CHAPTER 3: ASSESSMENT OF CLASSIFICATION ACCURACY

A comprehensive assessment was conducted to evaluate the thematic accuracy of the St. John benthic habitat map. Thematic accuracy was characterized for major and detailed geomorphological structure, major and detailed biological cover, and percent coral cover classifications (see Chapter 1 for classification scheme description).

3.1. FIELD DATA COLLECTION

Target locations for the accuracy assessment (AA) procedure were determined by an iterative, GIS-based, stratified random sampling technique to ensure that all bottom classifications would be assessed. Based on guidelines from other recent accuracy assessment analyses (Battista et al. 2007a, 2007b), a minimum of 25 points were assigned to each of the 13 detailed structure classes within the draft habitat map. An additional 175 points were distributed based on the proportion of area of each detailed structure class in the map. Points were randomly placed within each class using Hawth's Analysis Tools (Beyer 2004) in ArcGIS at a minimum distance of 50 m apart. The minimum distance was selected to ensure there would be no overlap between surveys. No buffer from polygon edges was used. Next, the number of points that fell within each detailed primary cover class was calculated. Where necessary, additional points were randomly added and re-distributed from classes with many points to ensure that there was a minimum of 25 points within each detailed cover class, with the exception of live coral, due to the small number of polygons in the draft map that received this classification. These steps resulted in a total of 520 sample target locations.

Data were collected over a two-week field mission from February 9-20, 2009. Sample locations were navigated to using a hand-held Garmin 76 WAAS-enabled GPS unit. Underwater video from a SeaViewer Sea-Drop 950 camera was taken at each site, provided the location was safely accessible by the survey vessel (Figure 3.1). A weight was tied to the bottom of the camera to help lower the camera to the bottom, and the camera operator adjusted the camera position to get a downward and side view of the habitat at each location. Video length depended on the habitat type and vessel drift and ranged from approximately 30 seconds to two minutes. Videos of large, homogeneous sand habitats were generally short while heterogeneous hardbottom habitats, especially edges, were typically longer. While the video was being recorded, GPS waypoints were recorded on board the vessel using a Trimble GeoXT GPS receivers. At least three epics (i.e., points) were logged at each site, but this number was generally much higher and depended on the satellite signal, length of the video clip, current speed and vessel drift. This resulted in a string of epics that tracked boat position at each site. An observer categorized each site according to the video for each level of the map classification scheme: major/detailed geomorphological structure, major/detailed biological cover, and percent coral. Data was entered into a custom data dictionary on the Trimble data logger and recorded on waterproof data sheets. Videos were recorded to tape using a Sony Walkman video recorder, and converted to digital video clips using Final Cut Pro software.

Figure 3.1. Picture of the field crew deploying drop camera (left) and camera approaching bottom (right).

Not all sites were accessible by survey vessel and the drop camera. Shallow, nearshore sites were surveyed by snorkel. Sites were categorized in the same way, but in lieu of drop camera video, a digital camera in an underwater housing was used to take pictures. Mangrove target locations were generally assessed from the boat after approaching the target as close as possible, and were again documented with digital pictures. In these situations, an exact GPS waypoint could not be taken at the survey site. A few targets were inaccessible using either of these methods due to high surf or unsafe sea conditions and were not surveyed. In addition, several sites that were targeted in inland mangrove lagoons were inaccessible by road and could not be surveyed. In a few cases, poor sea conditions or turbidity precluded a positive classification of the habitat, and these points were removed from the analysis. A total of 481 sites were sufficiently surveyed to be included in the accuracy assessment (Figure 3.2). An additional five survey sites were successfully surveyed, but fell outside the boundaries of the final benthic habitat map.

