Atlantic Coastal Fish Habitat Partnership

Species-Habitat Matrix Project
Summary Report

August 2009

Introduction

Inception of the ACFHP Species-Habitat Matrix

In May 2007, the Atlantic Coastal Fish Habitat Partnership (ACFHP) held its first workshop to discuss the continuing formation of a new partnership for the Atlantic coast under the auspices of the National Fish Habitat Action Plan. At this workshop, the ACFHP Science and Data Working Group was established to provide scientific support to the partnership. In particular, this group was formed to provide the scientific basis for a Conservation Strategic Plan for the ACFHP. With this in mind, partnership representatives Jake Kritzer (Environmental Defense Fund) and Mari-Beth DeLucia (The Nature Conservancy) suggested creating a matrix of species and their habitats to guide the partnership in determining which habitats along the Atlantic coast are used, on a broad regional scale, by the most species.

Following the initial workshop, a subgroup of the Science and Data Working Group convened to design the Matrix. The details of the design and subsequent activities are outlined in the methods section of this report.

Purpose of the ACFHP Species-Habitat Matrix

The primary purpose of the ACFHP Species-Habitat Matrix is to provide a starting point for prioritizing habitats (on both a coastwide and regional basis) in order to focus the protection and restoration efforts of ACFHP. It is a conservation planning tool to evaluate the relative importance of various coastal, estuarine, and freshwater habitats in terms of their value to a number of selected fish and invertebrate species. Specifically, the Matrix evaluates the importance of different habitat types as shelter, nursery, feeding, or spawning areas for each species. The goal is to provide an index of habitat value through this one lens. The Matrix is limited in that it does not consider other important functions of habitat that also benefit each species. Filtering water, processing nutrients, securing sediments, maintaining dissolved oxygen levels, and other ecosystem functions are critical for fishes and invertebrates, but are not considered in the analysis in order to keep the matrix and analyses simple and manageable. However, the additional ecosystem functions of habitats are considered separately in conservation planning in combination with the Matrix results.

Other Uses of the ACFHP Species-Habitat Matrix

While ACFHP designed this Matrix specifically to help the Partnership prioritize habitats, there are many other potential uses for this work in the future. The Matrix could assist natural resources agencies, non-governmental organizations, or other groups in identifying monitoring or research focuses, identifying data gaps, or assessment work. In addition, a comprehensive database for Atlantic coast species could be compiled from the associated references. Please note that any use of the Species-Habitat Matrix should keep in mind the Qualifiers and Exclusions noted in the following section.

Qualifiers and Exclusions

- The Matrix is not a comprehensive index of all species or habitats along the Atlantic coast.
- This Matrix will not assess the amount, condition, or vulnerability of habitat types.
- The Matrix does not begin to cover the full range of ecosystem services associated with habitats, and their importance to the health and sustainability of the ecosystem as a whole. It will not evaluate habitats in terms of ecological functions, such as buffering coastal areas, water filtration, nutrient processing, trapping and stabilizing sediments, and so on.
- A representative grouping of species was chosen for each region, in an attempt to cover most functional groups within the ecosystems of that region. The species lists include mostly finfish and selected motile invertebrates. Although bivalves are of tremendous ecological and economic value, most of the major species are included as habitat categories, and therefore are not included as species as well. In this way, they have heightened importance given that the focus of ACFHP is habitat protection and restoration.
- The Matrix does not consider the natural rarity of a habitat type, current habitat trends, or comparative use with information obtained from the *Assessment of Existing Information* (a separate ACFHP project).
- The use of pelagic habitats was not considered as part of this Matrix. This Matrix should only be used to evaluate utilization of physical habitat, not use of the water column. Water quality should be acknowledged as an important consideration for all species included in this Matrix.
- There may be habitats that are important for some species that do not fit readily into the scheme provided in this Matrix. While we acknowledge that not every habitat is included, we think that most habitats for most species are covered.
- Differentiations between life history stages for each species should be based upon the generally accepted distinctions provided in the literature for that species.

Methods

Regional Breakdown and Regional Leads

This Matrix was completed for four regions of the Atlantic coast (Figure 1). Each region had a regional lead that was responsible for finding volunteers to complete the Matrix for the various species included in that region. Regions and regional leads are as follows: New England (Cape Cod north to Canada), Leads- Lou Chiarella, Kim Damon-Randall, and Vin Malkoski; Mid-Atlantic (Cape Cod to Cape Hatteras), Leads- Bill Shadel, Marek Topolski, and Caroly Shumway; South Atlantic (Cape Hatteras to Cape Canaveral), Lead- Kay Davy; and South Florida (south of Cape Canaveral), Leads-Kent Smith, Eddie Matheson, and Jeff Beal. A complete list of Matrix contributors can be found in ***Appendix A*** of this report.

