A Characterization and Spatial Analysis of Stakeholder Socioeconomics, Resource Use, and Perceptions of Water Quality in Biscayne Bay, Florida

Samantha Dowdell
University of Miami, sammidowdell@gmail.com

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A CHARACTERIZATION AND SPATIAL ANALYSIS OF STAKEHOLDER SOCIOECONOMICS, RESOURCE USE, AND PERCEPTIONS OF WATER QUALITY IN BISCAYNE BAY, FLORIDA

By

Samantha C. Dowdell

A THESIS

Submitted to the Faculty of the University of Miami in partial fulfillment of the requirements for the degree of Master of Science

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the requirements for the degree of
Master of Science

A CHARACTERIZATION AND SPATIAL ANALYSIS OF STAKEHOLDER
SOCIOECONOMICS, RESOURCE USE, AND PERCEPTIONS OF WATER
QUALITY IN BISCAYNE BAY, FLORIDA

Samantha C. Dowdell

Approved:

Maria Estevanez, M.B.A./M.A.
Senior Lecturer of Marine Ecosystems
and Society

Manoj Shivlani, Ph.D.
Lecturer of Marine Ecosystems
and Society

Jill Richardson, Ph.D.
Senior Lecturer of Marine Ecosystems
and Society

Guillermo Prado, Ph.D.
Dean of the Graduate School

Juan Agar, Ph.D.
Lead Economist
Social Science Research Group
NOAA SEFSC Miami, Florida
A Characterization and Spatial Analysis of Stakeholder Socioeconomics, Resource Use, and Perceptions of Water Quality in Biscayne Bay, Florida

This project serves as a component of the NOAA Habitat Blueprint Biscayne Bay Habitat Focus Area (BB HFA), a multidisciplinary collaborative effort encompassing research conducted by NOAA Florida Sea Grant, Miami Waterkeeper, and the University of Miami’s Rosenstiel School of Marine and Atmospheric Science, amongst many other institutions and organizations.

Water quality in Biscayne Bay is of major concern to tourism, recreation, fisheries, and other regional economic activities. In recent years, environmental indicators such as harmful algal blooms have brought to light the threat human activity poses to Biscayne Bay resources. To ensure the conservation of Biscayne Bay species and ecosystem services, it is necessary to recognize the economic risks associated with water quality degradation. It is also important to understand industry perception of water quality and capacity to adapt to changing conditions.

The purpose of the BB HFA Economic and Spatial Study was to economically characterize marine-related industries in Biscayne Bay. This Master’s Thesis, part of the Economic and Spatial Study, focused specifically on commercial, recreational, and for-hire fisheries, as well as seafood wholesalers that source from the bay and recreational businesses that depend directly upon a healthy Biscayne Bay, such as SCUBA and snorkel
operators. Data for the recreational fishing sector was collected via online surveys, distributed via email addresses provided by the Florida Fish and Wildlife Conservation Commission. In-person, semi-structured interviews were conducted for all willing participants in the commercial and for-hire fishing sectors, fish wholesale industry, and recreational water operations industry. Participants were asked questions about personal demographics, resource use, economic expenditures related to resource use, and perceptions of water quality.

Using survey and interview data, socioeconomic and resource use profiles were constructed for each focus industry. Current water quality conditions and changes in water quality as perceived by industry stakeholders were described, as well as stakeholder adaptation strategies in the face of changing water quality conditions. Finally, stakeholder perceptions of water quality were analyzed based on industry and tenure to determine if these factors influence stakeholder attitudes.

In the face of threats such as harmful algal blooms and pollution from nuclear power plants, this information is critical to policymakers and industry participants alike. Aggregate results are publicly available in the mapping portal integrated into the study’s website. The mapping portal produced from this research provides endless applications for Biscayne Bay research and policy. This project, in combination with data from the SECOORA Data Catalog, FWC data, and additional NOAA Habitat Blueprint studies, is designed to serve as a critical component in ensuring the longevity of Biscayne Bay fisheries and recreational water operations, as well as a swimmable, fishable, drinkable bay.
DEDICATION

To my parents, Lisa and Tom, for everything.
ACKNOWLEDGEMENTS

To my advisory committee – thank you for your unwavering support and continuous guidance. Dr. Manoj Shivlani, thank you for providing me with this incredible opportunity, for helping me to develop this project every step of the way, and for helping me grow as a young professional. Maria Estevanez, thank you for providing endless assistance and opportunities to develop my skill sets and my career and for providing me with a home away from home. Dr. Juan Agar, thank you for challenging me to ensure that I considered important details and set realistic expectations. Dr. Jill Richardson, thank you for ensuring I stayed on task and for providing administrative and career counseling.

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To my funding sources, Miami Waterkeeper, the National Oceanic and Atmospheric Administration, the University of Miami, the Southeast Coastal Ocean Observation Regional Association, and the American Water Resources Association Florida Section - thank you for providing the resources necessary to carry out this project.

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Mangrove in Biscayne Bay. Evan D’Alessandro.

*Biscayne Bay, broad and brimming with fish, was the highway on which the people moved in their small sailing craft under shifting starch-white clouds and while great blue and great white herons, American egrets and roseate spoonbills dipped and wheeled and came to rest in the shallows along the shore.*

*Across the Bay, Miami Beach, actually the first of the Florida keys, was preceded south in the curved march of islands by Key Biscayne which had its own history. Pedro (el) Biscaino lived there and gave the Bay its name. He was a Basque who had held the title ‘Keeper of Swans’ at the court of Spain.*

*The thing that made the Bay country was fresh water. Calusa Indians, discoverers, pirates, seamen of all descriptions, had been sailing up the Miami River to stock up on fresh water for centuries. You could dip a tin cup in the Miami River and bring up a crystal-clear drink, and there were places in the Bay itself where fresh cold water bubbled up.*

*J. Muir (1953)*

*Biscayne Bay: Environmental History and Annotated Bibliography (Cantillo et al. 2000)
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>List</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIST OF FIGURES</td>
<td>x</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>xiv</td>
</tr>
<tr>
<td>Chapter</td>
<td></td>
</tr>
<tr>
<td>1 INTRODUCTION</td>
<td></td>
</tr>
<tr>
<td>1.1 Biscayne Bay Geography and Ecology</td>
<td>2</td>
</tr>
<tr>
<td>1.2 Economic Sectors</td>
<td>3</td>
</tr>
<tr>
<td>1.2.1 Commercial Fishing</td>
<td>4</td>
</tr>
<tr>
<td>1.2.2 Recreational and For-Hire Fishing</td>
<td>5</td>
</tr>
<tr>
<td>1.2.3 Seafood Wholesale and Retail</td>
<td>6</td>
</tr>
<tr>
<td>1.2.4 Recreational Water Operations</td>
<td>9</td>
</tr>
<tr>
<td>1.3 Water Quality</td>
<td>10</td>
</tr>
<tr>
<td>1.3.1 Historic Water Quality Regimes</td>
<td>10</td>
</tr>
<tr>
<td>1.3.2 Causes for Immediate Concern</td>
<td>13</td>
</tr>
<tr>
<td>1.4 Stakeholder Perceptions and Participatory Mapping</td>
<td>16</td>
</tr>
<tr>
<td>1.5 Purpose and Objectives</td>
<td>17</td>
</tr>
<tr>
<td>2 METHODS</td>
<td>19</td>
</tr>
<tr>
<td>2.1 Data Collection</td>
<td>20</td>
</tr>
<tr>
<td>2.1.1 Online Survey Distribution</td>
<td>20</td>
</tr>
<tr>
<td>2.1.2 In-Person Interview Samples and Protocol</td>
<td>25</td>
</tr>
<tr>
<td>2.1.2.1 For-Hire Fishing Operations</td>
<td>25</td>
</tr>
<tr>
<td>2.1.2.2 Seafood Wholesalers and Bait Retailers</td>
<td>26</td>
</tr>
<tr>
<td>2.1.2.3 Recreational Water Operators</td>
<td>27</td>
</tr>
<tr>
<td>2.1.2.4 Commercial Fishers</td>
<td>28</td>
</tr>
<tr>
<td>2.1.2.5 Interview Protocol</td>
<td>29</td>
</tr>
<tr>
<td>2.1.3 Survey and Interview Instruments</td>
<td>30</td>
</tr>
<tr>
<td>2.2 Data Analysis</td>
<td>32</td>
</tr>
<tr>
<td>2.2.1 Statistical Analyses</td>
<td>33</td>
</tr>
<tr>
<td>2.2.2 Spatial Analyses</td>
<td>33</td>
</tr>
<tr>
<td>2.2.2.1 Creating Maps for Online Surveys</td>
<td>33</td>
</tr>
<tr>
<td>2.2.2.2 Zip Codes</td>
<td>35</td>
</tr>
<tr>
<td>2.2.2.3 Points from Qualtrics Online Surveys</td>
<td>35</td>
</tr>
<tr>
<td>2.2.2.4 Points and Polygons from SeaSketch</td>
<td>37</td>
</tr>
<tr>
<td>2.2.2.5 Analyzing Patterns and Clusters</td>
<td>38</td>
</tr>
<tr>
<td>2.3 Limitations and Delimitations</td>
<td>40</td>
</tr>
<tr>
<td>2.3.1 Limitations</td>
<td>40</td>
</tr>
<tr>
<td>2.3.2 Delimitations</td>
<td>44</td>
</tr>
<tr>
<td>2.4 Distribution and Response</td>
<td>45</td>
</tr>
<tr>
<td>2.4.1 Survey Distribution and Response Rates</td>
<td>45</td>
</tr>
</tbody>
</table>
## 3 STAKEHOLDER INDUSTRY PROFILES

<table>
<thead>
<tr>
<th>Subsection</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1 Recreational Fishers</td>
<td>51</td>
</tr>
<tr>
<td>3.1.1 Demographics</td>
<td>51</td>
</tr>
<tr>
<td>3.1.2 Resource Use</td>
<td>55</td>
</tr>
<tr>
<td>3.1.3 Economics</td>
<td>61</td>
</tr>
<tr>
<td>3.1.4 Perceptions of Water Quality</td>
<td>63</td>
</tr>
<tr>
<td>3.2 For-Hire Fishers</td>
<td>69</td>
</tr>
<tr>
<td>3.2.1 Demographics</td>
<td>69</td>
</tr>
<tr>
<td>3.2.2 Resource Use</td>
<td>70</td>
</tr>
<tr>
<td>3.2.3 Economics</td>
<td>76</td>
</tr>
<tr>
<td>3.2.4 Perceptions of Water Quality</td>
<td>77</td>
</tr>
<tr>
<td>3.3 Commercial Fishers</td>
<td>82</td>
</tr>
<tr>
<td>3.3.1 Demographics</td>
<td>82</td>
</tr>
<tr>
<td>3.3.2 Resource Use</td>
<td>83</td>
</tr>
<tr>
<td>3.3.3 Economics</td>
<td>90</td>
</tr>
<tr>
<td>3.3.4 Perceptions of Water Quality</td>
<td>92</td>
</tr>
<tr>
<td>3.4 Seafood Wholesale and Bait Retail</td>
<td>98</td>
</tr>
<tr>
<td>3.4.1 Demographics</td>
<td>98</td>
</tr>
<tr>
<td>3.4.2 Resource Use</td>
<td>99</td>
</tr>
<tr>
<td>3.4.3 Economics</td>
<td>102</td>
</tr>
<tr>
<td>3.4.4 Perceptions of Water Quality</td>
<td>103</td>
</tr>
<tr>
<td>3.5 Recreational Water Operators</td>
<td>108</td>
</tr>
<tr>
<td>3.5.1 Demographics</td>
<td>108</td>
</tr>
<tr>
<td>3.5.2 Resource Use</td>
<td>110</td>
</tr>
<tr>
<td>3.5.3 Economics</td>
<td>116</td>
</tr>
<tr>
<td>3.5.4 Perceptions of Water Quality</td>
<td>119</td>
</tr>
</tbody>
</table>

## 4 UNDERSTANDING STAKEHOLDER PERCEPTIONS

<table>
<thead>
<tr>
<th>Subsection</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1 Influence of Industry</td>
<td>126</td>
</tr>
<tr>
<td>4.2 Influence of Tenure</td>
<td>129</td>
</tr>
<tr>
<td>4.3 Adaptation Strategies by Industry</td>
<td>131</td>
</tr>
</tbody>
</table>

## 5 CONCLUSIONS

<table>
<thead>
<tr>
<th>Subsection</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1 Major Findings and Policy Implications</td>
<td>135</td>
</tr>
<tr>
<td>5.2 Future Studies</td>
<td>138</td>
</tr>
</tbody>
</table>

WORKS CITED | 140 |

GIS DATA AND TOOLS | 149 |

APPENDIX 1: Consent Forms | 151 |
APPENDIX 2: Online Surveys | 156 |
APPENDIX 3: In-Person Interviews | 233 |
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1</td>
<td>Geographic extent of Biscayne Bay</td>
<td>3</td>
</tr>
<tr>
<td>Figure 2</td>
<td>Northern Biscayne Bay</td>
<td>10</td>
</tr>
<tr>
<td>Figure 3</td>
<td>Central Biscayne Bay</td>
<td>12</td>
</tr>
<tr>
<td>Figure 4</td>
<td>Southern Biscayne Bay</td>
<td>13</td>
</tr>
<tr>
<td>Figure 5</td>
<td>Online survey pilot responses by date</td>
<td>24</td>
</tr>
<tr>
<td>Figure 6</td>
<td>Online survey responses by date (full distribution)</td>
<td>24</td>
</tr>
<tr>
<td>Figure 7</td>
<td>Breakdown of survey error</td>
<td>40</td>
</tr>
<tr>
<td>Figure 8</td>
<td>Venn diagram of interview participant industry overlap</td>
<td>49</td>
</tr>
<tr>
<td>Figure 9</td>
<td>Recreational fisher zip codes by percent respondents</td>
<td>53</td>
</tr>
<tr>
<td>Figure 10</td>
<td>Percent difference between survey zip codes and full FWC sample</td>
<td>54</td>
</tr>
<tr>
<td>Figure 11</td>
<td>Number of trips per month by number of respondents</td>
<td>57</td>
</tr>
<tr>
<td>Figure 12</td>
<td>Species groups fished by percent respondents</td>
<td>58</td>
</tr>
<tr>
<td>Figure 13</td>
<td>Percent of recreational fishers who accessed each fishing region</td>
<td>59</td>
</tr>
<tr>
<td>Figure 14</td>
<td>Point density of fishing areas weighted by fishing region selection rate</td>
<td>60</td>
</tr>
<tr>
<td>Figure 15</td>
<td>Average per trip costs for recreational fishers</td>
<td>62</td>
</tr>
<tr>
<td>Figure 16</td>
<td>Changes in water quality condition, as perceived by recreational fishers</td>
<td>63</td>
</tr>
<tr>
<td>Figure 17</td>
<td>Types of water quality degradation, as perceived by recreational fishers</td>
<td>64</td>
</tr>
<tr>
<td>Figure 18</td>
<td>Water quality degradation factors, as perceived by recreational fishers</td>
<td>65</td>
</tr>
<tr>
<td>Figure 19</td>
<td>Areas of water quality concern, as perceived by recreational fishers</td>
<td>66</td>
</tr>
<tr>
<td>Figure 20</td>
<td>Recreational fishing contingent adaptation strategies</td>
<td>68</td>
</tr>
<tr>
<td>Figure 21</td>
<td>For-hire fishing launch points</td>
<td>72</td>
</tr>
<tr>
<td>Figure 22</td>
<td>Current for-hire fishing grounds by participant count</td>
<td>73</td>
</tr>
<tr>
<td>Figure 23</td>
<td>Current for-hire fishing grounds by trips per year</td>
<td>74</td>
</tr>
</tbody>
</table>
Figure 49. Current water quality condition, as perceived by wholesalers ............... 103
Figure 50. Changes in water quality condition, as perceived by wholesalers .......... 104
Figure 51. Observations of water quality improvements by wholesalers .............. 104
Figure 52. Types of water quality degradation, as perceived by wholesalers .......... 105
Figure 53. Observations of water quality degradation by wholesalers ................. 106
Figure 54. Causes of water quality degradation, as perceived by wholesalers ......... 107
Figure 55. Wholesale contingent adaptation strategies ........................................ 108
Figure 56. Gear and activity types offered by recreational water operators ............ 111
Figure 57. Recreational water operator launch points .......................................... 112
Figure 58. Current operating areas for rec. water ops. by participant count ............ 113
Figure 59. Current operating areas for rec. water ops by trips per year .................. 114
Figure 60. Current operating areas for rec. water ops. by gear rentals per day ........ 115
Figure 61. Historic recreational water operating grounds by participant count ....... 116
Figure 62. Average per trip costs for rec. water ops. that used vessels .................. 117
Figure 63. Average per trip costs for rec. water ops. that didn’t use vessels .......... 118
Figure 64. Current water quality condition, as perceived by rec. water ops .......... 119
Figure 65. Changes in water quality condition, as perceived by rec. water ops ....... 120
Figure 66. Observations of water quality improvements by rec. water ops .......... 121
Figure 67. Types of water quality degradation, as perceived by rec. water ops ....... 122
Figure 68. Observations of water quality degradation by rec. water ops ............ 122
Figure 69. Causes of water quality degradation, as perceived by rec. water ops .... 123
Figure 70. Rec. water ops. contingent adaptation strategies .................................. 124
Figure 71. Perceived change in water quality condition by industry ..................... 127
Figure 72. Types of water quality degradation identified by industry .................... 127
Figure 73. Causes of water quality degradation identified by industry ................. 128
Figure 74. Changes in water quality condition as perceived by tenure. ...................... 130
Figure 75. Types of water quality degradation as identified by tenure ...................... 130
Figure 76. Causes of water quality degradation by tenure..................................... 131
Figure 77. Contingent adaptation strategies by industry ......................................... 132
LIST OF TABLES

