banks) have traditionally used the Belt Transect method. In the Pacific and Florida regions, fish surveys are conducted using the Reef Visual Census (RVC) method. To standardize fish data collection methods and for comparison purposes, all jurisdictions will be using the RVC method for conducting fish surveys beginning in 2016. This protocol will describe fish surveys conducted in the U.S. reefs in the Atlantic, Caribbean and Gulf of Mexico.

The 2016 RVC protocols for Puerto Rico have substantial differences than previous versions (years) as a result of NCRMP standardization throughout the project's regions (*e.g.* Florida and Pacific regions). Specific differences in methodologies between regions, where applicable, are noted within the protocols.

## Goal of Fish Surveys

The goal of the fish community surveys is to collect and report information on species composition, density, size, abundance, and derived metrics (*e.g.*, species richness, diversity) using the RVC point count method (Brandt et al., 2009) in a stratified random sampling design on hardbottom and coral reef habitats in the U.S. coral reef jurisdictions. While all jurisdictions will use the RVC method, slight adjustments must be made in order to account for regional implementation nuances. These protocols are intended for use in Puerto Rico in 2016 and may be refined in subsequent years.

LPI and Coral Demographic surveys may be completed on the same dive as fish surveys (Appendix I, Figure A). If the surveys are implemented simultaneously then the benthic team should establish the transect on the appropriate habitat with the least amount of interference with the fish surveys.

## General Task Description

In the U.S. Caribbean, RVC will be implemented by a team of two divers, each conducting a 7.5 m radius point count fish survey. The team of two divers serve as a site replicate and data are averaged between both surveys to reduce variability. In Florida, two teams of two divers are deployed and each is averaged respectively.

For benthic surveys, detailed benthic information will be collected at a subset of fish survey sites. Sites that require both fish and benthic surveys a team of two benthic divers will be deployed simultaneously with the fish team (Appendix I). Refer to *Line Point-Intercept Survey Protocol* and *Coral Demographic Survey Protocol for the U.S. Caribbean and Flower Garden Banks National Marine Sanctuary:2016*).

RVC Diver responsibilities include collecting:

- Fish information
- Benthic cover information
- Overall topographic information
- Site photos

## General Site Information

### *Navigating to site*

Once in the field, the boat captain navigates to selected site using a handheld GPS unit. On-site, divers are deployed and maintain contact with each other throughout the entire census.

1. Each boat will have up to three GPS units:
  - a. One for navigation to sites, and
  - b. One GPS unit attached to dive flag/float carried by each team deployed, uniquely identified for each team, benthic and/or fish.
    - i. Each dive team will have dive flag/float and GPS. Record each team's unique GPS # and dive flag numbers on the daily boat log (Figure 1; Appendix II).
2. Dive teams enter the water at selected GPS coordinates, descend to bottom, affix the surface float line to the bottom, set up survey areas and begin data collection.
3. As the dive team(s) deploy from the vessel, the boat captain will use the navigational GPS to take a waypoint of the surface float/flag(s) and record the coordinates on the boat log (Appendix II).
4. Once benthic or fish survey is complete, that team is to begin ascent to surface.

**\*\*Boat driver should take extreme care to avoid divers in the water.\*\***

### *Establishing the cylinders*

1. As the team descends and assesses the site, the fish team ascertains the presence of hardbottom and observed habitat type at the site.
  - a. Hardbottom presence/absence
    - i. Absent – If hardbottom is absent from the site (*i.e.*, continuous sand or seagrass combined with limited visibility),

