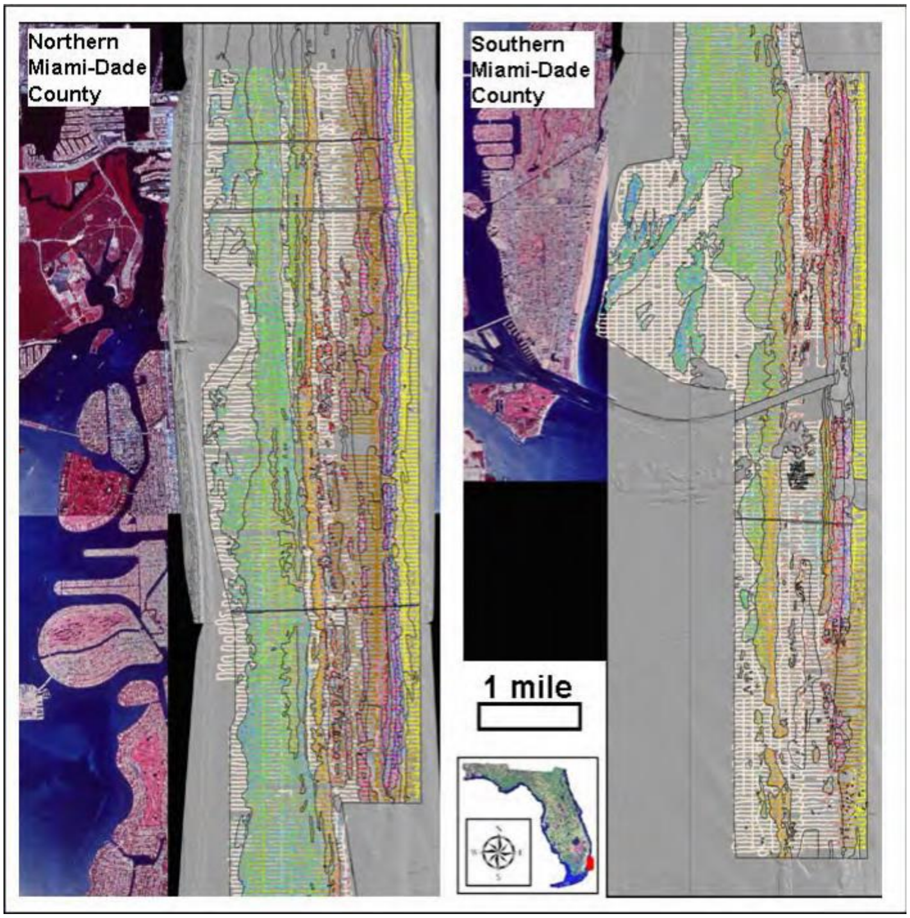
Benthic Habitat Mapping of Miami-Dade County: Supervised Classification of Single-Beam Hydroacoustic Data



Southeast Florida Coral Reef Initiative
Land Based Sources of Pollution
Local Action Strategy Project 8

Southeast
Florida
Coral Reef
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Acting above to protect what's below.

LBSP Project 8

Final Report
December 2011

Benthic Habitat Mapping of Miami-Dade County: Supervised Classification of Single-Beam Hydroacoustic Data

Final Report

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INTRODUCTION

Mapping activities in Southeast Florida have progressed substantially in the last few years (Banks et al., 2008; Collier et al., 2008; Walker et al., 2008). High resolution laser bathymetry has been acquired for the nearshore seafloor (<30 m depth) from Fowey Rocks in south Miami-Dade County to Jupiter Inlet in north Palm Beach County. In addition to bathymetry, the benthic habitats have been mapped for all of Broward and Palm Beach counties. The benthic habitat mapping efforts employed a combined-technique approach incorporating laser bathymetry, aerial photography, acoustic ground discrimination (AGD), video groundtruthing, limited sub-bottom profiling, and expert knowledge (Walker et al., 2008). Nova Southeastern University's Oceanographic Center (NSUOC) and the National Coral Reef Institute (NCRI) led this effort with interagency funding by National Oceanic and Atmospheric Administration (NOAA), Florida Department of Environmental Protection (FDEP), and Florida Fish and Wildlife Research Institute (FWRI). The maps were produced by outlining the features in the high resolution bathymetric data and classifying the features based on their geomorphology and benthic fauna. *In situ* data, video camera groundtruthing, and acoustic ground discrimination were used to help substantiate the classification of the habitats using aerial photography and geomorphology. Accuracy assessment of the maps have shown high levels of accuracy comparable to that of using aerial photographs in clear water (Walker et al., 2008).

The Broward and Palm Beach mapping efforts were accomplished using a two phased approach. The first phase was an expert driven visual interpretation of high resolution bathymetry to outline the geomorphological features at a 1:6000 scale with a one acre minimum mapping unit (mmu). The second phase was the analyses of an acoustic ground discrimination survey which was used to further discriminate the sea floor based on the density of organisms. The AGD provided an additional map layer of relative estimated benthic cover density, including benthic cover density of gorgonians and macroalgae. These data supplemented the geomorphology-based layer to include not only mapping between features, but also the variability of within-habitat features.

This report describes the phase two acoustic mapping of the benthic habitats of Miami-Dade County, using the same dual-frequency single-beam BioSonics DT-X echosounder used for the 2006 acoustic mapping of Palm Beach County. An innovative approach to supervised classification was used to refine a training dataset into fourteen pure end-member classes of geomorphological and biological elements. The acoustic mapping products will complement the phase one benthic habitat map by (i) providing accurate, high resolution descriptions of within-habitat variability, (ii) refining the estimate of hardbottom habitat extent, (iii) subclassifying phase one benthic habitats, (iv) adding a biological layer of gorgonian abundance and distribution, and (v) providing cross-shelf bathymetric transects at sub-meter spacing. It is likely that more synergies will be found as the fusion of phase one and two mapping products progresses.

METHODOLOGY

Acoustic Data Acquisition

The acoustic survey was conducted between the dates of August 9, 2010 and May, 9 2011. The survey encompassed 32.1 square miles and extended from 25.9484° (SR 860) in the north to 25.6934° (SR 878) in the south (Figure 1). North of Government Cut, survey depth ranged from 4 m (200-500 m from the high tide line) to 43 m, at the deep edge of the 2009 benthic habitat map (BHM) (Walker 2009). South of Government Cut, the survey depth ranged from 6.5 m (~4 km from the high tide line) to 41 m, at the deep edge of the BHM. The survey was conducted along pre-planned lines; east-west lines were spaced 75m apart and north-south lines were spaced 150m apart. The total east-west and north-south traverses were 663 and 158 miles, respectively. Acoustic data were acquired with a BioSonics DT-X echosounder and two multiplexed, single-beam digital transducers with full beamwidths of 10° (38 kHz) and 6.4° (418 kHz). The two transducers were located on a swing-arm mounted to the gunwale of the 7.5m survey vessel, with the GPS antenna directly above the transducers (Figure 2). Global positioning data were collected with a Trimble Ag132 dGPS, differentially corrected against the Wide Area Augmentation System (WAAS) signal to achieve positioning accuracies less than 0.9 m horizontal dilution of precision. This was the exact same system used for the 2006 acoustic survey of Palm Beach County. Vessel speed was maintained between 4-4.5 knots to avoid turbulence-induced signal contamination.

Post-Processing of Acoustic Data

The 38 and 418 kHz acoustic data were processed with BioSonics Visual Bottom Typer (VBT v2.0) seabed classification software to obtain the following acoustic energy parameters, computed as the time integral of the squared amplitude of echo intensity; E0 (pre-bottom backscatter), E1′ (the leading edge of the first echo envelope), E1 (the trailing edge of the first echo envelope), and E2 (complete second echo envelope). VBT also computed the Hausdorff fractal dimension (FD) of the E1 envelope, simplified by gridding the echo envelope into 'box' dimensions (Figure 3). VBT uses a time-varied gain (TVG) adjustment to correct echo intensity for spherical spreading and adsorption losses and a linear depth-normalization algorithm to normalize E1 to a user-input reference depth (set to the average survey depth of 20m). The reference depth algorithm attempts to account for the dilation of echo length with increasing depth by adjusting the width of the E1′ and E1 bottom sampling windows. However, the value of E1 was found to vary consistently with depth. The values of E1′, E2, and FD also varied with depth. This suggests other factors were at work. These factors likely include less-than-perfect TVG and reference depth compensation and depth-dependent proportions of specular and incoherent backscatter. To produce depth-invariant values of acoustic parameters, empirical depth-normalization models were produced using acoustic records collected within the Sand-Shallow and Sand-Deep polygons of the 2009 BHM, which was produced from visual-interpretation of LiDAR and aerial imagery and video ground-validation (Walker 2009). This empirical approach reference depth compensation assumed that the main variable affecting the values of acoustic parameters was depth, given the relative homogeneity of the Sand-Shallow and Sand-Deep habitats (and the large number of records employed). 200,000+ acoustic records were binned into 0.5m depth increments and curves were fitted to each acoustic parameter. These models were then used to empirically normalize the 38 kHz logE1′, logE1, logE2, FD and 418 kHz logE1′, logE2, and FD to the average survey depth of 20m (Figure 4). The 38 and 418 kHz E0′s and the 418 kHz were depth-invariant and did not require normalization. Correction factors were applied to each acoustic record, calculated as the ratio of model-predicted value of the acoustic parameter at the actual depth divided by the model-predicted value of the acoustic parameter at the reference depth.

Quality Analysis

After empirical depth normalization, survey records were passed through a series of Quality Analysis (QA) filters to identify and remove irregular acoustic returns (mainly the result of excessive vessel pitch and roll). The QA filters included minimum and maximum depth filters (0.005 and 0.995 percentiles, respectively), lower and upper percentiles of log-transformed, depth-normalized acoustic parameters (0.01 and 0.99, respectively), and maximum slope (16°, based of sequential depth-picks). In addition to flagging excessive pitch and roll, the maximum slope filter also removed echoes acquired on steep slopes. On a steep slope the acoustic wavefront ensonifies an ellipse instead of a circle, resulting in a stretched and flattened echo envelope. The functionality of this filter is illustrated in Figure 5. The QA′d 38 and 418 kHz records were then merged into a single dataset. Only records for which all ten acoustic parameters passed QA filters were retained. Of the 628,394 records collected during the survey, 536,884 (85.4%) remained after QA and the 38 ¢;> 418 kHz merge.

Supervised Classification (Multi-Pass DA)

The merged 38 and 418 kHz survey records were assigned to a benthic class using an innovative method of supervised classification that refined a training dataset into pure end-member classes via multiple passes through discriminant analysis (DA) (Figure 6). A total of twelve predictor variables were utilized (418kHz depth, 38-418 kHz depth, 38 kHz E0, E1′, E1, E2, FD and 418 kHz E0, E1′, E1, E2, FD). Figures 7-12, created by averaging the values of acoustic survey records contained within BHM polygons, provide a general impression of the discriminatory capabilities of individual acoustic parameters. The training dataset was assembled from two streams of information. First, the survey data was joined with the 2009 BHM in ArcGIS 9.3, pairing each acoustic record with a spatially coincident BHM geomorphological classification. A subset of survey data (25,923 records) was randomly selected for the training dataset, which initially consisted of fifteen categories of detailed geomorphological structure; (1) Sand-Borrow, (2) Sand-Shallow, (3) Sand-Deep, (4) Artificial, (5) Colonized Pavement-

Shallow, (6) Colonized Pavement-Deep, (7) Ridge-Shallow, (8) Ridge-Deep, (9) Individual Patch Reef, (10) Aggregated Patch Reef-Shallow, (11) Aggregated Patch Reef-Deep, (12) Linear Reef-Inner, (13) Linear Reef-Middle, (14) Linear Reef-Outer, and (15) Spur and Groove. This number was eventually reduced to the following eight categories through a series of exploratory DA's, by eliminating minor constituents and grouping acoustically-similar bottom types; (1) Sand-Shallow, (2) Sand-Deep, (3) Colonized Pavement-Shallow and Ridge-Shallow, (4) Aggregated Patch Reef-Deep, (5) Ridge-Deep, (6) Linear-Inner, (7) Linear-Middle, Linear-Outer and Colonized Pavement-Deep, and (8) Spur and Groove. Figure 13 illustrates the rationale for combining BHM classes on the basis of geomorphological similarity. In the first example, the LiDAR topography of the acoustically-indistinguishable Colonized Pavement-Deep and Linear Reef-Outer classes can be seen to appear very similar to each other. The second example illustrates the same scenario for the Colonized Pavement-Shallow and Ridge-Shallow classes.

The second element of the training dataset was a large collection of 60-second acoustic samples acquired over erect colonies of gorgonians. Spatially-coincident videos were reviewed for areal cover (0%, 1-10%, 10-25%, 25-50%, 50-100%), canopy height (0.25-0.50m, 0.50-1.0m, 1.0-1.5m), and substrate rugosity (low and high). Of the 143 60-second samples submitted to the training dataset, 93 were collected during the Miami survey (hold-outs from accuracy assessment) and 50 were collected during the 2006 acoustic survey of Palm Beach County (which utilized the same echosounding apparatus). Each 60-second sample was assigned to one of six classes based on areal cover, canopy height, and rugosity; (1) 10-25% cover / 0.25-0.50m / low rugosity, (2) 10-25% cover / 0.25-0.50m / high rugosity, (3) 10-25% cover / 0.50-1.5m / low rugosity, (4) 10-25% cover / 0.50-1.0m / high rugosity, (5) 25-50% cover / 0.50-1.5m / low rugosity, and (6) 25-50% cover / 0.50-1.0m / high rugosity. The need to differentiate between substrate rugosity reinforces the widely-accepted notion that acoustic returns are informed by the combination of structural and biological attributes of the ensonified seabed.

The total number of 60-second samples was reduced from 143 to 87 in a series of exploratory DA's. Samples were sequentially rejected on the basis of poor classification accuracy, so that only most acoustically distinguishable gorgonian samples remained in the final version of the training dataset, now consisting of 14 categories (eight BHM categories and six gorgonian categories). Figure 14 displays representative wave envelopes and cumulative echograms for a selection of training categories. The presence of gorgonians can be seen as an increase in E1 (due to signal scattering within the canopy and the resultant increase of echo path length) and a decrease in E2 (due to the reduced probability of a scattered echo completing two returns). The training dataset was refined into pure end-member classes by multiple passes through DA. Only those records that classified correctly and exceeded a minimum probability of group membership were passed on to the next DA.

Classification of Survey Data

DA generates a set of Fisher's linear discriminant functions, derived from the linear combinations of predictor variables that provide the greatest discrimination between the pre-defined categories. The Fisher's linear discriminant coefficients obtained from the third DA were used to classify the survey records into one of fourteen categories. A discriminant score was calculated for each category by multiplying the Fisher's coefficient by the corresponding acoustic variable, summing the products and adding a constant. The record was classified as the category with the greatest discriminant score.

Accuracy Assessment

AA targets were assigned to BHM categories in ArcGIS 9.3, using the stratified random sampling protocol within Hawth's Tools. A total of 437 external accuracy assessment (AA) samples were collected directly following the acoustic survey. Because it would not be feasible to raise and lower the transducer arm between samples, the transits between points were made with the transducers in the water, which limited vessel speed to 5 knots. For this reason, AA samples were situated within six cross-shelf corridors to reduce the distance between AA targets. Targets were approached with the vessel at idle speed. Once the vessel was on station, the engines were put into neutral and a weighted drop video camera was rapidly deployed and towed a few feet above the seabed. The video camera was rigged to point straight down for accurate estimation of planar gorgonian cover. Periodically, the camera was lowered to contact the seabed for a close-up view of biological cover and bottom type. Video and sonar data were collected for a period of 60 seconds. The Trimble dGPS latitude and longitude and UTC time were burned onto the recorded video for post-survey synchronization with acoustic data.

AA videos were reviewed post-survey and; (i) assigned to one of seven bottom types (sand-ripples, sand-flats, sand-crustose, algal plain, sand over hardbottom, sand and hardbottom, and hardbottom), (ii) AA sample purity (the percentage of pings acquired within the target habitat), (iii) planar percent cover and canopy height of macroalgae and gorgonians (for samples acquired over mixed sand and hardbottom habitats, a separate categorization was made for hardbottom gorgonian cover), (iv) the Absence/Presence of live hard coral, giant barrel sponges (*Xestospongia muta*), encrusting sponges and white zooanthids (*Palythoa caribaeorum*), and staghorn coral (*Acropora cervicornis*), (v) the Absence/Presence of a transition between bottom types (E.g. sand to colonized pavement) and mixed relief (e.g. patch reef on colonized pavement), and (vi) the percentage of seabed estimated to be reef (Appendix A1-A6). The AA acoustic data was subjected to the same VBT processing, QA, and 38 ¢;> 418 kHz merging as described for the survey data.

The AA was conducted using two main approaches; (1) direct comparison of acoustic survey classifications to spatially-coincident BHM classifications, and (2) synoptic comparisons of acoustic survey classifications to visually-interpreted cover and bottom type. In the first approach, a confusion matrix was constructed as an array of numbers arranged in rows (acoustic classification) and columns (BHM classification). Typically, such a matrix is square (i.e. an equal number of model and truth classes), but in this case there were more model classes due to the addition of gorgonians to the training dataset (for which there was no corresponding BHM classification). Overall accuracy (Po) was calculated as the sum of the major diagonal divided by the total number of survey samples acquired within a BHM category. 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. The producer's and user's accuracies provide different perspectives on classification accuracy. The producer's accuracy (omission/exclusion error) indicates how well the mapper classified a particular category, i.e. the percentage of times that substrate known to be sparsely covered was correctly interpreted sparse cover. The user's accuracy (commission/inclusion error) indicates how often map categories were classified correctly, i.e. the percentage of times that a sample classified as sparse cover was actually sparse and not abundant or contiguous.

In the second approach, a number of comparisons were made between the acoustic and video classifications to provide a synoptic picture of classification efficacy. The gorgonian percent cover would be calculated using (i) the frequency of acoustic classifications within a particular BHM category and (ii) the average percent cover of the six gorgonian classes (Classes 9-12 = 10-25%, average = 17.5%, Classes 13-14 = 25-50%, average = 37.5%). As an example, the total acoustically-predicted percent cover, irrespective of canopy height, for the 8,169 acoustic records falling with the eleven Ridge-Deep BHM polygons would be calculated as follows;

Total % Cover of Gorgonians within Ridge-Shallow habitat (acoustic) = [(sum (Class 9-12 records) × 0.175 + (sum (Class 13-14 records) × 0.375]/[sum (Class 1-14 records)]
= [(451) × 0.175 + (38) × 0.375]/[8,169] = 1.14%

AA samples were calculated using a similar approach, the only difference being the addition of the 1-10% cover category. As an example, the total visually-interpreted percent cover, irrespective of canopy height, for the 21 AA samples collected within the Ridge-Deep BHM polygons would be calculated as follows;

Total % Cover of Gorgonians within Ridge-Shallow habitat (AA) = [(sum (AA records assigned 1-10%) × 0.055 + sum (AA records assigned 10-25%) × 0.175 + sum (AA records assigned 25-50%) × 0.375]/[sum (AA records within the Ridge-Shallow habitat)]
= [(15) × 0.055 + (3) × 0.175 + (0) × 0.375]/[21] = 6.43%

RESULTS & DISCUSSION

Supervised Classification (Multi-Pass DA)

The multi-pass DA refined the training dataset into pure end-member classes of geomorphological and biological attributes with only a modest reduction of data. The overall accuracy of the 26,594 training records submitted to the 1stPass DA was 59.3% for fourteen categories (eight geomorphological BHM categories and six gorgonian categories). That was quite high for a first pass, recognizing *a priori* that many of the categories were not mutually exclusive. By definition (Walker 2009), sand is a component of the Sand-Shallow, Sand-Deep, Colonized Pavement-Shallow, Ridge-Shallow, Ridge-Deep, Aggregated Patch Reef-Deep, and Spur and Groove habitats. Moreover, the topographic complexity of some hardbottom categories varied considerably within and between mapped polygons. A wide range of topographic complexity is evident in the LiDAR surface of the Linear Reef-Inner polygons in Figure 13b. The Linear Reef-Inner polygons circumscribed by the Ridge-Shallow habitat are far less complex than the strip of Linear Reef-Inner on the east side of the image. Further evidence of the heterogeneity of BHM polygons can be seen in Table 1, a compilation of the review of 437 60-second AA videos (Appendix A1-A6). A large percentage of AA traverses crossed a habitat boundary and encountered variable relief (particularly acoustic classes 4-8), even though the average AA sample "purity" (percentage of pings acquired within the target habitat) was greater than 90% for all categories.

The overall predictive accuracy increased to 98.2% in the 3rdPassDA by strategically removing 55% of the training records, based on the results of the 1st and 2ndPass DA's (Figure 6). The refining effect of the multi-pass DA technique was apparent in the scatterplots of discriminant functions (analogous to the principle components). With each successive pass the gaps between acoustic classes increased, transforming the training dataset from a diffuse continuum of records to widely separated discrete clusters (Figure 16). Scatterplots of the higher-order discriminant functions (e.g. DF3 versus DF4) illustrate the utility of a multivariate dataset. While the first two discriminant functions differentiated the disparate BHM categories (~80% of the total variance within the training dataset), it was the higher-order discriminant functions that differentiated the gorgonian categories from the rest of the pack.

Accuracy Assessment of BHM Categories

To assess the agreement between the supervised classification of acoustic data and the visual-interpretation of BHM categories, the 450,000+ classified survey records were joined with the BHM in ArcGIS 9.3 and submitted to a confusion matrix of Model (acoustic classifications) versus Truth (BHM classifications). The acoustic classifications agreed closely with the BHM (Table 2). The overall accuracy was 68.7% for the eight BHM categories (gorgonian classifications were not included in this analysis). The Tau coefficient for equal probability of group membership (Te) was 0.642 ± 0.002 ($\alpha=0.05$), i.e. the rate of misclassifications was 64.2% less than would be expected from random assignment of acoustic records to BHM class. The close agreement between acoustic and BHM classifications is apparent in the clean breaks of the classified acoustic trackplot, coincident with the demarcations of BHM habitats (Figures 17-18).

Acoustic Prediction of Within-Habitat Variability of BHM Categories

The high classification accuracy and close agreement of acoustic and BHM habitat boundaries validated the efficacy of the acoustic methodology, which allowed for more detailed interpretations of acoustic classifications. However, faithful reproduction of the BHM was not a primary justification for conducting the acoustic survey. Instead, the dense along-track sampling intensity of the acoustic survey (~ 1 record every 2m) allowed for detailed analysis of within-habitat variability of the relatively large BHM polygons (demarcated using a 1 acre minimum mapping unit). The synoptic (i.e. survey-wide) acoustic interpretation of within-habitat variability is displayed in Table 3. Adapted from Table 2, it quantifies the acoustically-predicted geomorphological and biological (i.e. gorgonian cover) composition of the eight BHM categories. Table 3 accurately reflects *a priori* assumptions of within-habitat variability. By the definition of BHM categories (Walker 2009), the Sand-Shallow habitat should be the most homogeneous habitat and the Aggregated Patch Reef-Deep habitat should be the most heterogeneous habitat. This can be seen to be true by scanning down the columns of Table 3. Within the Sand-Shallow habitat, the greatest "confusion" is with Colonized Pavement, Linear Reef, Sand-Deep, and Ridge-Shallow. The Colonized Pavement and Ridge-Shallow habitats are defined as having variable and shifting sand cover. The vertical relief of the Inner and Middle Linear Reefs, which are often circumscribed by sand, can be very low in places and can thus be expected to have a sizable sand component. Moreover, the spatial patterns of the Sand-Shallow "misclassifications" were not random.

In Figure 17, the majority of "misclassifications" were within (i) the sand gap between the Ridge-Shallow and Linear Reef-Inner habitats, where pockets of Sand-Shallow acoustically classified as hardbottom, and (ii) along the edge of the Sand-Shallow/Sand-Deep boundary which runs alongside the Middle Linear Reef, where large areas of Sand-Shallow acoustically classified as Sand-Deep (i.e. more sorted, harder packed). Similarly, in Figure 18 the majority of "misclassifications" were within the sand gap between Linear Reef-Inner and Linear Reef-Outer, south of Government Cut. In this context, the 55% reduction in training records required to achieve pure end-member categories can be understood as the natural result of 1 MMU benthic habitats not being mutually exclusive. Thus, the "misclassifications" of Table 3 are actually measures of within-habitat variability. Table 4 is a further reduction of Table 2, grouping the acoustic classifications of benthic habitats into sand and hardbottom categories (it was assumed that the gorgonian classifications of Tables 2-3 were situated on hardbottom).

Table 4 is useful in that it provides a more refined estimate of the amount of hardbottom habitats within the survey area.

Subclassification of Sand-Shallow Benthic Habitat

Figure 19 displays the acoustic classification of survey records within the Sand-Shallow BHM category and the visual-interpretation of bottom type for 55 AA samples acquired within Sand-Shallow polygons. The Sand-Shallow samples were subcategorized into four categories of bottom type; Sand-Ripples (nearshore), Hard-Packed Sand Flats (well-sorted, coarse grain), Sand over Hardbottom (thin veneer of sand overlying pavement), and Sand/Hardbottom Mix (combination of sand and exposed hardbottom). The frequency of acoustic classifications for the nearshore records (red boundaries of Figure 19) was 94.6% Sand-Shallow, 0.0% Sand-Deep, 3.2% hardbottom (classes 3-8), and 2.1% gorgonians (classes 9-14). The frequency of acoustic classifications for the offshore records was 71.0% Sand-Shallow, 7.8% Sand-Deep, 15.2% hardbottom, and 6.0% gorgonians.

The agreement between acoustic classifications and visually-interpreted bottom type was assessed by collecting classified acoustic survey records within a 50m buffer of each AA traverse (Table 5). The eight AA samples characterized as Sand-Ripples classified as 94.9% Sand-Shallow (the Sand-Ripples samples were ideal examples of the BHM definition of Sand-Shallow). The 33 AA samples characterized as Hard-Packed Sand Flats classified as 71.2% Sand-Shallow and 23.7% Sand-Deep. Again, this agreed with the definition of BHM categories; Sand-Deep is better sorted and can be crusted over, i.e. semi-consolidated. The 14 AA samples characterized as Sand over Hardbottom and Sand/Hardbottom Mix classified as 34.0 and 25.9% hardbottom, respectively. The visually-estimated macroalgae and gorgonian cover were also consistent with the assigned bottom types. It can therefore be concluded that the acoustics detected a fundamental difference between the nearshore and offshore Sand-Shallow BHM polygons. As discussed in the previous section, the spatial patterns of acoustic "misclassifications" produced consistently-classified clusters spanning large distances. This creates the ideal scenario for using the acoustics to subclassify portions of the Sand-Shallow habitat, e.g. the mixed sand and hardbottom in the gap between Ridge-Shallow and Linear Reef-Inner habitats, and the Sand-Deep "misclassifications" along the Sand-Shallow/Sand-Deep boundary could be subclassified as hard-packed sand flats).