Table 1. Description of FWC Licenses .......................................................... 8
Table 2. Breakdown of provided email addresses by sector ......................... 21
Table 3. Boundaries of fishing regions used in online surveys ..................... 34
Table 4. Number of in-person interviews completed by pre-determined sector.... 47
Table 5. Percent interviews that fit into each re-classified industry ............... 47
Table 6. Age of recreational fishing respondents ........................................ 51
Table 7. Gender of recreational fishing respondents ................................... 52
Table 8. Race of recreational fishing respondents ...................................... 52
Table 9. Recreational fishing respondent experience .................................. 56
Table 10. Recreational fishing primary gear types ....................................... 56
Table 11. Recreational fishing launch regions ............................................. 57
Table 12. Recreational fishing popular species groups fished in combination .... 58
Table 13. Recreational fishing regions fished ............................................. 61
Table 14. Recreational fishing number of boats owned ............................... 62
Table 15. Average trip costs for recreational fishers .................................... 62
Table 16. Sources of water quality degradation, as perceived by recreational fishers 64
Table 17. Areas of water quality concern, as perceived by recreational fishers .... 67
Table 18. Recreational fishing contingent adaptation alternate regions ........... 68
Table 19. Age of for-hire fishing participants ............................................. 69
Table 20. Gender of for-hire fishing participants ........................................ 69
Table 21. Race of for-hire fishing participants .......................................... 69
Table 22. Home zip codes for for-hire fishers ........................................... 70
Table 23. For-hire fishing experience ....................................................... 70
Table 24. For-hire fishing gear types................................................................. 71
Table 25. Average per trip costs for for-hire fishers........................................ 76
Table 26. Age of commercial fishing participants........................................... 82
Table 27. Gender of commercial fishing participants..................................... 82
Table 28. Race of commercial fishing participants......................................... 83
Table 29. Commercial fishing zip codes......................................................... 83
Table 30. Commercial fishing experience ....................................................... 84
Table 31. Commercial fishing gear types....................................................... 84
Table 32. Seafood product sales in the commercial fishing industry ................. 90
Table 33. Average per trip costs for commercial fishers.................................. 92
Table 34. Age of seafood wholesale participants.......................................... 98
Table 35. Gender of seafood wholesale participants..................................... 98
Table 36. Race of seafood wholesale participants......................................... 98
Table 37. Home zip codes for seafood wholesalers....................................... 99
Table 38. Seafood wholesale experience in Miami-Dade County...................... 99
Table 39. Wholesale customer base.................................................................. 102
Table 40. Recreational water operator age .................................................... 108
Table 41. Recreational water operator gender............................................... 108
Table 42. Recreational water operator race .................................................... 109
Table 43. Recreational water operator zip codes............................................ 109
Table 44. Recreational water operator experience........................................ 110
Table 45. Types of services offered by recreational water operators ................. 111
Table 46. Average per trip costs for rec. water ops. that used vessels............... 117
Table 47. Average per trip costs for rec. water ops. that didn’t use vessels......... 117
Table 48. Average rec. water ops. gear value............................................... 118
Chapter 1

Introduction
Biscayne Bay is a shallow estuarine lagoon encompassing over 1,110 km$^2$ (Buck 2017) and stretching the entire length of the Greater Miami Area. As the most prominent feature in Miami-Dade County’s landscape, Biscayne Bay is of critical ecological and economic importance to the region (Hazen and Sawyer 2005). Coral reefs and mangroves along the shoreline provide critical nursery habitat to many important commercial and recreational marine species (Ault et al. 2001), as well as opportunities for scuba and snorkel operations.

### 1.1 Biscayne Bay Geography and Ecology

Biscayne Bay formed along Southeastern Florida’s coast between 5,000 and 2,000 years ago; as the sea level rose, water filled the limestone depression between two ridges (Cantillo et al. 2000; Florida DEP 2012a). It now lies between the Miami shoreline and barrier islands (Milano 2000), stretching from Oleta River State Park to the southern reaches of Barnes Sound (Hazen and Sawyer 2005; Figure 1).

The bay is home to a wide variety of ecologically and commercially important coastal and marine species. Diverse ecosystems support both Atlantic and Caribbean species, providing for rich fisheries. Coastal mangrove communities serve as nurseries for reef fish, rookeries for seabirds, and critical habitat for Florida manatees (NPS 2015). Patch reefs and seagrass beds bridge mangrove marshes, barrier islands, and the Florida Reef Tract. Shallow coastal bays provide ideal habitat for sport fish, including bonefish, tarpon, and snook, while patch reefs support commercial species such as muttons, groupers, snappers, and grunts (Ault et al. 2001). Numerous threatened and endangered species, including the American crocodile, smalltooth sawfish, five species of sea turtle, and seven
species of stony coral depend on the bay for nursery, spawning, colonization, nesting, and/or hunting grounds (NPS 2015).

![Geographic extent of Biscayne Bay](image)

Figure 1. Geographic extent of Biscayne Bay.

1.2 Economic Sectors

As Miami-Dade’s central environmental feature, Biscayne Bay contributes significantly to the county’s economy. While some industries, such as shipping, are water quality-independent, other sectors depend directly on healthy ecosystems. Commercial, recreational, and for-hire fishing industries, as well as seafood wholesale and recreational water operations, are of special interest because these sectors are immediately economically and spatially linked to regional water quality. Commercial and for-hire
fishers and recreational water operators spend most of their time on the water, and their livelihoods depend directly on catching edible fish and/or attracting customers to engage in recreational water-based activities. Fishing and recreational businesses should take note of water quality concerns for the safety and longevity of their operations. Consequently, seafood retailers and wholesalers may have secondhand knowledge regarding Biscayne Bay water quality conditions, as they source directly from local fishers. While recreational fishers likely do not depend on the bay as a source of livelihood, their behavior is largely influenced by fishing success (Freeman 1995), and abundant fish populations are reliant on healthy ecosystems. Thus, their economic contributions to the regional economy in terms of space and time are affected by water quality conditions.

In 2005, the South Florida Water Management District commissioned an assessment of Biscayne Bay’s contribution to the regional economy from the consulting group Hazen and Sawyer. The study determined the value of recreational activities, commercial fishing, commercial shipping, and cruise ship operations. The Biscayne Bay Economic and Spatial Study was designed to update the research conducted by Hazen and Sawyer and to collect detailed socioeconomic and geographic information from industries directly tied to water quality.

1.2.1 Commercial Fishing

According to the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA, as amended in 2007), “the term ‘commercial fishing’ means fishing in which the fish harvested, either in whole or in part, are intended to enter commerce or enter commerce through sale, barter or trade” (MSFCMA 2007). The Florida Wildlife Conservation Commission (FWC) monitors and enforces all fisheries laws and regulations
in the state, including gear restrictions, seasonal and area closures, size limits, and other species protections. The FWC requires any individual, crew, or vessel wishing to harvest and sell commercial quantities of saltwater products to possess a Saltwater Products License (SPL). SPL holders may sell products to other SPL holders and to licensed wholesale dealers (myfwc.com; Table 1).

Commercially targeted species in the Miami area include spiny lobster, pink and bait shrimp, amberjack, ballyhoo, and yellowtail snapper (FWC Commercial Landings Summary). In 2014, 21,408,000 pounds of fish were harvested commercially off Florida’s East Coast, grossing $52,302,000 (NMFS 2014). Miami area landings in 2014 totaled 2,503,294 pounds and had an estimated value of $12,562,492 (FWC Commercial Landings Summary). This indicates that Miami area landings composed just over 8.5% of Florida’s East Coast commercial tonnage that year.

The most recent regional economic study reported that in 2002, commercial fishing in Miami-Dade County contributed $28,336,000 in gross output and $17,404,000 in income, each at 0.03% of the county’s total. The industry provided residents with 469 jobs, 0.04% of the county’s total (Hazen and Sawyer 2005).

1.2.2 Recreational and For-Hire Fishing

The MSFCMA defines "recreational fishing" as “fishing for sport or pleasure” (MSFCMA 2007). Fishers may engage in recreational fishing from shore or from a boat, which may be privately owned, rented, or hired. The FWC requires all recreational fishers over the age of 16 and under the age of 65 to possess a Recreational Saltwater License (Table 1). Additional permits are also required to fish certain species, such as tarpon and spiny lobster (myfwc.com). In Miami, recreational species targeted include lobster, shrimp,
stone crab, groupers, mackerels, drums, and snappers (FWC 2016). The most recently recreational trip statistics report that in 2014, 3,523,000 out-of-state anglers and 2,984,000 in-state anglers took 24,823,000 recreational fishing trips (NMFS 2014).

For-hire fishing, defined as “fishing from a vessel carrying a passenger for hire…who is engaged in recreational fishing” (MSFCMA 2007) composes a subset of recreational fishing activity. The FWC requires all for-hire fishing operations to possess either a Charter Captain or Boat License (Table 1). A charter license permits customers to take and possess saltwater organisms without a Recreational Saltwater License (myfwc.com). In the Biscayne Bay region, specialized for-hire captains take clients to coastal flats, where they can target bonefish, tarpon, and snook. Deep-sea charters may target offshore species outside of the bay, such as sailfish and billfish.

While for-hire fishing is recognized as a significant component of Southeast Florida’s economy, recent regional economic studies have not isolated for-hire fishing from recreational fishing for analysis. The 2005 report by Hazen and Sawyer reported that in 2004, residents and visitors spent nearly $548 million on recreational fishing, including chartered trips (Hazen and Sawyer 2005).

1.2.3 Seafood Wholesale and Retail

Seafood wholesalers play a major role in the seafood supply chain. In Florida, licensed commercial fishers (i.e. those who possess an SPL) may only sell their catch to other SPL holders and licensed wholesale dealers. Wholesale dealers may then sell to other licensed wholesale dealers or to licensed restaurants. To purchase from wholesale dealers and sell directly to the public, businesses must possess a Retail Saltwater Products Dealer License (Table 1). Seafood processing, defined by the Florida Department of Agriculture
and Consumer Services (DOACS) as “[processing] of…saltwater finfish [and]…other forms of aquatic where such animal life is intended for human consumption, primarily for wholesale distribution” requires acquisition of additional permits from the DOACS.

At the wholesale dealer and retail level, quality of product is key. Wholesale dealers and retailers must not only ensure they are purchasing safe products, but also that they maintain product safety via appropriate controls (e.g. storage conditions). They are subject to inspection and regulatory enforcement by the Food and Drug Administration (FDA) under the Food, Drug and Cosmetic Act; the Public Health Act; and other related regulations (U.S. Food and Drug Administration). Under the Food Code, the FDA also provides guidance to state and local agencies with jurisdiction over food retail, vending, and service operations (Procedures for the Safe and Sanitary Processing and Importing of Fish and Fishery Products 1995). Adherence to the FDA’s strict regulatory code is critical to the prevention of food borne illness; thus, wholesale dealers must be aware of pertinent environmental conditions that may affect the quality and safety of their product, such as toxic cyanobacterial blooms (U.S. EPA).

In 2014, the state of Florida reported 46 processing plants and 313 wholesale plants, providing 4,010 total jobs (NMFS 2014). Exact figures for the economic value of this sector to Miami-Dade’s economy have not been reported, nor have wholesale dealers been tapped as a source of knowledge regarding Biscayne Bay water quality.
Table 1. Description of FWC Licenses required for recreational, commercial, and for-hire fishing, as well as for seafood wholesale. Information available at myfwc.com.

<table>
<thead>
<tr>
<th>LICENSE TYPE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Commercial Saltwater Products Licenses</strong></td>
<td>• Saltwater product – “any marine fish, shellfish, clam, invertebrate, sponge, jellyfish, coral, crustacean, lobster, crab, shrimp, snail, marine plant, echinoderm, sea star, brittle star or urchin, etc.; except non-living shells and salted, cured, canned or smoked seafood.”&lt;br&gt;• “…must have the SPL to commercially harvest and sell saltwater products.”&lt;br&gt;• “…may sell only to a licensed Florida wholesale dealer.”&lt;br&gt;• “…may be issued in the name of an individual or a valid commercial vessel registration number issued in the name of the license applicant. Any vessel used to harvest commercial quantities of saltwater products must have a commercial vessel registration.”</td>
</tr>
<tr>
<td><strong>Recreational Saltwater Licenses</strong></td>
<td>• “…required for residents and nonresidents to take or attempt to take saltwater fish, crabs, clams, marine plants or other saltwater organisms (other than non-living seashells and lionfish with certain gear).”&lt;br&gt;• “…required to land saltwater species in Florida regardless of where they are caught (state or federal waters).”</td>
</tr>
<tr>
<td><strong>Charter and Headboat Operators’ and Guides’ Licenses</strong></td>
<td>• Charter Captain or Boat License “is required to carry paying customers (where a fee is paid directly or indirectly) for the purpose of taking, attempting to take, or possessing saltwater fish or organisms.”&lt;br&gt;• “Customers authorized to fish under the vessel license are not required to hold a recreational saltwater fishing license.”</td>
</tr>
<tr>
<td><strong>Saltwater Wholesale Dealer Licenses</strong></td>
<td>• “…required to purchase saltwater products from persons holding an SPL or another licensed from other licensed wholesale dealer and to sell saltwater products to any licensed wholesale dealer, retail dealer or restaurant.”</td>
</tr>
</tbody>
</table>
1.2.4 Recreational Water Operations

Recreational water operations are directly tied to water quality, as businesses such as SCUBA, snorkel, and kayak tours depend on swimmable waters and healthy ecosystems to attract customers. These businesses are also large contributors to the Miami-Dade economy. In 2004, visitors and residents spent 65.5 total million person-days participating in recreational activities related to Biscayne Bay. Recreational activities, including recreational fishing, provided $3,789,000,000 in gross output and $2,112,000,000 in income to Miami-Dade County, accounting for 4.44% and 3.40% of the County’s total, respectively. Additionally, the recreational sector pertaining to Biscayne Bay provided 57,100 jobs in Miami-Dade County, representing 4.42% of employment in the County (Hazen and Sawyer 2005).

The most popular activities, as identified by visitors and residents, included viewing the bay while dining, shopping, jogging, and strolling (25% of person-days); swimming from shore (17%); fishing from a boat (13%); and sailing (9%). While the number of recreational person-days spent in Biscayne Bay plummeted in the early 1990’s due to the severe impacts of Hurricane Andrew, historical person-days show a strong increasing trend since the 1980’s (Hazen and Sawyer 2005). Meanwhile, visitation rates to Biscayne National Park, Oleta River State Park, the Barnacle Historic Park, and Bill Baggs Cape Florida State Park remained largely the same, hovering just above 1.5 million visitors per year in 2003 and 2013, grossing $3.8 billion and $4.6 billion respectively (Youngquist 2013).
1.3 Water Quality

Despite Biscayne Bay’s significant contribution to the regional economy, previous developments and current activities alike continue to deteriorate water quality and threaten fragile ecosystems.

1.3.1 Historic Water Quality Regimes

The bay is traditionally divided into three segments (Corcoran et al. 1984): north, central, and south. The northern portion of the bay (Figure 2) lies adjacent to the Miami metropolitan area, extending from Dumfoundling Bay and Oleta River State Park to the Rickenbacker Causeway (Caccia and Boyer 2005).

Figure 2. Northern Biscayne Bay.
Oleta River, Arch Creek, Biscayne Canal, Little River, Miami River drain into the northern bay. Estuarine before the construction of Haulover Cut (Cantillo et al. 2000), this region has been the most heavily impacted by urban development. It covers 10% of total bay area and contains numerous islands, of which only Belle Isle and Virginia Key are natural. Approximately 40% of northern Biscayne Bay has been dredged or filled; most of the region now lacks benthic vegetation, and its shoreline mangroves have been replaced by seawalls (DERM 1981; Cantillo et al. 2000). The region has been historically marked by high turbidity, phytoplankton biomass, high total phosphorus, and low dissolved oxygen, all the effects of canal runoff, the Munisiport Landfill, and urban landscape (Caccia and Boyer 2005).

Central Biscayne Bay reaches from the Rickenbacker Causeway to Featherbed Bank (Figure 3). This region is characterized by higher rates of exchange with the open ocean, higher circulation, and lower residence times. These factors are largely due to the absence of barrier islands in the central bay, which enables improved water quality conditions, as harmful pollutants are more quickly dispersed (Caccia and Boyer 2005). Inshore central bay is still impacted by freshwater canal inflows from Coral Gables Waterway, Snapper Creek, Cutler Drain (Cantillo et al. 2000), which provide influxes of nitrogen and phosphorus, leading to phytoplankton blooms and regional seagrass declines (Lirman et al. 2016). The region’s mangrove wetlands remain largely intact, and soft corals and sponges can be found in the southernmost parts of central Biscayne Bay. Seagrasses dominate the benthic vegetation but are lost in the center of bay. Chicken Key and Soldier Key are the only natural islands in the region (Cantillo et al. 2000).
Figure 3. Central Biscayne Bay.

Southern Biscayne Bay (Figure 4) starts at Featherbed Bank and ends at the US 1 Bridge to Key Largo (Caccia and Boyer 2005; Corcoran et al. 1984; Hazen and Sawyer 2005). This extent is plagued by nitrate-heavy runoff from agricultural fields; ammonium pollution from Black Point Landfill and Sewage Treatment Plant; and fuel, chemical runoff, and heavy metal contamination from Homestead Air Force Base (Caccia and Boyer 2005). Additionally, Florida Power and Light’s (FPL) Turkey Point Nuclear Power Plant has posed a threat to water quality in the southern bay since its activation in 1968 (Dolan 2012).
1.3.2 Causes for Immediate Concern

Human activities have been affecting water quality in Biscayne Bay since European colonists drained the swampy South Florida landscape (Kruczynski and Fletcher 2012, pp. 5-7). While there have been many documented changes in the ecology of the region, recent events, such as extensive algal blooms, accelerating seagrass die-offs, and contamination events, indicate that water quality conditions are rapidly declining in certain regions of the bay. These events result in habitat loss for fish species and other local fauna, as well as threats to human health.
The Miami-Dade Department of Environmental Resource Management (DERM) began monitoring seagrass health and water quality in 1985. Prior to 2005, DERM reported zero algal blooms and only one seagrass die-off event. Since 2005, DERM has reported four major events: (1) a phytoplankton bloom and coinciding seagrass die-off in the southern basins, (2) a macroalgal bloom and subsequent seagrass die-off in the north central inshore region, (3) a phytoplankton/diatom bloom in the southern bay, and (4) an ongoing seagrass loss event in the northern bay (Avila et al. 2017).