1. Then the dive will be terminated and an alternate selected,
2. **Do not swim around looking for hardbottom.**
  - ii. Present – If hardbottom is present, continue habitat type assessment
- b. Observed habitat type – If the team(s) deploy over hardbottom they are to establish cylinders where deployed.
  - i. If necessary, during descent, divers will swim to appropriate habitat
    1. If divers enter the water over sand, they will swim to nearby reef habitat for sampling.
    2. If divers enter the water over hardbottom different from that expected **and** observe expected habitat type nearby, they will swim to habitat for sampling.
  - ii. If divers enter the water over hardbottom different from that expected and **do not** observe expected habitat type nearby, they will establish cylinders where deployed and indicate the type of habitat on the datasheet and boat log.
2. Under optimal visibility conditions the distance between dive buddies should be 15 m (Appendix I). The reel can be secured to the bottom and serve as a starting point to measure the radius of the sampling cylinder using the APT (i.e., 7.5 m or 5.0 m depending on visibility), as a visual aid to measure visibility, as a point of reference (e.g., edge of cylinder) during data collection and as a point of return for both divers following data collection.
3. Determine visibility of cylinder.
  - a. If horizontal visibility is greater than or equal to 7.5m, then the radius of the cylinder will be 7.5m.
  - b. If the horizontal visibility is less than 7.5m but greater than 5m, then the diver will set up in the middle of a 5 m cylinder and slightly move from the middle to observe the area needed to fulfill the 7.5 m cylinder. The APT, or some other type of marker, can be used to mark the initial midpoint.
4. **Terminating the dive** – surveys should be terminated and alternates chosen under the following conditions:
  - a. **Visibility is less than 5 m**, the dive should be terminated and an alternate selected.
  - b. **Bottom currents are strong enough that the divers cannot maintain a stationary position**, the dive should be terminated and an alternate selected.

- c. **Depth of the selected site is greater than 99 ft**, then the team should terminate the dive and choose an alternate.

**\*\* ALWAYS** Indicate reasons for terminating dives on boat logs.

Reasons to terminate a dive:

- Visibility (> 5m)
- Strong currents
- Depth (> 99ft)

If benthic team is deploying with the RVC team, they may set up benthic transect adjacent to cylinders or they may need to swim to hardbottom if it is patchy (Appendix I).

### *Recording the station information*

Station information is recorded in two primary locations prior to entering the water: (1) *Boat/Dive log* and (2) *datasheet* (Figure 1 and Figure 3). The log and data sheet are to have the same information recorded on both.

Key fields to record for station information include:

1. *Site* – The 4-digit station number.
2. *Station* – The location of each “team” of replicate fish divers at the station. **Always ‘1’ for Caribbean**. In Florida there are 2 teams of replicate divers, thus teams will be 1 or 2.
3. *Team (Team member assignment)* – Letter code identifying the type of data is being collected by the diver within their dive group.
  - a. Fish (A/B) – A two-diver fish team consists of a Diver A and Diver B.
  - b. Benthic (J/X) – The diver collecting LPI data is assigned the code ‘J’; divers collecting Demographic data is assigned ‘Y’.

**\*\*** Codes are assigned to diver positions on within the team and type of data collect; therefore, diver team codes will change by station.

Example: Figure 1 provides an example of a boat log and the specific station information to record at the dive site. The first dive of the day consisted of four divers, one fish group and one benthic group. The fish divers are Clark and Blondeau, identified by the A/B codes used. Clark for the first dive is identified as team member A and Blondeau is B. Notice for the second dive of the day, Clark is assigned diver B for the fish team.

Date	DOD	Site	Station	Team	Diver	O2%	PSI IN	TIME IN	Flag #
4/12/16	1	1200	1	A	Clark				1
	1	1200	1	B	Blondeau				1
	1	1200	1	J	Edwards				2
	1	1200	1	X	Viehman				2
4/12/16	2	1026	1	A	Nemeth				1
	2	1026	1	B	Clark				1
	2	1026	1	J	Viehman				2
	2	1026	1	X	Blondeau				2

**Figure 1.** Example of boat log with specific station information filled out. DOD = Dive of the day.

### RVC Sequence of events

The Reef fish Visual Census (RVC) methodology is modified from Bohnsack and Bannerot (1986), and occurs with the diver remaining at a fixed site. Fish are surveyed within an imaginary cylinder centered on the diver and extending from the substrate to the limits of vertical visibility, usually the surface but could be the limit of visibility.

Fish data collection occurs in three phases: (1) Predive, (2) fish counting/measuring, (3) and site/benthic/topographic assessment (Figure 2).