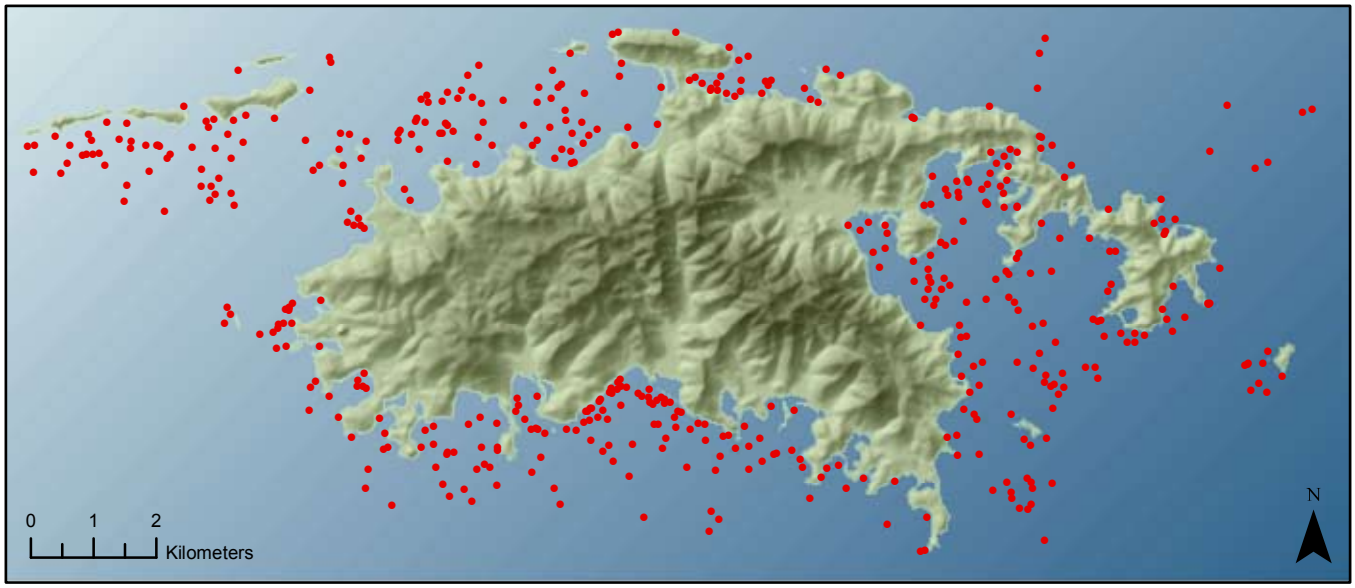

Figure 3.2. Red dots depict the location of the 481 sites visited to obtain habitat information for assessment of thematic map accuracy.

3.2. EVALUATION OF ASSESSMENT DATA

The GPS data were processed using Trimble Pathfinder software. GPS data, which were originally recorded as code phase signals, were differentially post-processed to the Continually Operating Reference System (CORS) station at St. Thomas, U.S. Virgin Islands (VITH). The true positional accuracy of individual epics was determined to be within 1 m for 96% of the points. For each survey site, individual epics were averaged to generate an "average" GPS point. The GPS data were then exported and plotted in ArcGIS along with the corresponding field notes. In most cases, the average point was a sufficient representation of the survey site; however in cases where the survey was conducted along or crossed a polygon edge, the average GPS point did not always fall into the polygon that was assessed. In these cases, the survey point was shifted to the portion of the transect and polygon that was classified (Figure 3.3). For sites where no Trimble data was collected (e.g., sites surveyed by snorkel), the target GPS point was used.

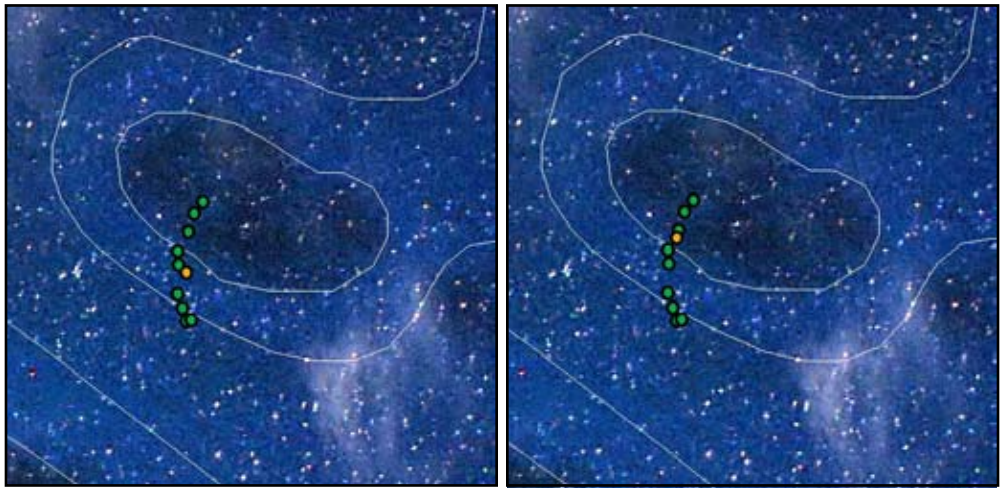

Figure 3.3. Example of case where survey track line, represented by the green points, crossed more than one habitat type/polygon. Although the "average" point (orange) fell in sand (left), the adjacent individual patch reef was the polygon that was actually assessed, therefore the point was shifted slightly north (right).

Prior to analysis, each video clip and digital picture was re-analyzed and viewed in concert with the benthic habitat map overlaid on the orthophotography. It should be noted that all analysis at this stage was made by a photointerpreter independent of the scientist who created the map. Patchiness of the biological cover was assessed at the polygon level, and hence it was often necessary to adjust the classifications that were initially recorded in the field to reconcile the differences between the video and map scales. For example, a site may have been classified as continuous seagrass based on the video clip alone, but if the patchiness of the polygon was actually only 50% - <90% upon examination of the imagery, the patchiness for the survey point was changed to 50% - <90% (Figure 3.4). Similar adjustments were sometimes necessary to correctly characterize detailed structure. For example, heterogeneous hardbottom classes, such as pavement with sand channels, could not always be correctly classified from the video alone. In other cases, additional information on the position, size and shape of hardbottom features was needed to determine whether the structure should be classified as aggregate reef or a patch reef (either individual or part of an aggregated patch reef feature if below the MMU).