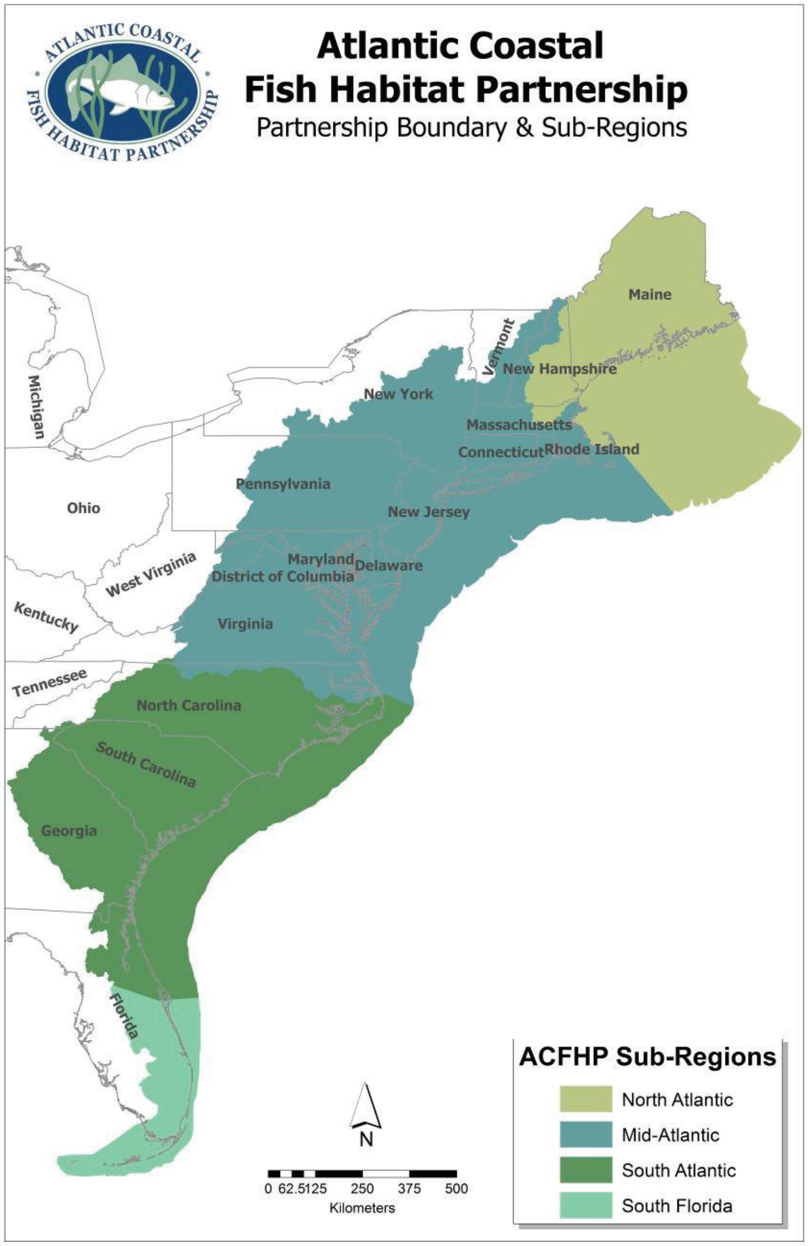

Figure 1. ACFHP Regions

Discussion of Spreadsheet and Determination of Categories

The ACFHP Species-Habitat Matrix exists in a series of Microsoft Excel spreadsheets. The left-hand columns consist of 26 habitat types nested within seven habitat categories (see *Habitat Characterizations* below for more detail). The species are listed across the top of each row, with four columns included per species (one for each life stage: eggs/larvae, juveniles/YOY, adults, and spawning adults). At each intersection of a habitat type and species' life stage is a "score" reflecting the species' use of the habitat type at that life stage. By summing these scores across a habitat type, an index of the habitat's value for a collective group of species can be generated. An example of a completed matrix for red drum is illustrated in Figure 2 below.

Additionally, each region had its own list of species covering the major functional groups found in that region. An attempt was made to cover a range of trophic levels (e.g., from bay anchovy to oyster toadfish to various coastal sharks), as well as to include species of commercial and recreational importance. Strictly freshwater species are not included within the focus of ACFHP, and therefore are not present in the Matrix.

Each species could be scored for one, two, three, or four regions, depending on its relative prevalence in each region. Therefore, some species, such as American eel, were scored for all regions, whereas a species like Caribbean reef squid was only scored for South Florida. The species list for each region was determined by a group of experts from that region. Ultimately, 36 species were scored for New England, 55 for Mid-Atlantic, 62 for South Atlantic, and 62 for South Florida (see ***Appendix B*** for complete lists). The total number of species included in the ACFHP Species-Habitat Matrix across all regions was 131.

Red Drum **South Atlantic**

Habitat Category	**Habitat Type**	**Eggs-Larvae**	**Juv/YOY**	**Adults**	**Spawning adults**
Marine and estuarine shellfish beds	Oyster reef		H	M	
	Scallop beds				
	Hard clam beds				
	Dead shell accumulations		H	M	
Other sessile fauna	Primary coral reef architecture				
	Patch reef, soft corals or anemones amidst soft sediment				
	Live rock			L	
Macroalgae	*Fucus* sp., *Laminaria* sp., *Ulva lactuca* mats, *Sargassum* sp., and other drift algae				
SAV	Tidal fresh and oligohaline *spp.*		L		
	Mesohaline and polyhaline *spp.*		L		
Tidal vegetation	Saltwater marsh	VH	VH	M	
	Brackish marsh		L		
	Tidal freshwater marshes		L		
	Mangrove		H		
Coastal inert substrate	Loose fine bottom		M	H	M
	Loose coarse bottom		M		M
	Firm hard bottom		L	L	H
	Structured sand habitat		M	M	

Habitat Category	Habitat Type	Eggs-Larvae	Juv/YOY	Adults	Spawning adults
Riverine	Higher gradient headwater tributaries				
	Lower gradient tributaries		H		
	Higher gradient large mainstem river				
	Lower gradient large mainstem river		H		
	Low order coastal streams		H		
	Non-tidal freshwater mussel beds				
	Coastal headwater ponds				
	Non-tidal freshwater marshes				

Figure 2. Example of Red Drum Species-Habitat Matrix

Habitat Characterizations (see ***Appendix C*** *for more detailed descriptions)*

Marine and Estuarine Shellfish Beds
- Oyster reef
- Scallop beds
- Hard clam beds
- Dead shell accumulations

Other Sessile Fauna
- Primary coral reef architecture
- Patch reef, soft corals, or anemones amidst soft sediment
- Live rock (inert hard bottom with hydroids, bryozoans, tube worms, sponges, etc.)

Macroalgae
- *Fucus* sp., *Laminaria* sp., *Ulva lactuca* mats, *Sargassum* sp., and other drift algae

Submerged Aquatic Vegetation (SAV)
- Tidal fresh and oligohaline spp.
- Mesohaline and polyhaline spp.

Tidal Vegetation
- Saltwater marsh
- Brackish marsh
- Tidal freshwater marshes
- Mangrove

Coastal Inert Substrate

Loose fine bottom

Loose coarse bottom

Firm hard bottom

Structured sand habitat

Riverine

Higher gradient headwater tributaries

Lower gradient tributaries

Higher gradient large mainstem river

Lower gradient large mainstem river

Low order coastal streams

Non-tidal freshwater mussel beds

Coastal headwater ponds

Non-tidal freshwater marshes

Instructions and Scoring

Each regional matrix was distributed to the regional leads, who, in turn, distributed it to the other contributors to fill out. The following instructions, scoring scheme, and format for references were sent along with the Microsoft Excel spreadsheets in an attempt to standardize the evaluations:

Overall Summary

Attached you will find the ACFHP Species-Habitat Matrix Excel workbook. Note that the list of species across the top of the table divides into four major life history stages for each species. Down the left hand side of the table, you will notice a list of habitat types. ACFHP wants to score, or evaluate, the relative importance of each specific habitat type to a given life history stage for each species. This "Matrix" will help us in identifying key species-habitat relationships for the Partnership's efforts.

Each species' use of a habitat will be scored using an algorithm that will ultimately aid in identifying those habitats types and categories which provide the greatest amount of benefit for multiple species. Species' use of specific habitats will be evaluated on a five score basis: Very High, High, Medium, Low, or Unknown. Your job will be to fill in the cells of each life history stage with a VH, H, M, L, or U. The scoring system (i.e., what each letter stands for) is described below. Ultimately, we will be able to replace these letters and test several numeric scoring methods.