#### *Predive*

Station information is to be recorded in two primary locations prior to entering the water: *Boat/Dive log* and *datasheet* (Figure 1 and Figure 3).

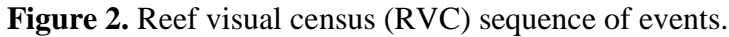
Divers should pre-populate station information, same as recorded on the boat log, on their datasheet prior to entering the water.

- **Field ID** – The **Field ID** is a unique alpha-numeric number the diver is to record on the datasheet at each station.

**FIELD ID = (SITE #) + (STATION #) + (TEAM letter)**

Example (Figure 3): Diver Clark recorded the **Field ID** 12001A. According to the boat/dive log (Figure 1), Clark is diver A for site 1200 (and 1 used for all Caribbean fish surveys).

- Dive start time is the time divers leave the boat.
- The diver can enter visibility as they will need to determine visibility as they establish the cylinder.

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estimation for most species, one 360-degree rotation is typically made for each species (Figure 4).

For example (Figure 4), fishes are measured by total number (N), average size (AVG), minimum size (Min) and maximum size (Max). For single fish, the number and size are listed. For two fish, the diver can list both sizes, either in the Min and Max columns, or if they are the same size, list the number twice.

**Figure 4.** Example of fish observations during RVC survey.

TOTAL	100%	100%	TOTAL		100%	100%			
Species	N	Av	Min	Max	Species	N	Av	Min	Max
STVA	100	3	3	5					
SPBA	1	80							
SPV1	4	20	18	27					
HAFL	13	16	12	19					
SPAU	12	8	6	11					
	3	24	21	26					
COGL	2		4	5					
OCCH	17,15,13,21,14								
MAFL	1	19							

Some species, parrotfish in particular, have individuals that have bimodal size groups.

- If the diver is comfortable with estimating both groups individually then it is recommended that they do so.
- This provides a greater resolution of the community structure of these species. For example in Figure 3, the species code SPAU (*Sparisoma aurofrenatum*, redband parrotfish) commonly has groups of small individuals and larger individuals on site.
- If the diver is not experienced or comfortable with this technique then one range of sizes will be sufficient.

Important commercial and/or recreational species such as groupers and snappers should be individually sized up to a total of 10 (Table 1). If there are more than the remainder should be estimated with minimum, maximum, and average sizes. These species are:

**Table 1.** List of commercial and/or recreational species for individual sizing.

Species Name	Common Name	Species Name	Common Name
<i>Cephalopholis cruentata</i>	graysby	<i>Lutjanus jocu</i>	dog snapper
<i>Cephalopholis fulva</i>	coney	<i>Lutjanus mahogoni</i>	mahogany snapper
<i>Dermatolepis inermis</i>	marbled grouper	<i>Lutjanus synagris</i>	lane snapper
<i>Epinephelus adscensionis</i>	rock hind	<i>Mycteroperca bonaci</i>	black grouper
<i>Epinephelus guttatus</i>	red hind	<i>Mycteroperca interstitialis</i>	yellowmouth grouper
<i>Epinephelus morio</i>	red grouper	<i>Mycteroperca tigris</i>	tiger grouper



<i>Epinephelus striatus</i>	Nassau grouper	<i>Mycteroperca venenosa</i>	yellowfin grouper
<i>Lutjanis analis</i>	mutton snapper	<i>Mycteroperca phenax</i>	scamp
<i>Lutjanis apodus</i>	schoolmaster	<i>Ocyurus chrysurus</i>	yellowtail snapper
<i>Lutjanus buccanella</i>	blackfin snapper	<i>Lachnolaimus maximus</i>	hogfish
<i>Lutjanus cyanopterus</i>	cubera snapper	<i>Pterois volitans</i>	red lionfish
<i>Lutjanus griseus</i>	gray snapper	<i>Lutjanus jocu</i>	dog snapper
<i>Cephalopholis cruentata</i>	graysby	<i>Lutjanus mahogoni</i>	mahogany snapper

**Exception 1:** Not all species loiter around the cylinder and let themselves be counted.

- Highly mobile species such as jacks, sharks or skittish species may zoom in and out of the cylinder while a diver is in the identifying phase of the survey.
- The diver may record numbers and sizes of those fish that are most likely not going to be in the cylinder when the 5 minute identification phase is complete.
- It's good practice to note number and size when first sighted rather than rely on memory later in the survey.