Subclassification of the Sand-Deep Benthic Habitat

Figure 20 displays the acoustic classification of survey records within the Sand-Deep BHM category alongside the visual-interpretation of bottom type for 45 AA samples acquired within the Sand-Deep polygons. The Sand-Deep samples were subcategorized into six categories of bottom type; Sand-Flat (well sorted, coarse grain), Crustose (surficial sediment crusted into clumps of varying size), Sand over Hardbottom (thin veneer of sand overlying pavement), and Sand/Hardbottom Mix (combination of sand

and exposed hardbottom), Hardbottom, and Algal Plain (sand partially consolidated by abundant and diverse macroalgae, suitable for colonization by encrusting and erect colonies of sponges and small deep-water gorgonians). Arguably the most ecologically significant habitat is the Algal Plain, a claim that could be supported by common occurrence of various species of fish seen in the AA videos. As with the Sand-Shallow category, there was a clear longitudinal component to the zonation of acoustic classifications. East of Outer Linear Reef, 70.3% of the acoustic classifications were Ridge-Deep. Visual-interpretation was exclusively divided between Sand over Hardbottom – Sand/Hardbottom Mix and Algal Plain; fourteen AA samples were classified as Algal Plain, eight as Sand over Hardbottom, and one as Sand/Hardbottom mix. One stretch of 10 consecutive Algal Plain classifications, just north of Government Cut, extended for nearly a mile. Another stretch of 5 consecutive Sand over Hardbottom classifications extended for over half a mile. Given the number of large gaps in AA coverage, it's likely that Sand over Hardbottom and Algal Plain habitats extend homogeneously over even larger expanses. West of the Outer Linear Reef, 79.1% of the acoustic classifications were Sand-Deep. Most of the balance (16.2%) of acoustic classifications was split between Aggregated Patch Reef-Deep and Colonized Pavement-Deep/Linear Reef-Middle/Linear Reef-Outer.

The agreement between acoustic classifications and visually-interpreted bottom type was assessed by collecting classified acoustic survey records within a 50m buffer of each AA traverse (Table 6). The sixteen AA samples characterized as Sand-Flat and Sand-Crustose classified as 91.0% Sand-Deep and 7.9% hardbottom (both the Sand-Flat and Sand-Crustose subcategories are representative of the BHM definition of Sand-Deep). As previously seen with Sand-Shallow, the AA samples characterized as Sand over Hardbottom and Mixed Sand and Hardbottom classified very similarly; 32.7% Sand-Deep/64.9% hardbottom and 46.2% Sand-Deep/53.1% hardbottom, respectively. The 2 Hardbottom samples and 14 Algal Plains samples acoustically classified as 91.6% and 83.5% hardbottom, respectively. While the 14-class acoustic classification did not clearly distinguish between Algal Plain, Sand over Hardbottom, and Mixed Sand/Hardbottom, the author is confident that the Sand-Deep dataset could be accurately clustered into these categories for revisions to the current BHM.

Classification of Gorgonian Cover and Canopy Height

Figure 21 displays the complete survey trackplot, highlighting the three acoustic categories of gorgonian percent cover and canopy height; (1) 10-25% 0.25-0.50m, (2) 10-25% 0.50-1.5m, and (3) 25-50% 0.50-1.5m. The gorgonian classifications corresponded very closely with the breaks between BHM sand and hardbottom categories. In general, gorgonian cover was predicted wherever there was hardbottom. There were a few notable exceptions. The northern half of the BHM Colonized Pavement-Shallow polygon just south of Haulover Inlet was devoid of acoustically-predicted gorgonian cover. However, that same northern portion classified acoustically as Sand-Shallow, demonstrating the ephemeral nature of shifting sand cover on these nearshore hardbottom habitats. Predicted gorgonian cover appears to be lower south of Government Cut. This suspicion was validated by the frequency of acoustic records that classified into the three major categories of gorgonian cover (and the resultant quantification of gorgonian cover), computed separately for the nine BHM hardbottom categories north and south of Government Cut (Table 7). A more visually-intuitive map of gorgonian cover was produced by joining the classified acoustic trackplot with the BHM in ArcGIS 9.3 and computing the percent cover of gorgonians from frequency of acoustic classifications within 292 polygons of detailed geomorphological structure (Figure 22).

The efficacy of the acoustic prediction of gorgonians was assessed using three approaches. First, a synoptic characterization of gorgonian cover by BHM category was produced by the relatively uncomplicated and straightforward method of visual-interpretation of the 437 AA samples (Table 8). Gorgonian cover was found to be greatest on the Spur and Groove habitat (14.1%), followed by a large grouping of six categories that were essentially equivalent; Colonized Pavement-South (10.8%), Ridge-Shallow (10.2%), Linear Reef-Middle (10.2%), Aggregated Patch Reef-Deep (9.6%), Linear Reef-Outer (8.5%), and Colonized Pavement-Deep (8.2%). The Ridge-Deep (6.4%) and Linear Reef-Inner (5.4%) formed a third group and the three sand categories a fourth. Table 9 uses the same frequency of visually-interpreted gorgonian classifications from the 437 AA samples, but this time they are compared to the frequency of acoustic survey classifications (and the resultant acoustically and visually percent cover). In general, the acoustic classifications follow the trends of the AA classifications, but the acoustically predicted cover is about half of the visually- estimated cover. This comparison suggests that while the relative abundance and spatial distribution of acoustic predictions is accurate, the absolute abundance would require a bias adjustment. The third and final approach is a simple comparison of the average acoustically-predicted cover of the 423 AA samples against the range of gorgonian cover for four categories of cover (Table 10). Similar to Table 9, it can be seen that the acoustics do well at detecting the trend, but with some under-estimation. Again, the acoustic predictions of cover could be easily corrected using this type of calibration tool.

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Table 1. Visual interpretation of 60-second Accuracy Assessment (AA) videos (excerpts from AA1-AA6). AA Sx Purity is the percentage of AA acoustic records that fell within the target Benthic Habitat Map (BHM) polygon. Although most AA samples were completely contained within the target BHM polygon, the review of AA videos revealed frequent transitions of bottom types (e.g. sand to pavement) and variable vertical relief (e.g. spurs with deep broad channels), and inevitable trade-off from using a 1 acre minimum mapping unit.

Acoustic Class	# of AA Samples	Dominant BHM Bottom Type	AA Sx Purity	BtmType Transition	Mixed Relief
1	55	Sand-Shallow	95.73%	10.91%	1.82%
2	49	Sand-Deep	97.71%	8.16%	0.00%
3	38	Colonized Pavement-Shallow	99.94%	10.53%	0.00%
3	52	Ridge-Shallow	98.76%	7.69%	0.00%
4	55	Aggregated Patch Reef-Deep	95.55%	83.64%	63.64%
5	21	Ridge-Deep	97.36%	42.86%	33.33%
6	37	Linear Reef-Inner	95.71%	37.84%	5.41%
7	20	Colonized Pavement-Deep	90.50%	55.00%	0.00%
7	18	Linear Reef-Middle	94.65%	44.44%	16.67%
7	32	Linear Reef-Outer	96.05%	37.50%	12.50%
8	48	Spur and Groove	93.15%	68.75%	58.33%

Table 2. Confusion matrix of acoustically-classified survey records (MODEL) and BHM classifications (TRUTH). Overall predictive accuracy was 68.7% for the eight categories of benthic habitat class (survey records that classified as gorgonian were not included in the analysis).

		TRUTH									
		Sand-S	Sand-D	ColPav-S Ridge-S	APR-D	Ridge-D	Linear-I	ColPav-D LinearM/O	S & G	Row	Users
MODEL Benthic Habitats	Sand-S	167374	510	23261	468	13	3778	2182	51	197637	84.7%
	Sand-D	7600	18507	0	492	611	1	737	9	27957	66.2%
	ColPav-S Ridge-S	5641	66	75199	38	1	12563	985	68	94561	79.5%
	APR-D	146	2066	0	2127	1484	1	1104	204	7132	29.8%
	Ridge-D	0	17464	0	669	5972	0	172	19	24296	24.6%
	Linear-I	2942	21	27522	17	0	26183	2549	225	59459	44.0%
	ColPav-D LinearM/O	9311	1828	1073	970	39	6657	12669	396	32943	38.5%
	S & G	241	247	22	976	49	285	3271	1223	6314	19.4%
Gorgonians	10-25% 0.25-0.50m	7426	124	20285	177	0	4852	4226	294	37384	n/a
	10-25% 0.50-1.5m	411	149	21913	1446	451	1574	715	607	27266	n/a
	25-50% 0.50-1.5m	280	217	928	200	38	703	1129	196	3691	n/a
	Column	193255	40709	127077	5757	8169	49468	23669	2195	309254	<= Diag
	Producers	86.6%	45.5%	59.2%	36.9%	73.1%	52.9%	53.5%	55.7%	Tot =>	450299
							Overall Accuracy (Benthic Habitat Categories) =>				68.7%

Table 3. Columns represent the acoustic interpretation of within-habitat variability of one acre mmu BHM categories, including gorgonian cover. Adapted from the confusion matrix of acoustically-classified survey records (Table 2).

			TRUTH							
			Sand-S	Sand-D	ColPav-S Ridge-S	APR-D	Ridge-D	Linear-I	ColPav-D LinearM/O	S & G
MODEL	Benthic Habitats	Sand-S	83.1%	1.2%	13.7%	6.2%	0.2%	6.7%	7.3%	1.5%
		Sand-D	3.8%	44.9%	0.0%	6.5%	7.1%	0.0%	2.5%	0.3%
		ColPav-S Ridge-S	2.8%	0.2%	44.2%	0.5%	0.0%	22.2%	3.3%	2.1%
		APR-D	0.1%	5.0%	0.0%	28.1%	17.1%	0.0%	3.7%	6.2%
		Ridge-D	0.0%	42.4%	0.0%	8.8%	69.0%	0.0%	0.6%	0.6%
		Linear-I	1.5%	0.1%	16.2%	0.2%	0.0%	46.3%	8.6%	6.8%
		ColPav-D LinearM/O	4.6%	4.4%	0.6%	12.8%	0.5%	11.8%	42.6%	12.0%
		S & G	0.1%	0.6%	0.0%	12.9%	0.6%	0.5%	11.0%	37.2%
	Gorgonians	10-25% 0.25-0.50m	3.7%	0.3%	11.9%	2.3%	0.0%	8.6%	14.2%	8.9%
		10-25% 0.50-1.5m	0.2%	0.4%	12.9%	19.1%	5.2%	2.8%	2.4%	18.4%
		25-50% 0.50-1.5m	0.1%	0.5%	0.5%	2.6%	0.4%	1.2%	3.8%	6.0%
		Column	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 4. Further simplification of the confusion matrix, reduced to acoustically-predicted sand and hardbottom constituents of the eight BHM classes. Gorgonian classifications were lumped with hardbottom classifications, consistent with their preferred habitat.

		TRUTH							
		Sand-S	Sand-D	ColPav-S Ridge-S	APR-D	Ridge-D	Linear-I	ColPav-D LinearM/O	S & G
MODEL	Sand	86.9%	46.2%	13.7%	12.7%	7.2%	6.7%	9.8%	1.8%
	HardBottom	13.1%	53.8%	86.3%	87.3%	92.8%	93.3%	90.2%	98.2%
	Column	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

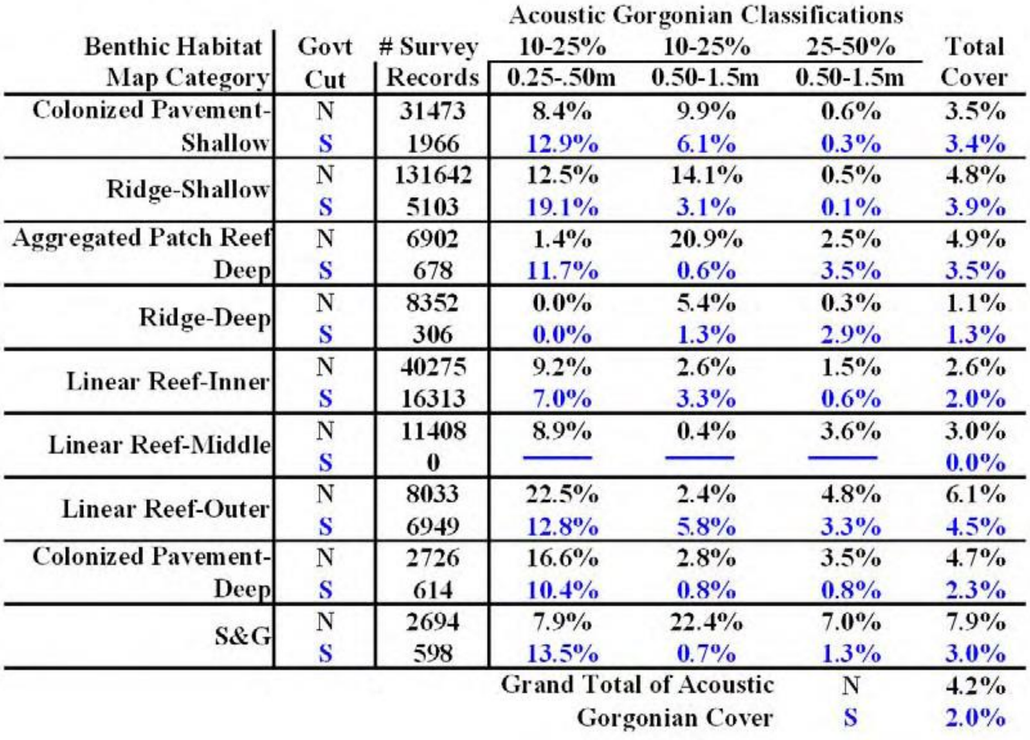
Table 5. Subclassification of AA samples acquired within the Sand-Shallow habitat, based on the review of AA videos, into bottom types of (1) Sand-Ripples, (2) Hard-Packed Sand Flat, (3) Sand over Hardbottom, and (4) Mixed Sand and Hardbottom. Acoustically-classified survey data was selected using a 50m buffer around the traverse of individual AA records. The frequency of acoustic classifications validated the subclasses of bottom type. The acoustic classification of the nearshore sand with ripples samples averaged 94.9% Sand-Shallow. The Hard-Packed Sand Flat classified as 23.7% Sand-Deep (which tends to be well-sorted and semi-consolidated). The Sand over Hardbottom (thin veneer of sand over pavement) and Mixed Sand and Hardbottom subclassifications both had substantial proportions of Hardbottom (BHM Classes 3-8). The visual estimation of macroalgae and gorgonian cover agreed with the subclassifications; the harder bottom types had higher cover of both**.**

Visual Classification of Bottom Type	# of AA Sx's	Frequency of Sand-Shallow AA Acoustic Classifications				Acoustic Gorgonian Cover	Visually Estimated Cover			
							Macroalgae		Gorgonian	
		Sand-Shallow	Sand-Deep	Hardbottom	Gorgonians		Cover	Ht (cm)	Cover	Ht (m)
Sand-Ripples	8	94.9%	0.0%	2.7%	2.5%	1.3%	9.8%	4.9	0.7%	0.38
Hard-Packed Sand Flat	33	71.2%	23.7%	3.8%	1.3%	1.2%	32.0%	4.4	0.5%	0.50
Sand over Hardbottom	7	44.8%	16.0%	34.0%	5.2%	2.1%	27.0%	2.0	2.4%	0.63
Mixed Sand and Hardbottom	7	58.5%	11.8%	25.9%	3.8%	3.3%	39.4%	3.3	4.9%	0.66
	55									

Table 6. Subclassification of AA samples acquired within the Sand-Deep habitat, based on the review of AA videos, into bottom types of (1) Sand-Flat and Sand-Crustose, (2) Sand over Hardbottom, (3) Mixed Sand and Hardbottom, (4) Hardbottom, and (5) Algal Plain. Acoustically-classified survey data was selected using a 50m buffer around the traverse of individual AA records. The frequency of acoustic classifications validated the subclasses of bottom type. The acoustic classification of Sand-Flat and Crustose samples averaged 91.0% Sand-Deep (both are representative of the BHM definition of Sand-Deep). As with the Sand-Shallow samples, the Sand over Hardbottom and Mixed Sand and Hardbottom classified similarly (although they were bother "harder" than their Sand-Shallow counterparts). The Hardbottom and Algal Plain samples both predominantly classified as Hardbottom.

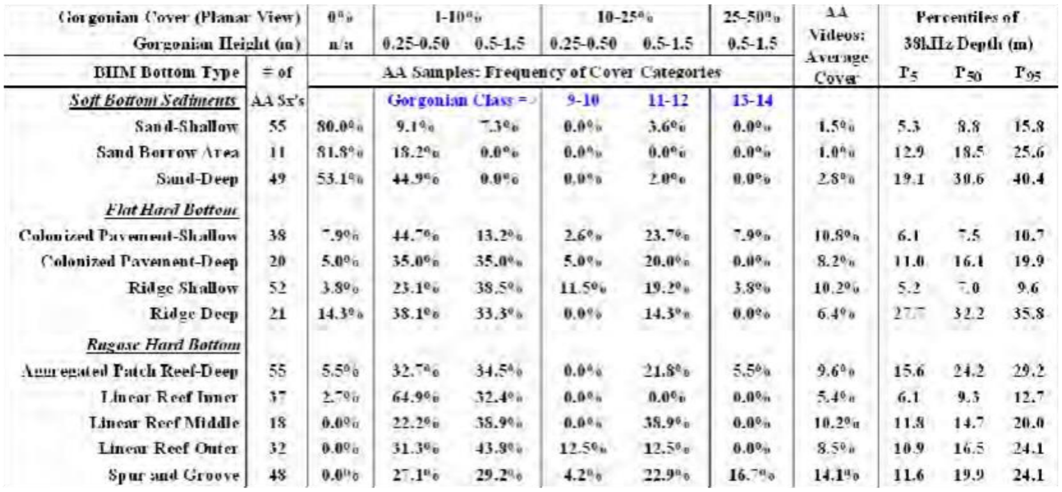
Visual Classification of Bottom Type	# of AA Sx's	Frequency of Sand-Deep AA Acoustic Classifications				Acoustic Gorgonian Cover	Visually Estimated Cover			
							Macroalgae		Gorgonian	
		Sand-Shallow	Sand-Deep	Hardbottom	Gorgonians		Cover	Ht (cm)	Cover	Ht (m)
Sand Flat and Crustose	16	0.3%	91.0%	7.9%	0.8%	0.2%	50.8%	2.5	0.4%	0.38
Sand over Hardbottom	10	0.5%	32.7%	64.9%	1.9%	2.9%	45.0%	3.2	5.0%	0.38
Mixed Sand and Hardbottom	3	0.0%	46.2%	53.1%	0.7%	2.8%	13.0%	1.3	5.5%	0.38
Hardbottom	2	1.9%	4.5%	91.6%	1.9%	3.2%	25.3%	2.5	5.5%	0.56
Algal Plain	14	0.0%	15.7%	83.5%	0.8%	2.6%	61.6%	3.3	1.2%	0.38
	45									

Table 7. Comparison of the acoustically-predicted gorgonian cover on the hardbottom habitats North and South of Government Cut, validating the visually-apparent difference in gorgonian abundance evidenced by the classified survey trackplot of Figure 21.



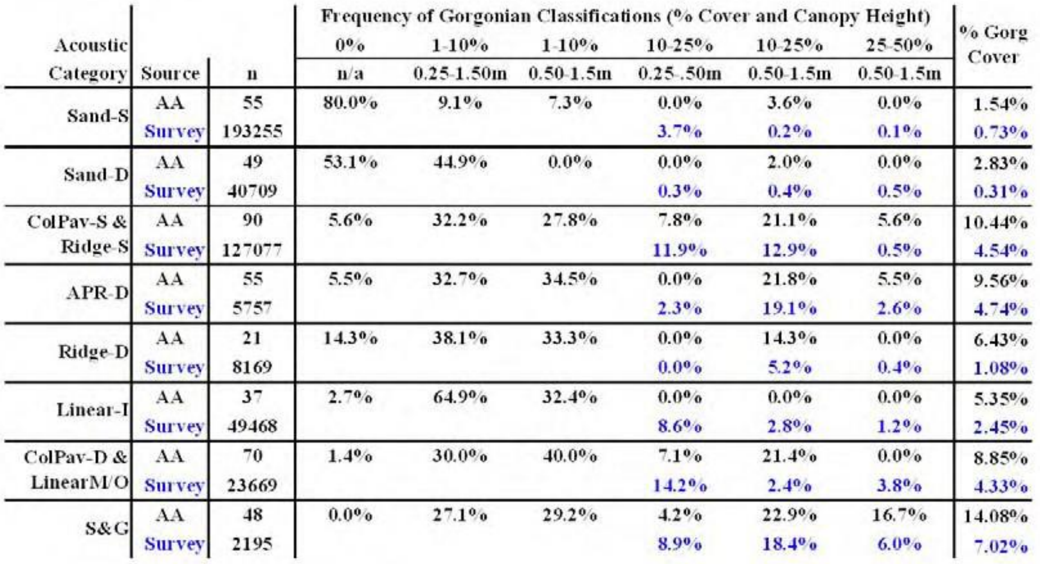
Benthic Habitat Map Category	Govt Cut	# Survey Records	Acoustic Gorgonian Classifications 10-25% 0.25-.50m	 10-25% 0.50-1.5m	 25-50% 0.50-1.5m	Total Cover
Colonized Pavement-Shallow	N	31473	8.4%	9.9%	0.6%	3.5%
	S	1966	12.9%	6.1%	0.3%	3.4%
Ridge-Shallow	N	131642	12.5%	14.1%	0.5%	4.8%
	S	5103	19.1%	3.1%	0.1%	3.9%
Aggregated Patch Reef Deep	N	6902	1.4%	20.9%	2.5%	4.9%
	S	678	11.7%	0.6%	3.5%	3.5%
Ridge-Deep	N	8352	0.0%	5.4%	0.3%	1.1%
	S	306	0.0%	1.3%	2.9%	1.3%
Linear Reef-Inner	N	40275	9.2%	2.6%	1.5%	2.6%
	S	16313	7.0%	3.3%	0.6%	2.0%
Linear Reef-Middle	N	11408	8.9%	0.4%	3.6%	3.0%
	S	0	—	—	—	0.0%
Linear Reef-Outer	N	8033	22.5%	2.4%	4.8%	6.1%
	S	6949	12.8%	5.8%	3.3%	4.5%
Colonized Pavement-Deep	N	2726	16.6%	2.8%	3.5%	4.7%
	S	614	10.4%	0.8%	0.8%	2.3%
S&G	N	2694	7.9%	22.4%	7.0%	7.9%
	S	598	13.5%	0.7%	1.3%	3.0%
			Grand Total of Acoustic Gorgonian Cover		N	4.2%
					S	2.0%

Table 8. An uncomplicated and reliable method for assessing the efficacy of acoustic predictions of gorgonian cover. A synoptic characterization of gorgonian cover obtained from the visual-interpretation of gorgonian cover from the 437 AA videos.



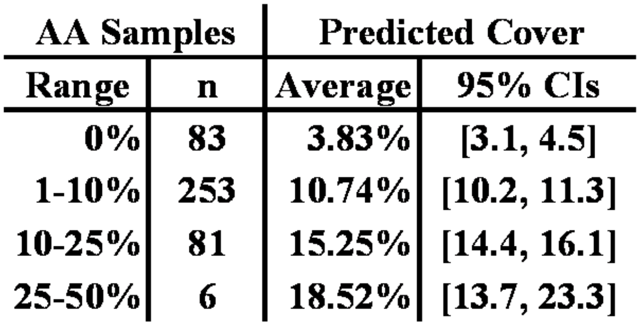
Gorgonian Cover (Planar View)		0%	1-10%		10-25%		25-50%	AA Videos: Average Cover	Percentiles of 38kHz Depth (m)		
Gorgonian Height (m)		n/a	0.25-0.50	0.5-1.5	0.25-0.50	0.5-1.5	0.5-1.5				
BHM Bottom Type	# of AA Sx's	AA Samples: Frequency of Cover Categories							P_5	P_{50}	P_{95}
Soft Bottom Sediments			Gorgonian Class =>		9-10	11-12	13-14				
Sand-Shallow	55	80.0%	9.1%	7.3%	0.0%	3.6%	0.0%	1.5%	5.3	8.8	15.8
Sand Borrow Area	11	81.8%	18.2%	0.0%	0.0%	0.0%	0.0%	1.0%	12.9	18.5	25.6
Sand-Deep	49	53.1%	44.9%	0.0%	0.0%	2.0%	0.0%	2.8%	19.1	30.6	40.4
Flat Hard Bottom											
Colonized Pavement-Shallow	38	7.9%	44.7%	13.2%	2.6%	23.7%	7.9%	10.8%	6.1	7.5	10.7
Colonized Pavement-Deep	20	5.0%	35.0%	35.0%	5.0%	20.0%	0.0%	8.2%	11.0	16.1	19.9
Ridge Shallow	52	3.8%	23.1%	38.5%	11.5%	19.2%	3.8%	10.2%	5.2	7.0	9.6
Ridge Deep	21	14.3%	38.1%	33.3%	0.0%	14.3%	0.0%	6.4%	27.7	32.2	35.8
Rugose Hard Bottom											
Aggregated Patch Reef-Deep	55	5.5%	32.7%	34.5%	0.0%	21.8%	5.5%	9.6%	15.6	24.2	29.2
Linear Reef Inner	37	2.7%	64.9%	32.4%	0.0%	0.0%	0.0%	5.4%	6.1	9.3	12.7
Linear Reef Middle	18	0.0%	22.2%	38.9%	0.0%	38.9%	0.0%	10.2%	11.8	14.7	20.0
Linear Reef Outer	32	0.0%	31.3%	43.8%	12.5%	12.5%	0.0%	8.5%	10.9	16.5	24.1
Spur and Groove	48	0.0%	27.1%	29.2%	4.2%	22.9%	16.7%	14.1%	11.6	19.9	24.1

Table 9. Synoptic comparison of the efficacy of gorgonian classification. The visual interpretation of gorgonian cover from the 437 AA videos is compared to the acoustic classification of survey records.