Regional Guidelines

- There are four regions within ACFHP:
    - New England (Canadian border to Cape Cod)
    - Mid-Atlantic (Cape Cod to Cape Hatteras)
    - South Atlantic (Cape Hatteras to Cape Canaveral)
    - South Florida (Cape Canaveral south)
- Each region will submit ONE matrix. It is up to the regional leads to compile and combine results from their team members.

- Team members must cite their findings, and multiple citations per species are strongly encouraged wherever possible.
- Multiple team members working on the same species would be ideal, but one person per species is acceptable.

General Guidelines

- Use the best available literature – scientific journal articles, agency reports, ASMFC documents, species reviews, fishery management plans, federal reports, etc. – to help you identify and score important habitats for the species within your region. You can also cite expert opinion, but please make sure you document it well (include full name, contact info, and agency or organization).
- The east-west limits of ACFHP range from headwaters that are, or once were, accessible from the sea to the three-mile state jurisdictional limit. If a species' life stage primarily occurs beyond the three-mile limit (e.g., "Spawning Adults" for American eel), that life stage should not be included in the Matrix. Future expansions of the Matrix might range further offshore, but initially our focus is the headwater to three-mile extent of ACFHP.
- Document your references for each rank or species-habitat relationship in a separate Microsoft Word (or compatible) document, and record any comments you may have. See example format at end of this document.
- Only use the "Spawning Adults" column if habitat use by adults is fundamentally different between spawning and non-spawning periods (e.g., diadromous species). If it is not, only complete the "Adults" column and grey out the "Spawning Adults" column.
- "YOY" and "Juvenile" have been combined into one category because available information for different species is defined differently, with information for some species specific to young of the year and information for other species applicable more broadly to immature fish. This column combines these young life stages.
- If the species does not use the habitat for a specific life history stage, leave the corresponding cell blank. This means that blank cells have a meaning, so if the habitat use is actually unknown, be sure to indicate that with a U.
- For any species that are not found in your region, please make their columns gray so that we know those species were not considered.
- Do not combine scoring letters (e.g., H-M). Use the literature and your best professional judgment if you cannot decide between two scores. Document any additional thoughts or rationale in your accompanying documentation.

Scoring Scheme

- *Very High (VH)*: Essential contributor; the given life history stage for this species cannot be completed without enough high quality occurrences of this habitat type.
- *High (H)*: Important contributor to the success of this life history stage; can be occasionally substituted by use of one or more additional habitat types, but the majority of this life history stage takes place in this habitat type.
- *Moderate (M)*: Moderate contributor; one of many habitat types which contribute to the success of this species life history stage; substitutions with other habitat types are frequently found; not a major contributor of success but one of many.
- *Low (L)*: Not an essential contributor, used incidentally; other habitat types play a much greater role in success for this life history stage.
- *Unknown (U)*: If something is truly an unknown (to science) you can put a U. Be sure to include any questions or issues which might be related to the issue in your accompanying documentation.

Example Format for References and Comments

Name:	Jane Doe
ACFHP Region:	South Atlantic
Assigned Species:	American eel, American shad, etc.

Reference(s):

American eel (general)

Van Den Avyle, M. J. 1984. Species profiles: Life histories and environmental requirements of coastal fishes and invertebrates (South Atlantic) – American eel. U.S. Fish and Wildlife Service Report No. FWS/OBS-82/11.24, and U.S. Army Corps of Engineers Report No. EL-82-4, Washington D.C.

U.S. Fish and Wildlife Service. 2007. 12-month Finding on a Petition to List the American Eel as Threatened or Endangered. Washington, D.C.

American eel (eggs-larvae)

Helfman, G. S., D. E. Facey, L. S. Hales, Jr., and E. L. Bozeman, Jr. 1987. Reproductive ecology of the American eel. American Fisheries Society Symposium 1: 42-56.

American eel (comments or notes)

[Note: When a reference is specific to a life history stage please note here.]

Although American eels spawn in the Sargasso Sea, exact location, depth, etc. is still unknown.

American shad (NEW PAGE)

Repeat format above

Matrix Review and Completion

Once the original contributors from each region completed a scored matrix for each species, the coastwide matrix leads (Mari-Beth DeLucia, Emily Greene, Jake Kritzer, and Jessie Thomas-Blate) compared the scores for each species among regions. The Matrix leads determined that all species had some minor differences, and most species had some major differences in their scoring among regions. The group was not sure if this was a reflection of actual regional differences or subjective interpretation of the literature.

Consequently, a Species-Habitat Matrix Review Work Group of experts was formed (see ***Appendix A*** for a list of members). This work group met on February 19 and 20, 2009, in Raleigh, North Carolina, to discuss these regional differences and review each completed matrix based on literature cited and personal knowledge of the species. At this meeting, differences among regions were discussed and altered as appropriate. Following the meeting, the revised matrices were distributed to the original contributors for their final review.

A series of additional reviews occurred via conference calls with a subset of workgroup experts. For species for which the workgroup members did not feel qualified to render a score, independent reviews were utilized (see ***Appendix A*** for a list of these individuals).

Analysis

After completion and review of the Matrix, rankings (i.e., L, M, H, and VH) were converted to numerical scores using the **"4-3.5-2-1" System** in which Very High = 4; High = 3.5; Moderate = 2; and Low = 1. Rankings of "U" (unknown) were not part of the analysis, but were recorded as knowledge gaps. This scoring/ranking system was modified by the Matrix developers from The Nature Conservancy's 5-S Planning Framework (TNC 2000). The non-linear numeric relationship reflects that habitats ranked Very High or High represent important or essential habitats to a specific life stage, and should receive proportionally higher numerical scores than those habitats that are only used occasionally or in conjunction with many other habitats by a species. However, this also allows for a variety of analyses to be run on the results that can answer questions such as, "what habitat type received the most scores regardless of ranking?"

Analyses were run on both the broader Habitat Categories (i.e., Riverine), as well as the more specific Habitat Types (i.e., low order coastal streams). The results of this analysis can be found, ranked according to the five highest scoring habitats for each metric, in region-specific summary tables in ***Appendix D***.

Matrix Analysis Metrics (assessed by region):

Habitat Category with Highest Overall Score: Sum of scores across all fish species and life stages for all habitat types within a habitat category.

Habitat Type with Highest Overall Score: Sum of scores across all fish species and life stages within a habitat type.

Habitat Type with Highest Nursery Score: Sum of scores across all fish species within a habitat type, for the juvenile/young-of-year life stage.

Habitat Type with Highest number of H/VH Scores: Count of boxes valued with H and VH scores, across all fish species and life stages within a habitat type.

Habitat Type with Highest number of L/M Scores: Count of boxes valued with L and M scores, across all fish species and life stages within a habitat type.

Habitat Type with Highest # of Boxes with Any Score: Count of boxes valued with L, M, H, and VH scores, across all fish species and life stages within a habitat type.