In 2005, a phytoplankton bloom formed in the southern basins and persisted through 2007. The bloom was linked to periods of drought and hypersalinity followed by Hurricane Katrina, which resulted in a massive freshwater/nutrient discharge and rapid decrease in salinity. The southern basins lost approximately 49% of pre-bloom seagrass coverage, and seagrass community composition shifted in some areas from Halodule-dominated to Thalassia-dominated (Avila et al. 2017). Also in 2005, an Anodyomene bloom developed in the north central inshore region. This macroalgal bloom persists today and has resulted in a 76.40% loss in seagrass cover. It has been linked to excess inputs of anthropogenic sources of nitrogen, such as sewage leaks, in the region (Avila et al. 2017).

A phytoplankton/diatom bloom developed along the inshore and southern bay regions in 2013. High rates of discharge and associated nutrient and salinity patterns have been proposed as possible explanations for the bloom (Avila et al. 2017). Also in 2013, losses of Syringodium were noted in the Julia Tuttle Basin in northern Biscayne Bay. This decline in seagrass cover has continued to accelerate and has resulted in increased turbidity due to loose sediments, as well as loss of fish habitat (Buck 2017). While exact causes for this seagrass die-off have not been identified (Avila et al. 2017), potential explanations
include persistent eutrophication (Millette 2017) and disturbance from Port Miami expansion activities (Stevenson 2017).

Algal blooms and subsequent seagrass die-offs are not only detrimental to local ecology, they are also potential responses to and causes of serious environmental threats with human health implications. Northern Biscayne Bay is a phosphorus-limited system that has demonstrated consistently increasing levels of chlorophyll $a$, an indicator of eutrophication (Millette 2017). Potential sources of excess phosphorus in the region include untreated and partially-treated wastewater discharge (Environmental Protection Agency 2017). Northern Biscayne Bay has experienced significant discharges of partially-treated wastewater in recent years due to leakages, heavy rainfall events, and storm surges. In 2015, five million gallons of partially-treated wastewater were discharged into the Oleta River region, contaminating water sources used for fishing, swimming, and drinking (Staletovich 2015). In July 2017, Miami Waterkeeper exposed a sewage leak off Key Biscayne, which county officials had failed to repair for close to a year. The discharge included fecal coliform, phosphorus, and bacteria found in feces (Staletovich 2017). These discharges are not only potential sources of excess phosphorus for algal blooms, but also of bacteria harmful to humans using contaminated water sources for fishing, swimming, and drinking (Environmental Protection Agency 2017).

The bioaccumulation of beta-N-methylamino-L-alanine (BMAA), a neurotoxin linked to neurodegenerative diseases such as Alzheimer’s Disease and Parkinson’s Disease, is an additional human health concern pertaining to algal blooms in Biscayne Bay. Both laboratory and environmental studies have demonstrated that nearly all species of cyanobacteria produce BMAA as secondary metabolites (Cox et al. 2005; Metcalf et al.
BMAA has the potential to dramatically bioaccumulate in food webs, as demonstrated by a 50-fold biomagnification of total BMAA in the cyanobacteria-cycad-fruit bat bioaccumulation in Guam (Cox et al. 2003; Banack and Cox 2003; Murch et al. 2004a,b; and Banack et al. 2006). Recent studies detected variable levels of BMAA in specimens from southern Biscayne Bay, including pink shrimp and blue crabs, which are consumed by humans. Some specimens contained nearly 7000 ug/g BMAA, “a concentration associated with a potential long-term human health hazard” (Brand et al. 2010). Clearly, water quality, especially indicators related to harmful algal blooms, is of great concern to the ecological, human, and economic health of the Biscayne Bay Region.

1.4 Stakeholder Perceptions and Participatory Mapping

To effectively manage water quality in Biscayne Bay, it is critical to understand how stakeholders perceive historic and current water quality conditions. Stakeholder perceptions are useful in establishing baselines of environmental and socioeconomic conditions. Perceptions can be continuously evaluated to determine if baseline perceptions are shifting. Stakeholder perceptions can also be used to help environmental managers develop monitoring regimes, as well as to interpret and communicate results in meaningful ways. Effective communication can provide opportunities for stakeholders to help improve the quality of environmental management and governance (Bennett 2016).

Data availability is one of the major limiting factors in characterizing spatial resource use and understanding possible spatial adaptations to environmental degradation. In the United States, as well as in many other countries, spatial data for commercial fisheries is collected via logbooks and electronic monitoring systems, but this information
is typically only shared with government agencies. Comparable datasets are not collected for recreational or for-hire fisheries (Beaudreau and Whitney 2016), nor are they accumulated for recreational water operations. For this reason, recent analyses used Volunteered Geographic Information (VGI), i.e. information provided via the Internet by users who are not experts in geographic information systems (GIS). A recent study by Cui and Mahoney (2015) used an online survey with integrated Google Maps-based spatial questions to determine recreational boater movements on the water in Florida. Participatory mapping is another approach to obtaining detailed spatial data from fishers and recreational water operators. Beaudreau and Whitney (2016) used participatory mapping via in-person interviews with fishers to document changes in fishing space and intensity from 1950-2010 in Puget Sound. While detailed catch per unit effort (CPUE) maps are preferable for spatial analyses, Internet VGI and in-person participatory mapping can be used to accumulate detailed spatial use data and describe industry flexibility.

1.5 Purpose and Objectives

Water quality in Biscayne Bay is degraded by numerous sources, including nutrient loading from agricultural activities; pollution from Turkey Point, landfills, and Homestead Air Force Base (Caccia and Boyer 2005); and dredge and fill activities associated with coastal development and port expansion (Silverstein 2015). Events such as harmful algal blooms and seagrass die-offs serve as immediate indicators of water quality deterioration (Lirman et al. 2016). Other factors, such as increasing nutrient levels (Caccia and Boyer 2005), are gradual and continuous; while these threats are not as directly perceivable, they result in steady habitat loss for economically and ecologically critical species. South Florida, especially Miami-Dade County, is dependent on a healthy Biscayne Bay for
commercial fishing and recreation conducted by both residents and tourists (Hazen and Sawyer 2005).

The purpose of this study was to characterize those industries dependent on Biscayne Bay water quality, specifically commercial, recreational, and for-hire fisheries, as well as seafood wholesalers that source from the bay and recreational businesses that depend directly upon a healthy bay, such as SCUBA and snorkel operators.

To ensure industries dependent on Biscayne Bay are adequately protected, it is necessary to understand and identify the economic risks associated with water quality degradation, the specific locations where water quality is affecting local businesses, and industry strategies to adapt to degrading water quality. Thus, the specific objectives of this research were to:

1. Construct socioeconomic and resource use profiles of the focus industries,

2. To describe current water quality conditions and changes in water quality as perceived by industry stakeholders,

3. And to describe stakeholder adaptation strategies in the face of changing water quality conditions.
Chapter 2

Methods
2.1. **Data Collection**

Institutional Review Board (IRB) approval for this study was obtained in June 2017. Data collection consisted of two components: online surveys and in-person interviews, which ran from June 2017 through September 2017. Participants were selected from the commercial, for-hire, and recreational fishing sectors, as well as from the seafood wholesale and recreational water operation industries in the Biscayne Bay region. Interviewers were selected from a pool of qualified graduate students studying marine policy and were thoroughly trained in interview techniques.

2.1.1 **Online Survey Distribution**

Online surveys were sent to recreational fishers, commercial fishers, for-hire fishers, and seafood wholesalers via Qualtrics, an online survey platform. Participants were identified via the Florida Fish and Wildlife Conservation Commission (FWC) public records license database, accessed in June 2017 via an online request for public records. Survey participants met the following conditions: (1) Held a current Recreational Saltwater Fishing License (RLS), Charter captain or headboat license, Saltwater Products License (SPL), and/or Wholesale Dealer License (WD); (2) Provided an address in Miami-Dade County; and (3) Voluntarily included an email address in their license application.

For RLS’s, SPL’s, and WD’s, all records for each license type were downloaded from the FWC license database in separate comma separated value (.csv) files and imported into the statistics package R. R was used to extract only those licenses held in Miami-Dade County. Microsoft Office Excel was then used to extract only those records with email addresses and to remove records with duplicate email addresses to ensure equal contact amongst fishers. The databases contained many duplicates, as fishers may register for
multiple permit types (e.g. many recreational fishers obtain a Saltwater Fishing RLS, a Lobster Permit, and a Snook Permit). For for-hire fishing licenses, the entire FWC list of all Florida freshwater and saltwater fish and game licenses was downloaded. R was used to extract those in Miami-Dade, and Microsoft Office Excel was used to select Charter Captain and Charter Boat licenses with email addresses and to remove duplicate email addresses. See Table 2 for full breakdown of licenses.

Table 2. Breakdown of provided email addresses by sector. The “After Duplicate Emails Removed” column indicates the final lists imported into the Qualtrics database for survey distribution. The “% of Total” column refers to the percent of the individuals registered for each license type in Miami-Dade that were included in the final contact list for each license type.

<table>
<thead>
<tr>
<th>License Type</th>
<th>In Miami-Dade</th>
<th>With Email</th>
<th>After Duplicate Emails Removed</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>RLS</td>
<td>133,457</td>
<td>82,832</td>
<td>43,540</td>
<td>54.6%</td>
</tr>
<tr>
<td>SPL</td>
<td>1,437</td>
<td>1,282</td>
<td>308</td>
<td>74.8%</td>
</tr>
<tr>
<td>WD</td>
<td>157</td>
<td>153</td>
<td>151</td>
<td>96.8%</td>
</tr>
<tr>
<td>For-Hire</td>
<td>193</td>
<td>83</td>
<td>38</td>
<td>43.2%</td>
</tr>
</tbody>
</table>

Once duplicate email addresses were removed from the recreational fishing sector, contacts were imported into Qualtrics as the recreational fishing contact list, providing for 43,540 contacts for recreational fishers (54.6% of the total Miami-Dade recreational fishing population registered with the FWC). The SPL list contained 308 contacts (74.8% of individuals who obtained Saltwater Products Licenses in Miami-Dade), the WD list contained 151 contacts (96.8% of individuals who obtained Wholesale Dealer Licenses in Miami-Dade), and the For-Hire list contained 38 contacts (43.2% of individuals who obtained Charter Boat and/or Charter Captain Licenses in Miami-Dade) after duplicates were removed. The SPL, WD, and For-Hire lists were combined (497 total records), and duplicates were once again removed, providing for 470 contacts for the commercial fishing, for-hire fishing, and seafood wholesale sectors. These contacts were imported into
Qualtrics as the SPL/WD/For-Hire contact list. Qualtrics immediately rejected any email addresses that did not adhere to email address format, providing for final lists of 43,534 RLS and 468 SPL/WD/For-Hire.

Surveys were largely the same for all license types, but questions were tailored for each sector (see Appendix 2 for full survey templates). Online surveys served as a census sample of recreational fishers and as attempted census samples for commercial fishers, for-hire operations, and seafood wholesalers. As very few responses were recorded for commercial fishers, for-hire operations, and seafood wholesalers, the online survey was instead used as a first point of contact.

Online survey distribution was initiated via emails to participants containing a letter of consent, which serves to provide information about the study and to list participant rights (Appendix 1). The FWC licensing database included license holders as young as 16 years-old, but surveys were only to be administered to participants 18 years or older. The first survey question asked for the survey respondent’s age. If a respondent selected “Under 18,” the survey was automatically terminated. If a participant selected any age range above 18, he/she was directed to the full survey.

The survey was translated into Spanish and allowed respondents to answer in their language of choice. A random sample of 4,353 (10.0% of total) email addresses for Recreational Saltwater Fishing License holders was selected for a pilot study. The recreational fishing community was by far the largest sector sampled. As the survey template was extremely similar between sectors, the recreational pilot study was used to suggest any potential adjustments to the survey instrument before distribution to the full recreational sample, as well as to the for-hire, commercial, and wholesale industries. The
The final survey was sent to all recreational email addresses that met all criteria listed above and were not selected for the pilot study, as well as all SPL/WD/For-Hire email addresses. A request for contact information (name, phone number, email) preceded the SPL/WD/For-Hire online survey. After submitting contact information (used to contact participants for in-person interviews) or skipping this section, respondents were re-directed to the online survey. All online survey responses were anonymous, so SPL/WD/For-Hire contact information was not linked to responses recorded for the survey.

The pilot study was distributed in late June. After three weeks, responses rates and comments were analyzed to determine if adjustments should be made for the full sample distribution. One adjustment was made: the addition of “private dock” as a response option with respect to where respondents launch their boats (responses were previously limited to “marina” or “boat ramp”). The final survey was distributed in early July. All surveys were closed in early September, eleven weeks after pilot survey distribution and eight weeks after full survey distribution. Surveys were left open through early September to allow responses to continue to record for the entire duration of the interview portion of the study, as data collection for all study components was not scheduled to begin until mid-September. Distribution followed a modified email survey procedure as established by Dillman et al. (2014). For both the pilot sample and the full sample, reminder emails were sent one week after the initial survey link was distributed, and reminder emails were sent one week before the study closed. Unfortunately, the final reminder email for the full distribution failed due to licensing permission complications. However, due to the threat posed by Hurricane Irma, both studies were closed on September 4th. Figure 5 and Figure
6 display survey responses by date with respect to reminder emails for the pilot study and full distribution respectively.

Figure 5. Online survey pilot responses by date. The survey was initially distributed on June 19th, 2017. Reminder emails were distributed on June 26th, one week after initial distribution. A final reminder was sent August 31st, approximately one week before the survey was closed on September 4th.

Figure 6. Online survey responses by date (full distribution). The survey was initially distributed on June 19th, 2017. Reminder emails were distributed on June 26th, one week after initial distribution. A final reminder was scheduled to send on August 31st, approximately one week before the survey was closed on September 4th, but failed due to licensing permission complications.
Qualtrics saves incomplete responses, allowing respondents to start and complete surveys at different times. A two-week duration was set so that partial responses were recorded after this period. On September 4th, when all surveys were closed, all partial responses were immediately recorded.

2.1.2 **In-Person Interview Samples and Protocol**

In-person, semi-structured interviews were conducted for for-hire fishing operations, seafood wholesalers, and recreational water operations (such as SCUBA, snorkel, kayak, and stand up paddleboard tour and/or gear rental companies). All individuals in these industries that met the study criteria (as detailed below) were interviewed. Key informants in the commercial fishing sector were identified and interviewed.

2.1.2.1 **For-Hire Fishing Operations**

Previous studies conducted with the county’s for-hire fishing operations (Shivlani and Villanueva 2007; Brinson et al. 2006) identified as many as 120 for-hire fishing operations. The FWC license database listed 88 unique for-hire captain and/or headboat licenses in Miami-Dade County. However, this study was only concerned with operations that relied on the bay and surrounding waters as a significant source of income, that took trips frequently (to be able to identify short and medium- to long-term trends in water quality), and that had a financial stake in the region’s marine resources.

This study used a series of criteria to identify for-hire fishing operations that utilized Biscayne Bay. First, an operation needed to have a physical presence on the waterfront (i.e. at one or more major marinas in Miami-Dade County). If an operation did not have a physical presence on the waterfront, it must have used physical advertisements to identify it as a for-hire fishing businesses (e.g. via business cards at bait shops and/or marinas).
Finally, operations had to rely on the bay and adjacent areas as a primary source of income, as determined by tenure in the region and the frequency of trips taken per year. Together, these criteria ensured that only those operations that consistently utilized Biscayne Bay were considered for the study.

A combination of online research and ground-truthing identified 31 for-hire fishing operations. However, even through a combination of site visits, phone calls, and emails, 11 of the 31 identified operations could not be located and/or reached. The effective population of for-hire operations that depended on Biscayne Bay comprised 20 operations, and all were interviewed from July-September 2017 using an in-person questionnaire (see Appendix 3) as part of a census survey effort.

2.1.2.2 Seafood Wholesalers and Bait Retailers

Previous efforts working with seafood wholesalers and/or bait retailers (bait shops) in Miami-Dade County (Shivlani and Estevanez 2011; EDAW 2006) used a key informant approach and thus did not determine effective totals for seafood wholesalers and/or bait shops in the county. Hazen and Sawyer (2005) identified 215 bait and seafood wholesale and retail businesses in the Miami River and Biscayne Bay subareas of Miami-Dade County using Standard Industrial Classification (SIC) codes and spatial location information. While these approaches helped characterize stakeholders and/or quantify the potential population in the industry, none of the previous studies could accurately determine the effective population and characteristics of those bait and seafood wholesale and retail locations that specifically relied on Biscayne Bay.

The FWC license database listed 156 unique wholesale dealers in Miami-Dade County. This study used a series of criteria to identify those firms that were specifically
dependent on bay-caught species. Businesses needed to rely on bay-caught species, have a physical presence (in the case of bait or retail shops), and sell seafood products on a consistent (year-round) basis. These criteria ensured that only those firms with (a) a full-time stake in and (b) knowledgeable about the fishery (and, thus, bay conditions) were included in the sample population.

Using this approach, 98 of the 156 firms were confirmed to have online presences, but only 41 met the established criteria for inclusion in the study. Out of the 41 businesses identified, 14 could not be located or did not respond to email and telephone efforts to reach them. The effective population of wholesalers and retail bait shops was set at 27 businesses, and all were interviewed between June and September 2017 as part of a census survey effort.