**Exception 2:** After the 5 minute identification phase, new species may be added as the diver is counting and measuring the species identified in the first 5 minutes.

- The diver should draw a line under the initial 5 minute list and add the fish below that line.
- The diver can add new species for 5 more minutes and draw another line under the second grouping of species.
- If the fish survey is continuing into 15 minutes, new species can be added in a third grouping (Figure 5).

Species	N	Avg	Min	Max	Species	N	Avg	Min	Max
HAFL	21	17	11	20					
LATR	1	29							
STLE	3	5	4	7					
EPGU	21, 24, 19								
CARU	1	27							
LUJO	1	22							
CALA	1	31							

**Figure 5.** Example of adding new fish species after the 5 and 10 minute segments.



## The survey is over when all fish have been identified, counted, and sized.

### *Site/Benthic/Topographic assessment*

Following the fish survey, site information is collected and recorded on the Fish/Habitat data sheet (Figure 6). The following variables are measured and recorded:

1. Habitat type: chosen from the following categories (circle one on the Fish/Habitat datasheet). At the surface, the diver should discuss with their buddy and other team members and try to come to a consensus. If a consensus is not achieved divers should note that in the Field/Boat Log. **NOTE: habitat types are different in the U.S. Caribbean, Florida and Flower Garden Banks (Appendices III-V respectively).**
2. Water temperature and currents: temperature and visibility at the bottom; water current estimated by divers for each paired survey; categories as follows: None (none), Mod. (diver is able to stay in same position with a gentle kick), High (diver struggles to stay in same position).
3. Substrate Slope: the maximum and minimum depths within the sample cylinder. These values refer to the maximum and minimum depths on the imaginary plane underlying the sample cylinder. If there is a slope these depths will be different.
4. Max Vertical Relief: the maximum vertical relief within the sample cylinder of both hard (e.g., coral structure, coralline spur, rocky outcrop) and soft (e.g., octocorals, sponges and macroalgae) substrate. These values should not be zero.
5. Surface Relief Coverage: for hard vertical relief (e.g., coral structure, coralline spur, rocky outcrop): the estimated percentages of hard/soft relief that fall into the following categories (all values in meters): < 0.2, 0.2-0.5, .05-1.0, 1.0-1.5, and >1.5. These values should sum to 100%.
6. Surface Relief Coverage for soft vertical relief (e.g., octocorals, sponges and algae): the category (< 0.2, 0.2-0.5, .05-1.0, 1.0-1.5, and >1.5m) representing the average vertical relief of all soft relief should be indicated by writing “100%” by that category.
7. Abiotic Footprint: the percentage of the cylinder comprised of sand, hardbottom and rubble. These percentages should sum to 100%.
  - a. Sand is defined as coarse biogenic or oolitic sand (grain sizes typically between 0.5-2 mm) and finer silt sized particles (< 0.2 mm).
    - i. Sand is considered the substratum when sediment depth is usually 2-3 cm in depth or greater.
    - ii. It excludes a surface “dusting” of sediment particles overlying a consolidated substratum.

- b. Rubble ranges from coarse gravel (> 5 mm) to unconsolidated and moveable rocks (e.g. dislodged and moveable coral fragments). This category differs from consolidated hardbottom because of its loose and moveable nature.
- c. Consolidated hardbottom includes solid, consolidated lithogenic or biogenic substratum, including living and dead coral, and non-coral hard-bottom. Areas covered by seagrass should be coded as sand, since the biotic “grass” is growing in the abiotic sand substrate.
8. **Biotic Cover**
- a. **SAND**: the percentage of the sand substrate that corresponds to the following categories: bare, under/supporting growth of macroalgae, under/supporting growth of seagrass, under / supporting growth of sponges, and other. These values should sum to 100%. See preceding section for sand definition.
- b. **HARDBOTTOM**: While looking at an aerial, canopy view of the cylinder, the percentage of the hardbottom substrate covered with algae < 1 cm height (e.g., turf algae, *Lobophora*), macroalgae > 1 cm height (e.g., *Halimeda*, *Dictyota*), live coral, octocoral, sponge, and other abundant benthic taxonomic groups. These values should sum to 100%.
- c. **Submerged debris**: indicate if live fishing traps, trap debris, fishing gear (line, etc) or other man-made debris.