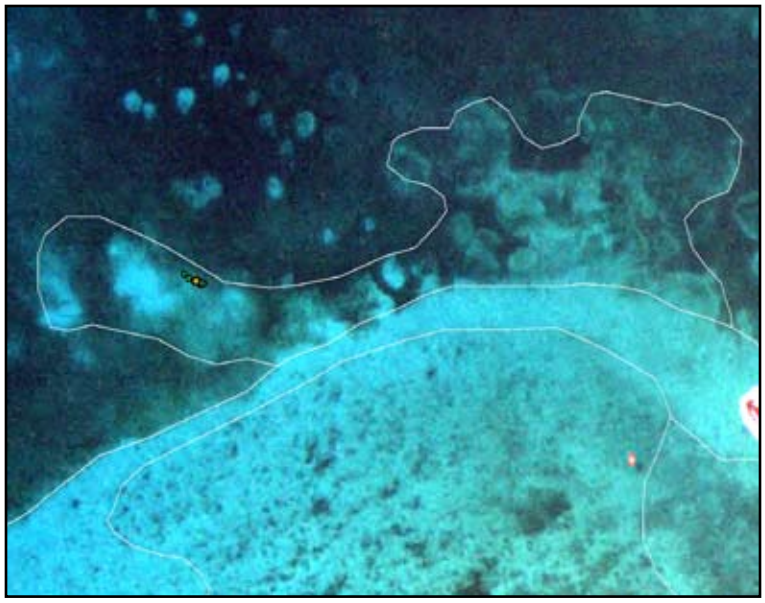

Figure 3.4. Example of case where video survey was conducted over an area of continuous seagrass, but examination of the imagery revealed that patchiness of the polygon was 50% - <90%.

Following these adjustments, data were then spatially joined to the benthic habitat layer to extract the map classification for each point. Sites that differed between field notes and map classification were evaluated both in GIS and from video to determine possible source of disagreement. At this stage, additional special cases were identified that were a product of the differences in scale between the video data and imagery. For example, there were several occurrences where the survey video documented sand with no cover, but the point was located within a heterogeneous polygon that was mapped as sand with patchy *Seagrass* or *Algae*, *Sand with Scattered Coral and Rock*, or *Aggregated Patch Reefs* that could only be perceived at the broad scale of the aerial photography. For these cases, the points were only classified for structure based on both the video and imagery. Since the mapped polygon cover was not observed in the accuracy assessment video, they were not included in the assessment of biological cover.

In some cases, the patchiness of biological cover within softbottom polygons could not be determined from the imagery due to turbidity. These polygons were primarily located within Coral Bay and were mapped with advice from the expert review workshop. Accuracy assessment points that fell within these polygons were handled in two ways. First, as described above, points that would otherwise have been classified as *No Cover* were removed from the analysis of biological cover and analyzed for structure only. If algal or seagrass cover was documented in the video, these points were included for major cover (e.g., *Seagrass* or *Algae*) but their patchiness was classified as *Unknown* because it cannot be estimated from the remotely sensed imagery and they were not included in the detailed cover analysis. In total, 24 sites were excluded in the major biological cover analysis and an additional 15 sites were excluded from the detailed biological cover analysis for one of the reasons described above.

Percent coral cover was classified for both hardbottom and softbottom habitats; however it is defined as the percent coral cover on the hardbottom substrate within that polygon (see Chapter 1). If a site was determined to be located within a hardbottom polygon but no hardbottom was seen in video (e.g., *Aggregated Patch Reefs*), coral cover could not be sufficiently assessed at that site. Hence, such sites were not included in the error matrix for percent coral cover.

Following this process, 481 points were included in the accuracy assessment analysis for major and detailed structure, 457 for major biological cover, 442 for detailed biological cover, and 475 for percent coral cover.

3.3. ANALYSIS OF THEMATIC ACCURACY

The thematic accuracy of the St. John benthic habitat map was characterized in several ways from these data. Error matrices were computed for the attributes major and detailed geomorphological structure, major and detailed biological cover, and percent coral cover. Overall accuracy, producer's accuracy, and user's accuracy were computed directly from the error matrices (Story and Congalton 1986). The error matrices were constructed as a square array of numbers arranged in rows (map classification) and columns (accuracy assessment, or ground-truthed classification). The overall accuracy (P_o) was calculated as the sum of the major diagonal (i.e. correct classifications, divided by the total number of accuracy assessment samples).

The producer's and user's accuracies were calculated to characterize the classification accuracy of individual map categories. The producer's accuracy (omission/exclusion error) is a measure of how well the mapper classified a particular habitat (e.g., the percentage of times that substrate ground-truthed as sand was correctly mapped as sand). The user's accuracy (commission/inclusion error) is a measure of how often map polygons of a certain habitat type were classified correctly (e.g., the percentage of times that a polygon classified as sand was actually ground-truthed as sand). Each diagonal element was divided by the column total to yield a producer's accuracy and by the row total to yield a user's accuracy.