2.1.2.3 Recreational Water Operators

This study defines “recreational water operations” as operations that have fee-for-service systems in place to support activities on and/or in the water, including diving, snorkeling, kayaking, canoeing, stand up paddleboarding, and surfing. Rental and/or tour operators providing support for powerboats, personal watercraft, jet skis, and other activities that do not directly relate to natural resource appreciation and environmental conditions were not considered. It is common practice to separate recreational users into groups based on their level of contact with the water, as the relative importance of water quality varies between user groups (Koteen et al. 2002; Breen et al. 2017). This is not to suggest that rental operators or guides outside of the established sample could not provide useful information on water quality conditions, but this study chose to focus only on those operations that involved more of a “hands on” approach.
There was no master list of recreational water operators available for Miami-Dade County. Previous studies (Shivlani and Villanueva 2007; Fedler 2017) interviewed dive operators in Miami-Dade and all of Florida, respectively. However, no estimate of the number of water-quality dependent operators exists for Miami-Dade County. Therefore, this study used a series of criteria to bound the sample population. First, operators needed to have a physical presence (e.g. a storefront or gear rental location). Second, operators had to consistently offer trips in Biscayne Bay. This criterion eliminated operations based on an on-demand system and those that operated primarily outside the bay, thereby narrowing the sample to operations that demonstrated a dependency on the bay and its resources. Finally, the activity or activities offered had to involve the operators themselves, such that the operators could remark on the quality of the bay, its resources, and water quality.

Using this approach, 57 operators were identified via initial online research. A total of 47 operators met the established criteria for inclusion in the study. Out of the 47 operators identified, 17 could not be located and did not respond to calls or emails requesting participation. The effective population of recreational water operators comprised 30 operators, who were all interviewed between June and September 2017 as part of a census survey effort.

2.1.2.4 Commercial Fishers

The FWC Saltwater Products License database listed 412 unique license holders. However, commercial fishers in Miami-Dade County did not have an online presence and were difficult to locate at docks and marinas. Thus, this study used a key informant approach that incorporated snowball sampling (i.e. respondent identification of other potential participants) to identify and interview 21 total commercial fishers. The sample
commercial fishing population for this study was identified via site visits and personal referrals.

All major marinas that allowed commercial fishing vessels were visited to identify any present commercial operations. Once physical presence was confirmed, slips were visited at least twice in the hopes of meeting captains and/or crew members in-person. If captains and crew members were not met, the physical presence and apparent gear types were recorded, but no further contact could be made.

Additionally, interviews with all sectors concluded with a request for referrals (name and industry plus at least one point of contact - dock location, phone number, and/or email address). Unlike for-hire fishing, seafood wholesale, and recreational water operations, commercial fishing is not a customer facing business. Therefore, having personal referrals were particularly helpful in identifying and contacting commercial fishers. Commercial fishers were also identified via the SPL online survey, which requested contact information (name, phone number, email). Contact with all personal referrals and voluntarily provided information followed the contact protocol detailed below.

**2.1.2.5 Interview Protocol**

For all referrals and/or businesses with known locations, phone numbers, and/or email addresses, the contact protocol was as follows:

1. In-person: Attempted to meet in-person (i.e. visit business location, marina, dock, etc.) and request an in-person interview (conducted immediately or scheduled for later date).
2. Phone: Called phone number and requested to meet for in-person interview. If the interviewee could not meet in-person, interviewer requested to conduct interview over the phone.
3. Email: If in-person and phone contact attempts were not successful, interviewer followed up with an email requesting an in-person interview.

Interviews were conducted over the course of 42 interview days from July through September 2017 and took place at the participants’ location of choice (most frequently the marina or storefront where the business was located). All interviews commenced with participant review of the letter of consent (Appendix 1). Interviewers used online Qualtrics interview templates; data was entered via an iPad and stored in the Qualtrics database. Spatial data was collected using a participatory mapping approach in SeaSketch, a web application, on iPads. Interviews were audio recorded (with interviewees’ consent) via a recording application on the iPads, allowing for capture of open-ended responses and anecdotal data. Post-interview, recordings were saved using unique interview IDs and were uploaded into a shared Google Drive folder. When multiple interviewers were present, interview notes were audio recorded and electronically written via Livescribe pens. Upon interview completion, Livescribe data was uploaded to the Livescribe application. Interview recordings and notes allowed for post-interview coding when necessary.

2.1.3 Survey and Interview Instruments

Qualtrics templates were used for online surveys and in-person interviews. Both survey and interview instruments collected information related to the following topics (see Appendices 2 and 3 for full survey and interview templates):

- Module 1: Demographics (e.g. age, race, gender, zip code)
- Module 2: Resource use trends and patterns (e.g. number of years operating in Miami-Dade, trips per month, vessel launch regions, target species, gear types, gear value, current operating areas)
• Module 3: Economics (e.g. per trip expenditures; vessel data – number, value, length, horsepower)

• Module 4: Perceptions of water quality (e.g. changes in water quality condition, types of degradation, reasons for degradation, areas of highest concern, hypothetical action in degraded water quality scenario)

For online surveys, spatial data collection was integrated into the Qualtrics survey instrument as heat map questions using map layouts created in ESRI ArcGIS Pro 2.0.1. Respondents were asked to click on the maps to identify fishing areas and areas of particular water quality concern. To collect more precise, geographically referenced spatial data during in-person interviews, interviewers used SeaSketch, an online collaborative marine spatial platform developed and maintained by the McClintock Lab at the University of California Santa Barbara (UCSB). Dr. McClintock, his team, and UCSB, graciously provided a free educational SeaSketch license for this project.

While SeaSketch was designed to be used on a laptop or desktop, this study piloted the program on iPads so that interviews could be conducted at marinas and other field locations where use of laptop computers would have proved excessively difficult. To record spatial data, interviewers worked with participants using a participatory mapping approach. Point data recorded launch points (marinas, boat ramps, etc.), and polygons were drawn for current operating areas, historic areas, regions where water quality may have improved, regions where water quality had degraded, and potential sites not currently utilized.

Data directly related to specific features, such as species fished in current fishing areas or types of water quality degradation witnessed at specific locations, was included in
the spatial feature configuration form. This means that when data was exported from SeaSketch as comma separated values (.csv) and GIS shapefile (.shp) file formats, information attached to specific polygons (e.g. species targeted at a respondent’s primary fishing location) was attributed to the appropriate spatial features. SeaSketch also provided the opportunity to change basemaps and turn on and off data layers as participants saw fit. For instance, a navigational charts layer could be turned on if a participant felt most comfortable locating his/her fishing grounds on a nautical chart.

After interviews were recorded, spatial data was downloaded from SeaSketch as .csv and .shp files. This data was uploaded into ArcPro and joined to the participants' Qualtrics interview data via a unique interview ID. Using these tools, full use spatial profiles for the Biscayne Bay focus industries was constructed.

2.2 Data Analysis

Online survey and in-person interview data were collected and analyzed using Qualtrics, Microsoft Office Excel, R, and SAS JMP. The online recreational pilot survey results and full distribution results were combined, when possible, to create one complete recreational fishing dataset. Summary statistics were reported for all questions of interest, and all spatial data were converted to data formats usable by ArcGIS Pro. Open-ended responses from in-person interviews were collected using recordings and Livescribe and were coded for analysis, when necessary, in Excel. Spatial data from in-person interviews was collected using SeaSketch and was downloaded for analysis in ERSI ArcGIS Pro 2.0.1. Qualtrics data were linked to spatial data via unique interview IDs. Summary statistics were reported for all industries, and a spatial-economic profile was created in ArcGIS Pro.
2.2.1 Statistical Analyses

Summary statistics were reported for all variables of interest in the online survey recreational fishing sample. Chi square test of frequencies was used to test for differences between the recreational respondent sample, the population of fishers emailed, and the full FWC population.

Summary statistics were reported for all variables in the interviewed industries.

2.2.2 Spatial Analyses

ArcGIS Pro 2.0.1 was used to analyze all location-based data collected in online surveys and in-person interviews. All data were projected using projected coordinate system NAD 1983 UTM Zone 17N because the entire study area fell within one Universal Transverse Mercator zone.

2.2.2.1 Creating Maps for Online Surveys

Maps for online surveys were created in ArcGIS Pro 2.0.1 using a feature dataset in projected coordinate system NAD 1983 UTM Zone 17N. A “Biscayne Bay” feature class was created and clipped into ten fishing regions. First, Union was used to overlay Biscayne Bay and a 1:12,000 Florida Shoreline shapefile (downloaded from Florida Fish and Wildlife Conservation Commission’s GIS Data Portal). All records originally found in the Florida shoreline shapefile (FID = 1) were deleted. Procedures for separating Biscayne Bay into ten fishing regions are detailed below and summarized in Table 3.

Colregs demarcation lines (as of July 2014) from the NOAA Data Catalog and western sides of barrier islands (as part of the Florida shoreline) were traced to create a single line, which was used to separate inshore areas from offshore areas. The three-nautical mile line delineating Florida territorial waters (downloaded as part of the Maritime Limits shapefile
from FWC Marine GIS and Mapping catalog) was used as the eastern boundary for all offshore regions. Coordinates for Oleta River State Park and Featherbed Bank were recorded from Google Maps, and latitudinal coordinates were used to split Biscayne Bay into separate regions.

Table 3. Boundaries of fishing regions used in online surveys.

<table>
<thead>
<tr>
<th>Region</th>
<th>Boundaries</th>
<th>No.</th>
<th>Name</th>
<th>North</th>
<th>South</th>
<th>East</th>
<th>West</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 North Bay</td>
<td></td>
<td>1</td>
<td>North Bay</td>
<td>Oleta River State Park</td>
<td>Rickenbacker Causeway</td>
<td>Shoreline</td>
<td>Colregs line/barrier islands</td>
</tr>
<tr>
<td>2 Offshore North Bay</td>
<td></td>
<td>2</td>
<td>Offshore North Bay</td>
<td>Oleta River State Park</td>
<td>Rickenbacker Causeway</td>
<td>Colregs line/barrier islands</td>
<td>3 nm</td>
</tr>
<tr>
<td>3 Central Bay</td>
<td></td>
<td>3</td>
<td>Central Bay</td>
<td>Rickenbacker Causeway</td>
<td>BNP northern boundary</td>
<td>Shoreline</td>
<td>Colregs line/barrier islands</td>
</tr>
<tr>
<td>4 Offshore Central Bay</td>
<td></td>
<td>4</td>
<td>Offshore Central Bay</td>
<td>Rickenbacker Causeway</td>
<td>BNP northern boundary</td>
<td>Colregs line/barrier islands</td>
<td>3 nm</td>
</tr>
<tr>
<td>5 North Biscayne National Park</td>
<td></td>
<td>5</td>
<td>North Biscayne National Park</td>
<td>BNP northern boundary</td>
<td>Featherbed Bank</td>
<td>Shoreline</td>
<td>Colregs line/barrier islands</td>
</tr>
<tr>
<td>6 Offshore North Biscayne National Park</td>
<td></td>
<td>6</td>
<td>Offshore North Biscayne National Park</td>
<td>BNP northern boundary</td>
<td>Featherbed Bank</td>
<td>Colregs line/barrier islands</td>
<td>3 nm</td>
</tr>
<tr>
<td>7 South Biscayne National Park</td>
<td></td>
<td>7</td>
<td>South Biscayne National Park</td>
<td>Featherbed Bank</td>
<td>BNP southern boundary</td>
<td>Shoreline</td>
<td>Colregs line/barrier islands</td>
</tr>
<tr>
<td>8 Offshore South Biscayne National Park</td>
<td></td>
<td>8</td>
<td>Offshore South Biscayne National Park</td>
<td>Featherbed Bank</td>
<td>BNP southern boundary</td>
<td>Colregs line/barrier islands</td>
<td>3 nm</td>
</tr>
<tr>
<td>9 Card Sound</td>
<td></td>
<td>9</td>
<td>Card Sound</td>
<td>BNP southern boundary</td>
<td>Card Sound Road</td>
<td>Shoreline</td>
<td>Shoreline</td>
</tr>
<tr>
<td>10 Barnes Sound</td>
<td></td>
<td>10</td>
<td>Barnes Sound</td>
<td>Card Sound Road</td>
<td>Shoreline (US 1 bridge)</td>
<td>Shoreline</td>
<td>Shoreline</td>
</tr>
</tbody>
</table>
Biscayne National Park boundaries were obtained as part of the National Park Boundaries shapefile from Data.gov. Northern and southern park boundaries were used to further split Biscayne Bay into regions. Finally, the Rickenbacker Causeway and Card Sound Road were identified using the Major Road shapefile from Miami-Dade County GIS Open Data; the roads were used to finish separating fishing regions.

2.2.2.2 Zip Codes

Zip codes were imported into ArcGIS Pro 2.0.1 by industry as tables, each with a field for respondent count. Tables were joined to a zip code shapefile, downloaded from the United States Census TIGER/Line® shapefile database. For all industries, zip codes were displayed in graduated colors by respondent count.

Multiple spatial tests were run to analyze differences in zip code representation between the full FWC Recreational Saltwater Fishing License database and the recreational respondent sample. First, the percent difference between the sample emailed and the respondent sample was calculated. Then, the map of percent differences was analyzed for patterns and/or clusters (see section 2.2.2.5). Global Moran’s I was run to test for spatial autocorrelation; a hot spot analysis using the Getis-Ord Gi* test statistic was run to identify statistically significant hot and cold spots; and Anselin Local Moran's I was used to identify statistically significant hot spots, cold spots, and spatial outliers.

2.2.2.3 Points from Qualtrics Online Surveys

Within each fishing region respondents identified, respondents were asked to identify their specific fishing areas. Respondents could click on images of each selected fishing region up to 10 times to identify their specific fishing grounds within the region. To account for variation in the number of fishing areas per region selected by each
respondent (ranging from 0 to 10), responses were weighted by the number of times each region was selected and divided by the number of clicks per region. The weighted points were then used to run a point density. This helped balance area selection but did not consider respondents who selected one or more fishing regions but chose not to select areas within regions. Thus, interpretation must consider the density of fishing areas in each region separately.

Within each fishing region respondents identified, they were also asked to identify the specific areas of greatest water quality concern. This did not account for water quality degradation in areas outside of respondents’ selected fishing regions. Much like the identification of specific fishing areas, respondents could click on images of each selected fishing region up to 10 times to identify their specific fishing grounds within the region. Clicks were weighted by the rate at which each region was selected and mapped as point densities. As with the fishing areas point density, this did consider respondents who selected one or more fishing regions but chose not to select areas within regions. It is also important to note that this portion of the study only asked respondents to identify the areas of highest water quality concern within their selected fishing region(s), not throughout Biscayne Bay.

For fishing areas and areas of water quality concern, Qualtrics data was formatted as image-specific pixel coordinates. ArcGIS Pro was used to determine the specific geographic coordinates in decimal degrees pertaining to each map layout. Qualtrics pixel outputs were converted to Geographic Coordinate System WGS 1984 decimal degrees in Microsoft Excel. The Excel table was imported into ArcGIS Pro, and decimal degree coordinates were displayed using the Display XY tool. Points by region were compared to
XY scatterplots in Excel. After comparison revealed that pixels were appropriately converted to decimal degrees, points were imported to the ArcGIS Pro project geodatabase feature dataset, at which time the feature class was automatically projected to NAD 1983 UTM Zone 17 N.

After points were imported into the feature dataset, they were clipped to the fishing regions based on the Qualtrics question number. This process ensured that only points in the region depicted in each Qualtrics image were attributed to that region and removed any points that may have been selected outside of the designated fishing regions. Points were then weighted by region (weight factor = number of respondents who selected region / number of clicks in region), and the Point Density tool was used to find the weighted distribution of fishing areas and areas of water quality concern across all regions.

2.2.2.4 Points and Polygons from SeaSketch

Spatial data from SeaSketch were imported into ArcGIS Pro 2.0.1 and were joined with corresponding SeaSketch CSV files using the “Response_ID” field. All feature classes were added to a feature dataset with a projected coordinate system of NAD 1983 UTM Zone 17 N. Corresponding feature classes from the pilot and the full study were merged to create single feature classes for each parameter (launch points, current areas, historic areas, areas of observed water quality improvement, areas of observed water quality degradation, and potential unutilized operating areas). A 1:12,000 Florida Shoreline shapefile was downloaded from Florida Fish and Wildlife Conservation Commission’s GIS Data Portal and was dissolved into a single record. Separate unions were then created between each merged feature class and the dissolved Florida shoreline. All records originally found in the Florida shoreline shapefile (FID = 1) were deleted, as were all files not originally
included in the merged feature class (FID = -1). Qualtrics interview data was joined to the edited union files by interview ID number, and Select by Attributes was used to focus on specific industries and target species. Each selection was exported to a new feature class, which was then dissolved by SeaSketch response ID to avoid double-counting spatially overlapping regions from the same interview participant, and the Count Overlapping Polygons tool was used to count all overlapping areas.

To map current areas by number of trips taken per year and number of gear rentals per day, a fishnet was created (cell size = 1,000 m). A spatial join was run to join the current areas to the fishnet. A merge rule was used so that trips per year and gear rentals per day were summed in each cell. Spatial joins were depicted using graduated colors for trips per year and gear rentals per day.

The Biscayne Bay Spiny Lobster Sanctuary shapefile was downloaded from the FWC GIS data portal and was used to clip lobster fishing areas, as it was assumed that all reported fishing was legal.

2.2.2.5 Analyzing Patterns and Clusters

The Spatial Autocorrelation (Global Moran’s I) tool was used to describe “the degree to which a set of spatial features and their associated data values tend to be clustered together in space (positive spatial autocorrelation) or dispersed (negative spatial autocorrelation)” (ESRI Technical Support). The tool measures spatial autocorrelation by considering both feature locations and feature values and determines if patterns are clustered, dispersed, or random. First, it calculates deviation from the mean for each feature and multiplies deviation values for all neighboring features to create a cross-product (ArcGIS Pro Tool Reference). “If the values in the dataset tend to cluster spatially (high
values cluster near other high values; low values cluster near other low values), the Moran's Index will be positive. When high values repel other high values, and tend to be near low values, the Index will be negative” (ArcGIS Pro Tool Reference).