Ratio of H/VH to L/M Scores: Count of H and VH scores (as described above) divided by the count of L and M scores (as described above).

Results and Discussion

<u>New England</u>

Coastal Inert Substrate was the highest scoring habitat category in the New England region. Of course, the ranking of the categories are clearly not independent of the number of habitat types within each. Still, four habitat types within the *Coastal Inert Substrate* category were among the five highest scoring of all habitat types, suggesting that high category ranking is not due solely to the number of habitat types, but also reflects their individual importance.

Loose Fine Bottom had the highest overall score among habitat types, and was also the highest ranked type for four of the five remaining analyses (i.e., highest juvenile/YOY score; highest number of H/VH scores; highest number of M/L scores; highest number of any score). This result is perhaps not surprising, given that *Loose Fine Bottom* is likely to be the most abundant habitat type, and therefore is likely to be used by the greatest number of species. If this is the case, the results highlight the fact that, although the Matrix is not designed to provide insights into habitat rarity, condition, or other features, these characteristics have an influence on habitat use and therefore on the Matrix results.

The only scoring system for which *Loose Fine Bottom* was not the top-ranked habitat was the ratio of H/VH to L/M scores. The purpose of this metric is to identify those habitat types that tend to be used mostly by habitat specialists, with less use by habitat generalists or less opportunistic use. The top five habitat types highlighted by this metric all fall within the *Riverine* category, a result that was influenced in part by the diadromous species in the Matrix. For diadromous species, *Riverine* habitats are of critical importance, but these habitats are not always of direct use to purely marine or estuarine species. However, the relative score of *Riverine* habitat meant that, not only did this category have the highest proportion of H and VH scores, but also that its aggregate score made it the second ranked category.

Submerged Aquatic Vegetation was the third highest ranked category in New England, a notable result given that the category only contains two habitat types. The importance of this category was driven largely by the *Mesohaline-Polyhaline Species* habitat type, which was one of the top five habitat types according to raw score, and one of the top types in four of the five other metrics considered. Like *Loose Fine Bottom*, the *Mesohaline-Polyhaline Species* habitat type only failed to rank by the ratio of H/VH to L/M scores, again due to the dominance of riverine habitat types. The highest position for *Mesohaline-Polyhaline Species* occurred when the scores were restricted to juvenile and YOY life stages, where it ranked second, underscoring the importance of this habitat type as a nursery ground.

<u>Mid-Atlantic</u>

The results for the Mid-Atlantic region were very similar to those for New England. *Coastal Inert Substrate* was the highest ranking category, and *Loose Fine Bottom* was the highest ranking habitat type by all metrics except for the ratio of H/VH to L/M scores. There again, the *Riverine* habitat types dominated. *Submerged Aquatic Vegetation* also scored fairly high, according to several metrics driven by the importance of *Mesohaline-Polyhaline Species* much more than by *Tidal Freshwater and Oligohaline Species*.

The similarity in the results between these two regions is no doubt due to a similar distribution of many important determinants of species and habitat abundance and distribution, as well as habitat use by species. These determinants may be either natural variables (e.g., oceanography, geology, hydrology, and climate) or anthropogenic (e.g., population density, urbanization, and agricultural patterns). These factors do not change abruptly at Cape Cod, and maintain a high degree of similarity between the two regions.

<u>South Atlantic</u>

Although the same factors that likely lead to the similarities between New England and the Mid-Atlantic also continue through the South Atlantic, the results show less similarity. This is driven in part by much larger differences in the suite of species considered in the South Atlantic compared to the more northern regions. The South Atlantic shares many tropical and sub-tropical species with the South Florida region, and the addition of those species has a pronounced effect on the results. The sheer number of new species changes the relative weight of others, and their ecology changes patterns of habitat use.

For example, the *Riverine* category, and the habitat types within it, does not rank as high in the South Atlantic as it does in the Mid-Atlantic and New England. In the South Atlantic, some diadromous species are no longer present (e.g., Atlantic salmon, sea-run brook trout, sea lamprey, and rainbow smelt), and those that remain are an even smaller proportion of the overall species list due to the new species considered. Also, *Oyster Reef* and *Live Rock* appear as more important habitat types in the South Atlantic by several metrics, likely reflecting the beginnings of the reef fish fauna that becomes truly dominant in South Florida.

Additionally, even along generally continuous gradients, it is possible to cross thresholds that lead to large ecological changes. One notable result in the South Atlantic is the greater importance of the *Tidal Vegetation* category and the *Saltwater/Brackish Marsh* type within it. Moving south along the Atlantic coast, the increases in elevation moving inland become much more gradual, resulting in more extensive marsh systems that allow for greater use by more species. *Coastal Inert Substrate* (especially *Loose Fine Bottom*) still ranks highly in the South Atlantic, but is not as dominant as it is in the northern regions.

South Florida

The arising dominance of reef fishes in the southern tropical and sub-tropical range of the Atlantic coast is clear in the South Florida region. The *Other Sessile Fauna* category scored highest; *Patch Reef, Soft Corals, and Anemones* was the highest scoring habitat type, and the *Primary Coral Reef Architecture* habitat type ranked highest in two of the five other metrics. The sheer number of species in the South Florida matrix, and the high ranks of the sessile fauna habitats within the region, perhaps suggest that these habitats need to be broken into more precise habitat types within this region than is required elsewhere in order to refine conservation planning.

Live Rock and *Firm Hard Bottom* also rank much higher than in any other region. *Firm Hard Bottom* is not part of the *Other Sessile Fauna* category, but has many of the same structural and functional attributes. In fact, unlike any of the other three regions, the results for *Coastal Inert Substrate* in South Florida are driven as much or more by the importance of *Firm Bottom* as they are by *Loose Fine Bottom*, which is the dominant type within the category elsewhere.

Only by the nursery habitat metric (i.e., highest juvenile/YOY score) does another habitat type rank highest, with *Mesohaline-Polyhaline SAV* in the top spot. Of course, many of the fishes that spend most of their lives on coral reefs also use SAV at young life stages.

Future directions

The results of this project will guide conservation strategic planning for ACFHP, in conjunction with other scientific projects. However, the Matrix effort produced an extensive database that may be used to address other ecological and management questions than those considered here. Those additional analyses will continue to help inform the work of ACFHP as the partnership further develops. At present, the initial results have provided a great deal of information on the importance of the various habitat types in each region, and shaped our planning to date.

As noted earlier, the Matrix does not consider all of the ecosystem functions provided by habitats, only their value as living space. A parallel planning tool would look at the full range of ecosystem services provided by a habitat type to help inform decision-making. For example, in all regions, *Shellfish Beds* generally scored very low. However, it is well known that shellfish are important in maintaining water quality, and therefore are important for other invertebrates and fishes, even if those species do not live directly on or among shellfish. Furthermore, the ACFHP Assessment of Existing Information is an example of another tool that provides more explicit information on habitat status and trends in each region.