NCRM RVC Datasheet 2018

Diver: RC Date: 4 April Field ID: 10001A Data Manager: Hile

Buddy: JB Sample Start Time: 1005 Habitat type: Pavement Underwater visibility: 8 m

Dive Start Time: 1000 Sample End Time: 1020 Bedrock ☐ Patch Reef ☐ Water temperature: 90 F

Dive End Time: 1030 Max Dive Depth: 49 ft Pavement ☒ Scat. Coral/Rock ☐ Current: None Mod. High

Station Depth: 48 ft Aggregate Reef ☐ in Sand ☐

Submerged Debris: ☒ None ☐ LiveTrap ☐ TrapDebris ☐ Fishing ☐ Other

Substrate Slope		Abiotic Footprint		Biotic Cover - Dominant Biological Cover %			
Max depth	Min depth	SAND	HARD-B	SAND		HARDBOTTOM	
<u>47</u> ft	<u>49</u> ft	<u>5</u> %	<u>90</u> %	"Bare"	<u>97</u>	Algae (<1cm)	<u>63</u>
Max vertical Relief		RUBBLE	<u>5</u> %	Macro Algae	<u>1</u>	Algae (>1cm)	<u>15</u>
Hard Relief <u>0.5</u> m		Total	100%	Sea grass		Live Stony Coral	<u>5</u>
Soft Relief <u>0.4</u> m				Sponge	<u>2</u>	Octocoral	<u>4</u>
Surface Relief Coverage %				Other 1		Sponge	<u>5</u>
Hard	Soft			Other 1		Other 1 <u>CCA</u>	<u>10</u>
< 0.2 m	<u>90</u> %						
0.2-0.5 m	<u>10</u> %						
0.5-1.0 m	<u>10</u> %						
1.0-1.5 m	<u>10</u> %						
> 1.5 m	<u>10</u> %						
TOTAL	100%			TOTAL	100%		100%

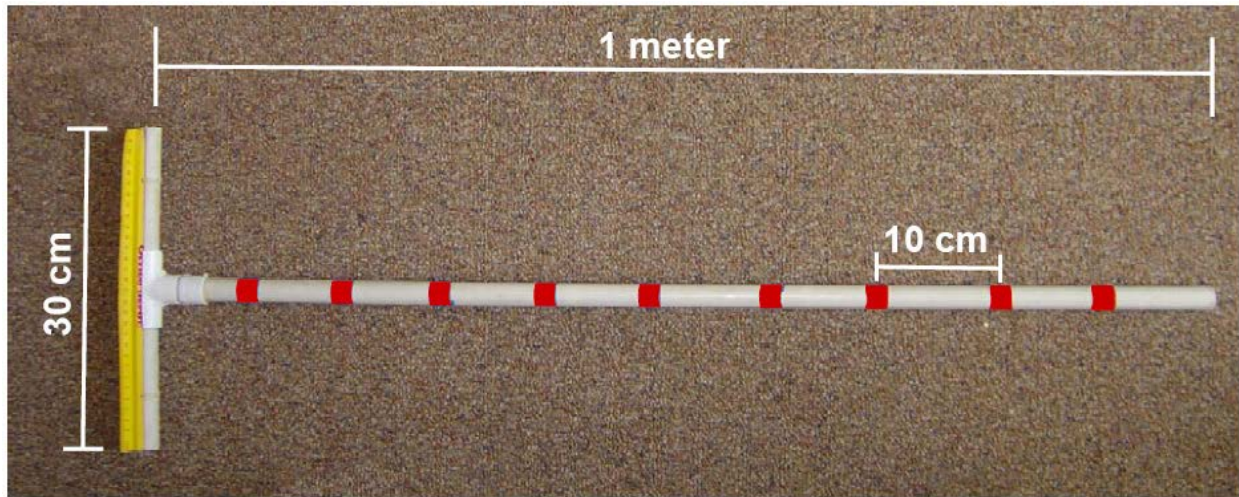
Species N Avg Min Max Species N Avg Min Max

**Figure 6.** Example of site information, benthic cover and topographic information gathered during an RVC survey in the U.S. Caribbean (note the habitat types).