The Hot Spot Analysis (Getis-Ord Gi*) tool was used to describe where features with either high or low values cluster spatially. The test statistic compares features in the context of neighboring features and is computed using an attribute for a given feature, the mean for the corresponding feature, and a spatial weight. The test produces z-scores and p-values that are used to determine statistical significance. Statistically significant hot spots have a high value and are also surrounded by features with high values. According to ArcGIS Pro Tool Reference, “the local sum for a feature and its neighbors is compared proportionally to the sum of all features; when the local sum is very different from the expected local sum, and when that difference is too large to be the result of random chance, a statistically significant z-score results.”

The Cluster and Outlier Analysis (Anselin Local Moran's I) tool was used to identify outliers and spatial clusters of features with high or low values. The tool computes a local Moran's I value, a z-score, a pseudo p-value, and a code representing the cluster type for each statistically significant feature. The test statistic is computed using an attribute for a given feature, the mean for the corresponding feature, and a spatial weight. Clusters are identified by statistically significant positive values, indicating that a feature “has neighboring features with similarly high or low values.” Outliers have statistically significant negative values, meaning that a feature has “neighboring features with dissimilar values” (ArcGIS Pro Tool Reference).
2.3 Limitations and Delimitations

2.3.1 Limitations

When considering the limitations of this study, it is important to acknowledge common sources of errors in survey- and interview-based studies (Figure 7). Total survey error is composed of errors of non-observation, errors of observation, and errors of processing. This design of this study attempted to limit these sources of error to the utmost extent possible.

Figure 7. Breakdown of survey error. Source: Qualtrics.

Errors of non-observation are related to issues accurately defining and reaching a representative sample of the population. Coverage/non-coverage error results when certain parts of the population are not included in the sampling frame. Sampling error occurs because the population is not sampled in a homogenous manner, i.e. certain groups are overrepresented, while other are underrepresented. Nonresponse error arises because not all members of the population respond to survey and interview requests (Dillman 1991). Online surveys were sent to all recreational, for-hire, and commercial fishers and wholesale dealers registered in Miami-Dade County with a valid email address in the FWC database.
to obtain a census sample of these industries. However, sampling error and non-coverage error occurred because email surveys could not be distributed to industry participants that did not provide valid email addresses in FWC license applications. For instance, sampling error likely occurred because certain user groups may be more likely to have access to email and/or provide valid email addresses. Non-coverage error occurred, at least within the recreational fishing community, because not all recreational fishers are required to register with the FWC. Disabled veterans, active duty military personnel, fishers over the age of 65, and fishers under the age of 16 are not required to purchase most recreational fishing licenses and thus were likely to be underrepresented by this study design.

In-person interviews were conducted with census samples of each industry (except commercial fishers); however, operations that fit the sample criteria but were not identified may have existed, resulting in non-coverage error for the in-person interview populations as well. Nonresponse error was addressed via reminder emails for online surveys and multiple attempts to contact individuals and businesses for in-person interviews. However, many online surveys were not answered, and some requests for online interviews were ignored. The percent of distributed online surveys and requests for in-person interviews that went unanswered were reported, as consideration of nonresponse bias is an important component of data analysis.

Errors of observation pertain to errors during data collection. These errors may arise from biases or questions that do not accurately capture what they are set out to capture – these errors that are built into the survey instrument. Errors of observation may also occur if a respondent does not accurately answer a question, even if the question is constructed and asked properly. Finally, an interviewer may mis-phrase a question, for instance by
asking it in a leading or confusing manner, causing the respondent to answer untruthfully (Dillman 1991).

This study design aimed to limit survey instrument and interviewer error by giving all interviewers in-depth understandings of the survey and by using survey instruments that were carefully crafted and provided structured means of asking and recording data. Pilot online surveys were used to determine potential confusing factors in the survey distribution. One edit was made before the full distribution, based on feedback from the pilot study, to reduce potential sources of error. The first two in-person interviews were used as pilot interviews, and minor tweaks to questions were made to improve survey format and reduce potential sources of error.

Respondent error is difficult to control for online surveys. This study aimed to minimize respondent confusion for both online surveys and in-person interviews by wording questions as clearly as possible, allowing respondents to skip questions they may not have known the answer to and/or feel uncomfortable answering. An “I don’t know” option was provided for questions, such as perceptions of water quality, for which respondents may not have had any opinion and/or background knowledge. While including a “no opinion” choice can increase the number of no-opinion responses (as fatigued respondents may choose to select this answer rather than considering their own opinion), it may also prevent respondents from selecting inappropriate, forced responses (Best and Radcliffe 2005).

Interviewers minimized instrument and respondent error by clarifying questions and assisting respondents with responses when possible. For instance, when asking for economic estimates for fishing gear, interviewers could ask fishers how many hand reels
and the approximate worth of each, providing the opportunity to do the math together and produce a more realistic estimate, rather than asking the respondent to estimate value more abstractly.

Respondent error was especially important to keep in mind when asking spatial questions. For all spatial questions during in-person interviews, interviewers worked with respondents, using a participatory mapping approach, to draw points and polygons representing launch points, current and historic operating areas, areas pertaining to perceived water quality improvements and/or degradation, and potential operating areas not currently accessed. To help capture locations as accurately as possible, data layers for benthic habitat, nautical charts, and many additional reference layers, were built into SeaSketch. For online surveys, maps were labeled with common reference points throughout the county and bay to help respondents correctly identify fishing grounds and areas of water quality concern.

Errors of processing occur after data is collected and recorded. Coding errors may occur when certain information is teased out of interviews so that qualitative data may be made quantitative or at least comparable between responses. Editing errors arise when data needs to be edited or clarified in certain instances and this rule is not applied correctly by the editor. Finally, adjustment errors occur when data must be adjusted, such as adding weights to certain responses (Organisation for Economic Co-operation and Development; Biemer 2010).

All processing errors were minimized by using Qualtrics and SeaSketch for data entry. Both survey instruments directly ask the questions this study is designed to answer, meaning data was minimally manipulated post-collection because Qualtrics and SeaSketch
were downloadable as .csv and shapefiles, allowing for direct import into Excel and ArcGIS.

2.3.2 Delimitations

Delimitations are specific decisions that were made to limit this study in some respect. First and foremost, this study was interested in industries that were directly dependent on water quality in Biscayne Bay, and therefore was focused on recreational, commercial, and for-hire fishing; seafood wholesale, and recreational water operations using Biscayne Bay. Swimmers were not contacted because there was no readily available list of individuals who use Biscayne Bay for recreational swimming. Registered boaters were not included because these recreational users are not necessarily in the water and thus are not necessarily interested in water quality as it pertains to ecological health; they are likely more concerned with a very basic aesthetic value. There were undoubtedly additional industries that were at minimum indirectly related to water quality in Biscayne Bay, such as the cruise industry based out of the Port of Miami, that were not included in this framework due to time and budgetary constraints. Boaters and other bay users should be contacted via online surveys in the future to determine how their use and perceptions are affected by water quality.

Another delimitation of this study is the fact that recreational fishers were not interviewed in person, only via email surveys. This was to avoid sampling error, as recreational activity is highly variable by season and location. To guarantee the most representative sample possible, i.e. to reach as many recreational fishers as possible within time and budgetary constraints, the best method was to email all FWC Recreational Saltwater Fishing License holders.
Similarly, recreational water operators were only represented via in-person interviews. Unlike fishing and seafood wholesale, recreational water operators are not required to possess common licenses. Thus, there is not a publicly accessible, comprehensive list of recreational water operators available from a local government agency. However, it is important to note that online surveys for seafood wholesale, commercial, and for-hire fishers were largely used to make initial contacts in the industries. This step was unnecessary for the recreational water operations industry, as SCUBA, snorkel, kayak, and other operators are arguably the most customer-facing of all industries sampled. Recreational water operators are also often involved in scientific research activities, even the University of Miami’s own programs, such as Rescue a Reef and Shark Research. For this reason, recreational water operators were often very interested in this research and did not require special prompting to participate.

2.4 Distribution and Response

2.4.1 Survey Distribution and Response

The online recreational fishing survey was successfully sent (i.e. emails did not bounce when sent) to 43,347 email addresses (99.6% of all Recreational Saltwater Fishing License holders in Miami-Dade who chose to provide email addresses on their FWC applications; approximately 54.4% of all FWC-registered recreational fishers in Miami-Dade County). A total of 1,074 responses were recorded for the recreational fishing survey, yielding a response rate of 2.48%. According to Dillman et al. 2014, this was a relatively low response rate. This is unsurprising, as this study did not offer incentives to survey respondents. Additionally, not all FWC registered fishers with Miami-Dade zip codes fish
in Biscayne Bay. Thus, it is likely that only those with a vested interest in Biscayne Bay (i.e. those who accessed it frequently) responded to the online survey.

The survey was modular (see Section 2.1.3) and allowed respondents to skip questions they did not feel comfortable answering. Thus, response rate differed by module and within each module. Approximately 72.9% of respondents answered questions about demographics, resource use, economic, and perceptions about water quality (Modules 1-4; see online survey flow in Appendix 2). Only 24.2% of respondents answered hypothetical questions regarding resource use if water quality became severely degraded (Module 5). Sample sizes were denoted parenthetically when applicable.

The online commercial fishing, for-hire fishing, and seafood wholesale survey was successfully sent to 467 email addresses (99.4% of all Saltwater Products, Wholesale Dealer, and Charter Captain, and Charter Boat License holders in Miami-Dade County who chose to provide email addresses on their FWC applications; approximately 71.2% of all FWC-registered commercial fishers, for-hire fishers, and wholesale dealers in Miami-Dade County). Only 10 responses were recorded for the commercial fishing, for-hire fishing, and seafood wholesale survey. While this yielded a response rate of 2.14%, the responses for this survey were not analyzed due to the small sample size. Contact information provided in the introductory portion of the survey, and individuals were contacted to set up in-person interviews.

2.4.2 Interview Industry Sample

Over the course of 42 interview days, a total of 86 individuals were interviewed from 84 separate operations. On two occasions, two interviews were conducted for an operation because one participant was not comfortable answering all questions (e.g.
economic questions). In these instances, a second participant from the same operation was interviewed. All personal data from both respondents was included in analysis, but data pertaining specifically to the operation was reconciled between the two responses and only counted once.

Of the 86 interview participants, 77 chose to share spatial data, which was recorded in SeaSketch (see Section 2.1.3). The eight participants who did not share spatial data were seafood wholesalers who could not spatially identify specific source areas (i.e. they sourced primarily from distributors and/or did not know specifically where the fishers they purchased from operated), nor did they have familiarity with water quality in Biscayne Bay.

Table 4 and Table 5 indicate how many individuals from each sector were interviewed.

Table 4. Number of in-person interviews (count) completed by pre-determined sector (n = 86).

<table>
<thead>
<tr>
<th>Industry</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial Fishing</td>
<td>10</td>
</tr>
<tr>
<td>For-Hire Fishing</td>
<td>21</td>
</tr>
<tr>
<td>Rec. Water Ops.</td>
<td>30</td>
</tr>
<tr>
<td>Seafood Wholesale</td>
<td>25</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>86</strong></td>
</tr>
</tbody>
</table>

Table 5. Percent interviews that fit into each re-classified industry (n = 86). Interviews may correspond to multiple categories. Note that some interviews fit into more than one category.

<table>
<thead>
<tr>
<th>Category</th>
<th># Interviews</th>
<th>% Interviews</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bait</td>
<td>16</td>
<td>18.6</td>
</tr>
<tr>
<td>For-Hire</td>
<td>22</td>
<td>25.6</td>
</tr>
<tr>
<td>Commercial</td>
<td>22</td>
<td>25.6</td>
</tr>
<tr>
<td>Education</td>
<td>4</td>
<td>4.65</td>
</tr>
<tr>
<td>Retail</td>
<td>21</td>
<td>24.4</td>
</tr>
<tr>
<td>Water Ops.</td>
<td>30</td>
<td>34.9</td>
</tr>
<tr>
<td>Wholesale</td>
<td>21</td>
<td>24.4</td>
</tr>
</tbody>
</table>
Table 4 lists the number of interviews by pre-determined industry (i.e. the industry immediately identified based on interviewer introduction of the participant). Table 5 provides the count and percent of total interviews for each industry, as identified post-interview. For example, an interviewer may have pre-determined that they were speaking with a seafood wholesaler by meeting the participant as the owner of a seafood market. However, during the course of the interview, the participant may have indicated that they also fished commercially (and thus answered questions corresponding to commercial fishing). Pre-interview, this participant would have been recorded as “Seafood Wholesale,” but post-interview, this participant would have been re-categorized as “Seafood Wholesale, Commercial Fishing.”

Figure 8 describes the relative number of interviews conducted by re-classified industry count, as well as the overlap between industries (overlap not to scale). A distinction was made between seafood wholesale and retail, as these industries have different levels of engagement with the fishing community. While a wholesaler may also qualify as a retailer, all retailers are not necessarily wholesalers (and vice versa). Wholesalers may only purchase seafood from fishers with valid Saltwater Products Licenses (commercial fishers) and may only sell to other wholesale dealers, to retailers, and to restaurants. A retail license is required to sell any seafood products to the end consumer (i.e. to the public). Seafood retailers may only purchase from wholesale dealers.
The most frequent overlap between industries was between wholesale, bait, and retail. This was to be expected, as all bait shops can be classified as wholesalers and/or retailers. Additionally, it is important to note that recreational water operators specializing in educational activities (e.g. operators who focused on school trips) were reclassified as both recreational water operators and "education."
Chapter 3

Stakeholder Industry Profiles
The following sections provide detailed demographic, economic, and resource use data for each of the focus industries. Each section also contains stakeholder perceptions of water quality, including contingent adaptation strategies under a water quality degradation scenario. This information can be used as a baseline for current conditions and perceptions in water-quality dependent industries. Chapter 4 examines how stakeholder perceptions of water quality may be influenced by factors such as industry and tenure.

3.1 Recreational Fishing

3.1.1 Demographics

Survey demographics were compared to that of the sample population and to the greater recreational FWC-registered recreational saltwater fishing community. Table 6 – Table 8 compare recreational fishing survey respondent age, gender, and race respectively to that of the full sample (i.e. all those emailed) and to all FWC-registered recreational saltwater fishing community. Compared to both the sample population and the FWC population, survey respondents over-represented older age classes and under-represented younger age classes (Table 6). Chi-square tests revealed significant differences between FWC, email, and survey respondent groups for age, gender, and race (p = 0.00 for all tests).

Table 6. Percent of survey respondents by age class (Survey %) compared to all those who received an email invitation (Email %) and to the full FWC recreational fishing license database (FWC %). *Survey respondents under 18 automatically skipped to the end of the survey. (Survey n = 1,074; Email n = 43,347; FWC n = 79,750.)

<table>
<thead>
<tr>
<th>Age</th>
<th>Survey %</th>
<th>Email %</th>
<th>FWC %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 18*</td>
<td>0.84</td>
<td>1.63</td>
<td>2.11</td>
</tr>
<tr>
<td>18 - 30</td>
<td>11.8</td>
<td>23.9</td>
<td>24.8</td>
</tr>
<tr>
<td>31 - 40</td>
<td>14.9</td>
<td>22.3</td>
<td>21.5</td>
</tr>
<tr>
<td>41 - 50</td>
<td>28.2</td>
<td>25.6</td>
<td>25.2</td>
</tr>
<tr>
<td>51 - 60</td>
<td>28.8</td>
<td>20.3</td>
<td>20.0</td>
</tr>
<tr>
<td>Over 60</td>
<td>15.5</td>
<td>6.32</td>
<td>6.44</td>
</tr>
</tbody>
</table>
Women were under-represented in the survey compared to both the sample population and the FWC population (Table 7). While the percent of female respondents was expected to be higher for respondents to accurately represent the FWC population, the expectation that over 80.4% of respondents would be male was met.

Table 7. Percent of survey respondents by gender (Survey %) compared to all those who received an email invitation (Email %) and to the full FWC recreational fishing license database (FWC %). (Survey n = 1,074; Email n = 43,347; FWC n = 79,750.)

<table>
<thead>
<tr>
<th>Gender</th>
<th>Survey %</th>
<th>Email %</th>
<th>FWC %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>86.3</td>
<td>83.4</td>
<td>80.34</td>
</tr>
<tr>
<td>Female</td>
<td>9.22</td>
<td>16.6</td>
<td>19.6</td>
</tr>
</tbody>
</table>

Survey respondents’ identification of race loosely follows the same patterns as the sample population and the FWC population (Table 8). Major differences include an over-representation of white fishers and under-representation of Hispanic fishers. However, racial identification in the survey followed United States Census sampling methods, whereby respondents were asked to select all racial groups to which they identify. The FWC database included only one racial group per FWC registrant. This many explain the over-representation of white fishers, as many respondents who identified as Hispanic and white may have been listed as only Hispanic in the FWC database. This difference in survey instrument did not account for the under-representation of Hispanic fishers.

Table 8. Percent of survey respondents by race (Survey %) compared to all those who received an email invitation (Email %) and to the full FWC recreational fishing license database (FWC %). (Survey n = 1,074; Email n = 43,347; FWC n = 79,750.)

<table>
<thead>
<tr>
<th>Race</th>
<th>Survey %</th>
<th>Email %</th>
<th>FWC %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hispanic</td>
<td>48.5</td>
<td>61.5</td>
<td>68.7</td>
</tr>
<tr>
<td>American Indian</td>
<td>0.74</td>
<td>0.03</td>
<td>0.02</td>
</tr>
<tr>
<td>White</td>
<td>47.7</td>
<td>33.2</td>
<td>23.7</td>
</tr>
<tr>
<td>Asian</td>
<td>1.40</td>
<td>0.86</td>
<td>0.87</td>
</tr>
<tr>
<td>Native Hawaiian</td>
<td>0.37</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Black</td>
<td>1.77</td>
<td>2.97</td>
<td>5.32</td>
</tr>
<tr>
<td>Other</td>
<td>3.17</td>
<td>1.39</td>
<td>1.31</td>
</tr>
<tr>
<td>Undisclosed</td>
<td>3.91</td>
<td>0.09</td>
<td>0.10</td>
</tr>
</tbody>
</table>
As a final measure of demographic representativeness, respondent zip codes were compared to zip codes provided in the FWC database.