In the future, the Matrix will be updated based on new information that emerges in the fish ecology and restoration literature. Matrix updates will also include information gathered from monitoring programs implemented under ACFHP-sponsored restoration projects. Through this process, the ACFHP Species-Habitat Matrix will identify knowledge gaps and set conservation priorities. In turn, new research to address priorities will feed back into the Matrix to make this evaluation more robust and improve our understanding of species-habitat relationships in future versions.

References

With more than 100 species included in the matrix, and multiple references used to rank habitat use by each, several hundred scientific papers, reports, books, management plans, and other sources were used to complete this analysis. Because this volume of literature is too great to list in full in this summary report, we are in the process of creating a searchable online database of the full reference list, as well as the notes for each species describing the scores given. Please contact the ACFHP Coordinator with questions about references and notes, and for updates on development of the online database.

Appendix A: Matrix Contributors

List of Matrix Developers

New England

Mike Brown (Maine Department of Marine Resources)
Brad Chase (Massachusetts Division of Marine Fisheries)
Lou Chiarella (NOAA Fisheries- Northeast)
Kim Damon-Randall (NOAA Fisheries- Northeast)
Merry Gallager (Maine Division of Inland Fisheries and Wildlife)
Dana Hartley (NOAA Fisheries- Northeast)
Mike Johnson (NOAA Fisheries- Northeast)
Jeremy King (Massachusetts Division of Marine Fisheries)
Jake Kritzer (Environmental Defense Fund)
Mark Lazzari (Maine Department of Marine Resources)
Greg Mackey (Maine Department of Marine Resources)
Vin Malkoski (Massachusetts Division of Marine Fisheries)
Sean McDermott (NOAA Fisheries- Northeast)
Rory Saunders (NOAA Fisheries- Northeast)
Marcy Scott (NOAA Fisheries- Northeast)
David Stevenson (NOAA Fisheries- Northeast)
James Sulikowski (University of New England)
Carl Wilson (Maine Department of Marine Resources)
Gail Wippelhauser (Maine Department of Marine Resources)

Mid-Atlantic

Mike Celestino (New Jersey Department of Environmental Protection)
Julie Devers (US Fish and Wildlife Service)
Bob Greenlee (Virginia Department of Game and Inland Fisheries)
James Mowrer (Virginia Department of Game and Inland Fisheries)
Jay Odell (The Nature Conservancy)
John Odenkirk (Virginia Department of Game and Inland Fisheries)
Anna Pfeiffer-Herbert (University of Rhode Island)
Harry Rickabaugh (Maryland Department of Natural Resources)
Bill Shadel (The American Littoral Society)
Caroly Shumway (The Nature Conservancy)
Jim Thompson (Maryland Department of Natural Resources)
Marek Topolski (Maryland Department of Natural Resources)
Alan Weaver (Virginia Department of Game and Inland Fisheries)
Keith Whiteford (Maryland Department of Natural Resources)

South Atlantic

Carolyn Belcher (Georgia Department of Natural Resources)
Prescott Brownell (NOAA Fisheries-Southeast)
Gabe Gaddis (Georgia Department of Natural Resources)
Chris Kalinowsky (Georgia Department of Natural Resources)
Jack McGovern (NOAA Fisheries-Southeast)
Ron Michaels (Georgia Department of Natural Resources)
Trish Murphey (North Carolina Division of Marine Fisheries)
Jim Page (Georgia Department of Natural Resources)
Eric Robillard (Georgia Department of Natural Resources)
Bill Roumillat (South Carolina Department of Natural Resources)

South Florida

Doug Adams (Florida Wildlife Research Institute)
Jeff Beal (Florida Fish and Wildlife Conservation Commission)
Theresa M. Bert (Florida Wildlife Research Institute)
David Blewett (Florida Wildlife Research Institute)
Angela Collins (Florida Wildlife Research Institute)
Jim Colvocoresses (Florida Wildlife Research Institute)
Bill Curnow (Florida Wildlife Research Institute)
Bob Glazer (Florida Wildlife Research Institute)
Bob Gorecki (Florida Wildlife Research Institute)
Kevan Gregalis (Florida Wildlife Research Institute)
Kathy Guindon (Florida Wildlife Research Institute)
Anthony Knapp (Florida Wildlife Research Institute)
Bob McMichael (Florida Wildlife Research Institute)
Melissa Nasuti (Florida Wildlife Research Institute)
Gregg Poulakis (Florida Wildlife Research Institute)
Caleb Purtlebaugh (Florida Wildlife Research Institute)
William Sharp (Florida Fish and Wildlife Conservation Commission)
Kent Smith (Florida Fish and Wildlife Conservation Commission)
Justin Solomon (Florida Wildlife Research Institute)
Ron Taylor (Florida Wildlife Research Institute)
Julie Vecchio (Florida Fish and Wildlife Conservation Commission)
Brent Winner (Florida Wildlife Research Institute)

List of Species-Habitat Matrix Review Work Group Members

Jeff Beal (Florida Fish and Wildlife Conservation Commission)
Lou Chiarella (NOAA Fisheries- Northeast)
Kim Damon-Randall (NOAA Fisheries- Northeast)
Kay Davy (NOAA Fisheries- Southeast)
Mari-Beth DeLucia (The Nature Conservancy)
Emily Greene (Atlantic Coastal Fish Habitat Partnership)
Jake Kritzer (Environmental Defense Fund)
Wilson Laney (U.S. Fish and Wildlife Service)
Vin Malkoski (Massachusetts Division of Marine Fisheries)
Eddie Matheson (Florida Fish and Wildlife Conservation Commission)
Jay Odell (The Nature Conservancy)
Doug Rader (Environmental Defense Fund)
Fritz Rohde (NOAA Fisheries- Southeast)
Caroly Shumway (The Nature Conservancy)
Jessie Thomas-Blate (Atlantic States Marine Fisheries Commission)
Marek Topolski (Maryland Department of Natural Resources)

List of Individuals Who Provided Additional Review or Specific Feedback

Hank Brooks (Virginia Institute of Marine Science)
Paul Caruso (Massachusetts Division of Marine Fisheries)
Chris Chambers (NOAA Fisheries- Northeast)
David Conover (Stony Brook University)
Dennis Devries (Auburn University)
Ashton Drew (North Carolina State University)
Jim Gartlan (Virginia Institute of Marine Science)
Steve Gephard (Connecticut Department of Environmental Protection)
Frank Germano (Massachusetts Division of Marine Fisheries)
Karen Greene (NOAA Fisheries- Northeast)
Lisa Hendrickson (NOAA Fisheries- Northeast)
Penny Howell (Connecticut Department of Environmental Protection)
Margaret Hunter (Maine Department of Marine Resources)
Kohl Kanwit (Maine Department of Marine Resources)
Alison Leschen (Massachusetts Division of Marine Fisheries)
Joseph Luczkovich (East Carolina University)
Jason McNamee (Rhode Island Department of Environmental Management)
Jack Musick (Virginia Institute of Marine Science)
Stew Michaels (Delaware Division of Fish and Wildlife)
Bob Sadzinski (Maryland Department of Natural Resources)
Byron Young