In addition, the Tau coefficient (T_e), a measure of the improvement of classification accuracy over a random assignment of map units to map categories (Ma and Redmond 1995), was calculated. As the number of categories increases, the probability of random agreement (P_r) diminishes, and T_e approaches P_o. Values of T_e were calculated as follows:

Tau coefficient = $T_e = (P_o - P_r) / (1 - P_r)$,

where $P_r = 1/r$. The variance of Tau (Ma and Redmond 1995) was calculated as:

Variance of Tau coefficient = $\sigma_r^2 = P_o(1 - P_o) / n(1 - P_r)^2$

Confidence intervals were then calculated for each Tau coefficient at the 95% confidence level (1-α), using the following generalized form:

95% CI = $T_e \pm Z_{\alpha/2}(\sigma_r^2)^{0.5}$

While stratification ensures adequate evaluation of all map categories, it has the undesired effect of introducing bias into the error matrix (Hay 1979; Card 1982). A minimum number of sites were targeted within each mapping category, which caused rare map categories to be sampled at a greater rate than common map categories. For example, although *Sand* habitat comprised 44% of the map area, only 23% of the target points were allocated for this habitat. Conversely, *Aggregated Patch Reefs* comprised only 1% of the map area, but received 5% of the allocated target sample points. The bias introduced by differential sampling rates was removed using the method of Card (1982), which utilizes the known map marginal proportions, i.e. the proportional areas of map categories relative to the total map area. The map marginal proportions were calculated as the area of each map category divided by the total mapped area of the St. John benthic habitat map. The map marginal proportions were also utilized in the computation of confidence intervals for the overall, producer's, and user's accuracies (Card 1982; Congalton and Green 1999). This method was also used in the recent accuracy assessment of the NOAA Florida Keys benthic habitat map (Walker and Foster 2009).

The known map marginal proportions (π_j) were computed from the GIS layer of the draft benthic habitat map for each of the four error matrices (major and detailed geomorphological structure, major and detailed biological cover), by dividing the area of each category by the total map area. Marginal proportions were not computed for the percent coral cover matrix, as this would have required an estimate of the percent hardbottom within each polygon to truly estimate the area of live coral. The map areas were exclusive to categories present in the error matrix. For the example of detailed structure category sand, π_j was 0.44 (23.3 km^2/53.4km^2). The individual cell probabilities, i.e. the product of the original error matrix cell values and π_j, divided by the row marginal (total map classifications per category), were computed for the off-diagonal elements using the following equation:

Individual cell probabilities = $\hat{P}_{ij} = \pi_j n_{ij} / n_{-j}$

The relative proportions of the cell values within a row of the error matrix were unaffected by this operation, but the row marginals were forced to the known map marginal proportions (i.e. the row total of a particular habitat now equaled the fraction of map area occupied by that habitat, instead of the total number of accuracy assessment points). The estimated true marginal proportions (p_i) were computed as the sum of individual cell probabilities down each column of the error matrix.

The π_j-adjusted overall, producer's, and user's accuracies were then computed from the new error matrix, now populated by individual cell probabilities. The values of the π_j-adjusted overall and producer's accuracies differ by design from those of the original error matrix, as they have been corrected for the areal bias introduced by the stratified random sampling protocol. The user's accuracy, in contrast, is not affected. The variances and confidence intervals of the overall, producer's, and user's accuracies were then computed from the following set of equations (Card 1982; Walker and Foster 2009):

Overall Variance = $V(\hat{P}_c) = \sum_{i=1}^{r} p_{ii}(\pi_i - p_{ii}) / n_i)$

Overall Confidence Interval = CI = $\hat{P}_c \pm 2[V(\hat{P}_c)]^{1/2}$

Producer's Variance = $V(\hat{\theta}_{ii}) = p_{ii} p_i^{-4} [p_{ii} \sum_{j \neq i}^{r} p_{ij}(\pi_j - p_{ij}) / n_{-j} + (\pi_i - p_{ii})(p_i - p_{ii})^2 / n_{i-j}]$

Producer's Confidence Interval = CI = $\hat{\theta}_{ii} \pm 2[V(\hat{\theta}_{ii})]^{1/2}$

User's Variance = $V(\hat{\lambda}_{ii}) = p_{ii}(\pi_i - p_{ii}) / \pi_i^2 n_i$

User's Confidence Interval = CI = $\hat{\lambda}_{ii} \pm 2[V(\hat{\lambda}_{ii})]^{1/2}$

3.4 ACCURACY ASSESSMENT RESULTS AND DISCUSSION

Major Geomorphological Structure

Error matrices for major geomorphological structure are displayed in Tables 3.1 and 3.2. The overall accuracy (P_o) at the major geomorphological structure level was 96% (Table 3.1). The Tau coefficient for equal probability of group membership is 0.941 ± 0.026 (α=0.05). The error matrix in Table 3.2 is populated by the individual cell probabilities (p_{ij}), which in review are the product of the original error matrix cell values (Table 3.1) and the map marginal proportions, divided by the row marginal of the original matrix (i.e., total map classifications per category). The adjusted overall accuracy, corrected for bias using the true map marginal proportions, was 96.7 (±1.7)% (α=0.05). The user's and producer's accuracies were similarly high for both hard and softbottom habitats (Table 3.2).