Acoustic Category	Source	n	Frequency of Gorgonian Classifications (% Cover and Canopy Height)						% Gorg Cover
			0%	1-10%	1-10%	10-25%	10-25%	25-50%	
			n/a	0.25-1.50m	0.50-1.5m	0.25-.50m	0.50-1.5m	0.50-1.5m	
Sand-S	AA	55	80.0%	9.1%	7.3%	0.0%	3.6%	0.0%	1.54%
	Survey	193255				3.7%	0.2%	0.1%	0.73%
Sand-D	AA	49	53.1%	44.9%	0.0%	0.0%	2.0%	0.0%	2.83%
	Survey	40709				0.3%	0.4%	0.5%	0.31%
ColPav-S & Ridge-S	AA	90	5.6%	32.2%	27.8%	7.8%	21.1%	5.6%	10.44%
	Survey	127077				11.9%	12.9%	0.5%	4.54%
APR-D	AA	55	5.5%	32.7%	34.5%	0.0%	21.8%	5.5%	9.56%
	Survey	5757				2.3%	19.1%	2.6%	4.74%
Ridge-D	AA	21	14.3%	38.1%	33.3%	0.0%	14.3%	0.0%	6.43%
	Survey	8169				0.0%	5.2%	0.4%	1.08%
Linear-I	AA	37	2.7%	64.9%	32.4%	0.0%	0.0%	0.0%	5.35%
	Survey	49468				8.6%	2.8%	1.2%	2.45%
ColPav-D & LinearM/O	AA	70	1.4%	30.0%	40.0%	7.1%	21.4%	0.0%	8.85%
	Survey	23669				14.2%	2.4%	3.8%	4.33%
S&G	AA	48	0.0%	27.1%	29.2%	4.2%	22.9%	16.7%	14.08%
	Survey	2195				8.9%	18.4%	6.0%	7.02%

Table 10. Direct comparison of the acoustic classification of gorgonian cover from the 60-second AA samples against the defining range of gorgonian cover for each category of gorgonian cover.



AA Samples		Predicted Cover	
Range	n	Average	95% CIs
0%	83	3.83%	[3.1, 4.5]
1-10%	253	10.74%	[10.2, 11.3]
10-25%	81	15.25%	[14.4, 16.1]
25-50%	6	18.52%	[13.7, 23.3]

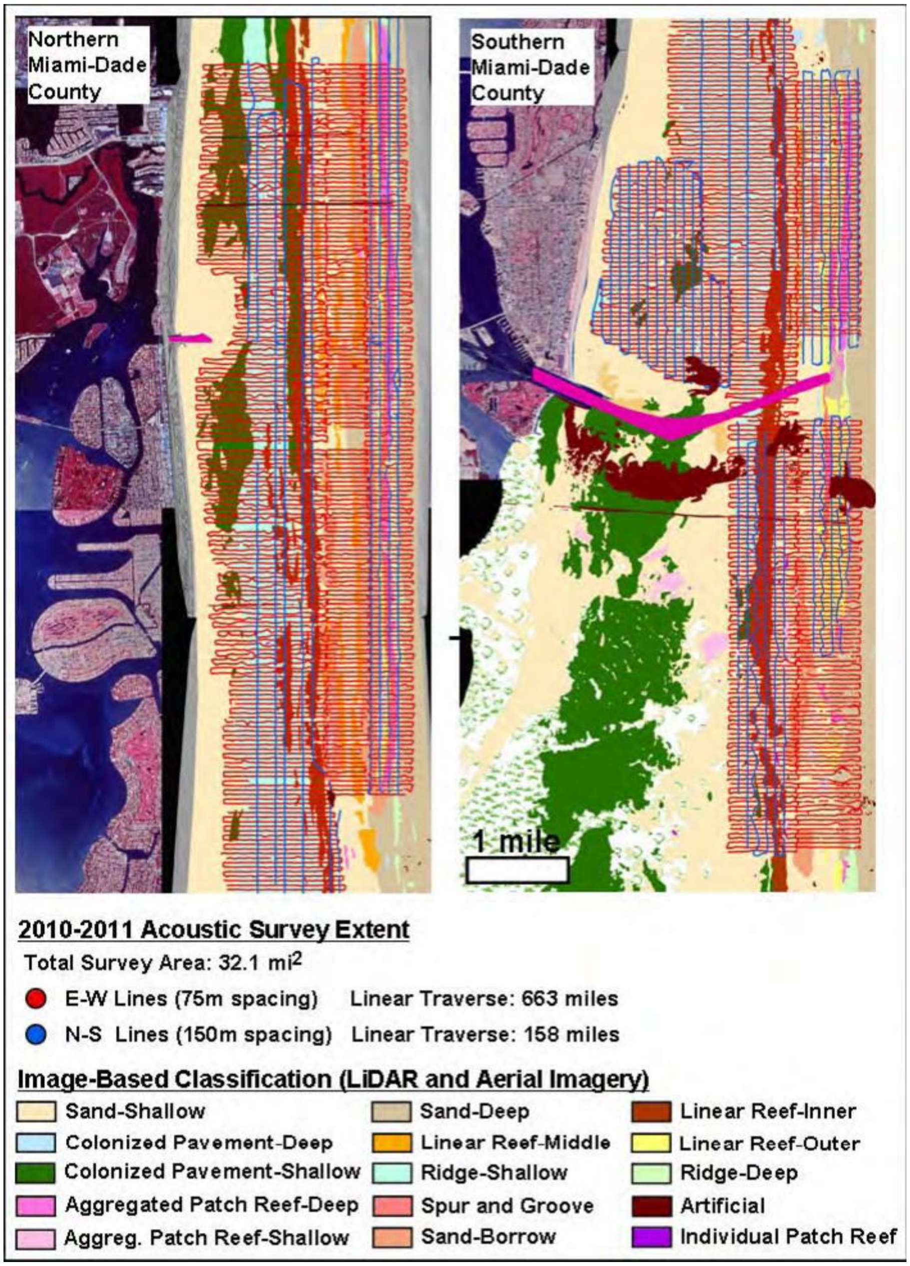


Figure 1. Trackplot (unclassified) of the 2010-2011 acoustic survey of Miami-Dade **C**ounty, overlying the 2009 benthic habitat map derived from visual interpretation of LiDAR and aerial imagery.

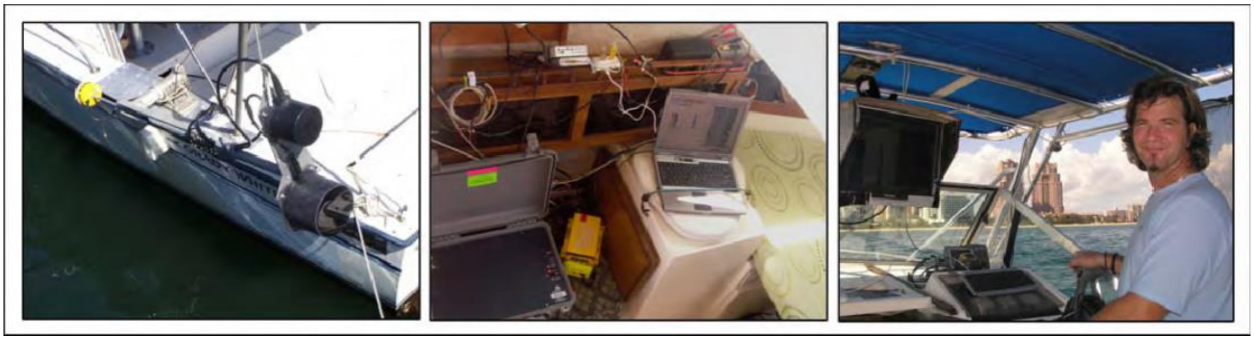


Figure 2. Acoustic equipment. (left) Swing-arm in horizontal (traveling) position with 420 and 38 kHz transducers and Trimble antenna. (middle) Inside v-berth of survey vessel with BioSonics DT-X echosounder, Trimble receiver, and acquisition PC. (right) Monitor displaying gps-navigation over pre-planned lines and real-time echo returns.

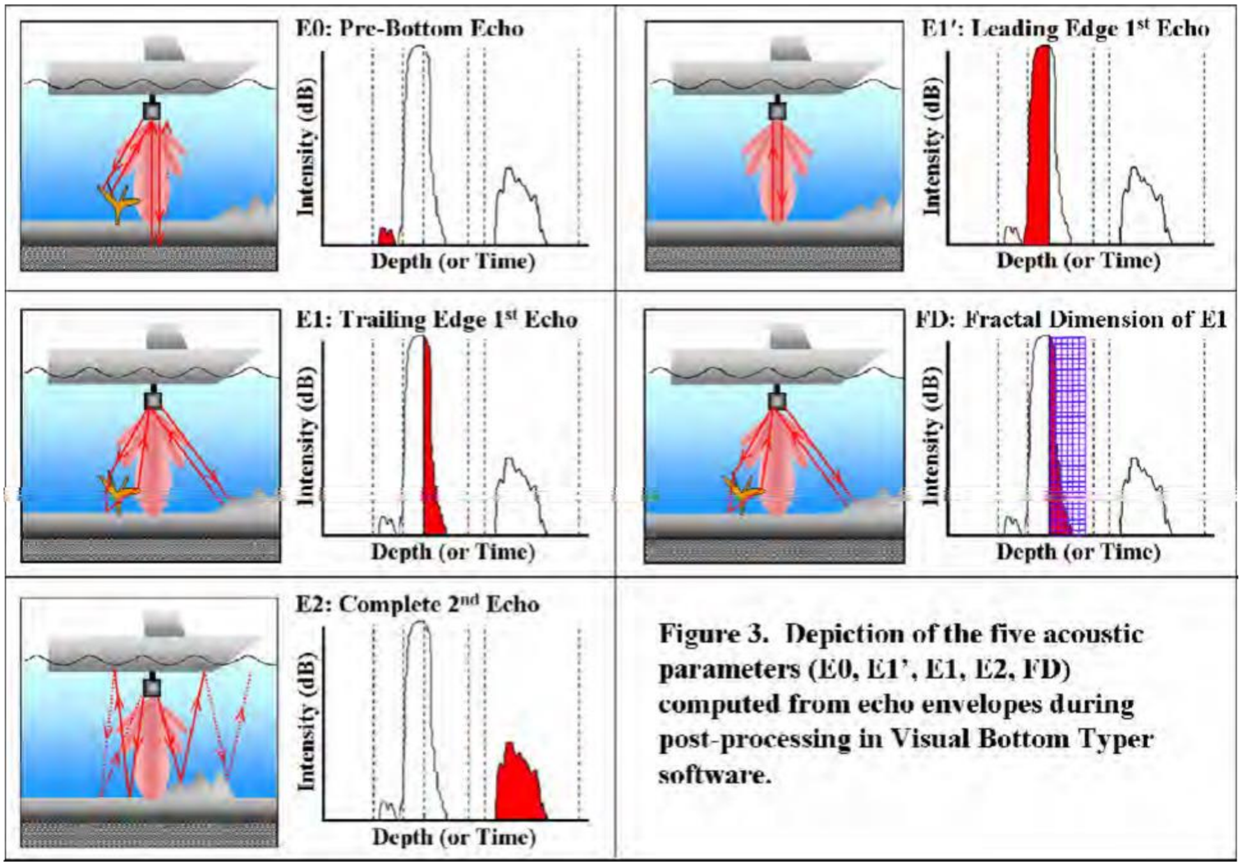


Figure 3. Depiction of the five acoustic parameters (E0, E1′, E1, E2, FD) computed from echo envelopes during post-processing in Visual Bottom Typer software.

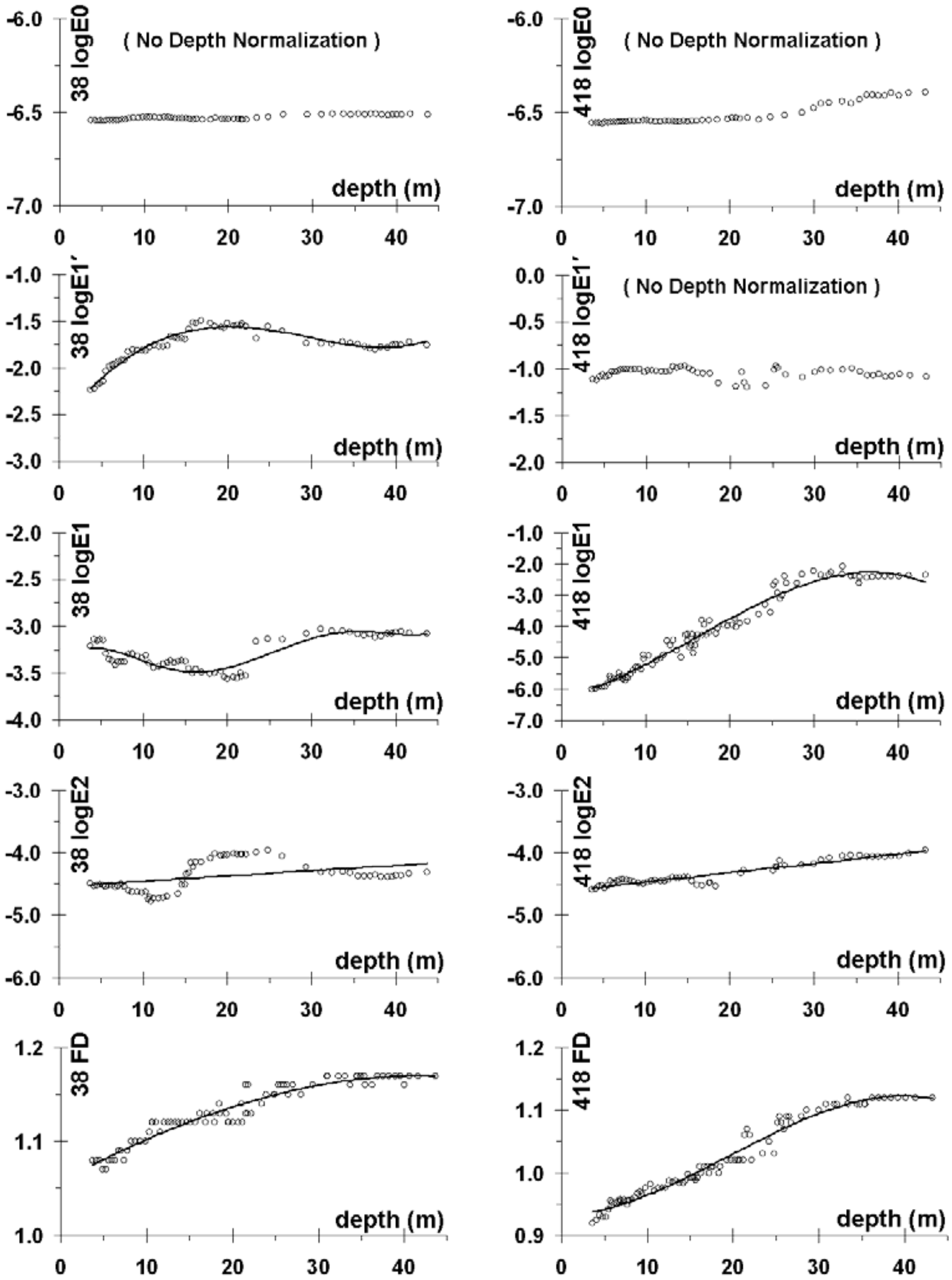


Figure 4. Empirical depth normalization. 200,000+ records acquired over Sand-Shallow and Sand-Deep habitats, binned into 0.5m increments of depth. Fitted curves (solid lines) were used tor empirically normalize acoustic parameters to the average survey depth of 20m. Correction factors were applied to each acoustic record, calculated as the ratio of model-predicted value of the acoustic parameter at the actual depth divided by the model-predicted value of the acoustic parameter at the reference depth. The 38 and 418 kHz E0's and the 38 kHz E1 and FD did not require empirical depth-normalization.

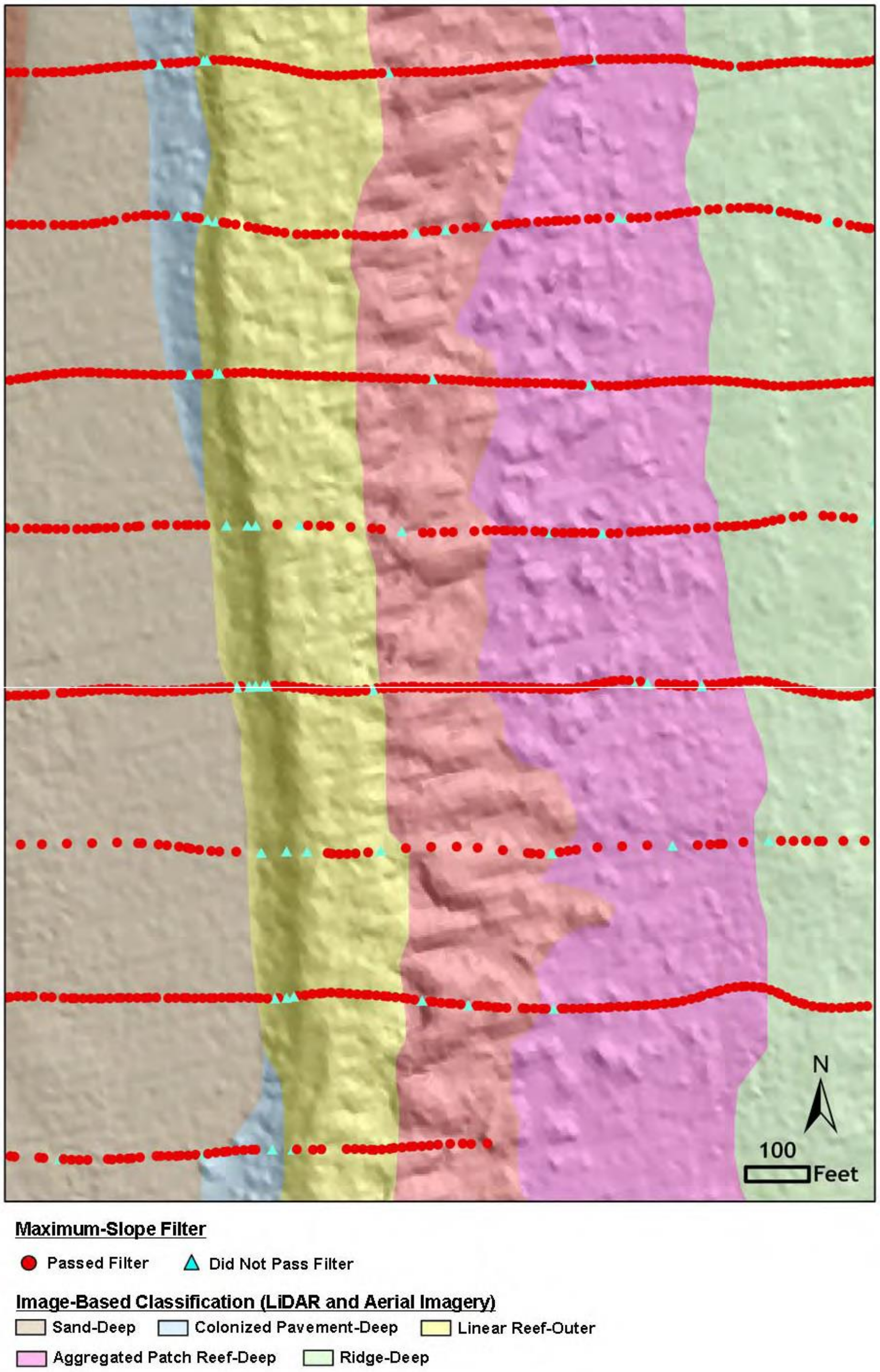
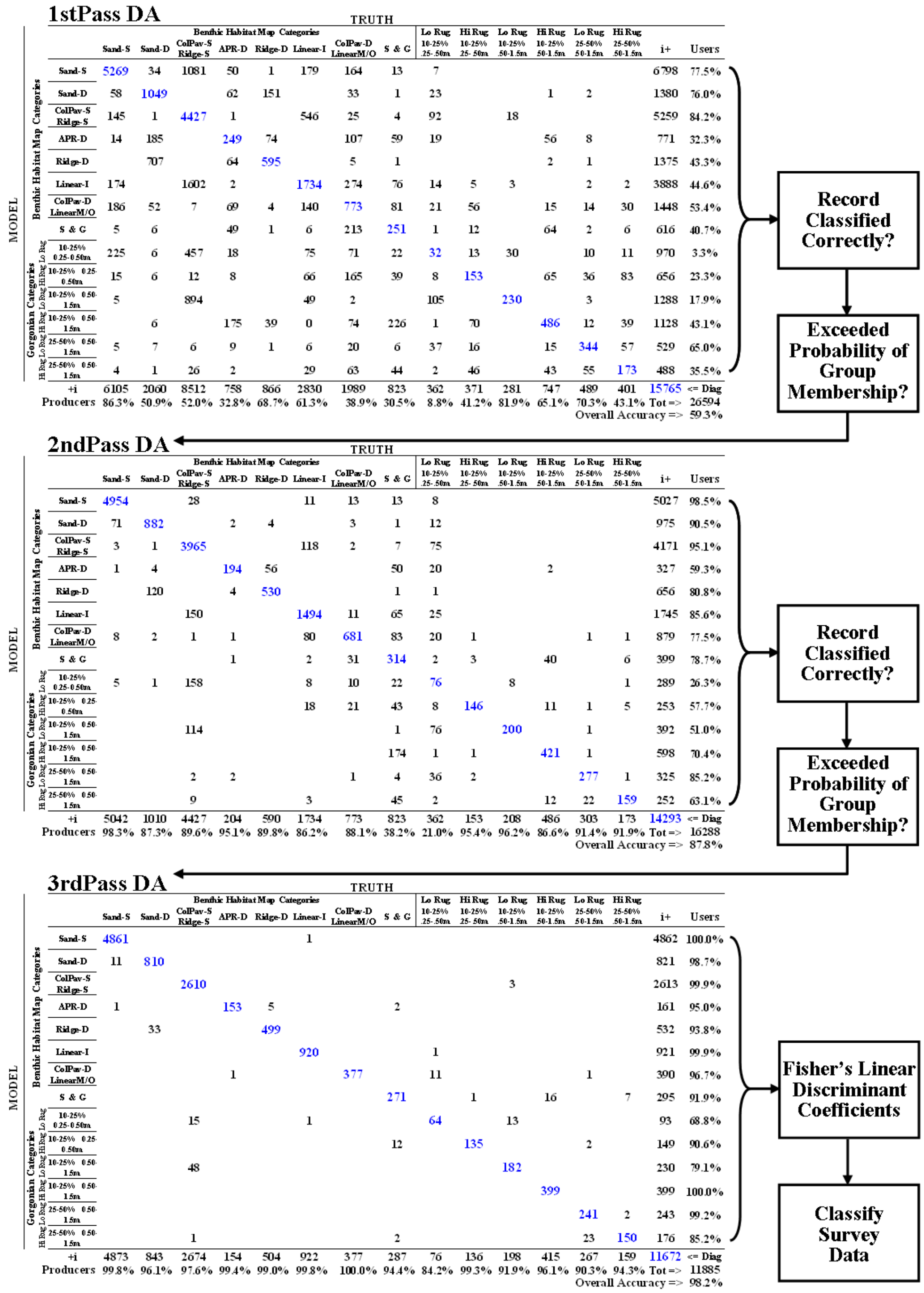


Figure 5. Illustration of the Maximum Slope Quality Analysis filter. This filter detects acoustic records acquired on steep edges, which is problematic because the signal wavefront ensonifies an ellipse instead of a circle, resulting in a stretched and flattened echo envelope. The filter also removes records acquired during excessive pitch and roll of the survey vessel (tilting the boat over a flat surface is equivalent to normal-incidence signal onto a steep slope).