Appendix B: List of Species Included for Each Region

New England

Alewife	Cunner
American eel	Horseshoe crab
American lobster	Little skate
American shad	Loligo squid
Atlantic cod	Northern shrimp
Atlantic herring	Ocean pout
Atlantic mackerel	Oyster toadfish
Atlantic menhaden	Pollock
Atlantic salmon	Rainbow smelt
Atlantic silverside	Red hake
Atlantic sturgeon	Sand lance
Atlantic tomcod	Sea lamprey
Bay anchovy	Sea-run brook trout
Black sea bass	Shortnose sturgeon
Blue crab	Spiny dogfish
Blueback herring	Tautog
Bluefish	Windowpane flounder
Butterfish	Winter flounder

Mid-Atlantic

Alewife	Horseshoe crab
American eel	Little skate
American lobster	Loligo squid
American shad	Northern puffer
Atlantic cod	Ocean pout
Atlantic croaker	Oyster toadfish
Atlantic herring	Pollock
Atlantic mackerel	Rainbow smelt
Atlantic menhaden	Red drum
Atlantic needlefish	Red hake
Atlantic salmon	Sand lance
Atlantic silverside	Sandbar shark
Atlantic sturgeon	Scup
Atlantic tomcod	Sea lamprey
Bay anchovy	Sea-run brook trout
Black sea bass	Shortnose sturgeon
Blue crab	Spanish mackerel

Blueback herring
Bluefish
Bonefish
Butterfish
Clearnose skate
Cunner
Cyprinidontids
Dusky shark
Gizzard shad
Hickory shad
Spiny dogfish
Spot
Spotted sea trout
Striped bass
Summer flounder
Tarpon
Tautog
Weakfish
Windowpane flounder
Winter flounder

<u>South Atlantic</u>

Atlantic croaker
American eel
American shad
Atlantic bluefin tuna
Atlantic bonito
Atlantic menhaden
Atlantic sharpnose shark
Atlantic silverside
Atlantic spadefish
Atlantic sturgeon
Bay anchovy
Black drum
Black grouper
Black sea bass
Blacktip shark
Blue crab
Blue runner
Blueback herring
Bluefish
Bonnethead shark
Brown shrimp
Cobia
Cocoa damsel
Crevalle jack
Cyprinidontids
Florida pompano
Gafftopsail catfish
Gag grouper
Jolthead porgy
King mackerel
Lane snapper
Little tunny
Oyster toadfish
Permit
Pigfish
Pinfish
Pink shrimp
Red drum
Red grouper
Red snapper
Reef croaker
Schoolmaster snapper
Sheepshead
Shortnose sturgeon
Silver perch
Silver sea trout
Southern flounder
Southern kingfish
Spanish mackerel
Spot
Spotted sea trout
Striped bass
Striped mullet
Summer flounder
Tarpon
Tautog

Great barracuda
Grey snapper
Grey triggerfish
Weakfish
White margate
White shrimp

South Florida

American eel
Atlantic sailfish
Atlantic spadefish
Bar jack
Barred hamlet
Black grouper
Black margate
Blacktip shark
Bluehead wrasse
Bonefish
Brown shrimp
Bucktooth parrotfish
Caribbean spiny lobster
Caribbean reef squid
Cero mackerel
Cobia
Crevalle jack
Dusky squirrelfish
Florida gar
Florida pompano
Florida stone crab
French angelfish
French grunt
Goliath grouper
Great barracuda
Green moray
Grey snapper
Gulf flounder
Hogfish
Jolthead porgy
King mackerel
Ladyfish
Lemon shark
Longsnout butterfly fish
Long-spined sea urchin
Mangrove rivulus
Mutton snapper
Oyster toadfish
Peacock flounder
Permit
Pinfish
Pink shrimp
Queen conch
Queen triggerfish
Red drum
Reef croaker
Sargent major
Schoolmaster snapper
Sheepshead
Sheepshead minnow
Snook (common)
Spanish mackerel
Spanish sardine
Spotted eagle ray
Spotted sea trout
Spotted spiny lobster
Stoplight parrotfish
Striped mullet
Tarpon
Tripletail
Yellowfin mojarra
Yellowtail snapper

Appendix C: Habitat Descriptions

Marine and Estuarine Shellfish Beds

Oyster reef

Structures formed by the Eastern oyster (*Crassostrea virginica)* that provide the dominant structural component of the benthos, and whose accumulated mass provides significant vertical relief (> 0.5 m).

Scallop beds

Areas of dense aggregations of scallops on the ocean floor. Common Atlantic coast species include: 1) the large Atlantic sea scallop (*Placopecten magellanicus*), which ranges from Newfoundland to North Carolina; 2) the medium-sized Atlantic calico scallop (*Argopecten gibbus*), which is found in waters south of Delaware; and 3) the bay scallop (*Argopecten irradians)*, which occurs from Cape Cod to Florida, as well as in the Gulf of Mexico.

Hard clam beds

Dense aggregations of the hard clam (*Mercenaria mercenaria)* found in the subtidal regions of bays and estuaries to approximately 15 meters in depth. Clams are generally found in mud flats and firm bottom areas consisting of sand or shell fragments.

Dead shell accumulations

Shells of dead mollusks sometimes accumulate in sufficient quantities to provide important habitat. Accumulations of Eastern oyster shells are a common feature in the intertidal zone of many southern estuaries.

Other Sessile Fauna

Primary coral reef architecture

Reef-building corals are of the order Scleractinia, in the class Anthozoa, of the phylum Cnidaria. Coral accumulations are restricted to warmer water regions, where the average monthly temperature exceeds 18°C (64°F) throughout the year. Through symbiosis with unicellular algae, reef-building corals are the source of primary production in reef communities.

Patch reef, soft corals, or anemones amidst soft sediment

A patch reef is an isolated, often circular, coral reef usually found within a lagoon or embayment. Soft corals are species of the anthozoan order Alcyonacea, of the subclass Octocorallia. In contrast to the hard or stony corals, most soft corals do not possess a massive external skeleton (examples: sea pens and sea fans). Anemones are cnidarians of the class Anthozoa, and possesses a flexible cylindrical body and a central mouth surrounded by tentacles found in soft sediments.

Live rock (inert hard bottom with hydroids, bryozoans, tube worms, sponges, etc.)