Table 3.1. Error matrix for major geomorphological structure.

		Accuracy Assessment (i)				
		Hard	**Soft**	**Other**	**$n_{.j}$**	**User's Accuracy (%)**
Map data (j)	**Hard**	**291**	8	0	299	**97.3%**
	Soft	10	**171**	1	182	**94.0%**
	Other	0	0	**0**	0	**n/a**
	$n_{i.}$	301	179	1	n=481	
	Producer's Accuracy (%)	**96.7%**	**95.5%**	**n/a**	**P_o = 96.0%**	
					T_e = 0.921 ± 0.035	

Detailed Geomorphological Structure

Error matrices for detailed geomorphological structure are displayed in Tables 3.3 and 3.4. The overall accuracy (P_o) at the detailed geomorphological structure level was 85.7%, with a Tau coefficient (T_e) of 0.846 ± 0.034 (α=0.05) (Table 3.3). The adjusted overall accuracy, corrected for bias using the true map marginal proportions, improved slightly to 88.8 (±2.9)% (α=0.05), because the classes that covered the most area were also the most correctly interpreted.

Table 3.2. Error matrix for major geomorphological structure, using individual cell probabilities. The overall accuracy and producer's accuracy were corrected for bias using the true map marginal proportions.

Map data (j) \ Accuracy Assessment (i)	Hard	Soft	Other	$\pi_{.j}$	User's Accuracy (%)	User's CI (±%)
Hard	**0.484**	0.010	0	0.494	**97.9%**	**1.6%**
Soft	0.021	**0.484**	0.001	0.506	**95.6%**	**3.0%**
Other	0	0	**0**	n/a	**n/a**	**n/a**
p_i	0.505	0.494	0.001	π=1		
Producer's Accuracy (%)	**95.8%**	**97.9%**	**n/a**	P_o = 96.7%		
Producer's CI (±%)	**2.8%**	**1.6%**	**n/a**	CI(±) = 1.7%		

Adjusted user's accuracy was above 70% for all categories with the exception of the *Spur and Groove* and *Mud* categories, which had a calculated user's accuracy of 60.0% and 63.9%, respectively (Table 3.4). Five of the fifteen points mapped as *Spur and Groove* ware validated as *Pavement with Sand Channels*. Three of these points were located within the same polygon, along with two points that were positively classified as *Spur and Groove*. Since the difference in the two classifications is primarily determined by the relief of the hard substrate, it is possible that varying degrees of relief within individual polygons contributed to this error. Often these two bottom types occur adjacent to each other and represent a continuum in range of relief rather than clearly distinct classes. Twelve of

Table 3.3. Error matrix for detailed geomorphological structure.

Map data (j) \ Accuracy Assessment (i)	Aggregate Reef	Aggregate Patch Reef	Individual Patch Reef	Spur and Groove	Pavement	Pav w/ Sand Channels	Rock Outcrop	Boulder	Reef Rubble	Rhodolith	Sand w/ SCR	Sand	Mud	Land	$n_{.j}$	User's Accuracy (%)
Aggregate Reef	**38**		1		6			1							46	**82.6%**
Aggregate Patch Reef		**28**	1								1				30	**93.3%**
Individual Patch Reef			**9**												9	**100.0%**
Spur and Groove				**9**	1	5									15	**60.0%**
Pavement	1		1		**59**				2						63	**93.7%**
Pav w/ Sand Channels				1	3	**27**									31	**87.1%**
Rock Outcrop	1			1			**34**	2							38	**89.5%**
Boulder					1		2	**10**							13	**76.9%**
Reef Rubble	1				1				**24**		2	5			33	**72.7%**
Rhodolith	1								1	**19**					21	**90.5%**
Sand w/ SCR		4			2						**15**				21	**71.4%**
Sand	1				1				2		4	**117**			125	**93.6%**
Mud												12	**23**	1	36	**63.9%**
Land															0	**n/a**
$n_{i.}$	43	32	12	11	74	32	36	13	29	19	22	134	23	1	n=481	
Producer's Accuracy (%)	**88.4%**	**87.5%**	**75.0%**	**81.8%**	**79.7%**	**84.4%**	**94.4%**	**76.9%**	**82.8%**	**100.0%**	**68.2%**	**87.3%**	**100.0%**	**n/a**	P_o =	**85.7%**

T_e = 0.846 ± 0.034

the 36 survey sites mapped as *Mud* were ground-truthed as Sand, the majority of which were located in the Coral Bay vicinity. *Sand* and *Mud* habitats in this area were often difficult to distinguish since the substrate composition was often a mixture of fine and coarse sediment rather than clearly separate and distinct classes. For example, sand was sometimes covered with a thin layer of silt.

Figure 3.5. Sand with scattered coral and rock was occasionally confused with other geomorphological structure types composed of varying combinations of hard and softbottoms.