Figure 9. Recreational fisher zip codes by percent respondents (n = 936).

Survey respondents were primarily from Miami-Dade County, with a small percentage from Monroe and Broward Counties. A very small percentage of respondents were from Seminole, Pinellas, Manatee, and Brevard Counties. Respondent zip codes were most heavily concentrated in the Biscayne Bay region, particularly in Kendall, Coral Gables, South Miami, and Pinecrest (Figure 9). The percent of respondents from each zip code was subtracted from the percent of FWC-registered recreational saltwater fishers
(Figure 10) to identify any difference in zip code representation. This map revealed Cutler Bay and Palmetto Bay to be concentrated areas of respondent over-representation. It also identified Hialeah to be a distinct area of survey under-representation.

Figure 10. Percent difference between survey respondent zip codes (n = 936) and the full FWC sample (n = 133,339).

Percent difference between FWC zip codes and recreational fishing zip codes was tested for spatial autocorrelation and statistically significant hot spots, cold spots, and outliers. The Spatial Autocorrelation tool using the Global Moran’s I statistic reported a P value of 0.000, indicating that zip code percent differences were highly clustered. Hot Spot Analysis using the Getis-Ord Gi* statistic revealed statistically significant hot spots (90.0%
confidence) in Palm Beach County. Cluster and Outlier Analysis using the Anselin Local Moran’s I test statistic revealed statistically significant clustered survey over-representation (LL) in coastal areas from Key Biscayne through Cutler Bay and clustered survey under-representation (HH) in Doral and Hialeah. Quail Heights and South Miami Heights near the South District Wastewater Treatment Plant and the South Dade Landfill were identified as survey under-representation outliers (HL, i.e. areas of low survey response rate surrounded by areas of relatively high survey response rate). Tamiami near Dolphin Mall was identified as an outlier of survey over-representation (LH, i.e. an area of high survey response rate surrounded by areas of relatively low survey response rate).

Overall, survey demographics followed the same major trends as the sample population and the FWC population with a few notable differences in terms of age, race, and zip code. It is important to acknowledge these biases when interpreting results. Compared to the overall population of saltwater fishers registered to fish in Miami-Dade County, this survey was biased towards older fishers, white fishers, and those residing in coastal zip codes from Cutler Bay to Coconut Grove. Additionally, this survey was biased against younger fishers, Hispanic fishers, and those residing in Doral, Hialeah, and Quail Heights.

3.1.2 Resource Use

Most respondents (73.9%) had been fishing for more than twenty years (Table 9). Fishing experience in Miami-Dade County followed the same major trend as fishing in general, with a slight shift towards fewer years of experience, indicating that many fishers had experience outside of Miami-Dade County.
Table 9. Respondent general fishing experience (n = 993) and fishing experience specifically in Miami-Dade County (n = 994).

<table>
<thead>
<tr>
<th>Years Fishing</th>
<th>% Respondents</th>
<th>General</th>
<th>In Miami-Dade</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1 year</td>
<td>1.01%</td>
<td>2.21%</td>
<td></td>
</tr>
<tr>
<td>1-5 years</td>
<td>7.45%</td>
<td>12.8%</td>
<td></td>
</tr>
<tr>
<td>6-10 years</td>
<td>4.83%</td>
<td>7.04%</td>
<td></td>
</tr>
<tr>
<td>11-15 years</td>
<td>5.74%</td>
<td>8.75%</td>
<td></td>
</tr>
<tr>
<td>16-20 years</td>
<td>7.05%</td>
<td>8.75%</td>
<td></td>
</tr>
<tr>
<td>&gt;20 years</td>
<td>73.9%</td>
<td>60.5%</td>
<td></td>
</tr>
</tbody>
</table>

Most recreational fishers (85.3%; n = 1,029) used hook and line gear (including rods and reels) gear as their primary gear type (Table 10). Only 8.45% of respondents used spear guns as their primary recreational fishing gear type, and even fewer (6.22%) of respondents primarily used SCUBA and/or snorkel to dive for lobsters. This did not account for fishers who use multiple gear types.

Table 10. Respondent primary gear types (n = 1,029).

<table>
<thead>
<tr>
<th>Gear Types</th>
<th>% Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hook and line/ rod and reel</td>
<td>85.3%</td>
</tr>
<tr>
<td>Lobster diving</td>
<td>6.22%</td>
</tr>
<tr>
<td>Spearfishing</td>
<td>8.45%</td>
</tr>
</tbody>
</table>

A large majority (85.0%; n = 936) of respondents fished primarily from a boat, while only 15.0% fished primarily from shore. The respondents who fished from boats most frequently identified Cutler Bay and Homestead as their primary launch regions, followed by South Miami/Coral Gables and Key Biscayne (Table 11). Few respondents identified Coconut Grove, North Miami Beach, Miami Beach, Downtown Miami/Miami River, or Bal Harbour as their primary launch regions. Respondents took an average of 4.46 trips per month (n = 980; std. dev. = 3.89; Figure 11).
Table 11. Primary launch regions for respondents who fish from boats (n = 739).

<table>
<thead>
<tr>
<th>Launch</th>
<th>% Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bal Harbour</td>
<td>2.44%</td>
</tr>
<tr>
<td>Coconut Grove</td>
<td>7.98%</td>
</tr>
<tr>
<td>Cutler Bay</td>
<td>20.8%</td>
</tr>
<tr>
<td>Downtown Miami/ Miami River</td>
<td>2.57%</td>
</tr>
<tr>
<td>Homestead</td>
<td>20.7%</td>
</tr>
<tr>
<td>Key Biscayne</td>
<td>14.8%</td>
</tr>
<tr>
<td>Miami Beach</td>
<td>5.14%</td>
</tr>
<tr>
<td>North Miami Beach</td>
<td>7.85%</td>
</tr>
<tr>
<td>South Miami/ Coral Gables</td>
<td>17.7%</td>
</tr>
</tbody>
</table>

Figure 11. Number of trips per month by number of respondents (n = 980).

More than half of respondents reported targeting reef fish (74.7%; n = 888; Figure 12) and/or pelagic species (56.4%). Just under half of respondents reported fishing for coastal species (43.2%), and about 36.7% reported targeting lobster. A total of 8.90% of respondents reported fishing other species.
Figure 12. Species groups fished by percent respondents (n = 888).

Table 12 reports the most popular combinations of target species. Reef fish alone was the most popular selection (14.5% of respondents), followed by reef fish and pelagic species (12.7%). All species groups were reported both alone and in combination with other species groups.

Table 12. Most popular species groups fished in combination by percent respondents (n = 888).

<table>
<thead>
<tr>
<th>Species Combinations</th>
<th>% Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reef</td>
<td>14.5</td>
</tr>
<tr>
<td>Reef, Pelagic</td>
<td>12.7</td>
</tr>
<tr>
<td>Reef, Lobsters, Pelagic</td>
<td>11.1</td>
</tr>
<tr>
<td>Coastal, Reef, Lobsters, Pelagic</td>
<td>10.8</td>
</tr>
<tr>
<td>Coastal</td>
<td>9.12</td>
</tr>
<tr>
<td>Coastal, Reef, Pelagic</td>
<td>7.77</td>
</tr>
<tr>
<td>Coastal, Reef</td>
<td>7.09</td>
</tr>
<tr>
<td>Pelagic</td>
<td>4.95</td>
</tr>
<tr>
<td>Reef, Lobsters</td>
<td>3.83</td>
</tr>
<tr>
<td>Lobsters, Pelagic</td>
<td>2.48</td>
</tr>
</tbody>
</table>

In terms of areas fished, respondents were first asked to identify all regions they fished (Figure 13). Regions 8 (Offshore South Biscayne National Park; 48.8%; n = 995), 7 (South Biscayne National Park; 35.1%), and 6 (Offshore North Biscayne National Park;
32.5%) were accessed by the highest percentage of respondents. A moderate percent of respondents reported fishing in Regions 5 (North Biscayne National Park; 26.6%), 4 (Offshore Central Bay; 24.5%), and 3 (Central Bay; 22.3%). Regions 10 (Barnes Sound; 9.78%), 9 (Card Sound; 15.5%), 1 (North Bay; 14.6%) and 2 (Offshore North Bay; 15.8%) were accessed by the fewest respondents.

![Recreational Fishing by Region](image)

Figure 13. Percentage of recreational fishers who reported accessing each fishing region. Regions 8 and 1 were most popular, while Regions 2 and 9 were least popular (n = 995).

Within each identified fishing region, respondents were then asked to identify their specific fishing areas. In Region 1, fishing area selection was most heavily concentrated in the basins between bridges and along the Rickenbacker Causeway (the boundary between
Regions 1 and 3; \( n = 822 \); Figure 14; Table 13). Fishing area selection was dispersed throughout Region 2, with no clearly concentrated areas. In Region 3, fishing area selection was most focused around the Rickenbacker Causeway, Key Biscayne, and the coastline around Matheson Hammock Park and Matheson County Preserve.

In Region 4, selection was most dense around the northern and southern tips of Key Biscayne, as well as along the state waters boundary (3 nm from the barrier islands). Selection in Region 5 was highest nearshore and along the boundary with Region 6 (the colregs demarcation line delineating the boundary between internal waters and territorial
waters). Region 6 fishing area selection was most dense along the eastern boundary (state boundary; 3 nm) and somewhat dense along the boundary with Region 5. In Region 7, fishing area selection was most intense very nearshore, specifically near Black Point and the Arsenicker Keys, as well as along the Upper Keys, specifically around Totten Key and Old Rhodes Key in the south and Sands Key in the north. Fishing areas in Region 8 were most frequently identified along the eastern boundary, especially in the southeastern corner of the region. Selection in Region 9 was heaviest along the shorelines, particularly near Card Sound Road and Broad Creek. Finally, fishing area selection in Region 10 was highest near Card Sound Road. The Rickenbacker Causeway through Bear Cut, the channels between Biscayne Channel and Key Biscayne, the Ragged Keys, Sands Cut, and Card Sound Road were areas of notable overlap between regions.

Table 13. Most frequently identified fishing areas in each fishing region (n = 822).

<table>
<thead>
<tr>
<th>Region</th>
<th>Most Frequently Identified Fishing Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Basins between bridges; along the Rickenbacker Causeway</td>
</tr>
<tr>
<td>2</td>
<td>Dispersed; no clearly concentrated areas</td>
</tr>
<tr>
<td>3</td>
<td>Rickenbacker Causeway; Key Biscayne; coastline around Matheson Hammock Park and Matheson County Preserve</td>
</tr>
<tr>
<td>4</td>
<td>Northern and southern tips of Key Biscayne; state waters boundary</td>
</tr>
<tr>
<td>5</td>
<td>Very nearshore; boundary with Region 6</td>
</tr>
<tr>
<td>6</td>
<td>Eastern boundary; boundary with Region 5</td>
</tr>
<tr>
<td>7</td>
<td>Very nearshore - Black Point and Arsenicker Keys; Upper Keys - Totten Key, Old Rhodes Key, and Sands Key</td>
</tr>
<tr>
<td>8</td>
<td>Eastern boundary – southeast corner</td>
</tr>
<tr>
<td>9</td>
<td>Shorelines - near Card Sound Road and Broad Creek</td>
</tr>
<tr>
<td>10</td>
<td>Card Sound Road</td>
</tr>
</tbody>
</table>

3.1.3 Economics

A majority of respondents owned one vessel (61.84%; n = 760; Table 14). A total of 19.6% own two boats, while a very small minority (5.92%) own more than two vessels.
Finally, about 12.6% of respondents did not own a boat, which was just less than the reported percent of respondents who fish from shore (approximately 15.0%).

Table 14. Percent respondents by number of boats owned (n = 760).

<table>
<thead>
<tr>
<th>Number of Boats</th>
<th>% Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>12.6%</td>
</tr>
<tr>
<td>1</td>
<td>61.8%</td>
</tr>
<tr>
<td>2</td>
<td>19.6%</td>
</tr>
<tr>
<td>&gt;2</td>
<td>5.92%</td>
</tr>
</tbody>
</table>

Mean per trip expenses varied greatly by expense type (Table 15; Figure 15). Fuel and oil was by far the largest expense category for recreational fishers, followed by bait and food and supplies. Air for SCUBA and ice were reported as relatively low costs.

Table 15. Trip expenses means and standard deviations (n = 858).

<table>
<thead>
<tr>
<th>Expense Type</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel and Oil</td>
<td>$99.60</td>
<td>$74.00</td>
</tr>
<tr>
<td>Ice</td>
<td>$17.10</td>
<td>$26.00</td>
</tr>
<tr>
<td>Bait</td>
<td>$42.00</td>
<td>$45.90</td>
</tr>
<tr>
<td>Food and Supplies</td>
<td>$43.70</td>
<td>$40.20</td>
</tr>
<tr>
<td>Air for SCUBA</td>
<td>$13.60</td>
<td>$19.30</td>
</tr>
<tr>
<td>Other</td>
<td>$33.00</td>
<td>$51.70</td>
</tr>
</tbody>
</table>

Figure 15. Average per trip costs for recreational fishers (n = 858).
3.1.4 Perceptions of Water Quality

A majority of respondents (32.9%; n = 990) noted that water quality in Biscayne Bay was somewhat worse than when they began fishing in the region (Figure 16). Approximately equal percentages of respondents reported that water quality was much worse (23.1%) or the same (25.6%) compared to when they began fishing. Small percentages of respondents indicated that water quality was somewhat better (8.43%), that water quality was much better (3.15%), or that they did not know (6.97%). The average response fell between somewhat worse and same (n = 890; mean = 1.31 on a scale where much worse = 0 and much better = 4; std. dev. = 1.05).

![Change in Water Quality Condition](image)

Figure 16. Respondent perception of how water quality in Biscayne Bay compared to water quality when respondents started fishing in the region (n = 890).

Water clarity was identified as the most prominent form of water quality degradation since respondents began fishing in Biscayne Bay (Figure 17). A majority of respondents (59.8%; n = 790) also reported noticing increases in trash levels. Only 47.7% of respondents noticed areas of dead seagrass and/or coral, and 31.9% reported increases in algae. Finally, a small subset of respondents (10.8%) reported “other” types of water
quality degradation including derelict fishing gear, fewer fish, increased sedimentation, and “no degradation.”

![Graph showing types of water quality degradation]

Figure 17. Types of water quality degradation in Biscayne Bay noticed by respondents since they began fishing in the region (n = 790).

Respondents identified land-based trash as the most important issue contributing to water quality degradation (Table 16; Figure 18), followed by sewage and outfalls and agricultural runoff. A majority of respondents also felt that vessel pollution was at least somewhat important. Climate change was identified as the least important factor contributing to water quality degradation but was still viewed to be at least somewhat important by more than 60% of respondents (n = 768).

Table 16. Means and standard deviations of sources of water quality degradation rankings (0 = not important at all, 1 = not that important, 2 = somewhat important, 3 = very important; n = 768).

<table>
<thead>
<tr>
<th>Source of Degradation</th>
<th>Mean Importance</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural runoff</td>
<td>2.44</td>
<td>0.82</td>
</tr>
<tr>
<td>Vessel pollution</td>
<td>2.23</td>
<td>0.85</td>
</tr>
<tr>
<td>Land-based trash</td>
<td>2.69</td>
<td>0.59</td>
</tr>
<tr>
<td>Sewage and outfalls</td>
<td>2.60</td>
<td>0.68</td>
</tr>
<tr>
<td>Climate change</td>
<td>1.86</td>
<td>1.05</td>
</tr>
</tbody>
</table>
Figure 18. Importance of specific water quality degradation factors, as identified by respondents (0 = not important at all, 3 = very important; n = 768).

Mean responses (on a scale where 0 = not important at all and 3 = very important) indicated that respondents identified agricultural runoff (n = 754; mean = 2.35; std. dev. = 0.82), vessel pollution (n = 746; mean = 2.23; std. dev. = 0.85), land-based trash (n = 768; mean = 2.69; std. dev. = 0.59) and sewage and outfalls (n = 763; mean = 2.60; std. dev. = 0.68) to be between “somewhat important” and “very important”. Climate change was identified as between “not important at all” and “somewhat important” (n = 744; mean = 1.86; std. dev. = 1.05).

In Region 1, the most frequently identified areas of water quality concern included Haulover Cut, the basin between Broad Causeway and NE 79th St., the basin between 79th St. and Julia Tuttle Causeway, and the area around the Rickenbacker Causeway (N = 657; Figure 19; Table 17). The most concentrated selected areas in Region 2 were Haulover Cut and Government Cut.
Figure 19. Point density of water quality concern weighted by fishing region selection rate (n = 657).

In Region 3, the most intensely selected areas were the Rickenbacker Causeway, nearshore habitats (excluding Cutler Channel), and the southern tip of Key Biscayne. Bear Cut and the southeastern tip of Key Biscayne were the most frequently identified areas in Region 4. In Region 5, nearshore areas were most frequently identified, especially around Black Point, as was the area immediately south of Key Biscayne. The areas immediately southeast of Key Biscayne and the Ragged Keys were most frequently selected in Region 6. In Region 7, selection was most concentrated nearshore, particularly around Black Point Marina and Turkey Point Nuclear Power Plant. The areas of highest concern in Region 8...
included the Ragged Keys, the offshore side of Sands Cut, about midway down Elliot Key, Caesar Creek, and Broad Creek. In Region 9, the highest density of selected areas occurred along the northwest nearshore portion of the Sound, near the Turkey Point cooling canals. Finally, the nearshore area by Card Sound Road, close to Alabama Jack’s, was most frequently selected as an area of water quality concern in Region 10.

Table 17. Most frequently identified areas of water quality concern (n = 657).