Calcareous rock that is removed from the vicinity of a coral reef with some of the life forms still living on it. These may include bacteria, coralline algae, sponges, worms, crustaceans, and other invertebrates.

Macroalgae

Large marine multi-cellular macroscopic algae (seaweeds). There are three types of macroalgae: green, brown, and red. Examples of macroalgae species found along the Atlantic coast:

Chlorophyta (green algae)

Ulva lactuca, sea lettuce

Phaeophyta (brown algae)

Fucus vesiculosus, bladderwrack; *Laminaria* spp.; *Sargassum* spp.

Rhodophyta (red algae)

Chondrus crispus, Irish moss

SAV

Submerged aquatic vegetation (SAV) refers to rooted, vascular plants that live below the water surface in large meadows or small patches in coastal and estuarine waters. SAV can be further classified by the range of salinity of the waters in which they are found.

Tidal fresh and oligohaline species

Generally found in areas where salinity ranges from 0.5 to 5.0 ppt. Examples include:
Vallisneria americana, wild celery
Ceratophyllum demersum, coontail

Mesohaline and polyhaline species

Generally found in areas where salinity ranges from 5.0 ppt up to 30 ppt. Examples include:
Zostera marina, eelgrass
Ruppia maritime, widgeon grass

Tidal Vegetation

Saltwater and brackish marsh

Saltmarsh is a type of marsh that is a transitional intertidal between land and brackish water. The low marsh zone floods twice daily, while the high marsh floods only during storms and unusually high tides. Smooth cordgrass (*Spartina alterniflora*) dominates the regularly flooded low marsh along much of the Atlantic coast. In addition, salt meadow cordgrass (*Spartina patens*), saltgrass (*Distichlis spicata*), and needle rush (*Juncus* sp.) species comprise much of the vegetative community of the mid to upper saltmarsh and brackish marsh.

Tidal freshwater marsh

Tidal freshwater marsh occurs where the average annual salinity is below 0.5 ppt. It is found along free-flowing coastal rivers, and is influenced twice daily by the incoming tides. Tidal freshwater marsh can be located just upstream of the salt front, where the river essentially backs up as it meets resistance from high tides. Tidal freshwater marsh is characterized by salt intolerant plant species. Plant species often found in freshwater tidal marshes include: giant cordgrass (*Spartina cynosuroides*), sawgrass (*Cladium jamaicense*), cattails (*Typha* sp.), arrow arum (*Peltandra virginica*), pickerelweed (*Pontedaria cordata*), blue flag (*Iris virginica*), and softstem bulrush (*Scirpus validus*).

Mangrove

The mangrove ecological community includes four tree species collectively called mangroves. This swamp system occurs along intertidal and supratidal shorelines in southern Florida. The four species found in Florida mangrove swamps are:

Rhizophora mangle, red mangrove
Avicennia germinans, black mangrove
Laguncularia racemosa, white mangrove
Conocarpus erectus, buttonwood

Coastal Inert Substrate

Loose fine bottom (mud, silt, sand)

Submerged underwater bottom habitat in estuaries and oceans where the dominate-sized sediment type is mud, silt, or sand.

Loose coarse bottom (gravel to cobble)

Submerged underwater bottom habitat in estuaries and oceans where the dominant sediment type ranges from gravel to cobble.

Firm hard bottom (boulders to embedded rock)

Submerged underwater bottom habitat in estuaries and oceans where embedded rock or boulders is the dominate sediment type.

Structured sand habitat (shoals, capes, offshore bars, etc.)

Linear, narrow sand features that develop where a stream or ocean current promotes deposition of sand.

Riverine

Higher gradient headwater tributaries

Streams in which the dominant substrate is comprised of gravel and cobble. The stream slope is greater than 2.0%. This characterization includes 1st to 3rd order streams.

Lower gradient tributaries

Streams in which the dominant substrate is comprised of sand, gravel, and small cobble. The stream slope is between 0.51% and 2.0%. This characterization includes 1^{st} to 3^{rd} order streams.

Higher gradient large mainstem river

Rivers in which the dominant substrate is sand, gravel, and cobble. The stream slope is between 0.51% and 2.0%. This characterization includes 4^{th} order rivers and above.

Lower gradient large mainstem river

Rivers in which the dominant substrate is fine sediments (silt-mud-sand). The stream slope is between 0.51% and 2.0%. This characterization includes 4^{th} order rivers and above.

Low order coastal streams

Generally low gradient 0% to 0.05% in slope. This characterization includes 1^{st} to 3^{rd} order streams located along the coast.

Non-tidal freshwater mussel beds

Freshwater mussel beds, located above tidal influence.

Coastal headwater pond

A pond connected to coastal streams and rivers, generally located near the headwaters.

Non-tidal freshwater marsh

A marsh that occurs in the non-tidal section along a river. The main feature of a freshwater marsh is its openness, with only low-growing or "emergent" plants. It may include grasses, rushes, reeds, typhas, sedges, and other herbaceous plants (possibly with low-growing woody plants) in a context of shallow water.

Appendix D: Summary Results of the Species-Habitat Matrix by Region

(Note: The habitat category in which a habitat type falls is shown in brackets. Raw analysis scores are shown in parentheses.)

New England	Highest Score	2nd Highest Score	3rd Highest Score	4th Highest Score	5th Highest Score
Habitat Category with Highest Overall Score	Coastal Inert Substrate (491)	Riverine (372)	Submerged Aquatic Vegetation (155)	Marine & Estuarine Shellfishbeds (133)	Tidal Vegetation (109)
Habitat Type with Highest Overall Score [Habitat Category]	Loose Fine Bottom (154.5) [Coastal Inert Substrate]	Loose Coarse Bottom (123) [Coastal Inert Substrate]	Structured Sand (108.5) [Coastal Inert Substrate]	Firm Hard Bottom AND Mesohaline-Polyhaline spp. (105) [Coastal Inert Substrate and Submerged Aquatic Vegetation]	
Highest Type with Highest Nursery (juv/yoy) Score [Habitat Category]	Loose Fine Bottom (52) [Coastal Inert Substrate]	Mesohaline-Polyhaline spp. (48.5) [Submerged Aquatic Vegetation]	Loose Coarse Bottom (38.5), Structured Sand (38), AND Firm Hard Bottom (37.5) [Coastal Inert Substrate]		
Habitat Type with Highest # of H/VH Scores	Loose Fine Bottom (22)	Higher Gradient Large Mainstem River (17)	Loose Coarse Bottom (16)	Structured Sand Habitat (15)	Mesohaline-Polyhaline (14)
Habitat Type with Highest # of L/M Scores	Loose Fine Bottom (50)	Loose Coarse Bottom (44)	Firm Hard Bottom (42)	Mesohaline-Polyhaline (36)	Structured Sand (35)
Habitat Type with Highest # of Boxes with Any Score	Loose Fine Bottom (72)	Loose Coarse Bottom (60)	Firm Hard Bottom (54)	Structured Sand Habitat AND Mesohaline-Polyhaline (50)	
Ration of H/VH to L/M Scores	Higher Gradient Large Mainstem River	Lower Gradient Tributaries	High Gradient Headwater Tributaries	Coastal Headwater Ponds	Lower Gradient Large Mainstem River