Categories with the lowest adjusted producer's accuracy were *Individual Patch Reef, Sand with Scattered Coral and Rock, Spur and Groove,* and *Reef Rubble* (Table 3.4). In all cases, there was a high degree of variance, and two of the categories (*Individual Patch Reef* and *Spur and Groove*) were relatively undersampled compared to the other map categories. There were several reasons why the resulting number of samples in these two categories were fewer than planned, including inaccessibility, different classifications in the final map compared to the draft map, and inadvertent sampling of an adjacent polygon. Patch reef and spur and groove features were often small and/or narrow, so the probability of drifting into an adjacent habitat tended to be more frequent than with larger features. Several points ground-truthed as *Sand with Scattered Coral and Rock* (Figure 3.5) were mapped as habitats that were similar in structure (i.e. *Sand, Reef Rubble* and *Aggregated Patch Reefs*).

Table 3.4. Error matrix for detailed geomorphological structure, using individual cell probabilities. The overall accuracy and producer's accuracy were corrected for bias using the true map marginal proportions.

Map data (j) \ Accuracy Assessment (i)	Aggregate Reef	Aggregate Patch Reef	Individual Patch Reef	Spur and Groove	Pavement	Pav w/ Sand Channels	Rock Outcrop	Boulder	Reef Rubble	Rhodolith	Sand w/ SCR	Sand	Mud	Land	$\pi_{\cdot j}$	User's Accuracy (%)	User's CI (±%)
Aggregate Reef	0.0576		0.0015		0.0091			0.0015							0.070	**82.6%**	**11.18%**
Aggregate Patch Reef		0.0199	0.0007								0.0007				0.021	**93.3%**	**9.11%**
Individual Patch Reef			0.0045												0.005	**100.0%**	**0.00%**
Spur and Groove				0.0042	0.0005	0.0023									0.007	**60.0%**	**25.30%**
Pavement	0.0025		0.0025		0.1478				0.0050						0.158	**93.7%**	**6.14%**
Pav w/ Sand Channels				0.0018	0.0053	0.0480									0.055	**87.1%**	**12.04%**
Rock Outcrop	0.0008			0.0008			0.0271	0.0016							0.030	**89.5%**	**9.96%**
Boulder					0.0011		0.0021	0.0106							0.014	**76.9%**	**23.37%**
Reef Rubble	0.0014				0.0014				0.0325		0.0027	0.0068			0.045	**72.7%**	**15.51%**
Rhodolith	0.0043								0.0043	0.0812					0.090	**90.5%**	**12.81%**
Sand w/ SCR		0.0048			0.0024						0.0179				0.025	**71.4%**	**19.72%**
Sand	0.0035				0.0035				0.0070		0.0140	0.4087			0.437	**93.6%**	**4.38%**
Mud												0.0148	0.0284	0.0012	0.044	**63.9%**	**16.01%**
Land															n/a	**n/a**	**n/a**
$p_{i\cdot}$	0.070	0.025	0.009	0.007	0.171	0.050	0.029	0.014	0.049	0.081	0.035	0.430	0.028	0.001	π=1		
Producer's Accuracy (%)	**82.3%**	**80.6%**	**49.0%**	**62.0%**	**86.4%**	**95.4%**	**92.7%**	**77.3%**	**66.6%**	**100.0%**	**50.8%**	**95.0%**	**100.0%**	**n/a**	**P_o =**	**88.8%**	
Producer's CI (±%)	14.6%	14.2%	31.5%	36.5%	6.3%	3.3%	8.8%	21.6%	20.6%	0.0%	21.7%	2.0%	0.0%	n/a	**CI(±) =**	**2.9%**	

Major Biological Cover

Error matrices for major biological cover are displayed in Tables 3.5 and 3.6. The overall accuracy (P_o) at the major biological cover level was 93.7%, with a Tau coefficient (T_e) of 0.921 ± 0.045 (α=0.05). The adjusted overall accuracy, corrected for bias using the true map marginal proportions, was similar at 93.0 (±2.4)% (α=0.05).

Table 3.5. Error matrix for major biological cover.

Map data (j) \ Accuracy Assessment (i)	Algae	Live Coral	Mangrove	Seagrass	No Cover	$n_{.j}$	User's Accuracy (%)
Algae	**316**	1		12	2	331	**95.5%**
Live Coral	2	**5**				7	**71.4%**
Mangrove			**15**		1	16	**93.8%**
Seagrass	6			**65**		71	**91.5%**
No Cover	5				**27**	32	**84.4%**
$n_{i.}$	**329**	**6**	**15**	**77**	**30**	n=457	
Producer's Accuracy (%)	**96.0%**	**83.3%**	**100.0%**	**84.4%**	**90.0%**	P_o = 93.7%	
						T_e = 0.921 ± 0.045	

Accuracy was high for all major cover levels. The category with the lowest producer's and user's accuracy was *Live Coral*, but the number of accuracy assessment points in this category was too few to robustly assess this category. The low sample size was due to the rarity of polygons mapped where coral was mapped as the dominant cover. However, a better assessment of the accuracy of mapped coral cover will be discussed in the section *Percent Coral Cover*. The other major source of producer's error was in the *Seagrass* category, due to the misclassification as *Algae*.