1stPass DA

TRUTH

MODEL		Benthic Habitat Map Categories															
		Sand-S	Sand-D	ColPav-S Ridge-S	APR-D	Ridge-D	Linear-I	ColPav-D LinearM/O	S & G	Lo Rug 10-25% .25-.50m	Hi Rug 10-25% 25- 50m	Lo Rug 10-25% .50-1.5m	Hi Rug 10-25% 50-1.5m	Lo Rug 25-50% 50-1.5m	Hi Rug 25-50% .50-1.5m	i+	Users
Benthic Habitat Map Categories	Sand-S	5269	34	1081	50	1	179	164	13	7						6798	77.5%
	Sand-D	58	1049		62	151		33	1	23			1	2		1380	76.0%
	ColPav-S Ridge-S	145	1	4427	1		546	25	4	92		18				5259	84.2%
	APR-D	14	185		249	74		107	59	19			56	8		771	32.3%
	Ridge-D		707		64	595		5	1				2	1		1375	43.3%
	Linear-I	174		1602	2		1734	274	76	14	5	3		2	2	3888	44.6%
	ColPav-D LinearM/O	186	52	7	69	4	140	773	81	21	56		15	14	30	1448	53.4%
	S & G	5	6		49	1	6	213	251	1	12		64	2	6	616	40.7%
Gorgonian Categories	Lo Rug 10-25% 0.25-0.50m	225	6	457	18		75	71	22	32	13	30		10	11	970	3.3%
	Hi Rug 10-25% 0.25-0.50m	15	6	12	8		66	165	39	8	153		65	36	83	656	23.3%
	Lo Rug 10-25% 0.50-1.5m	5		894			49	2		105		230		3		1288	17.9%
	Hi Rug 10-25% 0.50-1.5m		6		175	39	0	74	226	1	70		486	12	39	1128	43.1%
	Lo Rug 25-50% 0.50-1.5m	5	7	6	9	1	6	20	6	37	16		15	344	57	529	65.0%
	Hi Rug 25-50% 0.50-1.5m	4	1	26	2		29	63	44	2	46		43	55	173	488	35.5%
	+i	6105	2060	8512	758	866	2830	1989	823	362	371	281	747	489	401	15765	<= Diag
	Producers	86.3%	50.9%	52.0%	32.8%	68.7%	61.3%	38.9%	30.5%	8.8%	41.2%	81.9%	65.1%	70.3%	43.1%	Tot =>	26594
																Overall Accuracy =>	59.3%

2ndPass DA

TRUTH

MODEL		Benthic Habitat Map Categories															
		Sand-S	Sand-D	ColPav-S Ridge-S	APR-D	Ridge-D	Linear-I	ColPav-D LinearM/O	S & G	Lo Rug 10-25% .25-.50m	Hi Rug 10-25% 25- 50m	Lo Rug 10-25% .50-1.5m	Hi Rug 10-25% 50-1.5m	Lo Rug 25-50% 50-1.5m	Hi Rug 25-50% .50-1.5m	i+	Users
Benthic Habitat Map Categories	Sand-S	4954		28			11	13	13	8						5027	98.5%
	Sand-D	71	882		2	4		3	1	12						975	90.5%
	ColPav-S Ridge-S	3	1	3965			118	2	7	75						4171	95.1%
	APR-D	1	4		194	56			50	20			2			327	59.3%
	Ridge-D		120		4	530			1	1						656	80.8%
	Linear-I			150			1494	11	65	25						1745	85.6%
	ColPav-D LinearM/O	8	2	1	1		80	681	83	20	1			1	1	879	77.5%
	S & G				1		2	31	314	2	3		40		6	399	78.7%
Gorgonian Categories	Lo Rug 10-25% 0.25-0.50m	5	1	158			8	10	22	76		8			1	289	26.3%
	Hi Rug 10-25% 0.25-0.50m						18	21	43	8	146		11	1	5	253	57.7%
	Lo Rug 10-25% 0.50-1.5m			114					1	76		200		1		392	51.0%
	Hi Rug 10-25% 0.50-1.5m								174	1	1		421	1		598	70.4%
	Lo Rug 25-50% 0.50-1.5m			2	2			1	4	36	2			277	1	325	85.2%
	Hi Rug 25-50% 0.50-1.5m			9			3		45	2			12	22	159	252	63.1%
	+i	5042	1010	4427	204	590	1734	773	823	362	153	208	486	303	173	14293	<= Diag
	Producers	98.3%	87.3%	89.6%	95.1%	89.8%	86.2%	88.1%	38.2%	21.0%	95.4%	96.2%	86.6%	91.4%	91.9%	Tot =>	16288
																Overall Accuracy =>	87.8%

3rdPass DA

TRUTH

MODEL		Benthic Habitat Map Categories															
		Sand-S	Sand-D	ColPav-S Ridge-S	APR-D	Ridge-D	Linear-I	ColPav-D LinearM/O	S & G	Lo Rug 10-25% .25-.50m	Hi Rug 10-25% 25- 50m	Lo Rug 10-25% .50-1.5m	Hi Rug 10-25% 50-1.5m	Lo Rug 25-50% 50-1.5m	Hi Rug 25-50% .50-1.5m	i+	Users
Benthic Habitat Map Categories	Sand-S	4861					1									4862	100.0%
	Sand-D	11	810													821	98.7%
	ColPav-S Ridge-S			2610								3				2613	99.9%
	APR-D	1			153	5			2							161	95.0%
	Ridge-D		33			499										532	93.8%
	Linear-I						920			1						921	99.9%
	ColPav-D LinearM/O				1			377		11				1		390	96.7%
	S & G								271		1		16		7	295	91.9%
Gorgonian Categories	Lo Rug 10-25% 0.25-0.50m			15			1			64		13				93	68.8%
	Hi Rug 10-25% 0.25-0.50m								12		135			2		149	90.6%
	Lo Rug 10-25% 0.50-1.5m			48								182				230	79.1%
	Hi Rug 10-25% 0.50-1.5m												399			399	100.0%
	Lo Rug 25-50% 0.50-1.5m													241	2	243	99.2%
	Hi Rug 25-50% 0.50-1.5m			1					2					23	150	176	85.2%
	+i	4873	843	2674	154	504	922	377	287	76	136	198	415	267	159	11672	<= Diag
	Producers	99.8%	96.1%	97.6%	99.4%	99.0%	99.8%	100.0%	94.4%	84.2%	99.3%	91.9%	96.1%	90.3%	94.3%	Tot =>	11885
																Overall Accuracy =>	98.2%

Figure 6. Multi-Pass discriminant analysis (DA) for refining training dataset into pure end-member classes. Only those catalog records (1) classify correctly and (2) exceed a minimum probability for group membership are passed on to the next DA. The Fisher's Linear Discriminant Functions obtained from the 3rdPass DA were used to classify survey data into one of fourteen classes (8 BHM categories and 6 gorgonian categories).

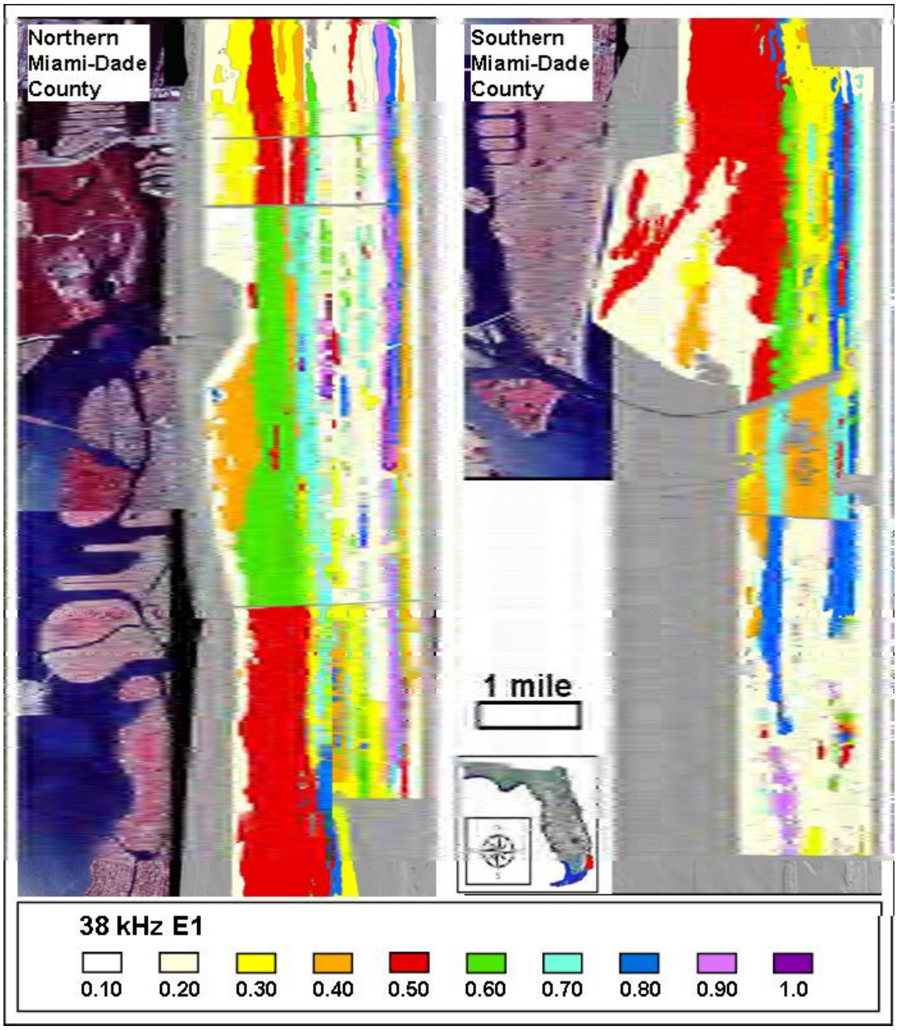


Figure 7. Benthic habitat maps (38 kHz E1). 291 benthic habitat polygons of 15 detailed categories of geomorphological structure were populated with 500,000+ acoustic survey records. These maps demonstrate the discriminatory power of individual acoustic parameters and hint at the potential of the dual-frequency multivariate dataset used in this survey.

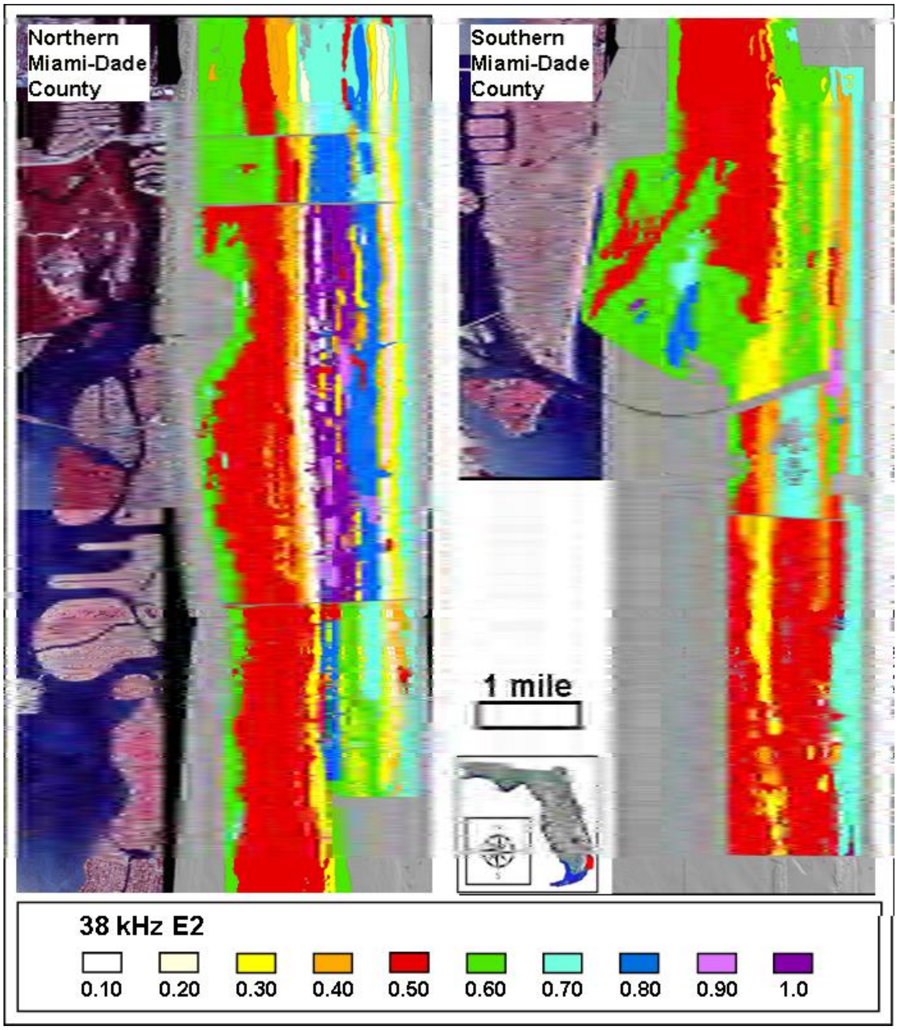


Figure 8. Benthic habitat maps (38 kHz E2). 291 benthic habitat polygons of 15 detailed categories of geomorphological structure were populated with 500,000+ acoustic survey records. These maps demonstrate the discriminatory power of individual acoustic parameters and hint at the potential of the dual-frequency multivariate dataset used in this survey.

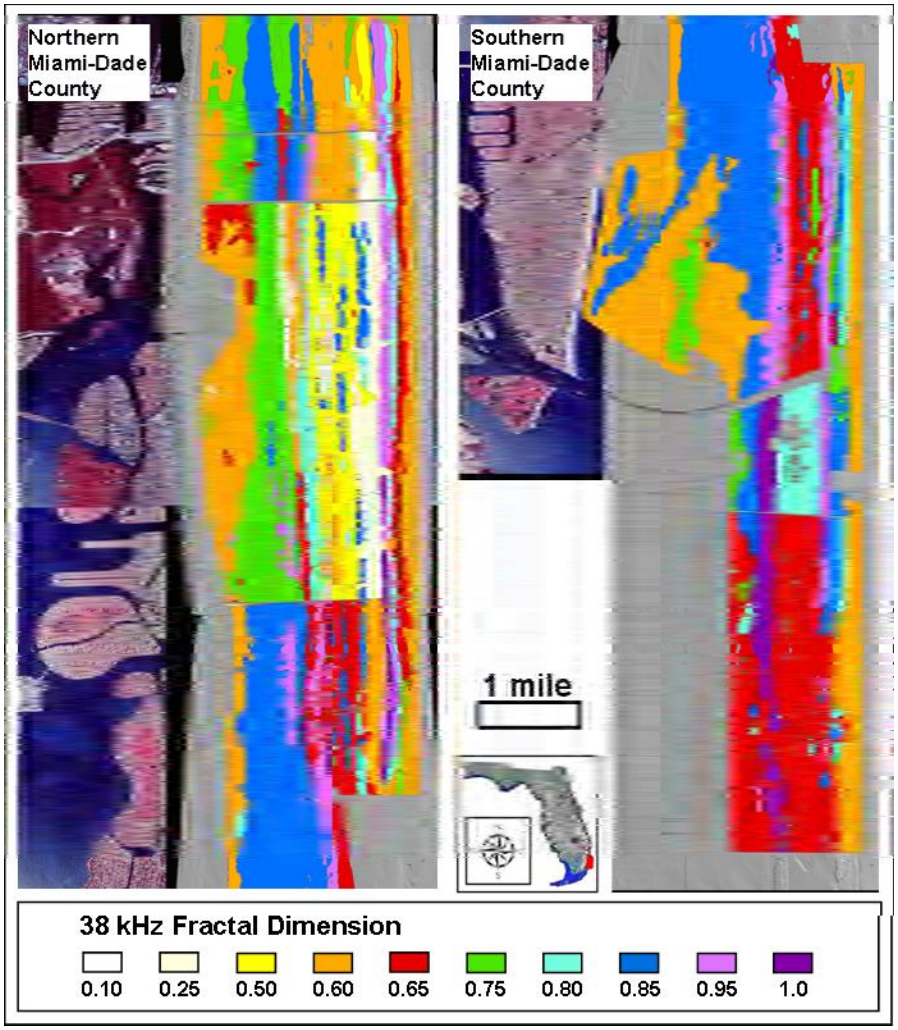


Figure 9. Benthic habitat maps (Fractal Dimension). 291 benthic habitat polygons of 15 detailed categories of geomorphological structure were populated with 500,000+ acoustic survey records. These maps demonstrate the discriminatory power of individual acoustic parameters and hint at the potential of the dual-frequency multivariate dataset used in this survey.

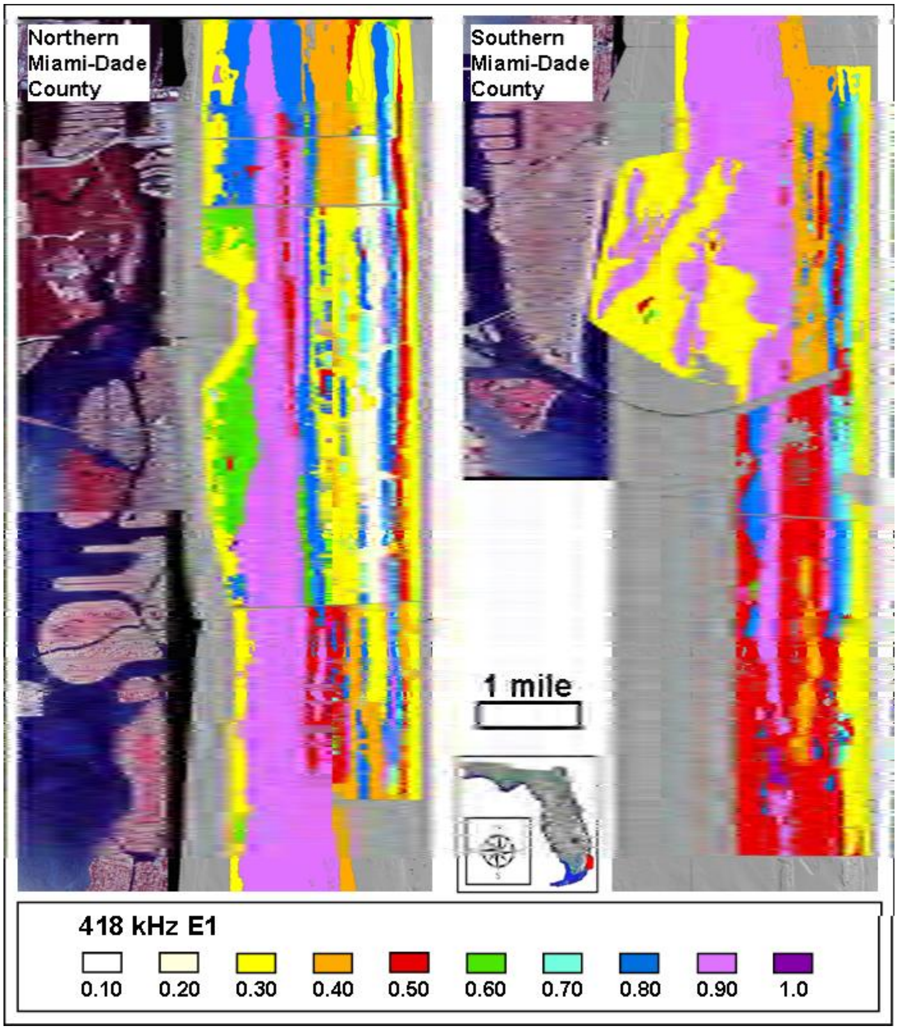


Figure 10. Benthic habitat maps (418 kHz E1). 291 benthic habitat polygons of 15 detailed categories of geomorphological structure were populated with 500,000+ acoustic survey records. These maps demonstrate the discriminatory power of individual acoustic parameters and hint at the potential of the dual-frequency multivariate dataset used in this survey.

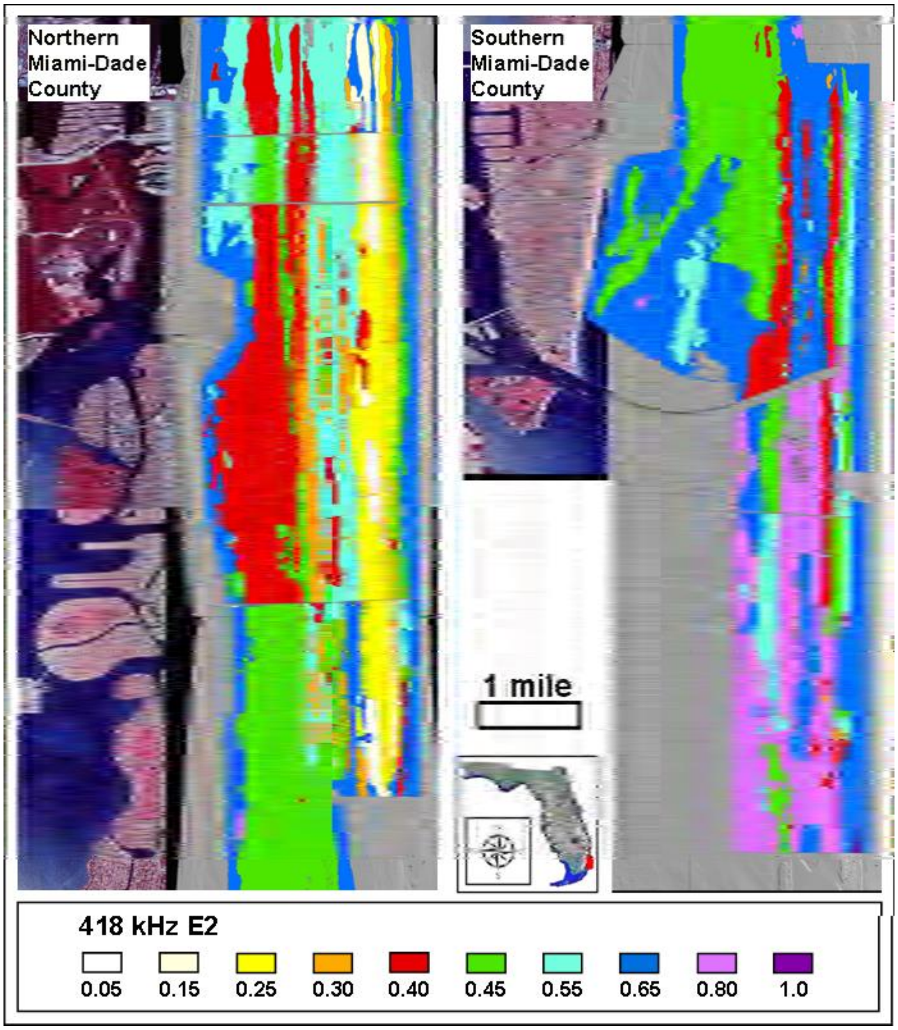


Figure 11. Benthic habitat maps (418 kHz E2). 291 benthic habitat polygons of 15 detailed categories of geomorphological structure were populated with 500,000+ acoustic survey records. These maps demonstrate the discriminatory power of individual acoustic parameters and hint at the potential of the dual-frequency multivariate dataset used in this survey.

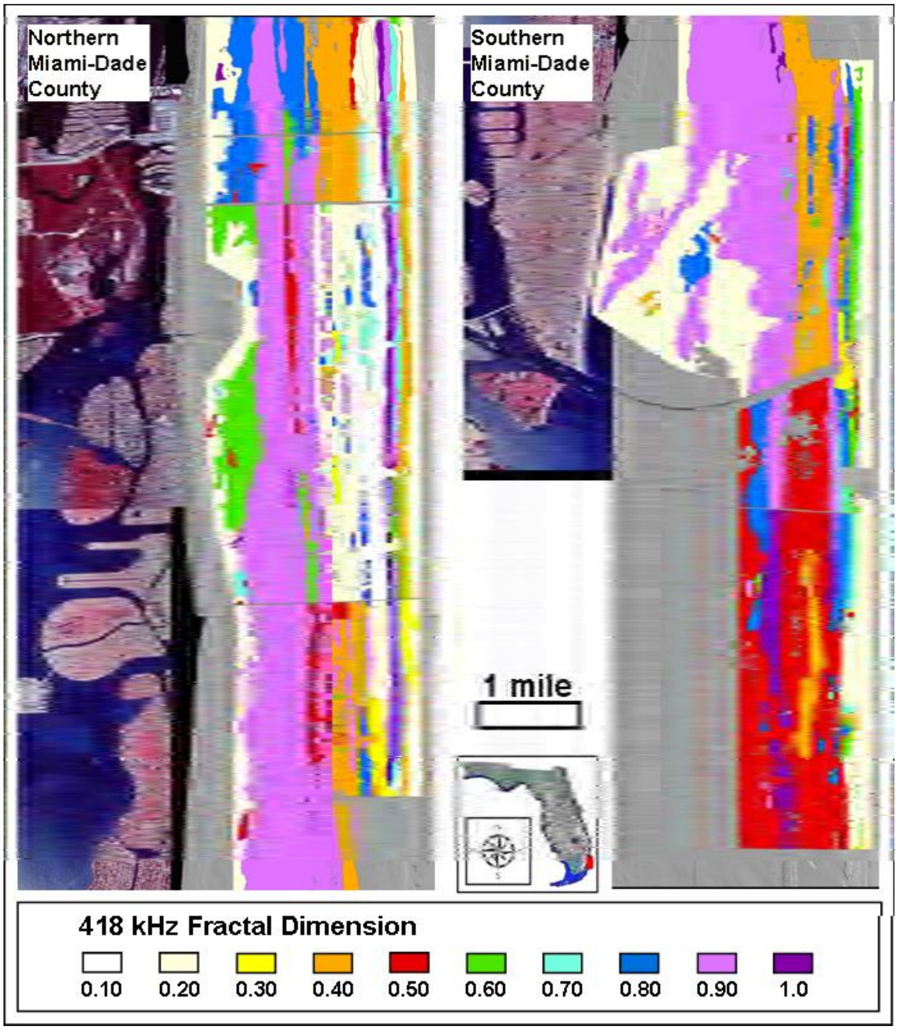


Figure 12. Benthic habitat maps (418 kHz Fractal Dimension). 291 benthic habitat polygons of 15 detailed categories of geomorphological structure were populated with 500,000+ acoustic survey records. These maps demonstrate the discriminatory power of individual acoustic parameters and hint at the potential of the dual-frequency multivariate dataset used in this survey.

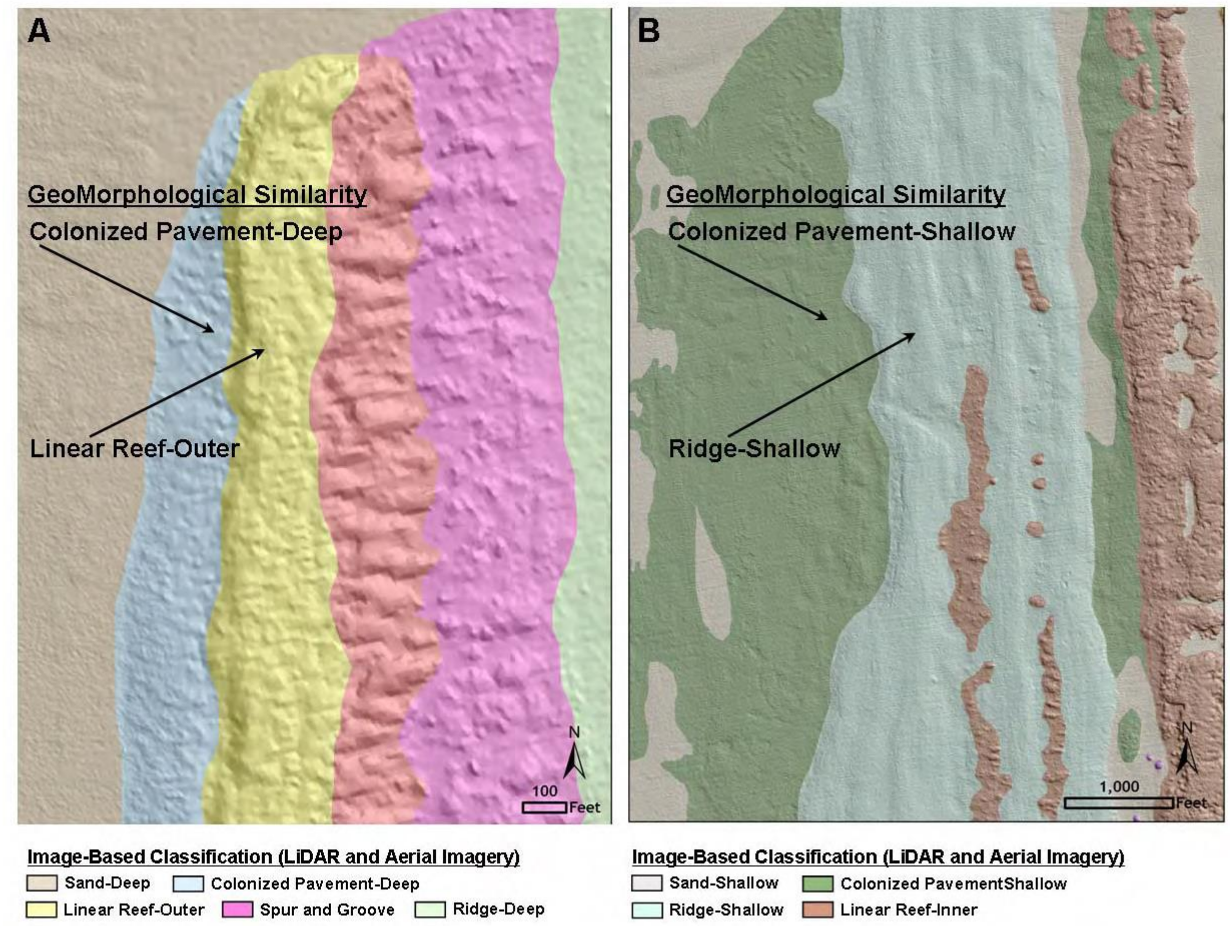


Figure 13. Illustration of the rationale for combining selected BHM habitat classes in the acoustic training dataset. (A) The LiDAR topography is very similar for the acoustically-indistinguishable Colonized Pavement-Deep and Linear Reef-Outer categories. (B) The major structural difference between Colonized Pavement-Shallow and Ridge-Shallow habitats is relief, which is not acoustically distinguishable. Otherwise the two habitats consistently appear very similar in the LiDAR imagery.