Mid-Atlantic	Highest Score	2nd Highest Score	3rd Highest Score	4th Highest Score	5th Highest Score
Habitat Category with Highest Overall Score	Coastal Inert substrate (647)	Riverine (575)	Submerged Aquatic Vegetation (265.5)	Marine & Estuarine Shellfish beds (219)	Tidal Vegetation (179)
Habitat Type with Highest Overall Score [Habitat Category]	Loose fine bottom (260) [Coastal Inert Substrate]	Mesohaline-Polyhaline spp. (175.5) [Submerged Aquatic Vegetation]	Lower Gradient Large Mainstem River (147) [Riverine]	Loose coarse bottom (134.5) [Coastal Inert Substrate]	Structured sand habitat (124.5) [Coastal Inert Substrate]
Habitat Type with Highest Nursery (juv/yoy) Score [Habitat Category]	Loose Fine Bottom (93.5) [Coastal Inert Substrate]	Mesohaline-Polyhaline spp. (70.5) [Submerged Aquatic Vegetation]	Lower Gradient Large Mainstem River (53) [Riverine]	Loose coarse bottom (50.5) [Coastal Inert Substrate]	Structured sand habitat (49) [Coastal Inert Substrate]
Habitat Type with Highest # of H/VH Scores	Loose fine bottom (41)	Lower gradient large mainstem river (23)	Mesohaline-Polyhaline spp. (22)	Lower gradient tributaries (21)	Higher gradient large mainstem river (19)
Habitat Type with Highest of #L/M Scores	Loose fine bottom (68)	Loose coarse bottom (67)	Firm hard bottom (57)	Mesohaline-Polyhaline spp. AND Structured sand habitat (55)	
Habitat Type with Highest # of Boxes with Any Score	Loose fine bottom (109)	Loose coarse bottom AND Mesohaline-Polyhaline spp. (77)	Firm hard bottom (70)	Structured sand habitat (67)	
Ration of H/VH to L/M Scores	Lower gradient tributaries	Higher gradient large mainstem river	High gradient headwater tribs AND lower gradient large mainstem river	Loose fine bottom	

South Atlantic	Highest Score	2nd Highest Score	3rd Highest Score	4th Highest Score	5th Highest Score
Habitat Category with Highest Overall Score	Coastal Inert Substrate (583.5)	Tidal Vegetation (555)	Riverine (480)	Submerged Aquatic Vegetation (237)	Marine and Estuarine Shellfish beds (218)
Habitat Type with Highest Overall Score [Habitat Category]	Saltwater/brackish marsh (353.5) [Tidal Vegetation]	Loose fine bottom (295.5) [Coastal Inert Substrate]	Mesohaline-Polyhaline spp. (151.5) [Submerged Aquatic Vegetation]	Lower gradient large mainstem river (126) [Riverine]	Tidal Freshwater marshes (125.5) [Tidal Vegetation]
Habitat Type with Highest Nursery (juv/yoy) Score [Habitat Category]	Saltwater/brackish marsh (154.5) [Tidal Vegetation]	Loose fine bottom (109.5) [Coastal Inert Substrate]	Mesohaline-Polyhaline spp. (79) [Submerged Aquatic Vegetation]	Oyster reef (55.5) [Marine and Estuarine Shellfish Beds]	Lower gradient large mainstem river (53) [Riverine]
Habitat Type with Highest # of H/VH Scores	Saltwater/brackish marsh (82)	Loose fine bottom (53)	Lower gradient tribs AND Higher gradient large mainstem river (18)	Live rock (17)	
Habitat Type with Highest # of L/M Scores	Mesopolyhaline-Polyhaline (80)	Loose fine bottom (68)	Dead shell accumulations (64)	Structured sand habitat (60)	Oyster reef (56)
Habitat Type with Highest # Boxes with Any Score	Loose fine bottom (121)	Saltwater/brackish marsh (114)	Mesohaline-Polyhaline spp. (88)	Dead shell accumulations (66)	Oyster reef AND Structured sand habitat (65)
Ration of H/VH to L/M Scores	Higher gradient large mainstem river	Saltwater/brackish marsh	High gradient headwater tributaries	Lower gradient tributaries	Loose fine bottom

South Florida	Highest Score	2nd Highest Score	3rd Highest Score	4th Highest Score	5th Highest Score
Habitat Category with Highest Overall Score	Other sessile fauna (937.5)	Coastal inert substrate (685.5)	Tidal vegetation (378.5)	Riverine (308.5)	Submerged Aquatic Vegetation (304.5)
Habitat Type with Highest Overall Score [Habitat Category]	Patch reef, soft coral or anemones amidst soft sediment (322) [Other Sessile Fauna]	Primary coral reef architecture (312.5) [Other Sessile Fauna]	Live rock (303) [Other Sessile Fauna]	Firm hard bottom (241.5) [Coastal Inert Substrate]	Loose fine bottom (185.5) [Coastal Inert Substrate]
Habitat Type with Highest Nursery (juv/yoy) Score [Habitat Category]	Mesohaline-polyhaline (139) [Submerged Aquatic Vegetation]	Patch reef, soft coral or anemones amidst soft sediment (110) [Other Sessile Fauna]	Live Rock (108.5) [Other Sessile Fauna]	Primary Coral Reef Architecture (97.5) [Other Sessile Fauna]	Mangrove (92) [Tidal Vegetation]
Habitat Type with Highest # of H/VH Scores	Primary coral reef architecture (69)	Patch reef, soft corals or anemones amidst soft sediment (66)	Live rock (59)	Firm hard bottom (46)	Mesohaline-polyhaline spp. (45)
Habitat Type with Highest # of L/M Scores	Mesohaline-polyhaline (54)	Loose coarse bottom (52)	Loose fine bottom (50)	Live rock (46)	Dead shell accumulations (45)
Habitat Type with Highest # Boxes with Any Score	Patch reef, soft coral or anemones amidst soft sediment (108)	Live rock (105)	Primary coral reef architecture AND Mesohaline-Polyhaline spp. (99)	Firm hard bottom (93)	
Ration of H/VH to L/M Scores	Primary coral reef architecture	Patch reef, soft corals or anemones amidst soft sediment	Live rock	Firm hard bottom	Mangrove AND Mesohaline-Polyhaline spp.