<table>
<thead>
<tr>
<th>Region</th>
<th>Most Frequently Identified Areas of Water Quality Concern</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Haulover Cut; basin between Broad Causeway and NE 79th St.; basin between 79th St. and Julia Tuttle Causeway; Rickenbacker Causeway</td>
</tr>
<tr>
<td>2</td>
<td>Haulover Cut; Government Cut</td>
</tr>
<tr>
<td>3</td>
<td>Rickenbacker Causeway; nearshore areas (excluding Cutler Channel); southern tip of Key Biscayne</td>
</tr>
<tr>
<td>4</td>
<td>Bear Cut; southern tip of Key Biscayne</td>
</tr>
<tr>
<td>5</td>
<td>Nearshore areas - Black Point, south of Key Biscayne</td>
</tr>
<tr>
<td>6</td>
<td>Southeast of Key Biscayne; Ragged Keys</td>
</tr>
<tr>
<td>7</td>
<td>Nearshore - Black Point Marina, Turkey Point Nuclear Power Plant</td>
</tr>
<tr>
<td>8</td>
<td>Ragged Keys; offshore side of Sands Cut; Elliot Key, Caesar Creek, and Broad Creek</td>
</tr>
<tr>
<td>9</td>
<td>Northwest nearshore portion - Turkey Point cooling canals</td>
</tr>
<tr>
<td>10</td>
<td>Card Sound Road - Alabama Jacks</td>
</tr>
</tbody>
</table>

The most concentrated cross-boundary areas include the Rickenbacker Causeway and Bear Cut, the channels between Biscayne Channel and Key Biscayne, nearshore areas near Black Point, and the Ragged Keys.

Respondents were asked to select all that would apply “if water quality in [their] fishing areas declined to a point where [they] could no longer fish [their] preferred species” (Figure 20). A large majority (69.0%; n = 802) indicated that they would fish elsewhere. “Other” responses included moving elsewhere to continue fishing regularly, working to restore the fishery, and fishing in freshwater ecosystems.
Respondents who indicated that they would fish elsewhere were then asked where they would fish (Table 18). Region 8 was most frequently identified (30.9%; n = 528), followed by Regions 6 (21.8%) and 9 (16.9%). Regions 1 (7.77%) and 3 (8.33%) were identified for alternative fishing grounds least frequently. The most popular response overall was “Other,” which was most frequently identified as somewhere in the Florida Keys (51.0% of “Other” text responses).

Table 18. Regions in which respondents would fish if unable to fish current species in current location (n = 528).

<table>
<thead>
<tr>
<th>Region</th>
<th>Description of Area</th>
<th>% Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>North Bay</td>
<td>7.77%</td>
</tr>
<tr>
<td>2</td>
<td>Offshore North Bay</td>
<td>15.0%</td>
</tr>
<tr>
<td>3</td>
<td>Central Bay</td>
<td>8.33%</td>
</tr>
<tr>
<td>4</td>
<td>Offshore Central Bay</td>
<td>15.9%</td>
</tr>
<tr>
<td>5</td>
<td>North Biscayne National Park</td>
<td>10.4%</td>
</tr>
<tr>
<td>6</td>
<td>Offshore North Biscayne National Park</td>
<td>21.9%</td>
</tr>
<tr>
<td>7</td>
<td>South Biscayne National Park</td>
<td>13.1%</td>
</tr>
<tr>
<td>8</td>
<td>Offshore South Biscayne National Park</td>
<td>30.9%</td>
</tr>
<tr>
<td>9</td>
<td>Card Sound</td>
<td>16.9%</td>
</tr>
<tr>
<td>10</td>
<td>Barnes Sound</td>
<td>17.2%</td>
</tr>
<tr>
<td>11</td>
<td>Other</td>
<td>41.3%</td>
</tr>
</tbody>
</table>
3.2 For-Hire Fishing Operations

3.2.1 Demographics

About half of for-hire fishing operators were over 40 years-old and half were younger (Table 19), indicating a lower average age than recreational fishing respondents. All 22 interviewed operators were male (Table 20), and 86.4% identified as white (either white alone or white plus some other race (Table 21). Only 18.2% of operators identified as Hispanic, and 9.09% identified as Asian.

Table 19. Age of for-hire fishing participants (n = 22).

<table>
<thead>
<tr>
<th>Age</th>
<th>% Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 18</td>
<td>0.00</td>
</tr>
<tr>
<td>18-30</td>
<td>31.8</td>
</tr>
<tr>
<td>31-40</td>
<td>18.2</td>
</tr>
<tr>
<td>41-50</td>
<td>18.2</td>
</tr>
<tr>
<td>51-60</td>
<td>9.09</td>
</tr>
<tr>
<td>Over 60</td>
<td>22.7</td>
</tr>
</tbody>
</table>

Table 20. Gender of for-hire fishing participants (n = 22).

<table>
<thead>
<tr>
<th>Gender</th>
<th>% Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>100</td>
</tr>
<tr>
<td>Female</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 21. Race of for-hire fishing participants (n = 22).

<table>
<thead>
<tr>
<th>Race</th>
<th>% Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hispanic</td>
<td>18.2</td>
</tr>
<tr>
<td>American Indian</td>
<td>0.00</td>
</tr>
<tr>
<td>White</td>
<td>86.4</td>
</tr>
<tr>
<td>Asian</td>
<td>0.00</td>
</tr>
<tr>
<td>Native Hawaiian</td>
<td>0.00</td>
</tr>
<tr>
<td>Black</td>
<td>9.09</td>
</tr>
<tr>
<td>Other</td>
<td>0.00</td>
</tr>
</tbody>
</table>
For-hire fishers interviewed were primarily from Miami-Dade County (Table 22). Most were from Miami Beach or North Miami Beach. The rest were from Coconut Grove, Cutler Bay, Homestead, or Broward County.

Table 22. Home zip codes for for-hire fishers (n = 22).

<table>
<thead>
<tr>
<th>Zip</th>
<th>% Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>33021</td>
<td>4.55</td>
</tr>
<tr>
<td>33023</td>
<td>4.55</td>
</tr>
<tr>
<td>33030</td>
<td>4.55</td>
</tr>
<tr>
<td>33056</td>
<td>4.55</td>
</tr>
<tr>
<td>33132</td>
<td>4.55</td>
</tr>
<tr>
<td>33133</td>
<td>4.55</td>
</tr>
<tr>
<td>33138</td>
<td>4.55</td>
</tr>
<tr>
<td>33139</td>
<td>4.55</td>
</tr>
<tr>
<td>33140</td>
<td>9.09</td>
</tr>
<tr>
<td>33143</td>
<td>4.55</td>
</tr>
<tr>
<td>33154</td>
<td>4.55</td>
</tr>
<tr>
<td>33155</td>
<td>4.55</td>
</tr>
<tr>
<td>33157</td>
<td>13.6</td>
</tr>
<tr>
<td>33160</td>
<td>9.09</td>
</tr>
<tr>
<td>33161</td>
<td>4.55</td>
</tr>
<tr>
<td>33181</td>
<td>4.55</td>
</tr>
<tr>
<td>33324</td>
<td>4.55</td>
</tr>
<tr>
<td>34736</td>
<td>4.55</td>
</tr>
</tbody>
</table>

3.2.2 Resource Use

More than half of participants had more than 20 years of experience (54.6%), while about 22.7% had 1-5 years of experience (Table 23). No for-hire fishers interviewed had less than one year of experience.

Table 23. General for-hire fishing experience (n = 22) and experience specifically in Miami-Dade County (n = 22).

<table>
<thead>
<tr>
<th>Years Fishing</th>
<th>General</th>
<th>In Miami-Dade</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1 year</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>1-5 years</td>
<td>22.7</td>
<td>22.7</td>
</tr>
<tr>
<td>6-10 years</td>
<td>4.55</td>
<td>9.09</td>
</tr>
<tr>
<td>11-15 years</td>
<td>4.55</td>
<td>4.55</td>
</tr>
<tr>
<td>16-20 years</td>
<td>13.6</td>
<td>9.09</td>
</tr>
<tr>
<td>&gt;20 years</td>
<td>54.5</td>
<td>54.5</td>
</tr>
</tbody>
</table>
Participants were also asked specifically about their experience fishing in Miami-Dade County (Table 23), and results were very similar, indicating that most for-hire fishers spent most of their fishing careers in the Miami-Dade region.

Over 90.9% of participants identified as full-time for-hire fishers, and participants reported that for-hire fishing made up an average of 89.8% of their personal income (n = 22; std. dev. = 24.0%).

Of the 22 for-hire fishers interviewed, 95.5% reported using hook and line (specifically rod and reel) gear (Table 24). Only 13.6% reported using nets (specifically cast nets). It is highly likely that all for-hire fishers who catch baitfish use nets, but most only reported their primary gear type. Finally, 4.55% reported using SCUBA (for spearfishing). When asked if they offered and/or permitted additional activities on their trips (e.g. SCUBA, snorkel, kayak, etc.), 81.8% of for-hire operators said they did not – their trips were strictly fishing.

Table 24. For-hire fishing gear types (n = 22).

<table>
<thead>
<tr>
<th>Gear Types</th>
<th>% Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rod and Reel</td>
<td>95.5</td>
</tr>
<tr>
<td>Cast Nets</td>
<td>13.6</td>
</tr>
<tr>
<td>SCUBA/Snorkel</td>
<td>4.55</td>
</tr>
</tbody>
</table>

For-hire fishing launch points were identified almost exclusively in the northern half of the county (Figure 21; n = 21). For-hire launch points were most dense near Crandon Marina and Haulover Marine Park.
For-hire fishers reported taking an average of 334.48 trips per year (n = 21; std. dev. = 225.63). Operators took 8.73 customers on an average trip (n = 22; std. dev. = 9.73), which lasted 6.24 hours (n = 21; std. dev. = 1.57). Almost all of for-hire operators’ trips were reported to take place within the Biscayne Bay region (n = 11; mean = 91.8% of trips; std. dev. = 15.4%).

When asked to identify their current fishing grounds, for-hire fishers most frequently identified territorial waters from Broad Causeway to NE 79th St (Figure 22; n = 22). For-hire fishers identified areas inside the bay infrequently, except for the north bay from Broad Causeway down to Government Cut.
Figure 22. Current for-hire fishing grounds by participant count (n = 22).

Current areas accessed by for-hire operations were also mapped by the number of annual trips (Figure 23; n = 21). The areas most frequently reported by for-hire fishing operations on an annual trip basis were offshore Miami Beach and Key Biscayne, extending out towards the outer limits of Florida submerged lands.
Figure 23. Current for-hire fishing grounds by trips per year (n = 21).

Only 31.8% of for-hire fishers chose to identify historic areas (i.e. areas they used to fish but no longer utilize). The identified areas were dispersed, and most did not overlap (Figure 24; n = 7). The only instances of overlap occurred inside the bay.
Figure 24. Historic for-hire fishing grounds by participant count (n = 7).

As shown in Figure 25, over 90.9% of for-hire operators reported fishing for reef species. A total of 86.4% reported fishing for pelagic species, and 77.3% for baitfish. Exactly half of for-hire respondents reported fishing for coastal species. Finally, most for-hire fishers reported both fishing for their own bait (77.3%) as well as purchasing bait (68.2%). Only one operation reported not using bait, which can be explained by the fact that the operator only guides spearfishing trips.
Figure 25. Species groups targeted by for-hire fishers (n = 22).

3.2.3 Economics

Trip expenses were calculated on a per-trip basis (Table 25; Figure 26). For-hire fishers reported spending the most on fuel and oil. Food and supplies were estimated to be less than half the annual expense of fuel and oil, while bait and ice costs were both extremely low relative to other expenditures. Bait may have been underrepresented, as the interview template did not specifically ask fishers about chum expense.

Table 25. Average per trip costs for for-hire fishers (n = 18).

<table>
<thead>
<tr>
<th>Expense Type</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel and Oil</td>
<td>$123.00</td>
<td>$86.90</td>
</tr>
<tr>
<td>Ice</td>
<td>$3.89</td>
<td>$9.93</td>
</tr>
<tr>
<td>Bait</td>
<td>$21.40</td>
<td>$21.20</td>
</tr>
<tr>
<td>Food and Supplies</td>
<td>$46.30</td>
<td>$88.10</td>
</tr>
<tr>
<td>Other</td>
<td>$202.00</td>
<td>$848.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$412.00</strong></td>
<td><strong>$924.00</strong></td>
</tr>
</tbody>
</table>
In terms of gear, each operation was estimated to possess an average of $29,100 worth of rods, reels, and associated tackle (n = 20; std. dev. = $26,000). The average vessel value was valued at $166,000 (n = 18; std. dev. = $166,000) and was estimated to be 37.7 feet (n = 20; std. dev. = 14.4) with 569 HP (n = 19; std. dev. = 313). Participants reported owning an average of 2.05 vessels per operation (n = 22; std. dev. = 1.13). Additionally, 77.3% of for-hire operators reported docking at marinas, while 22.7% reported using boat ramps. Finally, each for-hire operation employed an average of 5.82 people (including captain and crew; n = 22; std. dev. = 6.46).

3.2.4 Perceptions of Water Quality

Finally, fishers were asked a series of questions to understand their perceptions of water quality issues in Biscayne Bay. On a scale of very poor to very good (values 0-4), participants indicated that water quality in the bay was between poor and neutral (n = 16; mean = 1.50; std. dev. = 1.10). A total of 45.5% of respondents reported water quality to be poor or very poor, while only 13.6% of respondents indicated that water quality was good or very good (Figure 27).
On a scale of much worse to much better (values 0-4), for-hire fishers reported that they bay had gotten slightly worse since they began fishing in the region (n = 22; mean = 1.52; std. dev. = 1.21). A total of 50.0% indicated that water quality had gotten somewhat worse or much worse, while only 22.7% stated that water quality had gotten somewhat better or much better (Figure 28).
Out of all 22 for-hire operators, only 18.2% reported noticing improvements in Biscayne Bay water quality. About 4.55% noticed an improvement in water clarity, 4.55% noted improvement in seagrass and/or coral health, and 9.09% reported a decrease in trash. All those for-hire operations that reported noticing water quality improvements chose to identify specific improved areas (Figure 29; n = 4). The only instances of overlap occurred along the reef tract and near the Rickenbacker Causeway.

![For-Hire Fishing Water Quality Improvements](image)

Figure 29. Observations of water quality improvements by for-hire fishers (n = 4).

Conversely, 68.2% of respondents were aware of instances of water quality degradation in the bay. A total of 54.6% reported declines in seagrass and/or coral health, 50.0% a decrease in water clarity, 40.9% increases in levels of trash, and 27.3% increases
in algal levels. Approximately 18.2% observed “other” instances of water quality degradation including decreased salinity and fewer fish.

A total of 63.6% of for-hire fishers identified specific areas of observed water quality degradation (Figure 30; n = 14). The most frequently identified areas occurred inside the north bay. Of the 25 water quality degradation polygons drawn by for-hire fishers, 60.0% were attributed to runoff, 56.0% to sewage and outfalls, and 44.0% to vessel-related pollution and damage (Figure 31). Only 16.0% were linked to marine litter, 16.0% to land-based trash and 12.0% to climate change. A total of 32.0% were unattributed.

![For-Hire Fishing Water Quality Degradation](image)

Figure 30. Observations of water quality degradation by for-hire fishers (n = 14).
Finally, respondents were asked what they would do if water quality in their current areas was to decline to a point where fishing their preferred species would no longer be profitable and/or enjoyable (Figure 32). Over half of for-hire participants indicated they would fish elsewhere (59.1%). The second most common response was to target different species (40.9%), followed by “other” responses (36.4%), including implementing more catch and release efforts.

Figure 31. Causes of water quality degradation, as perceived by for-hire fishers (n = 25).
Figure 32. For-hire fishing adaptation strategies under a degraded water quality scenario (n = 22).

### 3.3 Commercial Fishing

#### 3.3.1 Demographics

Approximately 61.9% of commercial fishers were 50 years-old or younger, while 38.1% were at least 51 years-old (Table 26). All but one of the commercial fishers interviewed were male (95.2%; Table 27). Most identified as white (52.4%; Table 28) and/or Hispanic (42.9%). Only 4.67% identified as Asian, and another 4.67% as black or African American.

<table>
<thead>
<tr>
<th>Age</th>
<th>% Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 18</td>
<td>0.00</td>
</tr>
<tr>
<td>18-30</td>
<td>23.8</td>
</tr>
<tr>
<td>31-40</td>
<td>14.3</td>
</tr>
<tr>
<td>41-50</td>
<td>23.8</td>
</tr>
<tr>
<td>51-60</td>
<td>23.8</td>
</tr>
<tr>
<td>Over 60</td>
<td>14.3</td>
</tr>
</tbody>
</table>

Table 26. Age of commercial fishing participants (n = 21).

<table>
<thead>
<tr>
<th>Gender</th>
<th>% Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>95.2</td>
</tr>
<tr>
<td>Female</td>
<td>4.76</td>
</tr>
</tbody>
</table>

Table 27. Gender of commercial fishing participants (n = 21).
Table 28. Race of commercial fishing participants (n = 21).

<table>
<thead>
<tr>
<th>Race</th>
<th>% Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hispanic</td>
<td>42.9</td>
</tr>
<tr>
<td>American Indian</td>
<td>0.00</td>
</tr>
<tr>
<td>White</td>
<td>52.4</td>
</tr>
<tr>
<td>Asian</td>
<td>4.76</td>
</tr>
<tr>
<td>Native Hawaiian</td>
<td>0.00</td>
</tr>
<tr>
<td>Black</td>
<td>4.76</td>
</tr>
<tr>
<td>Other</td>
<td>0.00</td>
</tr>
<tr>
<td>Undisclosed</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Commercial fishers interviewed were from a diverse array of zip codes throughout Miami-Dade County including Opa-Locka, Hialeah, Coconut Grove, Doral, Pinecrest, Cutler Bay, and Homestead (Table 29).

Table 29. Commercial fishing zip codes (n = 21).