Table 3.6. Error matrix for major biological cover, using individual cell probabilities. The overall accuracy and producer's accuracy were corrected for bias using the true map marginal proportions.

Map data (j) \ Accuracy Assessment (i)	Algae	Live Coral	Mangrove	Seagrass	No Cover	$\pi_{.j}$	User's Accuracy (%)	User's CI (±%)
Algae	**0.7089**	0.0020		0.0272	0.0076	0.746	**95.1%**	**2.4%**
Live Coral	0.0047	**0.0085**				0.013	**64.3%**	**36.2%**
Mangrove			**0.0060**		0.0004	0.006	**93.8%**	**12.1%**
Seagrass	0.0147			**0.1322**		0.147	**90.0%**	**7.1%**
No Cover	0.0137				**0.0741**	0.088	**84.4%**	**12.8%**
$p_{i.}$	0.742	0.010	0.006	0.159	0.082	π=1		
Producer's Accuracy (%)	**95.5%**	**81.2%**	**100.0%**	**83.0%**	**90.3%**	P_o = 93.0%		
Producer's CI (±%)	**2.1%**	**33.7%**	**0.0%**	**9.4%**	**9.2%**	CI(±) = 2.4%		

Detailed Biological Cover

Error matrices for detailed biological cover are displayed in Tables 3.7 and 3.8. The overall accuracy (P_o) at the detailed biological cover level was 81.7%, with a Tau coefficient (T_e) of 0.798 ± 0.040 (α=0.05). The adjusted overall accuracy, corrected for bias using the true map marginal proportions, was similar at 81.0 (±3.1)% (α=0.05).

The greatest source of confusion at the detailed biological cover level was degrees of patchiness within *Algae* and *Seagrass* categories. For example, the adjusted user's and producer's accuracy of the *Seagrass 10%-<50%* were 16.7% and 10.8%, respectively (Table 3.8). Of the 12 sites mapped as *Seagrass 10%-<50%*, 10 were interpreted to have 50%-<90% patchiness in the accuracy assessment. However, it should be noted there were fewer sites surveyed within the 10% - <50% algae and seagrass categories than planned. As described in the methods, sites that were surveyed in a sand patch of a polygon that was mapped as patch vegetation were not included in the analysis, because the available information was insufficient to identify the major cover in the polygon. Many of these sites that were consequently removed were located in polygons that were mapped as submerged vegetation with a patchiness of 10% - <50%, contributing to the final lower sampling size in these categories. It is possible that a revised sampling technique, such as more points per polygon or a longer transect, is necessary to fully characterize heterogeneous habitats.

Table 3.7. Error matrix for detailed biological cover.

Map data (j)	Accuracy Assessment (i): Algae 10% - <50%	Algae 50% - <90%	Algae 90% - 100%	Live Coral 50% - <90%	Live Coral 90% - 100%	Mangrove 50% - <90%	Mangrove 90% - 100%	Seagrass 10% - <50%	Seagrass 50% - <90%	Seagrass 90% - 100%	No Cover 90% - 100%	$n_{.j}$	User's Accuracy (%)
Algae 10% - <50%	**16**	3						2	1		1	23	**69.6%**
Algae 50% - <90%	9	**71**	9					1				90	**78.9%**
Algae 90% - 100%	2	16	**180**	1				1	2	1	1	204	**88.2%**
Live Coral 50% - <90%				**2**								2	**100.0%**
Live Coral 90% - 100%		1	1	3								5	**0.0%**
Mangrove 50% - <90%												0	**n/a**
Mangrove 90% - 100%						1	**14**				1	16	**87.5%**
Seagrass 10% - <50%								**2**	10			12	**16.7%**
Seagrass 50% - <90%			2						**22**	1		25	**88.0%**
Seagrass 90% - 100%		1	3						2	**27**		33	**81.8%**
No Cover 90% - 100%	4	1									**27**	32	**84.4%**
$n_{i.}$	31	93	195	6	0	1	14	6	37	29	30	n=442	
Producer's Accuracy (%)	**51.6%**	**76.3%**	**92.3%**	**33.3%**	**n/a**	**0.0%**	**100.0%**	**33.3%**	**59.5%**	**93.1%**	**90.0%**	P_o = 81.7%	
												T_e =0.798 ± 0.040	

Table 3.8. Error matrix for detailed biological cover, using individual cell probabilities. The overall accuracy and producer's accuracy were corrected for bias using the true map marginal proportions.