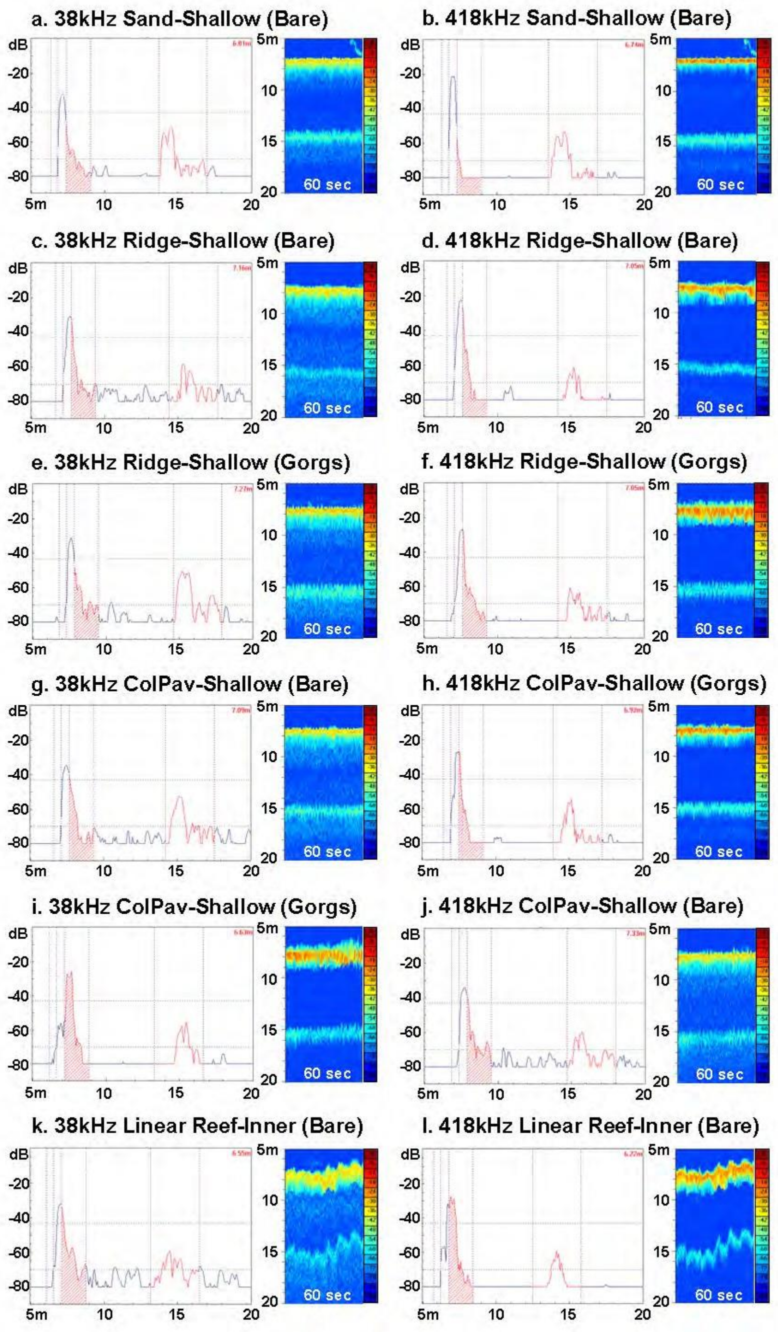

a. 38kHz Sand-Shallow (Bare)
b. 418kHz Sand-Shallow (Bare)
c. 38kHz Ridge-Shallow (Bare)
d. 418kHz Ridge-Shallow (Bare)
e. 38kHz Ridge-Shallow (Gorgs)
f. 418kHz Ridge-Shallow (Gorgs)
g. 38kHz ColPav-Shallow (Bare)
h. 418kHz ColPav-Shallow (Gorgs)
i. 38kHz ColPav-Shallow (Gorgs)
j. 418kHz ColPav-Shallow (Bare)
k. 38kHz Linear Reef-Inner (Bare)
l. 418kHz Linear Reef-Inner (Bare)

Figure 14. Visual Bottom Typer screenshots of representative samples for a few select BHM classes. The echo envelope of a single ping is on the left the 60 seconds of pings are on the right. The effect of gorgonians can be seen as a larger E1 (scattering within the canopy increases the path length and affected signal returns later), a decrease in E2 (due to scattering, less likely to make the double round trip), and an increase in the spikiness of E1 (greater FD).

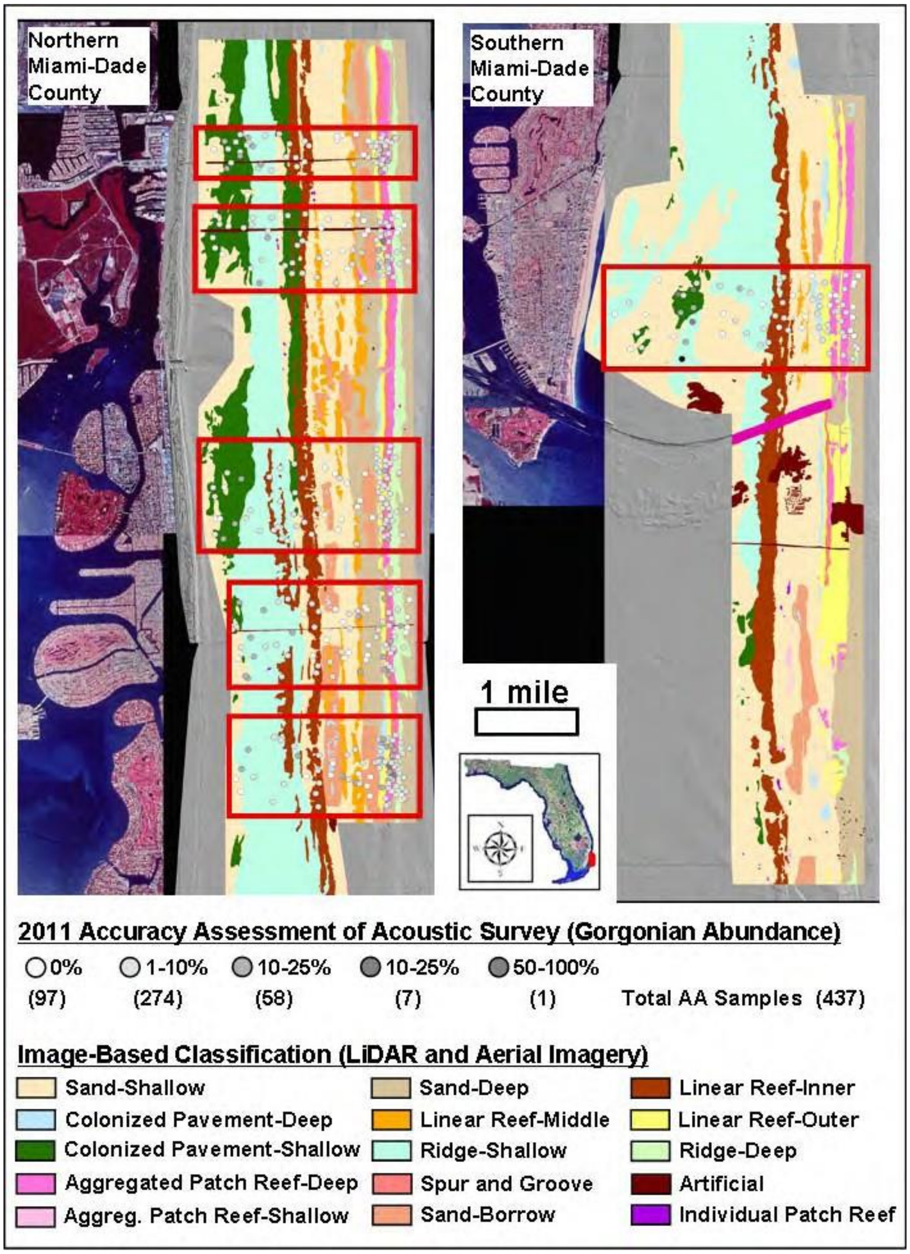


Figure 15. The six Accuracy Assessment (AA) corridors (red rectangles) and the 437 60-second AA sonar+video samples, presented as the visually-interpreted goronian percent cover.

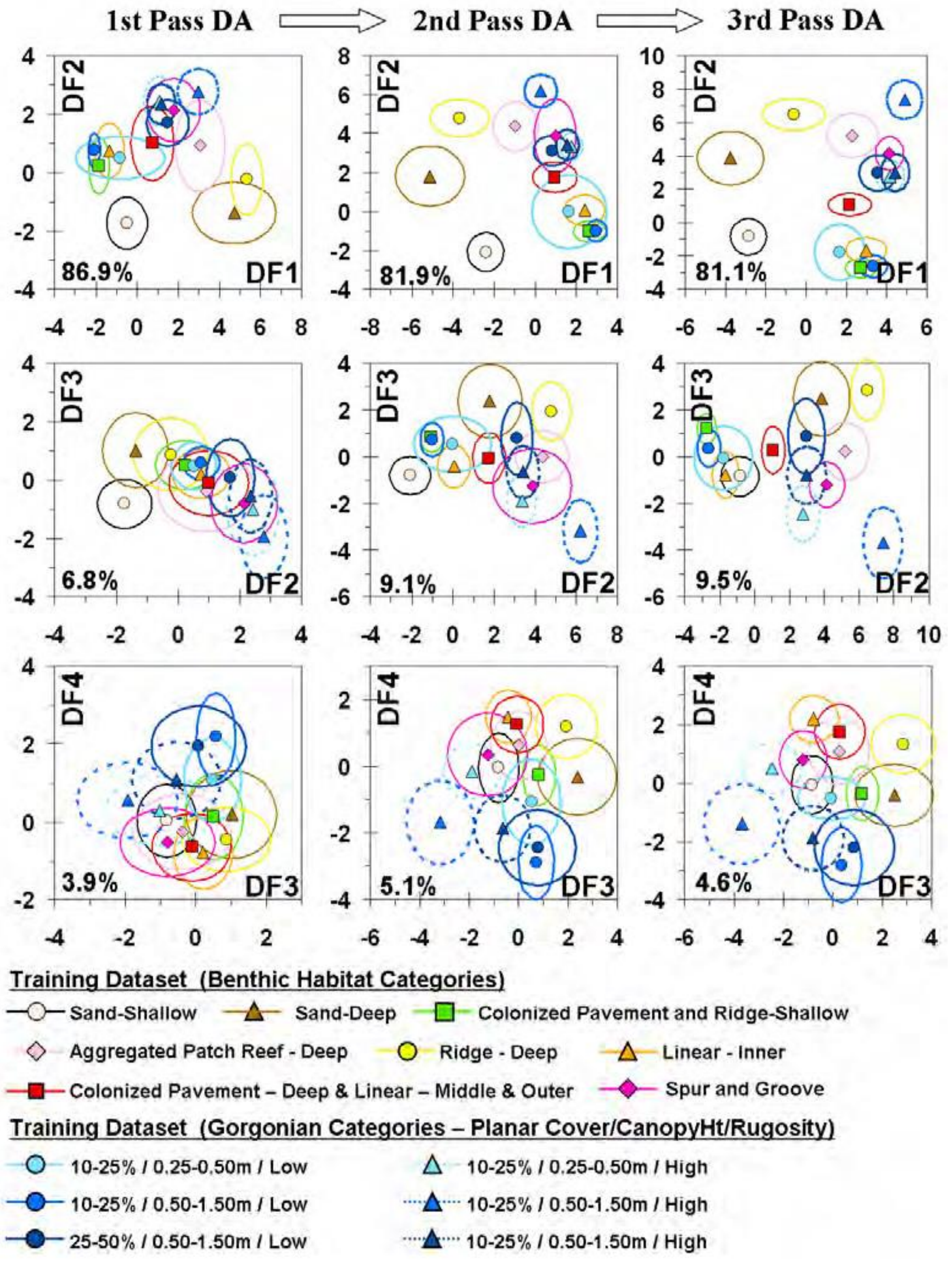


Figure 16. Scatterplots of Discriminant Functions (DF) for the Multi-Pass DA of the 14 category training dataset. Ellipses are one standard deviation about the mean. The percentages in the lower-left corner are the amount of variance accounted for by DF's. At the third pass there is a dramatic increase in the separation between groups (~55% of the training records were de-selected). The DF1&2 discriminate between the eight BHM categories, while DF3&4 separate differentiate the gorgonian clusters from the BHM categories.

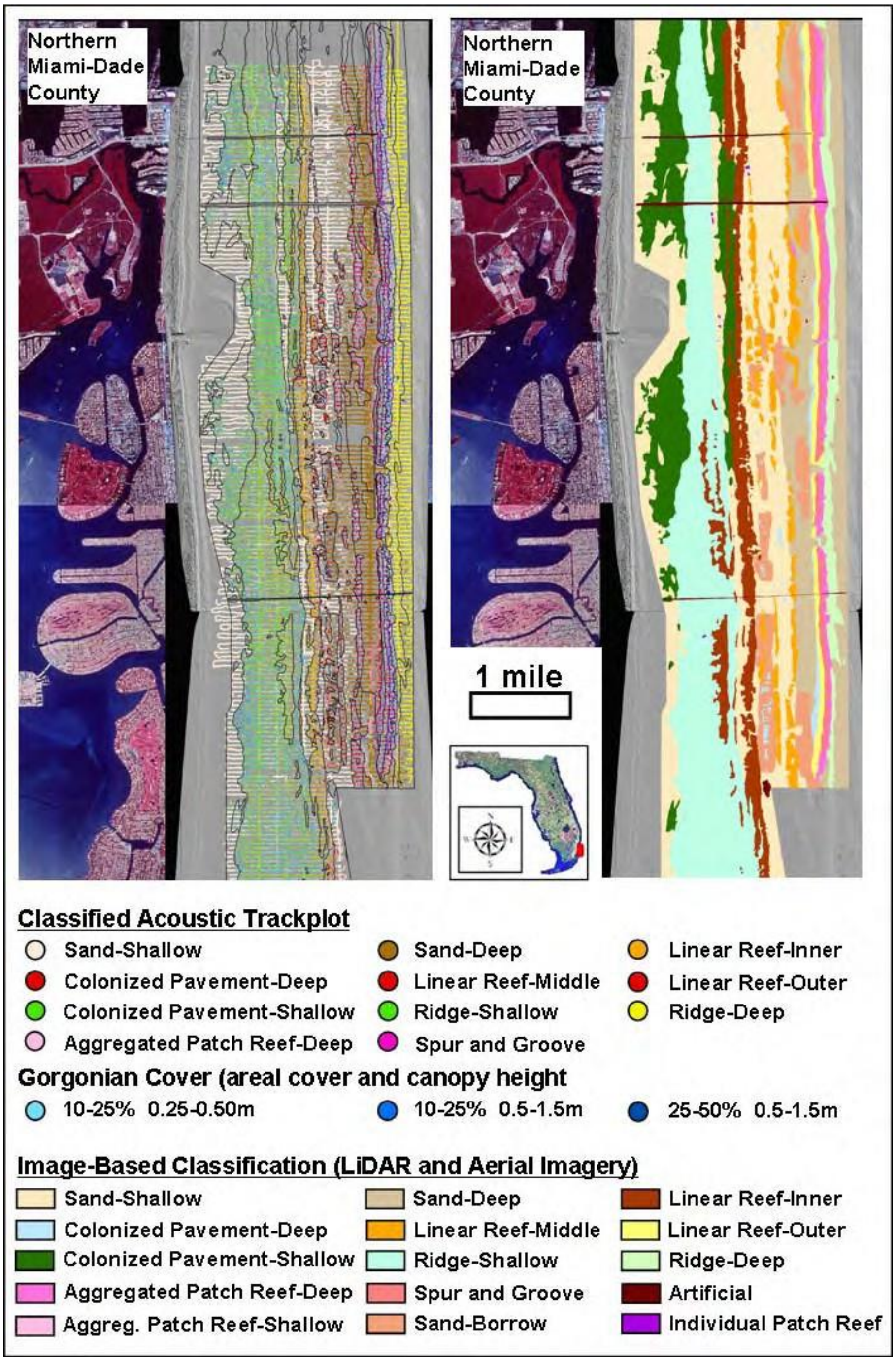


Figure 17. Trackplot of acoustically-classified survey data in the northern study area, alongside the benthic habitat map.

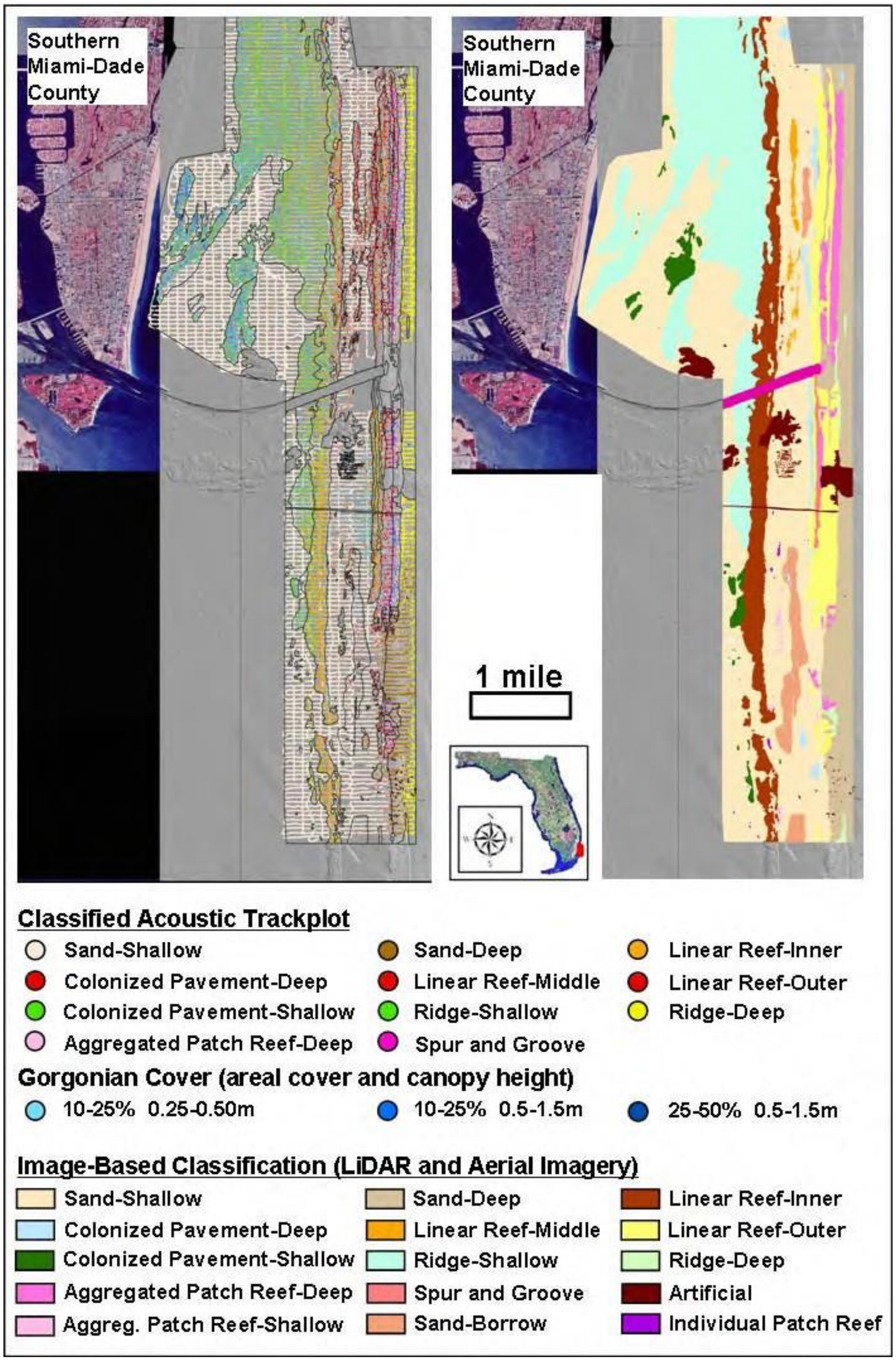


Figure 18. Trackplot of acoustically-classified survey data in the southern study area, alongside the benthic habitat map.

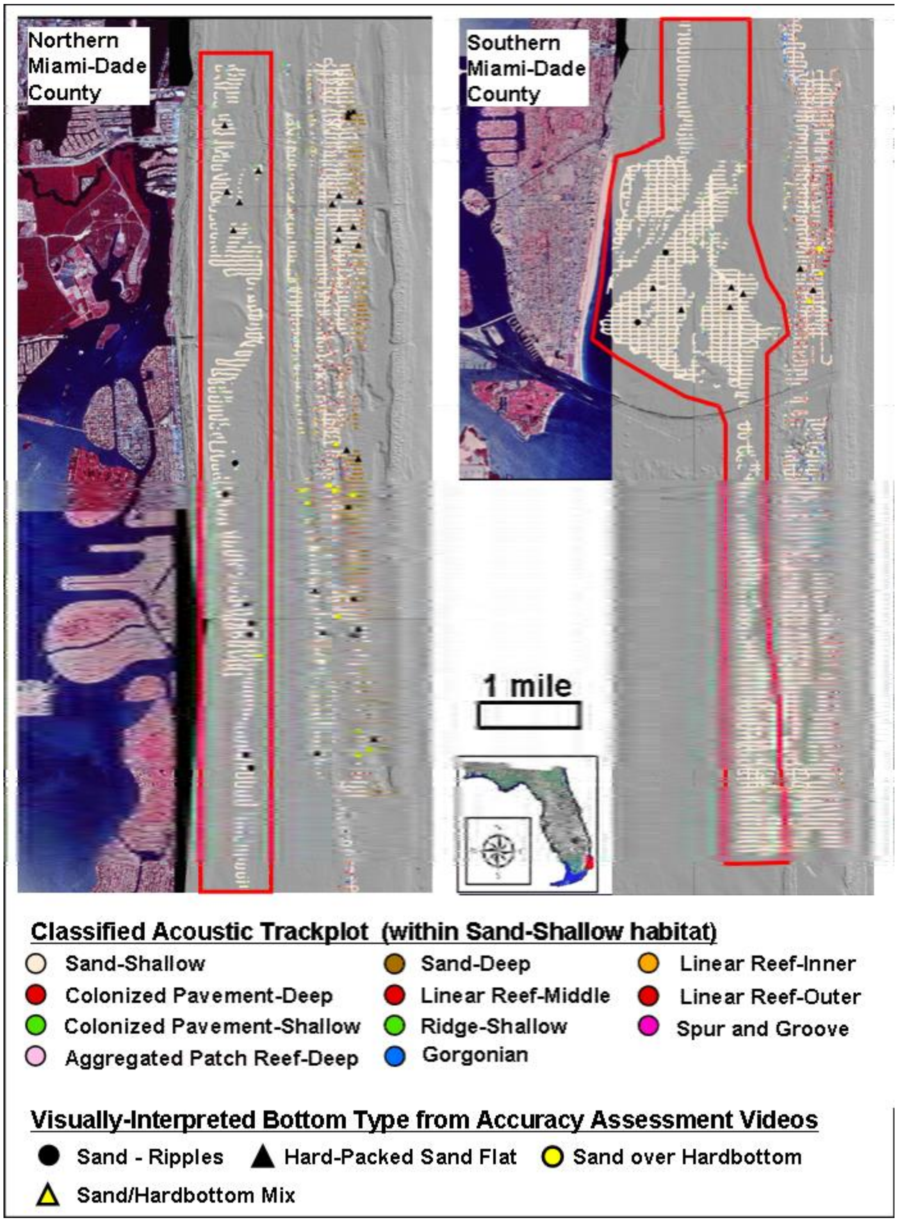


Figure 19. The same trackplot of acoustically classified survey data displayed in Figure 18, but restricted to the Sand-Shallow habitat of the benthic habitat map. 55 Sand-Shallow AA samples were re-classified into categories of Sand-Ripples, Hard-Packed Sand Flat, Sand over Hardbottom, and Sand/Hardbottom Mix. The acoustic classifications agree well with these bottom type designations (Table 5), suggesting it should be possible to subcategorize the Sand-Shallow habitat.