### Field Equipment

- SCUBA gear
- Fish survey datasheet, clipboard, pencil (& backup pencil)

- All Purpose Tool (Figure 7)
- Camera/housing



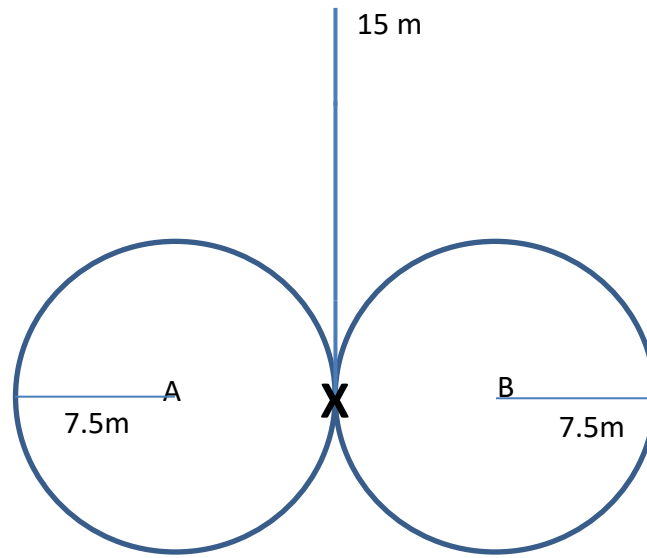
**Figure 7.** The All Purpose Tool (APT) used as a tool for measuring benthic relief, estimating fish lengths, and the dimensions of survey cylinder.

### Data sheet review

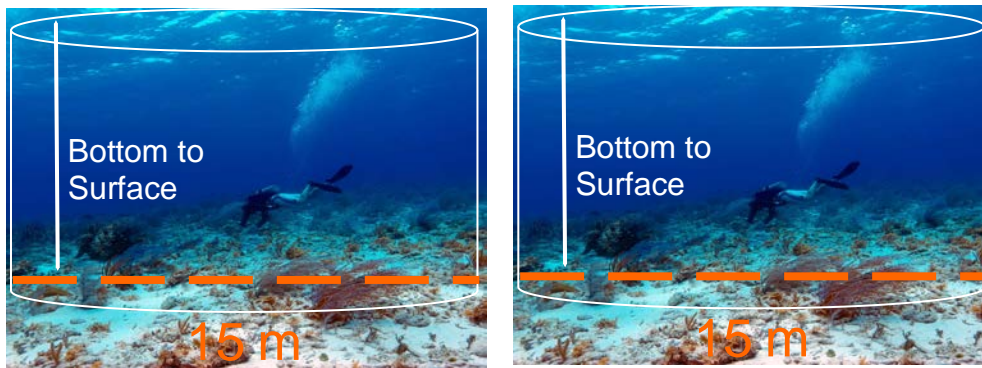
At end of survey, when divers are on boat, the dive team exchanges datasheets for review by checking for completeness and legibility. A diver cannot review his/her own datasheet.

1. *RVC fish datasheet* – Review includes, at a minimum, verifying the following:
  - a. Completeness and legibility of all site information prior to dive.
  - b. Completeness and legibility of all species, counts and size numbers.
  - c. Completeness and legibility of Topographic Complexity records
  - d. Concur on habitat type

## Appendix I. Illustrations of survey placement and cylinders



**Figure A.** Suggested placement of survey areas if continuous hardbottom. A and B represent two fish divers.



**Figure B.** Photos indicating optimal cylinder placement. The dive teams surface buoy will be tied to the bottom in between both cylinders. Benthic team may start transect in the vicinity of the fish teams surface buoy.