Map data (j)	Accuracy Assessment (i): Algae 10% - <50%	Algae 50% - <90%	Algae 90% - 100%	Live Coral 50% - <90%	Live Coral 90% - 100%	Mangrove 50% - <90%	Mangrove 90% - 100%	Seagrass 10% - <50%	Seagrass 50% - <90%	Seagrass 90% - 100%	No Cover 90% - 100%	$\pi_{.j}$	User's Accuracy (%)	User's CI (±%)
Algae 10% - <50%	**0.0901**	0.0169						0.0113	0.0056		0.0056	0.130	**69.6%**	**19.2%**
Algae 50% - <90%	0.0214	**0.1692**	0.0214					0.0024				0.214	**78.9%**	**8.6%**
Algae 90% - 100%	0.0039	0.0315	**0.3544**	0.0020				0.0020	0.0039	0.0020	0.0020	0.402	**88.2%**	**4.5%**
Live Coral 50% - <90%				**0.0014**								0.001	**100.0%**	**0.0%**
Live Coral 90% - 100%		0.0024	0.0024	0.0071								0.012	**0.0%**	**0.0%**
Mangrove 50% - <90%												0.000	**n/a**	**n/a**
Mangrove 90% - 100%						0.0004	**0.0056**				0.0004	0.006	**87.5%**	**16.5%**
Seagrass 10% - <50%								**0.0019**	0.0094			0.011	**16.7%**	**21.5%**
Seagrass 50% - <90%			0.0034						**0.0374**	0.0017		0.042	**88.0%**	**13.0%**
Seagrass 90% - 100%		0.0028	0.0085						0.0056	**0.0762**		0.093	**81.8%**	**13.4%**
No Cover 90% - 100%	0.0110	0.0027									**0.0741**	0.088	**84.4%**	**12.8%**
$p_{i.}$	0.126	0.226	0.390	0.010	0.000	0.000	0.006	0.018	0.062	0.080	0.082	π=1		
Producer's Accuracy (%)	**71.3%**	**75.0%**	**90.9%**	**13.5%**	**n/a**	**0.0%**	**100.0%**	**10.8%**	**60.3%**	**95.4%**	**90.3%**	P_o = 81.0%		
Producer's CI (±%)	**11.6%**	**8.6%**	**4.1%**	**8.4%**	**n/a**	**n/a**	**0.0%**	**16.0%**	**14.8%**	**6.2%**	**13.0%**	Ci(±) = 3.1%		

As mentioned previously, seagrass and algae on softbottom habitats were sometimes mapped incorrectly. This is to be expected, as it can be difficult to distinguish between the two in remotely sensed imagery. In addition, there is often a mix of vegetation types rather than a homogeneous seagrass or algae field.

Percent Coral Cover

The error matrix for percent coral cover is displayed in Table 3.9. The overall accuracy (P_o) at the detailed biological cover level was 85.7%, with a Tau coefficient (T_e) of 0.809 ± 0.042 (α=0.05). As mentioned previously, a second matrix using the true map marginal proportions, was not computed for percent coral cover.

Table 3.9. Error matrix for major geomorphological structure and percent coral.

		Accuracy Assessment (i)					
		Softbottom, Coral <10%	**Softbottom, Coral 10% - <50%**	**Hardbottom, Coral <10%**	**Hardbottom, Coral 10% - <50%**	**$n_{.j}$**	**User's Accuracy (%)**
Map data (j)	**Softbottom, Coral <10%**	**171**		**6**		177	**96.6%**
	Softbottom, Coral 10% - <50%			**3**		3	**0.0%**
	Hardbottom, Coral <10%	**9**		**172**	**24**	205	**83.9%**
	Hardbottom, Coral 10% - <50%			**26**	**64**	90	**71.1%**
	$n_{i.}$	179	0	207	88	n=475	
	Producer's Accuracy (%)	**95.0%**	**n/a**	**83.1%**	**72.7%**	**P_o = 85.7%**	
						T_e = 0.809 ± 0.042	

Only two of the possible coral categories were present in the map and accuracy assessment data (*<10%* and *10%-<50%*). Accuracy was very high for the softbottom habitats, where a low amount of coral is to be expected. There was lower accuracy for percent coral on hardbottom habitats. The decision between <10% and 10% - <50% is often difficult to determine, especially if there is a mix of octocorals and sclerectinians. Since percent coral cover was recorded at all sites regardless of whether it was the dominant cover type, this is a better measure of coral accuracy than is found under *Major Biological Cover*.

3.5 CONCLUSIONS

Although the classification schemes are not directly comparable due to region-specific categories, the level of accuracy for detailed structure was similar to that of other recent NOAA benthic habitat maps in the Florida Keys (86.2% [91.5% adjusted], Walker and Foster 2009), Palau (90.0%, Battista et al. 2007b), and the Main Hawaiian Islands (90.0%, Battista et al. 2007a).

Comparisons with other accuracy assessments at the biological cover level are difficult due to the differences in the classification scheme. Previous mapping efforts utilized a hierarchical classification scheme to characterize biological cover, in comparison to the dominance based scheme used here.

In comparison to the other aforementioned accuracy assessments, which were conducted in a subset, or test area, of their respective habitat maps, the relative small size of the St. John benthic habitat map enabled the entire mapping area to be included in the accuracy assessment. As a result, we were able to capture the full diversity of habitats in the survey (Figure 3.6) and produce a spatially comprehensive evaluation of the thematic accuracy.

Figure 3.6. Juvenile Bluehead Wrasses (*Thalassoma bifasciatum*) gather around a colony of *Montastraea sp.*

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