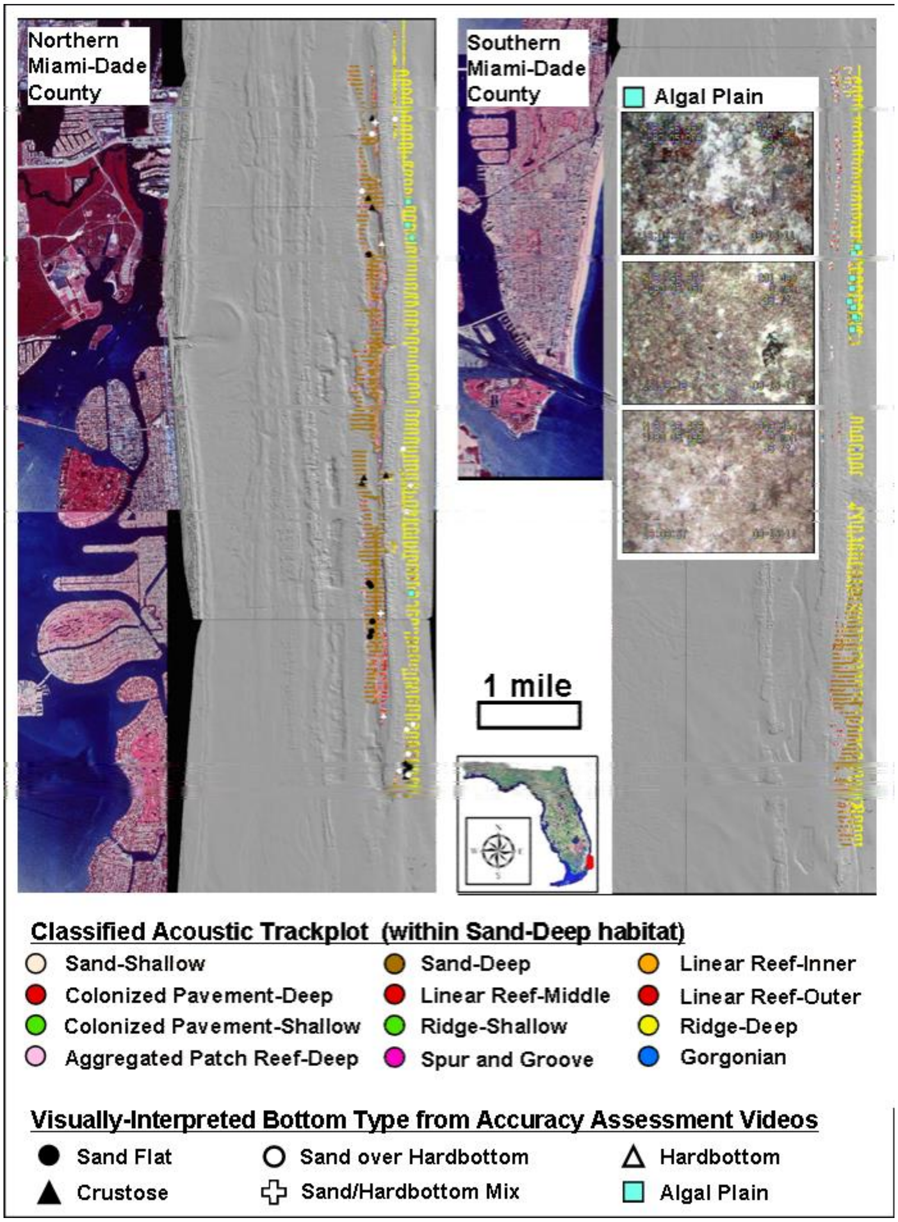


Figure 20. The same trackplot of acoustically classified survey data displayed in Figure 18, but restricted to the Sand-Deep habitat of the benthic habitat map. 45 Sand-Shallow AA samples were re-classified into categories of Sand-Flat, Crustose, Sand over Hardbottom, Sand/Hardbottom Mix, and Algal Plain. The acoustic classifications agree well with these bottom type designations (Table 6), suggesting it should be possible to subcategorize the Sand-Deep habitat. The Algal Plain subcategory would appear to be the most ecologically significant contribution.

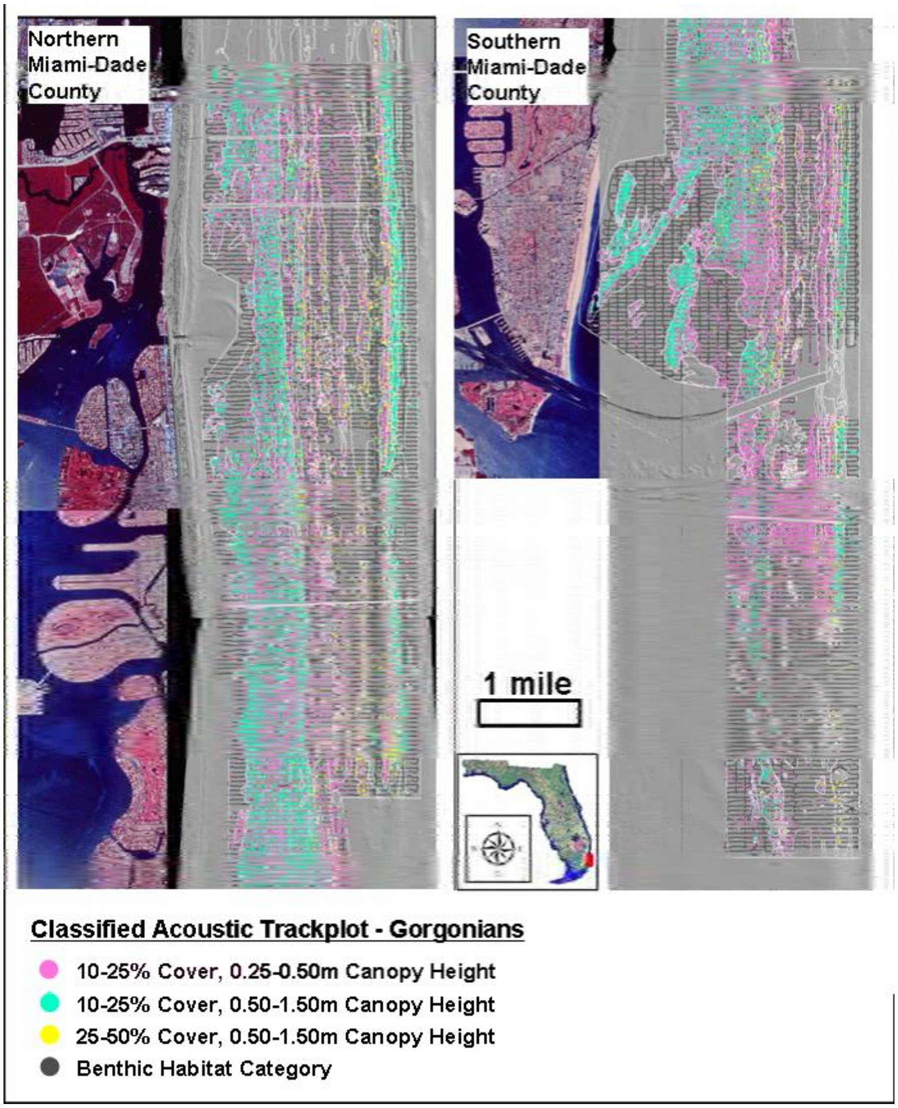


Figure 21. Acoustically classified survey trackplot highlighting the spatial distribution of gorgonian classifications. In general, where there is hardbottom there are gorgonians, but closer examination reveals patterns of zonation.

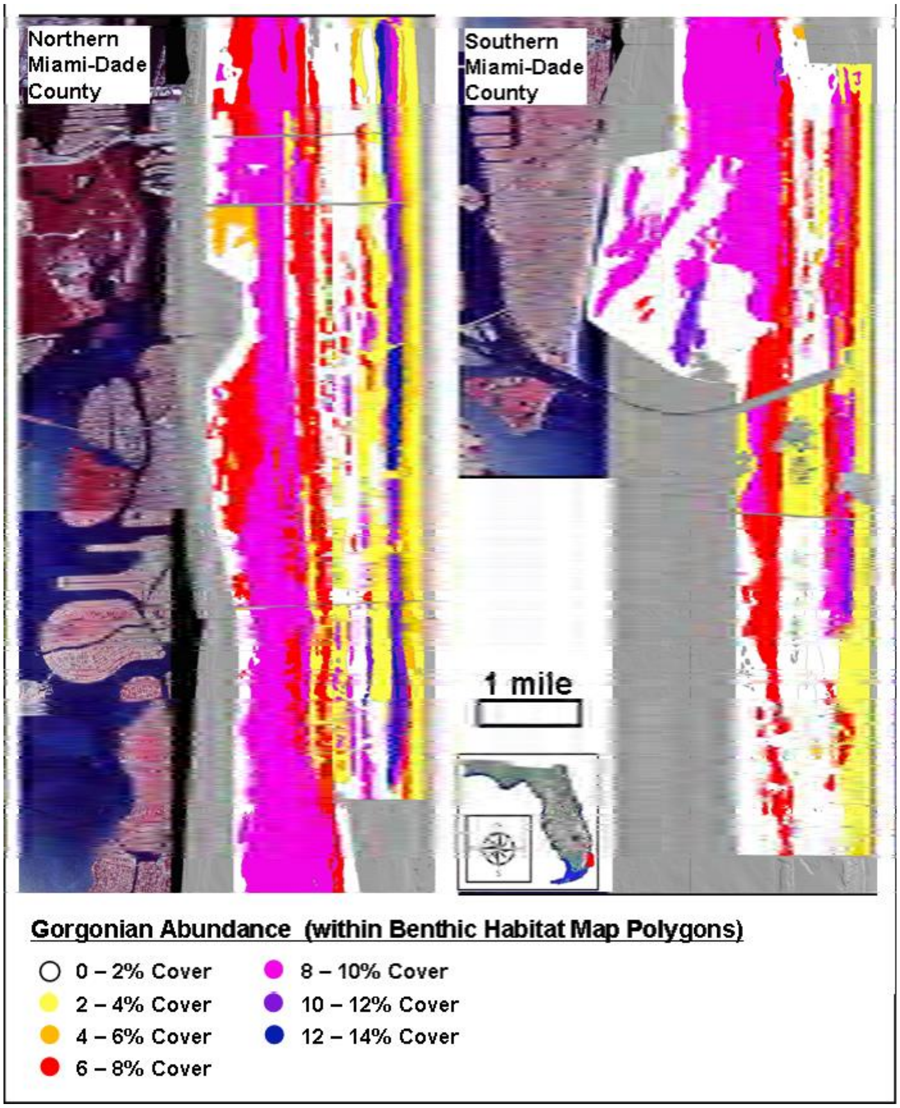


Figure 22. A more intuitively obvious method for displaying acoustic predictions of gorgonian cover. Acoustically classified survey trackplot highlighting the spatial distribution, 291 benthic habitat polygons of geomorphological structure were populated with 500,000+ acoustic survey records.

APPENDICES

Appendix A1. Samples 1-80 of Accuracy Assessment dataset.

Benthic Habitat Map Bottom Type (LiDAR/Aerial)		Video Bottom Type	% Cover	% Cover	% Cover	Absence / Presence							% Cover
1 = Sand-Shallow	10 = Linear Reef-Outer	1 = Sand-Ripple	0=0	0=0	0=0	0=No	0=No	0=No	0=No	0=No	0=No	0=No	1=1-10
2 = Sand - Deep	11 = Spur and Groove	2 = Sand-Flat	1=1-25	1=1-10	1=1-10	1=*S. radian*	1=Yes	1=Yes	1=Yes	1=Yes	1=Yes	1=Yes	2=10-25
3=Colonized Pavement-Shallow	12 = Sand Borrow Area	3 = Sand-Crustose	2=25-50	2=10-25	2=10-25	2=Yes							3=25-50
4= Ridge-Shallow	13 = Artificial	4 = Algal Plain	3=50-100	3=25-50	3=25-50								4=50-100
5 = Aggregated Patch Reef-Deep		5 = Sand over HB	cm	4=50-100	3=50-100								
6 = Ridge-Deep		6 = Sand & HB	0=0	m									
7 = Linear Reef-Inner		7 = HB	1=0.5	0=0									
8 = Colonized Pavement-Deep			2=3.75	1=.25-.50									
9 = Linear Reef-Middle			3=7.5	2=.50-1.0									
				3=1.0-1.5									

AA SxID	BHM BtmType	AA Sx Purity	Longitude	Latitude	38kHz Depth (m)	418kHz Depth (m)	Video Bottom Type	Macroalgae		Gorgonian		HB Only Cover	Live Coral	*X. muta*	Encrusting		*A. cerv*	BtmType Trans	Mixed Relief	%Reef
								Cover	Ht	Cover	Ht				Sponge	Palythoa				
1	4	100.0%	-80.110157	25.933788	5.18	4.96	7	2	2	2	1	2	2	0	0	1	0	0	0	0
2	4	100.0%	-80.108405	25.929332	5.40	5.17	7	2	2	1	1	1	2	0	1	1	0	0	0	0
3	4	100.0%	-80.109318	25.932563	5.62	5.31	7	2	2	2	1	2	2	0	0	1	0	0	0	0
4	6	100.0%	-80.085967	25.933655	32.96	32.88	7	3	3	1	2	1	0	0	0	0	0	0	0	0
5	4	100.0%	-80.106280	25.928890	8.00	7.48	7	3	2	1	2	1	2	0	0	0	0	1	0	0
6	6	100.0%	-80.085845	25.933627	33.64	33.46	7	3	3	1	1	1	2	0	0	0	0	0	0	0
7	4	100.0%	-80.107300	25.934109	6.48	6.11	7	3	2	1	2	1	2	0	0	0	0	0	0	0
8	4	100.0%	-80.108038	25.929793	5.67	5.39	7	3	2	2	1	2	2	0	1	0	1	0	0	0
9	2	100.0%	-80.086529	25.932960	30.20	30.07	5	3	3	1	1	1	2	0	0	0	0	0	0	0
10	4	100.0%	-80.110027	25.933048	5.16	4.98	7	2	2	1	1	1	2	0	1	1	0	0	0	0
11	3	100.0%	-80.111357	25.934279	6.88	6.64	7	2	2	1	1	1	2	0	0	0	0	0	0	0
12	3	100.0%	-80.113622	25.929255	6.43	6.10	7	2	2	2	2	2	2	0	0	0	0	0	0	0
13	3	100.0%	-80.104940	25.934337	10.18	10.01	7	2	1	1	1	1	0	0	0	0	0	1	0	0
14	4	80.5%	-80.110298	25.932712	6.19	6.03	7	2	2	1	1	1	2	0	0	1	0	0	0	0
15	3	100.0%	-80.111436	25.931693	6.35	5.99	7	2	2	1	1	1	2	0	0	0	0	0	0	0
16	3	100.0%	-80.113945	25.933303	6.32	5.86	7	2	2	2	2	2	2	0	0	0	0	0	0	0
17	3	100.0%	-80.111418	25.931075	6.50	6.14	7	2	2	2	1	2	2	0	0	0	0	0	0	0
18	13	100.0%	-80.112937	25.930100	6.59	6.33	7	1	1	1	2	1	2	0	0	0	0	0	0	0
19	3	100.0%	-80.112112	25.933178	6.42	6.10	7	1	1	1	1	1	2	0	0	1	0	0	0	0
20	3	100.0%	-80.113382	25.932135	6.37	5.97	7	2	2	1	1	1	2	0	0	0	0	0	0	0
21	12	100.0%	-80.092290	25.934221	20.24	20.16	5	2	2	0	0	0	0	0	0	0	0	0	0	0
22	1	100.0%	-80.095493	25.933305	13.98	13.89	2	2	3	0	0	0	0	0	0	0	0	0	0	0
23	2	100.0%	-80.089820	25.932430	18.36	18.26	6	1	1	1	1	1	0	0	0	0	0	1	0	0
24	1	100.0%	-80.115763	25.932132	6.13	6.03	2	1	3	0	0	0	0	0	0	0	0	0	0	0
25	2	100.0%	-80.090370	25.930766	18.51	18.40	5	2	3	1	1	1	0	0	0	0	0	0	0	0
26	12	100.0%	-80.091038	25.931173	19.74	19.66	5	3	2	0	0	0	0	0	0	0	0	0	0	0
27	2	100.0%	-80.090290	25.933217	18.98	18.88	2	3	3	0	0	0	0	0	0	0	0	0	0	0
28	3	100.0%	-80.103810	25.930952	9.10	8.96	7	3	2	1	1	1	0	0	0	0	0	1	0	0
29	1	100.0%	-80.094593	25.934122	14.82	14.79	2	2	3	0	0	0	0	0	0	0	0	0	0	0
30	1	100.0%	-80.095380	25.933910	14.20	14.11	2	3	3	0	0	0	0	0	0	0	0	0	0	0
31	11	100.0%	-80.088230	25.928987	19.66	19.55	7	1	2	2	2	2	2	1	0	0	0	1	1	2
32	10	62.5%	-80.088588	25.929958	17.01	16.86	7	3	2	2	1	2	2	1	0	0	0	0	0	0
33	11	100.0%	-80.088712	25.931158	16.17	16.05	7	3	2	1	1	1	2	1	0	0	0	0	0	0
34	11	100.0%	-80.088223	25.930580	19.39	19.49	7	3	2	2	1	2	2	1	0	0	0	1	1	4
35	11	100.0%	-80.088562	25.931918	17.48	17.19	7	3	2	1	2	1	2	1	0	0	0	1	0	0
36	10	100.0%	-80.088755	25.932397	16.96	16.76	7	3	2	1	1	1	2	1	0	0	0	0	0	0
37	11	100.0%	-80.088140	25.930103	20.42	20.32	7	1	1	1	1	1	0	0	0	0	0	1	1	2
38	11	100.0%	-80.088162	25.929747	19.92	19.83	7	2	2	1	1	1	2	1	0	0	0	1	1	3
39	11	73.2%	-80.087797	25.930428	22.47	22.56	7	1	2	1	1	1	2	1	0	0	0	1	1	2
40	11	100.0%	-80.088243	25.928668	19.76	19.66	7	2	2	2	2	2	2	1	0	0	0	1	1	3
41	7	100.0%	-80.102233	25.930769	6.96	6.84	7	1	1	1	2	1	2	1	0	1	0	1	0	0
42	7	53.5%	-80.100842	25.930183	9.60	9.49	7	1	2	1	1	1	2	0	0	0	0	1	1	3
43	7	61.9%	-80.103295	25.932854	10.23	10.04	7	1	1	1	1	1	2	1	0	0	0	1	0	0
44	7	100.0%	-80.100068	25.932536	9.81	9.72	7	3	2	1	1	1	2	1	0	0	0	0	0	0
45	7	100.0%	-80.102067	25.929463	7.85	7.67	7	2	2	1	1	1	2	0	0	1	0	1	1	4
46	7	100.0%	-80.100741	25.933256	9.45	9.25	7	3	2	1	1	1	2	1	0	1	0	1	0	0
47	9	100.0%	-80.092672	25.929743	17.38	17.23	7	2	2	1	1	1	2	0	0	0	0	0	0	0
48	10	50.6%	-80.089003	25.929983	15.87	15.64	7	2	2	1	1	1	2	0	0	0	0	1	0	0
49	10	100.0%	-80.088978	25.933003	16.45	16.25	7	3	2	1	2	1	2	1	0	0	0	1	0	0
50	10	100.0%	-80.089081	25.932431	16.27	16.06	7	3	2	1	1	1	2	0	0	0	0	1	0	0
51	5	85.0%	-80.087501	25.931583	24.82	24.61	7	2	2	1	1	1	2	1	0	0	0	1	0	0
52	5	100.0%	-80.087897	25.934042	23.35	23.17	7	2	2	1	2	1	2	1	0	0	0	1	1	3
53	5	100.0%	-80.088057	25.933182	21.31	21.05	7	2	2	1	1	1	2	1	0	0	0	1	1	4
54	5	100.0%	-80.087625	25.929008	23.25	23.10	7	2	2	1	2	1	2	1	0	0	0	1	1	3
55	5	100.0%	-80.087145	25.933203	27.89	28.04	7	1	2	1	1	1	2	0	0	0	0	1	0	0
56	5	100.0%	-80.087503	25.931901	25.05	24.82	7	2	2	2	3	1	2	1	0	0	0	1	0	0
57	5	93.0%	-80.086977	25.931327	28.41	28.24	7	1	2	1	2	1	2	1	0	0	0	1	1	2
58	5	100.0%	-80.087468	25.932517	26.68	26.52	7	1	2	1	1	1	0	0	0	0	0	1	0	0
59	5	100.0%	-80.087115	25.930156	26.50	26.34	7	2	2	2	2	2	0	1	0	0	0	1	0	0
60	5	100.0%	-80.088178	25.933646	21.16	20.96	7	2	2	1	1	1	2	1	0	0	0	1	0	0
61	6	97.4%	-80.085458	25.922032	35.12	35.03	5	3	3	0	0	0	0	0	0	0	0	0	0	0
62	6	100.0%	-80.085360	25.919957	35.10	34.92	5	3	3	0	0	0	0	1	0	0	0	0	0	0
63	6	97.7%	-80.085300	25.914818	32.92	32.75	5	3	3	1	1	1	0	0	0	0	0	0	0	0
64	4	100.0%	-80.106263	25.921828	7.92	7.52	7	2	2	1	2	1	2	1	0	0	0	0	0	0
65	4	100.0%	-80.107952	25.915602	6.34	6.05	7	2	2	1	1	1	2	1	0	1	0	0	0	0
66	4	92.3%	-80.106927	25.919850	6.15	5.98	7	2	2	1	1	1	2	0	1	0	0	0	0	0
67	4	100.0%	-80.106968	25.918877	6.17	5.83	7	2	2	2	1	2	2	0	0	0	0	0	0	0
68	6	100.0%	-80.085692	25.919453	32.84	32.65	7	2	1	0	0	0	0	0	0	0	0	1	1	2
69	4	100.0%	-80.109599	25.920835	5.08	4.83	7	2	2	1	1	1	2	0	0	1	0	1	0	0
70	4	100.0%	-80.109395	25.921865	5.07	4.82	7	2	2	1	2	1	2	1	0	0	0	1	0	0
71	4	100.0%	-80.108332	25.912113	5.67	5.35	7	2	1	2	2	2	2	0	1	1	1	0	0	0
72	5	100.0%	-80.087453	25.920946	24.69	24.55	7	1	1	1	1	1	2	1	0	0	0	1	1	4
73	5	100.0%	-80.091565	25.912087	21.64	21.53	7	2	2	0	0	0	0	0	0	0	0	0	0	0
74	5	100.0%	-80.087375	25.919290	24.09	23.84	7	2	1	1	2	1	2	1	0	0	0	1	1	2
75	5	100.0%	-80.087088	25.918123	26.18	26.03	7	2	1	1	2	1	2	1	0	0	0	1	1	2
76	5	100.0%	-80.087050	25.920477	26.54	26.20	7	3	1	1	2	2	0	1	0	0	0	1	1	1
77	5	70.7%	-80.088302	25.919767	19.72	19.47	7	2	2	1	2	1	2	1	0	0	0	1	0	0
78	5	100.0%	-80.086942	25.919402	27.31	26.89	7	2	1	1	1	1	2	1	0	0	0	1	0	0
79	5	100.0%	-80.086513	25.921558	29.25	29.09	7	2	2	1	2	1	2	1	0	0	0	1	1	3
80	5	97.8%	-80.086318	25.912888	27.14	27.00	7	1	2	1	1	1	2	1	0	0	0	1	1	3

Appendix A2. Samples 81-160 of Accuracy Assessment dataset.

Benthic Habitat Map Bottom Type (LiDAR/Aerial)		Video Bottom Type	% Cover	% Cover	% Cover	Absence / Presence							% Cover
1 = Sand-Shallow	10 =Linear Reef-Outer	1 = Sand-Ripple	0=0	0=0	0=0	0=No	0=No	0=No	0=No	0=No	0=No	0=No	1=1-10
2 = Sand - Deep	11 = Spur and Groove	2 = Sand-Flat	1=1-25	1=1-10	1=1-10	1=*S. radian*	1= Yes	1= Yes	1= Yes	1= Yes	1= Yes	1= Yes	2=10-25
3=Colonized Pavement-Shallow	12 = Sand Borrow Area	3 = Sand-Crustose	2=25-50	2=10-25	2=10-25	2=Yes							3=25-50
4= Ridge-Shallow	13 = Artificial	4= Algal Plain	3=50-100	3=25-50	3=25-50								4=50-100
5 = Aggregated Patch Reef-Deep		5 = Sand over HB	cm	4=50-100	3=50-100								
6 = Ridge-Deep		6 = Sand & HB	0=0	m									
7 = Linear Reef-Inner		7 = HB	1=0.5	0=0									
8 = Colonized Pavement-Deep			2=3.75	1=.25-.50									
9 = Linear Reef-Middle			3=7.5	2=.50-1.0									
				3=1.0-1.5									

AA SxID	BHM BtmType	AA Sx Purity	Longitude	Latitude	38kHz Depth (m)	418kHz Depth (m)	Video Bottom Type	Macroalgae Cover	Macroalgae Ht	Gorgonian Cover	Gorgonian Ht	HB Only Cover	Live Coral	*X. muta*	Encrusting Sponge	Encrusting Palythoa	*A. cerv*	BtmType Trans	Mixed Relief	% Reef
81	5	100.0%	-80.086675	25.915534	25.79	25.77	7	3	2	1	2	1	2	1	0	0	0	1	0	0
82	10	100.0%	-80.088412	25.921047	19.56	19.38	7	3	2	1	1	1	2	1	0	0	0	1	0	0
83	7	97.4%	-80.100750	25.922358	10.76	10.58	7	3	2	1	1	1	2	0	0	0	0	0	0	0
84	7	97.7%	-80.102997	25.913527	9.25	9.03	7	3	2	1	1	1	2	1	0	1	0	0	0	0
85	7	100.0%	-80.101273	25.918343	10.92	10.78	7	3	2	1	1	1	2	1	0	0	0	1	0	0
86	10	100.0%	-80.088350	25.914920	15.80	15.62	7	3	2	1	2	1	2	1	0	0	0	1	0	0
87	9	69.0%	-80.092996	25.916953	18.20	17.99	7	1	1	1	2	2	0	1	0	0	0	1	0	0
88	7	100.0%	-80.102946	25.915084	8.95	8.68	7	1	2	1	1	1	2	1	0	0	0	1	0	0
89	9	100.0%	-80.098598	25.915775	11.55	11.33	7	3	2	1	2	2	2	1	0	0	0	1	0	0
90	9	97.7%	-80.095752	25.912072	15.23	14.93	7	2	2	1	1	1	2	1	0	0	0	0	0	0
91	8	43.2%	-80.089144	25.918420	20.81	20.67	7	1	1	1	1	2	2	1	0	0	0	1	0	0
92	7	100.0%	-80.101306	25.913523	10.73	10.58	7	3	2	1	1	1	2	1	0	1	0	0	0	0
93	10	100.0%	-80.088200	25.914382	15.98	15.77	7	2	2	1	1	2	2	1	0	0	0	1	0	0
94	1	100.0%	-80.093898	25.914137	16.53	16.47	2	2	2	0	0	0	0	0	0	0	0	0	0	0
95	1	100.0%	-80.114444	25.916439	6.12	5.99	2	1	3	0	0	0	0	0	0	0	0	0	0	0
96	1	100.0%	-80.093640	25.920603	15.54	15.46	2	1	1	0	0	0	0	0	0	0	0	0	0	0
97	1	100.0%	-80.098168	25.920265	13.43	13.34	2	1	1	0	0	0	0	0	0	0	0	0	0	0
98	9	100.0%	-80.098880	25.912908	11.39	11.21	7	3	2	1	1	1	1	1	0	0	0	0	0	0
99	1	100.0%	-80.115470	25.922252	6.13	6.05	2	1	3	0	0	0	0	0	0	0	0	0	0	0
100	1	100.0%	-80.097037	25.916567	13.44	13.36	2	2	3	0	0	0	0	0	0	0	0	0	0	0
101	1	100.0%	-80.094718	25.916852	15.49	15.40	2	1	2	0	0	0	0	0	0	0	0	0	0	0
102	1	100.0%	-80.113408	25.920645	6.63	6.53	2	1	3	0	0	0	0	0	0	0	0	0	0	0
103	1	100.0%	-80.097276	25.914927	13.35	13.27	2	2	2	0	0	0	0	0	0	0	0	0	0	0
104	1	100.0%	-80.097032	25.921565	14.16	14.08	2	2	2	0	0	0	0	0	0	0	0	0	0	0
105	1	100.0%	-80.110253	25.925307	6.82	6.71	2	1	3	0	0	0	0	0	0	0	0	0	0	0
106	2	100.0%	-80.092084	25.922224	19.93	19.80	5	3	2	0	0	0	0	0	0	0	0	0	0	0
107	2	100.0%	-80.083873	25.915196	38.13	38.01	4	3	3	0	0	0	0	0	0	0	0	0	0	0
108	6	100.0%	-80.085711	25.916591	31.65	31.49	7	3	2	1	1	1	2	1	0	0	0	1	0	0
109	2	100.0%	-80.090452	25.919883	19.81	19.72	2	0	0	0	0	0	0	0	0	0	0	0	0	0
110	12	62.2%	-80.091005	25.919223	20.99	20.91	5	3	3	0	0	0	0	0	0	0	0	0	0	0
111	2	100.0%	-80.091072	25.912710	21.91	21.81	3	2	2	0	0	0	0	0	0	0	0	1	0	0
112	2	100.0%	-80.084472	25.920603	38.25	38.10	4	3	3	0	0	0	0	0	0	0	0	0	0	0
113	9	100.0%	-80.091514	25.916515	20.92	20.79	7	1	1	1	1	1	0	1	0	0	0	1	1	0
114	2	100.0%	-80.084615	25.917137	36.79	36.65	4	3	3	1	1	1	0	0	0	0	0	0	0	0
115	2	100.0%	-80.091100	25.921302	19.91	19.80	2	2	2	0	0	0	0	0	0	0	0	0	0	0
116	10	83.7%	-80.088370	25.918942	16.81	16.54	7	3	2	1	2	1	2	1	0	0	0	0	0	0
117	11	100.0%	-80.087172	25.913578	22.24	22.31	7	3	2	1	1	1	0	1	0	0	0	1	0	0
118	10	100.0%	-80.088613	25.916879	16.27	15.85	7	3	1	2	1	2	2	1	0	0	0	0	0	0
119	11	100.0%	-80.088068	25.922594	20.48	20.35	7	2	2	1	1	1	2	1	0	0	0	1	0	0
120	11	100.0%	-80.087245	25.914660	21.51	21.75	7	3	2	1	1	1	2	1	0	0	0	1	0	0
121	10	100.0%	-80.088057	25.913187	16.68	16.45	7	3	2	1	1	1	2	1	0	0	0	0	0	0
122	11	100.0%	-80.087107	25.914178	21.99	21.68	7	3	2	1	1	1	0	1	0	0	0	0	0	0
123	11	100.0%	-80.087971	25.918252	18.64	18.27	7	3	2	3	3	3	2	1	0	0	0	0	0	0
124	11	100.0%	-80.087203	25.915200	22.19	21.98	7	3	2	2	2	2	2	1	0	0	0	0	0	0
125	11	100.0%	-80.087818	25.917163	18.49	18.07	7	3	2	1	1	1	2	1	0	0	0	0	0	0
126	11	100.0%	-80.087290	25.915992	21.86	21.53	7	2	2	1	1	1	2	1	0	0	0	1	0	0
127	3	100.0%	-80.104143	25.914694	10.24	10.14	7	3	2	1	1	1	2	0	0	0	0	0	0	0
128	3	100.0%	-80.116025	25.918942	5.99	5.79	7	1	1	1	1	1	2	0	0	0	0	0	0	0
129	8	88.6%	-80.088775	25.915573	18.30	17.84	7	3	2	1	2	2	2	1	0	0	0	1	0	0
130	3	100.0%	-80.102083	25.917698	10.46	10.24	7	3	2	1	1	1	2	1	1	0	0	0	0	0
131	3	97.6%	-80.114888	25.920913	6.23	5.96	5	1	3	1	1	1	1	0	0	0	0	0	0	0
132	9	100.0%	-80.093093	25.914817	17.31	17.01	7	3	2	1	2	1	2	1	0	0	0	1	0	0
133	3	100.0%	-80.109738	25.914301	6.60	6.44	7	2	2	1	1	1	2	0	0	0	1	0	0	0
134	3	100.0%	-80.115638	25.917425	6.26	6.14	1	1	3	0	0	0	0	0	0	0	0	0	0	0
135	2	59.1%	-80.088909	25.914443	20.54	20.33	7	2	2	2	2	2	2	1	0	0	0	1	0	0
136	3	100.0%	-80.103611	25.922143	9.17	8.93	7	2	2	1	2	1	2	1	1	0	0	0	0	0
137	3	100.0%	-80.110937	25.920393	6.38	6.21	7	2	2	1	1	1	0	1	0	0	0	0	0	0
138	7	100.0%	-80.106987	25.883123	7.64	7.47	7	2	2	1	1	1	2	0	0	1	0	0	0	0
139	6	100.0%	-80.087138	25.880560	28.25	28.24	5	0	0	1	1	1	0	0	0	0	0	0	0	0
140	8	100.0%	-80.089270	25.887203	18.48	18.32	7	2	2	1	2	1	2	1	0	0	0	1	0	0
141	4	100.0%	-80.110901	25.877040	6.52	6.16	7	1	1	1	2	1	2	0	0	1	0	0	0	0
142	4	100.0%	-80.104983	25.873941	7.18	7.01	7	2	2	1	3	1	2	0	1	1	0	0	0	0
143	7	100.0%	-80.104118	25.873598	7.35	7.21	7	1	2	1	1	1	2	1	0	1	0	0	0	0
144	4	100.0%	-80.110109	25.878234	6.38	6.11	7	2	2	1	2	1	2	0	0	1	0	0	0	0
145	4	62.5%	-80.106262	25.875198	7.51	7.22	7	2	2	1	1	1	2	0	0	0	1	0	0	0
146	4	100.0%	-80.105677	25.875683	7.35	7.14	7	3	2	1	2	1	2	1	0	0	0	0	0	0
147	7	69.0%	-80.105243	25.884461	8.27	7.94	7	2	2	1	2	1	2	0	0	1	0	0	0	0
148	6	100.0%	-80.086742	25.876540	29.44	29.27	7	1	2	1	3	2	0	1	0	0	0	1	0	0
149	4	100.0%	-80.108643	25.875127	6.12	5.85	7	3	2	1	1	1	2	1	0	1	0	0	0	0
150	6	100.0%	-80.086083	25.877879	32.89	32.78	5	0	0	1	1	1	0	0	0	0	0	0	0	0
151	1	100.0%	-80.096085	25.883585	15.10	15.02	2	1	2	0	0	0	0	0	0	0	0	0	0	0
152	1	100.0%	-80.097777	25.884518	14.36	14.32	6	2	3	0	0	0	0	0	0	0	0	0	0	0
153	12	100.0%	-80.091177	25.883518	22.12	22.00	5	0	0	0	0	0	0	0	0	0	0	0	0	0
154	12	100.0%	-80.090032	25.877030	23.20	23.14	5	1	3	0	0	0	0	0	0	0	0	1	0	0
155	2	100.0%	-80.085110	25.874313	36.88	36.74	5	0	0	1	1	1	0	0	0	0	0	0	0	0
156	2	100.0%	-80.084408	25.878220	38.52	38.38	6	1	1	1	1	1	0	0	0	0	0	0	0	0
157	1	100.0%	-80.095191	25.876778	16.69	16.60	5	1	1	0	0	0	0	0	0	0	0	0	0	0
158	1	100.0%	-80.103013	25.877569	11.00	10.74	5	1	2	1	2	1	2	0	1	0	0	1	0	0
159	1	100.0%	-80.095760	25.875168	15.68	15.56	2	3	3	0	0	0	0	0	0	0	0	0	0	0
160	1	100.0%	-80.115895	25.877000	6.34	6.27	1	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix A3. Samples 161-240 of Accuracy Assessment dataset.

Benthic Habitat Map Bottom Type (LiDAR/Aerial)

1 = Sand-Shallow
2 = Sand - Deep
3= Colonized Pavement-Shallow
4 = Ridge-Shallow
5 = Aggregated Patch Reef-Deep
6 = Ridge-Deep
7 = Linear Reef-Inner
8 = Colonized Pavement-Deep
9 = Linear Reef-Middle
10 = Linear Reef-Outer
11 = Spur and Groove
12 = Sand Borrow Area
13 = Artificial

Video Bottom Type

1 = Sand-Ripple
2 = Sand-Flat
3 = Sand-Crustose
4 = Algal Plain
5 = Sand over HB
6 = Sand & HB
7 = HB

% Cover
0=0
1=1-25
2=25-50
3=50-100

cm
0=0
1=0.5
2=3.75
3=7.5

% Cover
0=0
1=1-10
2=10-25
3=25-50
4=50-100

m
0=0
1=.25-.50
2=.50-1.0
3=1.0-1.5

% Cover
0=0
1=1-10
2=10-25
3=25-50
3=50-100

Absence / Presence
0=No
1=*S. radian*
2=Yes

0=No
1=Yes

% Cover
1=1-10
2=10-25
3=25-50
4=50-100

AA SxID	BHM BtmType	AA Sx Purity	Longitude	Latitude	38kHz Depth (m)	418kHz Depth (m)	Video Bottom Type	Macroalgae		Gorgonian		HB Only Cover	Live Coral	*X. muta*	Encrusting		*A cerv*	BtmType Trans	Mixed Relief	%Reef
								Cover	Ht	Cover	Ht				Sponge	Palythoa				
161	2	100.0%	-80.085589	25.883695	34.94	34.78	5	0	0	1	1	1	0	0	0	0	0	0	0	0
162	1	100.0%	-80.094193	25.882228	18.08	18.02	2	2	3	0	0	0	0	0	0	0	0	0	0	0
163	2	100.0%	-80.092081	25.879548	19.64	19.53	2	2	3	0	0	0	0	0	0	0	0	0	0	0
164	8	100.0%	-80.089262	25.885830	19.35	19.16	7	3	2	1	2	1	2	1	0	0	0	1	0	0
165	3	100.0%	-80.111558	25.882902	7.92	7.60	7	3	3	2	2	2	0	0	0	1	0	0	0	0
166	3	100.0%	-80.115972	25.880310	6.76	6.66	5	1	3	1	2	1	0	0	0	0	0	0	0	0
167	3	100.0%	-80.115083	25.876970	6.67	6.60	1	1	3	0	0	0	0	0	0	0	0	0	0	0
168	3	100.0%	-80.102839	25.885072	10.44	10.13	7	2	2	1	2	1	2	1	0	0	0	0	0	0
169	3	100.0%	-80.115979	25.874636	5.92	5.79	1	1	2	1	1	1	0	0	0	0	0	0	0	0
170	1	100.0%	-80.114402	25.881672	6.92	6.82	1	1	3	0	0	0	0	0	0	0	0	0	0	0
171	3	100.0%	-80.112663	25.876208	7.29	7.12	7	2	2	2	2	2	2	0	0	1	0	0	0	0
172	3	100.0%	-80.102778	25.880778	11.17	10.97	7	2	2	1	1	1	2	0	1	0	0	0	0	0
173	3	100.0%	-80.113917	25.883825	7.22	7.10	1	1	3	1	2	1	0	0	0	0	0	1	0	0
174	3	100.0%	-80.116232	25.881622	6.37	5.98	7	2	3	1	2	2	0	0	0	0	0	1	0	0
175	8	100.0%	-80.089327	25.884408	19.65	19.44	7	3	2	1	2	1	2	1	0	0	0	1	0	0
176	3	100.0%	-80.114583	25.873978	6.37	5.87	7	3	2	2	3	2	0	0	0	0	0	0	0	0
177	1	97.5%	-80.098985	25.878308	14.71	14.60	5	1	1	1	2	1	2	0	0	0	0	1	0	0
178	10	100.0%	-80.088772	25.882243	16.72	16.54	7	3	2	1	2	1	2	1	0	0	0	0	0	0
179	9	100.0%	-80.095425	25.882932	15.54	15.35	7	3	2	1	3	1	2	1	0	0	0	0	0	0
180	7	100.0%	-80.101240	25.876398	9.14	9.02	7	3	1	1	2	1	2	1	1	1	0	0	0	0
181	7	97.8%	-80.101463	25.882927	10.66	10.47	7	3	2	1	1	1	2	1	0	0	0	0	0	0
182	9	97.6%	-80.092633	25.873068	16.35	16.20	7	3	2	1	2	1	0	1	0	0	0	0	0	0
183	7	100.0%	-80.100075	25.874563	11.31	11.31	7	3	2	1	1	1	2	1	0	1	0	0	0	0
184	2	100.0%	-80.092503	25.878655	19.54	19.45	2	2	1	0	0	0	0	0	0	0	0	0	0	0
185	10	100.0%	-80.088979	25.880833	18.58	18.47	7	3	2	1	2	1	2	1	0	0	0	0	0	0
186	4	100.0%	-80.105178	25.879505	7.98	7.72	7	2	2	1	2	1	2	1	1	0	0	0	0	0
187	1	65.9%	-80.097950	25.877453	16.08	15.92	5	2	2	0	0	0	2	0	0	0	0	0	0	0
188	10	100.0%	-80.087518	25.881408	26.06	25.91	7	1	2	1	1	1	0	1	0	0	0	1	1	2
189	10	100.0%	-80.088681	25.885475	15.62	15.38	7	3	2	1	2	1	2	1	0	0	0	0	0	0
190	5	77.3%	-80.087014	25.887652	25.61	25.40	7	1	2	1	2	2	2	1	0	0	0	1	1	2
191	5	100.0%	-80.087359	25.878383	25.70	25.60	7	1	2	1	2	2	2	1	0	0	0	1	2	3
192	11	85.7%	-80.087918	25.876124	22.83	22.79	7	1	2	1	1	2	2	1	0	0	0	1	1	1
193	5	100.0%	-80.087112	25.885123	27.03	26.87	7	1	2	1	2	2	0	1	0	0	0	1	1	3
194	11	100.0%	-80.088372	25.878388	18.30	18.00	7	3	2	1	3	1	2	1	1	0	0	0	0	0
195	5	100.0%	-80.087365	25.875532	25.82	25.71	7	2	2	2	2	3	2	1	0	0	0	1	1	4
196	5	100.0%	-80.087692	25.876622	23.74	23.50	7	1	2	1	3	1	2	1	0	0	0	1	1	2
197	5	100.0%	-80.087189	25.877280	27.24	27.09	7	1	2	1	2	2	2	1	0	0	0	1	1	3
198	5	100.0%	-80.087675	25.874330	24.25	24.00	7	1	2	1	2	3	2	1	0	0	0	1	1	2
199	11	88.4%	-80.087583	25.873643	24.95	24.90	7	2	2	2	2	3	2	1	0	0	0	1	1	4
200	5	100.0%	-80.087755	25.879028	25.34	25.31	7	1	2	1	1	1	2	1	0	0	0	1	1	2
201	5	91.1%	-80.087180	25.886800	25.30	25.05	7	2	2	1	3	2	2	1	0	0	0	1	1	3
202	1	61.5%	-80.102558	25.875790	11.11	10.98	6	1	2	1	2	1	2	0	0	0	0	1	0	0
203	11	100.0%	-80.088415	25.881205	18.89	18.66	7	2	2	1	2	1	2	1	0	0	0	0	0	0
204	10	100.0%	-80.088778	25.883801	15.64	15.52	7	2	2	1	1	1	2	1	0	0	0	0	0	0
205	11	100.0%	-80.088503	25.875357	18.16	17.96	7	3	2	1	3	1	2	1	0	0	0	0	0	0
206	2	100.0%	-80.088465	25.879860	23.63	23.56	2	1	1	0	0	0	0	0	0	0	0	0	0	0
207	11	100.0%	-80.087943	25.883317	21.68	21.42	7	2	2	1	3	1	2	1	0	0	0	1	1	4
208	11	100.0%	-80.087853	25.884662	22.34	22.16	7	1	2	1	1	1	2	1	0	0	0	1	1	3
209	10	100.0%	-80.088713	25.877203	17.02	16.89	7	3	2	1	1	1	2	1	0	0	0	0	0	0
210	6	100.0%	-80.086172	25.885924	32.10	31.94	5	0	0	1	1	1	0	0	0	0	0	0	0	0
211	11	100.0%	-80.088120	25.881777	21.10	20.98	7	1	2	1	2	2	2	1	0	0	0	1	1	1
212	11	100.0%	-80.087872	25.885533	21.37	21.26	7	2	2	1	2	2	2	1	0	0	0	1	1	3
213	11	100.0%	-80.088219	25.874119	21.02	20.74	7	2	2	1	3	1	2	1	0	0	0	1	1	3
214	11	100.0%	-80.087610	25.882830	24.62	24.59	7	2	2	1	1	1	2	1	0	0	0	1	1	3
215	11	100.0%	-80.088010	25.883983	21.08	20.93	7	2	2	2	2	2	2	1	0	0	0	1	1	4
216	4	100.0%	-80.105622	25.864483	7.75	7.58	7	2	2	1	1	1	2	0	0	1	0	0	0	0
217	4	100.0%	-80.103378	25.859973	7.53	7.12	7	3	2	2	2	2	2	0	0	0	1	0	0	0
218	4	100.0%	-80.105998	25.858127	7.39	7.07	7	2	2	1	2	1	2	0	0	0	1	0	0	0
219	7	100.0%	-80.104030	25.864915	7.40	7.26	7	2	2	1	1	1	2	0	0	1	0	0	0	0
220	1	57.1%	-80.110745	25.853168	6.28	6.12	6	2	1	2	2	2	2	0	1	0	0	0	0	0
221	6	100.0%	-80.086438	25.859230	30.20	30.02	7	2	2	1	3	1	2	1	0	0	0	1	1	2
222	4	100.0%	-80.111095	25.853474	5.92	5.54	7	2	2	2	1	2	2	0	0	0	0	0	0	0
223	4	100.0%	-80.107815	25.857830	7.33	7.07	7	2	2	1	2	1	2	0	0	1	0	0	0	0
224	4	100.0%	-80.108073	25.863297	6.30	6.05	7	3	2	2	1	2	2	0	0	1	0	0	0	0
225	6	100.0%	-80.085050	25.857656	35.18	35.05	5	0	0	1	1	1	0	0	0	0	0	0	0	0
226	6	100.0%	-80.085854	25.866248	33.68	33.53	5	0	0	1	2	1	0	0	0	0	0	0	0	0
227	4	100.0%	-80.110209	25.859235	5.93	5.63	7	2	2	2	2	2	2	0	0	1	1	0	0	0
228	6	87.5%	-80.085511	25.860817	33.95	33.82	7	2	2	2	2	2	0	0	0	0	0	0	0	0
229	6	100.0%	-80.086032	25.863293	31.67	31.44	5	1	2	1	3	1	0	1	0	0	0	1	1	1
230	4	100.0%	-80.109743	25.856340	5.82	5.55	7	2	2	2	2	2	2	0	0	1	0	0	0	0
231	1	100.0%	-80.111775	25.857763	6.12	5.99	1	1	1	1	1	1	2	0	0	0	0	1	0	0
232	1	100.0%	-80.094860	25.856068	15.76	15.70	2	2	1	0	0	0	0	0	0	0	0	0	0	0
233	1	57.1%	-80.097700	25.858841	14.77	14.68	6	3	2	0	0	0	2	0	0	0	0	0	0	0
234	8	59.1%	-80.093916	25.860523	16.33	16.19	7	1	2	1	3	1	2	1	0	0	0	1	0	0
235	12	100.0%	-80.096804	25.853321	18.57	18.53	5	1	2	1	1	1	2	1	0	0	0	1	0	0
236	12	100.0%	-80.096230	25.863331	18.49	18.41	5	2	2	0	0	0	0	0	0	0	0	0	0	0
237	1	100.0%	-80.094145	25.856905	15.93	15.90	2	3	2	0	0	0	0	0	0	0	0	0	0	0
238	5	100.0%	-80.086910	25.854248	26.48	26.28	7	1	2	1	2	1	2	1	0	0	0	1	1	2
239	1	100.0%	-80.094998	25.861437	15.47	15.38	2	3	2	0	0	0	0	0	0	0	0	0	0	0
240	1	100.0%	-80.112303	25.856056	6.15	6.03	1	1	3	0	0	0	0	0	0	0	0	0	0	0

Appendix A4. Samples 241-322 of Accuracy Assessment dataset.

Benthic Habitat Map Bottom Type (LiDAR/Aerial)
1 = Sand-Shallow
2 = Sand - Deep
3= Colonized Pavement-Shallow
4 = Ridge-Shallow
5 = Aggregated Patch Reef-Deep
6 = Ridge-Deep
7 = Linear Reef-Inner
8 = Colonized Pavement-Deep
9 = Linear Reef-Middle
10 =Linear Reef-Outer
11 = Spur and Groove
12 = Sand Borrow Area
13 = Artificial

Video Bottom Type
1 = Sand-Ripple
2 = Sand-Flat
3 = Sand-Crustose
4 = Algal Plain
5 = Sand over HB
6 = Sand & HB
7 = HB

% Cover
0=0
1=1-25
2=25-50
3=50-100

cm
0=0
1=0.5
2=3.75
3=7.5

% Cover
0=0
1=1-10
2=10-25
3=25-50
4=50-100

m
0=0
1=.25-.50
2=.50-1.0
3=1.0-1.5

% Cover
0=0
1=1-10
2=10-25
3=25-50
3=50-100

Absence / Presence
0=No 1=*S. radian* 2=Yes
0=No 1=Yes
0=No 1=Yes
0=No 1=Yes
0=No 1=Yes
0=No 1=Yes
0=No 1=Yes

% Cover
1=1-10
2=10-25
3=25-50
4=50-100

AA SxID	BHM BtmType	AA Sx Purity	Longitude	Latitude	38kHz Depth (m)	418kHz Depth (m)	Video Bottom Type	Macroalgae		Gorgonian		HB Only Cover	Live Coral	*X. muta*	Encrusting		*A. cerv*	BtmType Trans	Mixed Relief	%Reef
								Cover	Ht	Cover	Ht				Sponge	Palythoa				
241	1	100.0%	-80.099972	25.856428	10.94	10.87	2	1	1	0	0	0	0	0	0	0	0	0	0	0
242	9	100.0%	-80.092215	25.853948	14.95	14.68	7	3	2	2	3	2	2	1	0	1	0	0	0	0
243	1	100.0%	-80.101430	25.862643	10.37	10.29	2	1	2	0	0	0	0	0	0	0	0	0	0	0
244	10	100.0%	-80.088403	25.856183	16.08	15.81	7	3	2	2	2	2	2	1	0	0	0	0	0	0
245	11	54.5%	-80.087260	25.858509	24.84	24.46	7	2	2	2	2	1	2	1	0	0	0	1	1	4
246	3	100.0%	-80.113570	25.862220	5.49	5.05	7	0	0	3	2	3	2	0	0	0	0	0	0	0
247	7	100.0%	-80.100095	25.864184	9.36	9.17	7	3	2	1	1	1	1	0	0	1	0	0	0	0
249	8	58.7%	-80.089180	25.860402	19.81	19.57	7	1	1	1	3	1	0	1	0	0	0	1	0	0
250	1	100.0%	-80.112535	25.860823	6.08	5.98	2	3	1	1	2	1	0	0	0	0	0	1	0	0
251	7	100.0%	-80.099193	25.854916	10.00	9.72	7	2	3	1	1	1	0	0	0	0	0	0	0	0
252	3	100.0%	-80.113228	25.860458	5.79	5.66	7	3	2	1	1	1	2	0	0	1	0	0	0	0
253	7	100.0%	-80.099418	25.853863	9.34	9.14	7	2	3	1	1	1	2	0	0	0	0	1	0	0
254	7	100.0%	-80.099720	25.860695	9.50	9.33	7	3	2	1	2	1	2	1	0	0	0	0	0	0
255	9	100.0%	-80.097233	25.855536	14.31	14.22	7	1	2	1	2	1	2	0	0	0	0	1	1	2
256	7	100.0%	-80.105162	25.853332	7.35	7.14	7	2	2	1	2	1	2	0	0	1	0	1	0	0
257	7	100.0%	-80.099008	25.863048	13.55	13.35	7	2	2	1	2	1	2	1	0	0	0	1	0	0
258	3	100.0%	-80.112088	25.864432	6.42	6.18	7	2	2	2	2	2	2	0	0	0	0	0	0	0
259	7	100.0%	-80.104095	25.856452	7.11	6.95	7	2	2	1	1	1	2	1	0	0	0	0	0	0
260	9	68.2%	-80.092448	25.862219	16.79	16.65	7	2	2	2	2	2	0	1	0	0	0	1	0	0
261	2	100.0%	-80.084395	25.860548	38.41	38.27	5	0	0	0	0	0	0	0	0	0	0	0	0	0
262	8	74.4%	-80.089145	25.860188	19.78	19.60	5	2	1	1	1	1	0	0	0	0	0	1	0	0
263	2	100.0%	-80.091371	25.863645	20.53	20.48	3	2	1	0	0	0	0	0	0	0	0	0	0	0
264	2	100.0%	-80.090833	25.857980	19.69	19.60	3	3	1	0	0	0	0	0	0	0	0	0	0	0
265	9	100.0%	-80.095308	25.856975	14.58	14.22	7	3	2	1	2	1	2	1	0	0	0	0	0	0
266	9	73.3%	-80.092540	25.863093	18.07	17.81	7	1	2	1	2	2	2	1	0	0	0	1	1	3
267	2	100.0%	-80.089515	25.859158	19.45	19.32	6	1	1	1	1	1	0	0	0	0	0	1	0	0
268	2	100.0%	-80.091247	25.855752	20.00	19.93	3	3	1	0	0	0	0	0	0	0	0	0	0	0
269	2	100.0%	-80.084659	25.859798	37.56	37.46	5	2	1	0	0	0	0	0	0	0	0	0	0	0
270	10	100.0%	-80.088558	25.866385	16.74	16.53	7	3	2	2	2	2	2	1	0	0	0	0	0	0
271	2	100.0%	-80.090967	25.856487	19.99	19.94	3	1	1	0	0	0	0	0	0	0	0	0	0	0
272	2	100.0%	-80.084415	25.862133	38.80	38.69	4	3	3	0	0	0	0	0	0	0	0	0	0	0
273	2	100.0%	-80.091032	25.863285	20.55	20.50	3	3	1	0	0	0	0	0	0	0	0	0	0	0
274	2	100.0%	-80.084000	25.864699	39.52	39.42	5	1	1	0	0	0	0	0	0	0	0	0	0	0
275	8	86.0%	-80.093988	25.862658	16.21	15.86	7	2	2	1	3	2	2	1	0	0	0	1	0	0
276	5	100.0%	-80.086760	25.857403	27.90	27.81	7	2	1	1	1	1	0	1	0	0	0	1	1	2
277	5	100.0%	-80.087000	25.861912	27.57	27.44	7	3	2	1	2	1	2	1	0	0	0	1	1	3
278	11	100.0%	-80.087405	25.854742	22.67	22.47	7	2	2	1	2	1	2	1	0	0	0	1	1	3
279	11	100.0%	-80.087723	25.857490	21.71	21.37	7	2	2	1	2	1	2	1	0	0	0	0	0	0
280	11	100.0%	-80.087595	25.853483	18.69	18.40	7	3	2	2	2	2	2	1	0	0	0	0	0	0
281	11	100.0%	-80.087895	25.855133	17.89	17.70	7	3	2	1	2	1	2	1	0	0	0	0	0	0
282	11	100.0%	-80.087995	25.857975	18.10	17.98	7	3	2	1	2	1	2	1	0	0	0	0	0	0
283	11	57.5%	-80.087438	25.862835	24.69	24.55	7	3	2	1	2	1	2	1	0	0	0	1	1	3
284	10	100.0%	-80.088283	25.854290	15.53	15.27	7	2	2	2	2	2	2	1	0	0	0	0	0	0
285	10	97.7%	-80.088439	25.861460	16.10	15.87	7	3	2	1	2	1	2	1	0	0	0	0	0	0
286	11	51.3%	-80.087407	25.860873	24.84	24.85	7	3	2	1	2	1	2	1	0	0	0	1	1	3
287	5	68.2%	-80.087159	25.856754	24.36	24.19	7	2	2	1	2	1	2	1	0	0	0	1	1	4
288	5	69.2%	-80.087222	25.865627	25.95	25.74	7	2	2	1	2	2	2	1	0	0	0	1	1	3
289	11	71.1%	-80.088159	25.864856	18.05	17.74	7	3	2	2	3	2	2	1	0	0	0	0	0	0
291	1	100.0%	-80.091913	25.840387	17.77	17.70	2	2	1	1	1	1	0	0	0	0	0	0	0	0
292	1	100.0%	-80.094243	25.837955	14.88	14.72	5	2	1	1	1	1	0	0	0	0	0	0	0	0
293	1	66.7%	-80.092599	25.838778	17.37	17.30	5	2	1	0	0	0	0	0	0	0	0	0	0	0
294	12	100.0%	-80.090772	25.835415	26.77	26.71	5	3	1	0	0	0	0	0	0	0	0	0	0	0
295	12	100.0%	-80.091210	25.836958	26.85	26.69	5	3	1	0	0	0	0	0	0	0	0	0	0	0
296	1	100.0%	-80.112047	25.836195	5.77	5.70	1	0	0	0	0	0	0	0	0	0	0	0	0	0
297	12	100.0%	-80.089847	25.840470	22.13	22.00	5	0	0	1	1	1	0	0	0	0	0	0	0	0
298	12	100.0%	-80.090617	25.838280	26.43	26.38	5	3	1	0	0	0	0	0	0	0	0	0	0	0
299	8	100.0%	-80.096850	25.840343	18.07	17.92	7	2	1	0	1	1	2	0	0	0	0	1	0	0
300	1	100.0%	-80.112800	25.838093	5.99	5.92	1	1	2	0	0	0	0	0	0	0	0	0	0	0
301	1	100.0%	-80.101252	25.838426	10.65	10.56	2	1	3	0	0	0	0	0	0	0	0	0	0	0
302	7	100.0%	-80.099284	25.839276	10.05	9.90	7	3	2	1	1	1	2	1	0	1	0	0	0	0
303	9	100.0%	-80.095188	25.838334	12.88	12.53	7	3	2	2	2	2	2	1	0	0	0	0	0	0
304	9	100.0%	-80.093148	25.842428	15.93	15.63	7	2	2	1	2	1	2	1	0	0	0	1	0	0
305	7	100.0%	-80.099691	25.835869	10.15	9.90	7	2	2	1	1	1	2	1	0	1	0	0	0	0
306	7	100.0%	-80.099102	25.837441	8.71	8.41	7	3	2	1	2	1	2	1	0	1	0	0	0	0
307	7	71.4%	-80.099108	25.841573	12.45	12.36	7	1	1	1	2	1	2	1	0	0	0	1	0	0
308	7	100.0%	-80.099263	25.833897	10.70	10.56	7	2	2	1	2	1	2	1	0	1	0	1	0	0
309	1	59.1%	-80.094524	25.841653	14.77	14.64	6	2	1	1	2	2	2	1	0	0	0	1	1	3
310	10	100.0%	-80.088733	25.836697	15.78	15.44	7	3	2	2	2	2	2	1	0	0	0	0	0	0
311	9	100.0%	-80.093022	25.837420	14.44	14.10	7	2	2	2	3	2	2	1	0	0	0	0	0	0
312	9	97.7%	-80.092438	25.837286	15.70	15.50	7	2	2	1	2	1	2	1	0	0	0	0	0	0
313	2	100.0%	-80.089146	25.843918	18.97	18.81	7	1	1	1	1	1	0	0	0	0	0	0	0	0
314	8	100.0%	-80.097168	25.838598	16.33	16.24	5	0	0	0	0	0	0	0	0	0	0	0	0	0
315	10	100.0%	-80.087862	25.842805	14.90	14.74	7	2	1	2	1	2	2	1	0	0	0	0	0	0
316	8	100.0%	-80.088811	25.840959	16.69	16.47	7	1	1	2	2	1	2	1	0	0	0	1	0	0
317	10	100.0%	-80.087591	25.844002	15.41	15.16	7	3	2	1	2	1	2	1	0	0	0	0	0	0
318	10	100.0%	-80.088228	25.840490	14.44	14.24	7	2	1	1	2	1	0	1	0	0	0	1	0	0
319	8	100.0%	-80.089302	25.840597	18.18	18.00	7	1	1	1	1	1	2	1	0	0	0	0	0	0
320	8	100.0%	-80.089138	25.839680	17.29	17.21	7	2	1	1	2	1	2	1	0	0	0	0	0	0
321	8	100.0%	-80.089012	25.842090	17.59	17.50	7	1	1	1	1	1	2	1	0	0	0	0	0	0
322	8	100.0%	-80.088649	25.843398	17.50	17.20	7	2	2	2	2	2	2	1	0	0	0	0	0	0

Appendix A5. Samples 323-407 of Accuracy Assessment dataset.

Benthic Habitat Map Bottom Type (LiDAR/Aerial)
1 = Sand-Shallow
2 = Sand - Deep
3 = Colonized Pavement-Shallow
4 = Ridge-Shallow
5 = Aggregated Patch Reef-Deep
6 = Ridge-Deep
7 = Linear Reef-Inner
8 = Colonized Pavement-Deep
9 = Linear Reef-Middle
10 = Linear Reef-Outer
11 = Spur and Groove
12 = Sand Borrow Area
13 = Artificial

Video Bottom Type
1 = Sand-Ripple
2 = Sand-Flat
3 = Sand-Crustose
4 = Algal Plain
5 = Sand over HB
6 = Sand & HB
7 = HB

% Cover
0=0
1=1-25
2=25-50
3=50-100

cm
0=0
1=0.5
2=3.75
3=7.5

% Cover
0=0
1=1-10
2=10-25
3=25-50
4=50-100

m
0=0
1=.25-.50
2=.50-1.0
3=1.0-1.5

% Cover
0=0
1=1-10
2=10-25
3=25-50
3=50-100

0=No
1=*S. radian*
2=Yes

Absence / Presence
0=No
1=Yes

% Cover
1=1-10
2=10-25
3=25-50
4=50-100

AA SxID	BHM BtmType	AA Sx Purity	Longitude	Latitude	38kHz Depth (m)	418kHz Depth (m)	Video Bottom Type	Macroalgae		Gorgonian		HB Only Cover	Live Coral	*X. muta*	Encrusting		*A. cerv*	BtmType Trans	Mixed Relief	%Reef
								Cover	Ht	Cover	Ht				Sponge	Palythoa				
323	8	100.0%	-80.088512	25.843922	17.90	17.74	7	3	2	2	2	2	2	1	0	0	0	0	0	0
324	4	100.0%	-80.109880	25.838397	6.12	5.75	7	2	2	1	2	1	2	1	0	1	0	0	0	0
325	4	100.0%	-80.110752	25.842463	5.67	5.22	7	2	2	2	2	2	2	1	0	1	0	0	0	0
326	4	100.0%	-80.106785	25.834647	6.34	6.08	7	2	2	1	2	1	2	1	0	1	0	0	0	0
327	4	100.0%	-80.106457	25.844302	6.78	6.49	7	2	2	1	2	1	2	1	0	1	1	0	0	0
328	6	100.0%	-80.086351	25.836912	26.35	26.25	7	1	2	1	2	1	0	1	0	0	0	1	1	3
329	4	100.0%	-80.102547	25.841505	8.37	8.03	7	2	2	2	2	2	2	1	1	0	1	0	0	0
330	4	100.0%	-80.104874	25.837333	7.09	6.87	7	2	2	1	2	2	2	1	0	1	0	1	0	0
331	6	100.0%	-80.085630	25.843371	30.47	30.32	7	1	1	1	1	1	0	1	0	0	0	0	0	0
332	4	100.0%	-80.103230	25.842957	7.40	6.99	7	3	2	1	2	1	2	1	0	0	1	0	0	0
333	4	100.0%	-80.111838	25.839613	5.77	5.40	7	2	2	2	2	2	2	1	0	1	0	0	0	0
334	4	100.0%	-80.105398	25.843883	6.74	6.49	7	2	2	1	1	1	2	0	0	1	1	0	0	0
335	2	100.0%	-80.085367	25.841777	31.54	31.42	5	2	1	1	1	1	0	0	0	0	0	0	0	0
336	2	71.4%	-80.086540	25.835625	25.77	25.81	5	2	1	1	1	1	0	0	0	0	0	0	0	0
337	6	100.0%	-80.086157	25.841285	26.87	26.67	7	2	2	1	2	1	2	1	0	0	0	1	1	3
338	2	100.0%	-80.085123	25.838151	33.09	32.98	5	3	1	1	1	1	0	0	0	0	0	0	0	0
339	2	100.0%	-80.085610	25.835507	31.47	31.42	3	3	1	0	0	0	0	0	0	0	0	0	0	0
340	2	100.0%	-80.084893	25.836151	33.85	33.78	3	3	1	1	1	1	0	0	0	0	0	0	0	0
341	6	100.0%	-80.086037	25.838798	27.93	27.66	7	2	2	1	2	1	2	1	0	0	0	1	1	3
342	2	100.0%	-80.085502	25.836607	32.10	32.01	3	3	1	1	1	1	0	0	0	0	0	0	0	0
343	2	100.0%	-80.085558	25.834857	31.82	31.75	2	3	1	0	0	0	0	0	0	0	0	0	0	0
344	2	100.0%	-80.085116	25.835052	33.09	32.99	5	3	1	1	1	1	0	0	0	0	0	0	0	0
345	2	100.0%	-80.084282	25.842560	35.34	35.23	5	2	1	1	1	1	0	0	0	0	0	0	0	0
346	5	100.0%	-80.086530	25.840476	23.90	23.71	7	1	1	1	1	1	0	0	0	0	0	0	0	0
347	11	51.2%	-80.087718	25.836638	19.80	19.58	7	1	2	1	2	2	2	1	0	0	0	1	1	3
348	5	100.0%	-80.086482	25.844507	23.46	23.19	7	2	2	1	2	2	2	1	0	0	0	1	1	3
349	5	100.0%	-80.086772	25.838475	22.45	22.07	7	3	2	3	2	3	2	1	0	0	0	1	1	4
350	5	100.0%	-80.087240	25.836113	21.89	21.74	7	2	2	1	2	2	2	1	0	0	0	1	1	4
351	5	100.0%	-80.087718	25.834197	20.83	20.78	5	2	1	1	1	1	0	0	0	0	0	0	0	0
352	5	62.8%	-80.087087	25.837835	21.43	21.13	7	2	2	1	2	2	2	1	0	0	0	1	1	2
353	6	61.9%	-80.086291	25.840013	25.67	25.64	7	2	2	1	2	2	0	1	0	0	0	1	1	3
354	5	100.0%	-80.088102	25.834032	19.43	19.29	7	1	2	1	2	1	2	1	0	0	0	1	1	2
355	5	100.0%	-80.088155	25.835063	18.93	18.90	7	2	1	1	2	1	2	0	0	0	0	1	1	1
356	5	100.0%	-80.086738	25.839855	23.17	23.04	7	1	2	1	3	2	0	0	0	0	0	1	1	1
357	11	100.0%	-80.086928	25.843765	21.08	20.95	7	1	2	1	1	1	2	1	0	0	0	1	1	3
358	11	100.0%	-80.086719	25.842356	23.35	23.13	7	2	2	2	2	3	2	1	0	0	0	1	1	4
359	11	61.0%	-80.087538	25.839870	17.61	17.24	7	3	2	3	2	3	2	1	0	0	0	0	0	0
360	11	77.5%	-80.087047	25.841406	20.37	19.93	7	1	2	2	3	3	2	1	0	0	0	1	1	2
361	11	100.0%	-80.087167	25.840425	20.62	20.36	7	2	2	1	2	1	2	1	0	0	0	1	1	4
362	11	100.0%	-80.087462	25.838007	19.54	19.31	7	2	2	1	2	2	2	1	0	0	0	1	1	3
363	11	100.0%	-80.087238	25.842923	18.23	17.80	7	2	2	2	3	2	2	1	0	0	0	0	0	0
364	11	100.0%	-80.087551	25.839003	18.57	18.23	7	3	2	2	2	3	2	1	0	0	0	1	1	4
365	11	100.0%	-80.087747	25.837703	17.59	17.21	7	2	2	2	3	3	2	1	0	0	0	1	1	4
366	11	100.0%	-80.087708	25.837302	18.55	18.23	7	3	2	1	2	3	2	1	0	0	0	1	1	4
368	4	100.0%	-80.097066	25.782425	11.26	11.22	7	1	1	1	1	1	2	0	0	0	0	0	0	0
369	4	100.0%	-80.099707	25.775749	8.49	8.21	7	3	2	1	2	1	0	1	1	0	0	0	0	0
370	4	100.0%	-80.113163	25.771324	7.72	7.28	7	2	2	4	3	4	0	0	0	0	0	0	0	0
371	4	100.0%	-80.101880	25.781133	7.53	7.34	7	3	2	1	2	1	0	0	1	0	0	0	0	0
372	4	100.0%	-80.102528	25.775150	8.23	8.03	7	3	2	1	2	1	2	0	0	0	1	0	0	0
373	4	100.0%	-80.103560	25.781802	7.29	6.97	7	3	2	2	2	2	2	0	0	0	0	0	0	0
374	4	100.0%	-80.111343	25.776897	7.63	7.17	7	2	2	3	2	3	2	0	0	0	0	0	0	0
376	4	100.0%	-80.121817	25.779804	7.18	7.10	7	3	2	1	1	1	2	0	0	0	0	0	0	0
377	4	100.0%	-80.124163	25.778147	6.91	6.75	7	1	2	0	0	0	0	0	0	0	0	0	0	0
378	4	100.0%	-80.112573	25.773856	7.13	6.69	7	2	3	2	2	2	2	0	0	0	0	0	0	0
379	4	100.0%	-80.100225	25.773439	8.62	8.44	7	3	2	1	2	1	2	0	0	0	0	0	0	0
380	1	100.0%	-80.106489	25.775098	7.99	7.86	2	2	1	0	0	0	0	0	0	0	0	0	0	0
381	2	100.0%	-80.084915	25.782143	32.78	32.56	4	3	1	0	0	0	0	0	0	0	0	0	0	0
382	2	100.0%	-80.084835	25.774619	33.72	33.63	4	2	1	0	0	0	0	0	0	0	0	0	0	0
383	2	57.5%	-80.088770	25.780634	15.87	15.80	5	2	1	0	0	0	0	0	0	0	0	0	0	0
384	2	100.0%	-80.085432	25.775433	31.38	31.27	4	2	2	0	0	0	0	0	0	0	0	0	0	0
385	2	100.0%	-80.084252	25.772852	36.59	36.48	4	3	1	0	0	0	0	0	0	0	0	0	0	0
386	2	100.0%	-80.085060	25.777390	32.22	32.08	4	3	1	0	0	0	0	0	0	0	0	0	0	0
387	2	100.0%	-80.084045	25.783588	34.73	34.61	4	3	1	0	0	0	0	0	0	0	0	0	0	0
389	2	100.0%	-80.084592	25.773143	34.80	34.66	4	2	1	1	1	1	0	0	0	0	0	0	0	0
390	2	100.0%	-80.084750	25.782571	33.10	32.96	4	2	1	0	0	0	0	0	0	0	0	0	0	0
391	2	100.0%	-80.085041	25.771214	33.62	33.50	4	3	1	1	1	1	0	0	0	0	0	0	0	0
393	2	100.0%	-80.084924	25.778913	32.82	32.74	4	2	1	0	0	0	0	0	0	0	0	0	0	0
394	7	100.0%	-80.098868	25.773757	8.79	8.61	7	3	2	1	2	1	0	1	0	0	0	0	0	0
395	10	100.0%	-80.089960	25.774063	12.50	12.31	7	1	1	1	2	1	2	1	0	0	0	0	0	0
396	5	92.7%	-80.087493	25.779878	18.64	18.57	7	1	2	1	2	1	2	1	0	0	0	1	1	2
397	7	92.7%	-80.095632	25.775537	12.63	12.59	7	2	2	1	1	1	0	1	0	0	0	1	0	0
398	7	100.0%	-80.097725	25.777694	9.26	9.16	7	3	2	1	2	1	2	1	0	1	0	0	0	0
399	7	100.0%	-80.096327	25.783415	11.05	10.84	7	3	2	1	2	1	2	1	0	0	0	0	0	0
400	10	100.0%	-80.089582	25.782565	12.47	12.36	7	2	2	1	2	1	2	0	0	0	0	0	0	0
401	10	100.0%	-80.089210	25.775290	13.26	13.17	7	2	2	1	2	1	2	1	0	0	0	1	0	0
402	7	100.0%	-80.096347	25.777346	11.04	10.74	7	2	2	1	1	1	2	1	0	0	0	0	0	0
403	7	100.0%	-80.097111	25.775992	11.25	11.16	7	1	1	0	0	0	0	0	0	0	0	1	0	0
404	10	89.2%	-80.090262	25.780522	13.72	13.58	7	2	2	1	1	1	2	1	0	0	0	0	0	0
406	7	100.0%	-80.096495	25.779648	11.51	11.32	7	2	1	1	1	1	0	1	0	0	0	0	0	0
407	5	100.0%	-80.087970	25.778278	16.95	16.86	5	1	1	1	1	1	2	0	0	0	0	1	0	0

Appendix A6. Samples 408-444 of Accuracy Assessment dataset.

Benthic Habitat Map Bottom Type (LiDAR/Aerial)
1 = Sand- Shallow
2 = Sand - Deep
3= Colonized Pavement-Shallow
4 = Ridge-Shallow
5 = Aggregated Patch Reef-Deep
6 = Ridge-Deep
7 = Linear Reef-Inner
8 = Colonized Pavement-Deep
9 = Linear Reef-Middle
10 =Linear Reef-Outer
11 = Spur and Groove
12 = Sand Borrow Area
13 = Artificial

Video Bottom Type
1 = Sand-Ripple
2 = Sand-Flat
3 = Sand-Crustose
4 = Algal Plain
5 = Sand over HB
6 = Sand & HB
7 = HB

% Cover
0=0
1=1-25
2=25-50
3=50-100

cm
0=0
1=0.5
2=3.75
3=7.5

% Cover
0=0
1=1-10
2=10-25
3=25-50
4=50-100

m
0=0
1=.25-.50
2=.50-1.0
3=1.0-1.5

% Cover
0=0
1=1-10
2=10-25
3=25-50
3=50-100

Absence / Presence
0=No
1=*S. radian*
2=Yes

0=No	0=No	0=No	0=No	0=No	0=No	0=No
1= Yes	1=Yes	1= Yes	1=Yes	1=Yes	1= Yes	1= Yes

% Cover
1=1-10
2=10-25
3=25-50
4=50-100

AA SxID	BHM BtmType	AA Sx Purity	Longitude	Latitude	38kHz Depth (m)	418kHz Depth (m)	Video Bottom Type	Macroalgae		Gorgonian		HB Only Cover	Live Coral	*X. muta*	Encrusting		*A. cerv*	BtmType Trans	Mixed Relief	%Reef
								Cover	Ht	Cover	Ht				Sponge	Palythoa				
408	5	100.0%	-80.086758	25.775153	23.90	23.84	7	1	2	1	2	1	2	1	0	0	0	1	1	1
409	5	55.0%	-80.086960	25.776828	21.84	21.89	5	1	1	1	1	1	0	0	0	0	0	0	0	0
410	10	89.7%	-80.088882	25.771988	14.20	14.02	7	1	2	1	1	1	0	1	0	0	0	1	1	2
411	5	100.0%	-80.086443	25.774550	24.90	24.79	7	1	1	1	1	1	0	0	0	0	0	0	0	0
412	5	100.0%	-80.086608	25.771748	25.45	25.33	7	2	1	1	1	1	2	1	0	0	0	0	0	0
413	5	100.0%	-80.086162	25.783688	23.77	23.72	7	2	1	1	1	1	2	0	0	0	0	1	1	1
414	10	100.0%	-80.087490	25.778406	18.39	18.30	7	1	2	1	2	1	2	1	0	0	0	1	1	3
415	5	100.0%	-80.086058	25.778133	25.28	25.08	7	2	2	1	2	1	2	0	0	0	0	1	1	3
416	5	100.0%	-80.086320	25.781627	23.24	23.23	7	2	1	1	2	1	2	1	0	0	0	1	1	1
417	10	100.0%	-80.089178	25.776300	13.41	13.35	7	2	1	1	2	1	2	1	0	0	0	1	1	3
418	5	100.0%	-80.087745	25.780697	17.77	17.72	5	1	1	0	0	0	0	0	0	0	0	0	0	0
419	5	92.3%	-80.088752	25.779198	15.84	15.70	7	2	2	0	0	0	0	0	0	0	0	0	0	0
420	1	100.0%	-80.119125	25.778035	7.53	7.47	2	1	1	0	0	0	0	0	0	0	0	0	0	0
421	1	100.0%	-80.091677	25.783665	15.32	15.23	5	2	1	0	0	0	0	0	0	0	0	0	0	0
422	1	100.0%	-80.104293	25.777024	8.18	8.08	2	1	3	1	1	1	0	0	0	0	0	0	0	0
423	1	100.0%	-80.092819	25.777544	14.46	14.34	2	2	1	0	0	0	0	0	0	0	0	0	0	0
424	1	100.0%	-80.106283	25.778072	7.86	7.80	2	2	1	0	0	0	0	0	0	0	0	0	0	0
425	4	100.0%	-80.099833	25.779437	8.87	8.74	5	1	1	0	0	0	0	0	0	0	0	0	0	0
426	1	100.0%	-80.116986	25.783239	7.18	7.10	1	1	1	0	0	0	0	0	0	0	0	0	0	0
427	1	100.0%	-80.121653	25.772868	7.39	7.28	1	1	3	0	0	0	0	0	0	0	0	0	0	0
428	1	100.0%	-80.093380	25.775940	14.64	14.56	6	2	1	0	0	0	0	0	0	0	0	0	0	0
429	1	100.0%	-80.094899	25.780763	13.36	13.28	2	1	1	0	0	0	0	0	0	0	0	0	0	0
430	1	100.0%	-80.114520	25.774743	7.02	6.91	2	2	1	0	0	0	0	0	0	0	0	0	0	0
431	5	100.0%	-80.086630	25.779267	22.55	22.42	5	1	1	1	1	1	0	0	0	0	0	0	0	0
432	1	100.0%	-80.091495	25.780113	15.27	15.16	7	2	2	1	1	1	0	0	0	0	0	0	0	0
433	3	100.0%	-80.113708	25.780982	7.57	7.14	7	1	3	3	2	3	2	0	0	0	0	0	0	0
434	8	100.0%	-80.090582	25.775903	14.51	14.44	7	1	1	1	1	1	0	0	0	0	0	0	0	0
435	8	100.0%	-80.090416	25.779077	14.46	14.38	7	1	1	1	1	1	2	1	0	0	0	0	0	0
436	3	100.0%	-80.120442	25.775314	7.59	7.47	2	2	3	0	0	0	0	0	0	0	0	0	0	0
437	8	100.0%	-80.090792	25.777987	14.68	14.57	7	1	1	1	1	1	2	0	0	0	0	0	0	0
438	3	100.0%	-80.119772	25.773092	7.66	7.41	7	2	3	1	1	1	2	0	0	0	0	0	0	0
439	3	100.0%	-80.113328	25.778252	8.07	7.72	7	2	3	2	2	2	2	0	1	0	0	0	0	0
440	3	100.0%	-80.111168	25.781670	7.72	7.26	7	2	2	3	2	3	2	0	0	0	0	0	0	0
441	3	100.0%	-80.112822	25.780875	8.36	8.24	7	1	3	1	2	1	2	0	0	0	0	0	0	0
442	3	100.0%	-80.110619	25.782674	8.28	7.90	7	1	3	1	1	1	2	0	0	0	0	0	0	0
443	3	100.0%	-80.111168	25.778987	8.05	7.61	7	1	2	2	2	2	2	0	1	0	0	0	0	0
444	4	100.0%	-80.106809	25.782197	7.90	7.78	7	3	2	1	2	1	2	0	0	0	0	0	0	0