<table>
<thead>
<tr>
<th>Zip</th>
<th>% Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>33010</td>
<td>4.76</td>
</tr>
<tr>
<td>33012</td>
<td>9.52</td>
</tr>
<tr>
<td>33031</td>
<td>4.76</td>
</tr>
<tr>
<td>33129</td>
<td>4.76</td>
</tr>
<tr>
<td>33130</td>
<td>4.76</td>
</tr>
<tr>
<td>33138</td>
<td>4.76</td>
</tr>
<tr>
<td>33140</td>
<td>9.52</td>
</tr>
<tr>
<td>33145</td>
<td>4.76</td>
</tr>
<tr>
<td>33146</td>
<td>4.76</td>
</tr>
<tr>
<td>33156</td>
<td>9.52</td>
</tr>
<tr>
<td>33157</td>
<td>14.3</td>
</tr>
<tr>
<td>33169</td>
<td>4.76</td>
</tr>
<tr>
<td>33175</td>
<td>4.76</td>
</tr>
<tr>
<td>33187</td>
<td>4.76</td>
</tr>
<tr>
<td>33196</td>
<td>4.76</td>
</tr>
<tr>
<td>34736</td>
<td>4.76</td>
</tr>
</tbody>
</table>

3.3.2 Resource Use

About half of commercial fishers (47.6%) had more than 20 years of experience fishing commercially in general (Table 30) and specifically in Miami-Dade, indicating that most commercial fishers spent their entire careers in Miami-Dade.
Table 30. Commercial fishing general experience (n = 21) and specifically in Miami-Dade County (n = 21).

<table>
<thead>
<tr>
<th>Years Fishing</th>
<th>General</th>
<th>In Miami-Dade</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1 year</td>
<td>0.00</td>
<td>4.76</td>
</tr>
<tr>
<td>1-5 years</td>
<td>23.8</td>
<td>19.0</td>
</tr>
<tr>
<td>6-10 years</td>
<td>9.52</td>
<td>9.52</td>
</tr>
<tr>
<td>11-15 years</td>
<td>4.76</td>
<td>4.76</td>
</tr>
<tr>
<td>16-20 years</td>
<td>4.76</td>
<td>4.76</td>
</tr>
<tr>
<td>&gt;20 years</td>
<td>47.6</td>
<td>47.6</td>
</tr>
</tbody>
</table>

Just over half of commercial fishing participants reported fishing full-time (52.4%), while about 38.1% reported fishing commercially part-time. Many part-time commercial fishers also worked in seafood wholesale (e.g. fish markets or bait shops). Commercial fishers reported that on average, approximately 72.6% of their income comes from fishing activity (n = 19; std. dev. = 41.5%).

Most commercial fishers reported using hook and line gear (57.1%; Table 31). Many also reported using nets, including both cast nets for bait and butterfly nets for shrimping (42.9%). A total of 28.6% interviewed used stone crab traps, 23.8% used lobster traps, and 14.3% used snorkel/SCUBA for lobster fishing.

Table 31. Gear types used in the commercial fishing industry (n = 21).

<table>
<thead>
<tr>
<th>Gear Types</th>
<th>% Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hook and Line</td>
<td>57.1</td>
</tr>
<tr>
<td>Nets</td>
<td>42.9</td>
</tr>
<tr>
<td>SCUBA/Snorkel</td>
<td>14.3</td>
</tr>
<tr>
<td>Lobster Traps</td>
<td>23.8</td>
</tr>
<tr>
<td>Stone Crab Traps</td>
<td>28.6</td>
</tr>
<tr>
<td>Other</td>
<td>4.76</td>
</tr>
</tbody>
</table>

Commercial fishers launched from a variety of marinas, boat ramps, and private docks in the northern half of the county (Figure 33).
Many commercial fishers identified Bayside Marina. Fewer distinct launch points were identified in the southern half of the county. Overall, areas near Bayside Marina in the north and Black Point Marina and Boat Ramp in the south were most frequently identified as a launch point for commercial fishers.

On average, commercial fishers reported taking 206 trips (half- and full-day) per year (n = 18; std. dev. = 155), and trips were reported to last 7.37 hours (n = 19; std. dev. = 3.05). About 92.0% of trips were reported to occur in Miami-Dade County water (n = 10; std. dev. = 16.19%).
Bait species represented the most popular species group fished (61.9%; Figure 34). Nearly half of the commercial fishers reported fishing for lobster and/or reef fish (47.6% each). Crabs and pelagic species were also frequently targeted (38.1% and 33.3%, respectively). Approximately 23.8% of those interviewed targeted shrimp, and 9.52% targeted coastal species. A total of 42.9% reported they purchase bait, and 4.76% reported not using bait. This is likely because lobster fishers who used snorkel/SCUBA did not use bait.

Figure 34. Species groups targeted by commercial fishers (n = 21).

This was a key informant sample, thus maps of the fishing grounds of participants would not necessarily represent fishing grounds for the industry. Therefore, this study produced general maps of where commercial fishers target specific species groups but did not analyze areas based on participant count or trips per year. Commercial fishers, were asked not only where they personally fish, but also for the more general geographic extent of the fishery. This information was corroborated with benthic maps, maps of protected areas, and previous studies (Shivlani and Villanueva 2007).
Figure 35. Areas used by commercial fishers targeting stone crab and spiny lobster.

Trap fishers who targeted stone crab (Figure 35 in orange) reported that they set wood, wire, and plastic traps both inside the bay and outside of the bay, along the reef tract, from about Government Cut down to the Ocean Reef Club on Key Largo. They reported having distinct plots where they set their traps year after year. Lobsters (Figure 35 in red stripes) were reported to be fished inside the bay from Government Cut down to northern end of lobster sanctuary (outlined in blue), as well as outside the bay, along entire reef tract. Divers more often reported targeting lobsters inside bay, while trappers reported using wood and/or plastic traps placed as close to the reef as possible.
Figure 36. Areas used by commercial fishers targeting shrimp and bait species.

Shrimping (Figure 36 in pink) was reported to occur inside the bay, from the Rickenbacker Causeway down to Black Point, and occasionally all the way through Card Sound. Shrimpers noted that there used to be more activity north of the Rickenbacker, but conditions had deteriorated, and thus most shrimpers preferred to head farther south. This indicated that participants targeting shrimp were primarily targeting bait shrimp, as typically only juvenile shrimp are caught inside the bay. This is consistent with commercial fishery landings, which indicate that most shrimp landed are bait shrimp, and most commercial shrimping trips are specifically targeting bait shrimp (FWC 2016). Other bait species (Figure 36 in brown) were reported to be targeted around Key Biscayne, both inside
and outside of the bay. The map demonstrates the full extent of the bait fishing area as identified by commercial fishers, but it was reported that most effort was concentrated around Key Biscayne, which is consistent with previous findings (Shivlani and Villanueva 2007).

![Commercial Fishing Historic Areas](image)

Figure 37. Historic commercial fishing areas by participant count (n = 10).

Only 41.6% of commercial fishers chose to identify historic areas (i.e. areas they used to fish but no longer utilize). The identified areas were dispersed, and most did not overlap (Figure 37; n = 10). The only instances of overlap were in nearshore areas in the southern half of Biscayne National Park, near Black Point Marina and Homestead Bayfront Park.
3.3.3 Economics

Commercial fishers were asked approximately how much of their catch they sold and how much they kept for personal consumption. On average, 90.5% of landings was sold (n = 17; std. dev. = 20.5%), and 2.47% was kept (n = 17; std. dev. = 4.26%).

Most commercial fishers interviewed reported selling to seafood wholesalers and/or distributors (33.3%; Table 32). When broken down further, 19.1% reported selling to bait shops, 38.1% to fish houses, 14.3% to restaurants, and 23.8% to retail markets. A total of 19.1% reported selling directly to the public, indicating that some commercial fishers possessed Wholesale Dealer and Retail Licenses.

Table 32. Seafood product sales in the commercial fishing industry (n = 21).

<table>
<thead>
<tr>
<th>Sales</th>
<th>% Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public</td>
<td>19.0</td>
</tr>
<tr>
<td>Bait shops</td>
<td>19.0</td>
</tr>
<tr>
<td>Fish houses</td>
<td>38.1</td>
</tr>
<tr>
<td>Restaurants</td>
<td>14.3</td>
</tr>
<tr>
<td>Retail markets</td>
<td>23.8</td>
</tr>
<tr>
<td>Other</td>
<td>38.1</td>
</tr>
</tbody>
</table>

Of the 21 commercial fishers interviewed, only one reported fishing from shore and did not own a vessel. On average, commercial fishers owned 2.58 vessels (n = 19; std. dev. = 2.73). The average vessel was valued at $49,512.82 (n = 13; std. dev. = $60,164.38), was 35.62 feet long (n = 7; std. dev. = 16.00), and had 402.71 horsepower (n = 6; std. dev. = 330.48).

The average total hook and line gear value for fishers using hook and line gear was estimated to be $20,400 (n = 11; std. dev. = $29,300). SCUBA/Snorkel gear was valued at $26,800 per operation (n = 2; std. dev. = $32,900). Out of all 21 commercial fishers interviewed, a total of three operations reported using cast nets to catch bait species, one reported using bully nets to catch lobsters, one reported using nylon nets to catch shrimp,
and five reported using lampara and/or butterfly nets to catch shrimp. Fishers using lobster traps deployed an average of 1,720 traps (n = 5; std. dev. = 1,700). All reported lobster traps were made of wood. Fishers targeting stone crabs (n = 6) reported using an average of 308 wood traps (std. dev. = 684), 33.3 wire traps (std. dev. = 81.7), and 1,190 plastic traps (std. dev. = 1,670).

Commercial fishing operations employed an average of 4.00 people (including captain and crew) per operation (n = 15; std. dev. = 3.32). Most commercial fishers reported launching from marinas (42.7%), while 23.8% used boat ramps, and 19.1% had private docks (often belonging to fish houses to whom the fishers were contracted).

Commercial fishers were asked about trip costs (Table 33; Figure 38). On average (n = 15), commercial fishers spent about $153.00 per trip on fuel and oil (std. dev. = $101.00), $8.87 on ice (std. dev. = $17.60), $245.00 on bait (std. dev. = $636.00), $12.00 on food and supplies (std. dev. = $20.20). Bait costs were extremely variable (std. dev. = $636.00) because commercial fishers reported using a wide array of bait for different target species and gear types. For instance, lobster divers did not use bait; they used a tickle stick and bully net. Commercial fishers using traps to target lobsters had relatively low bait costs, as they reported using live lobsters to bait traps. Fishers targeting reef fish had relatively higher bait expenses, while those targeting stone crabs had extremely high bait costs. One stone crab fisherman estimated spending $700 per day on stone crab bait. Air was a very low expense compared to other expenses because very few commercial fishers dove and required air. Fishers also spent about $10.70 on “other” trip expenses (std. dev. = $25.10), including annual dive shop bills, tackle repairs, and sunscreen.
Table 33. Average per trip costs for commercial fishers (n = 15).

<table>
<thead>
<tr>
<th>Expense Type</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel and Oil</td>
<td>$153.00</td>
<td>$101.00</td>
</tr>
<tr>
<td>Ice</td>
<td>$8.87</td>
<td>$17.60</td>
</tr>
<tr>
<td>Bait</td>
<td>$245.00</td>
<td>$636.00</td>
</tr>
<tr>
<td>Food and Supplies</td>
<td>$12.00</td>
<td>$20.20</td>
</tr>
<tr>
<td>Air</td>
<td>$0.44</td>
<td>$1.72</td>
</tr>
<tr>
<td>Other</td>
<td>$10.70</td>
<td>$25.10</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$430.00</td>
<td>$669.00</td>
</tr>
</tbody>
</table>

Figure 38. Average per trip costs for commercial fishers (n = 15).

3.3.4 Perceptions of Water Quality

The survey included a series of questions related to commercial fishers’ perceptions of water quality in Biscayne Bay. On average, commercial fishers believed water quality to be between neutral and good (n = 14; mean = 2.21 on a scale where very poor = 0 and very good = 4; std. dev. = 0.89). A third of respondents (33.3%) of commercial fishers believed water quality to be “good,” 14.3% believed it to be “neutral,” and 19.1% stated it was “poor.”
When asked to compare current water quality to conditions when they began fishing in the bay, commercial fishers indicated that water was between “somewhat worse” and the “same” compared to when they began fishing in the bay (mean = 1.53; n = 21; std. dev. = 0.89; Figure 40).

A total of 28.6% of commercial fishers reported noticing water quality improvements in the bay. About 19.1% reported noticing improvements in seagrass and/or
coral health, 9.52% reported decreased trash levels, and 4.76% reported an increase in water clarity. Additionally, 9.52% reported more fish in the region since they began fishing. Only 23.8% of commercial fishers chose to identify areas of observed water quality improvements, none of which overlapped (Figure 41; n = 5).

Over three quarters (76.2%) of commercial fishers reported noticing water quality degradation in the bay (Figure 42). Increased trash was reported by 38.1% of commercial fishers, higher algal levels by 33.3%, areas of dead seagrass and/or coral health by 23.8%, and decreased clarity by 19.1%. Commercial fishers most frequently identified “other”
forms of water quality degradation (42.7%), including freshwater inflows (reported by 23.8% of commercial fishers) and fewer fish (14.3%).

<table>
<thead>
<tr>
<th>Types of Water Quality Degradation</th>
<th>Percent Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clarity</td>
<td></td>
</tr>
<tr>
<td>Trash</td>
<td></td>
</tr>
<tr>
<td>Dead seagrass and/or coral</td>
<td></td>
</tr>
<tr>
<td>Algae</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
</tbody>
</table>

Figure 42. Types of water quality degradation, as perceived by commercial fishers (n = 21).

A total of 61.9% of commercial fishers chose to identify specific areas of observed water quality degradation (Figure 43; n = 13). Nearly all identified areas were nearshore. The northern bay and near Black Point Marina were most frequently identified. Of the 19 water quality degradation polygons drawn by commercial fishers, 42.1% were attributed to sewage and outfalls, 31.6% to runoff, 26.3% to vessel-related pollution and damage, and 15.8% to marine litter (Figure 44). Only 10.5% were linked to land-based trash and 5.26% to climate change. A total of 36.8% was unattributed.
Figure 43. Observations of water quality degradation by commercial fishers (n = 13).

Finally, commercial fishers were asked what they would do if water quality degradation made targeting their preferred species in their current fishing areas unprofitable (Figure 45). Commercial fishers most frequently said they would stop fishing (52.4%). Many fishers said they would try fishing elsewhere (47.6%), while very few said they would target different species (9.52%). No commercial fishers stated that they would fish less frequently.
Figure 44. Causes of water quality degradation, as perceived by commercial fishers (n = 19).

Figure 45. Commercial fishing contingent adaptation strategies under a water quality degradation scenario (n = 21).
3.4 Seafood Wholesale and Bait Retail

3.4.1 Demographics

Seafood wholesalers were relatively evenly distributed across all age classes (Table 34) except under 18 (0.00%) and over 60 (11.1%). A total of 24 seafood wholesalers (88.9%) were male (Table 35), while only 3 (11.1%) were female. Most wholesalers identified as Hispanic (51.6%; Table 36) and/or white (48.2%). Only 3.70% identified as black or African American.

Table 34. Age of seafood wholesale participants (n = 27).

<table>
<thead>
<tr>
<th>Age</th>
<th>% Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 18</td>
<td>0.00</td>
</tr>
<tr>
<td>18-30</td>
<td>22.2</td>
</tr>
<tr>
<td>31-40</td>
<td>18.5</td>
</tr>
<tr>
<td>41-50</td>
<td>18.5</td>
</tr>
<tr>
<td>51-60</td>
<td>22.2</td>
</tr>
<tr>
<td>Over 60</td>
<td>11.1</td>
</tr>
</tbody>
</table>

Table 35. Gender of seafood wholesale participants (n = 27).

<table>
<thead>
<tr>
<th>Gender</th>
<th>% Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>88.9</td>
</tr>
<tr>
<td>Female</td>
<td>11.1</td>
</tr>
</tbody>
</table>

Table 36. Race of seafood wholesale participants (n = 27).

<table>
<thead>
<tr>
<th>Race</th>
<th>% Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hispanic</td>
<td>51.9</td>
</tr>
<tr>
<td>American Indian</td>
<td>0.00</td>
</tr>
<tr>
<td>White</td>
<td>48.1</td>
</tr>
<tr>
<td>Asian</td>
<td>0.00</td>
</tr>
<tr>
<td>Native Hawaiian</td>
<td>0.00</td>
</tr>
<tr>
<td>Black</td>
<td>3.70</td>
</tr>
<tr>
<td>Other</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Seafood wholesalers interviewed were from a diverse array of zip codes in Miami-Dade County (Table 37). A small percentage were from Broward County (3.70%) or Monroe County (3.70%).
Table 37. Home zip codes for seafood wholesalers (n = 25).

<table>
<thead>
<tr>
<th>Zip</th>
<th>% Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>33010</td>
<td>3.70</td>
</tr>
<tr>
<td>33011</td>
<td>3.70</td>
</tr>
<tr>
<td>33012</td>
<td>3.70</td>
</tr>
<tr>
<td>33014</td>
<td>3.70</td>
</tr>
<tr>
<td>33027</td>
<td>3.70</td>
</tr>
<tr>
<td>33031</td>
<td>7.41</td>
</tr>
<tr>
<td>33037</td>
<td>3.70</td>
</tr>
<tr>
<td>33055</td>
<td>3.70</td>
</tr>
<tr>
<td>33056</td>
<td>3.70</td>
</tr>
<tr>
<td>33130</td>
<td>3.70</td>
</tr>
<tr>
<td>33133</td>
<td>3.70</td>
</tr>
<tr>
<td>33138</td>
<td>7.41</td>
</tr>
<tr>
<td>33140</td>
<td>3.70</td>
</tr>
<tr>
<td>33157</td>
<td>7.41</td>
</tr>
<tr>
<td>33158</td>
<td>7.41</td>
</tr>
<tr>
<td>33170</td>
<td>3.70</td>
</tr>
<tr>
<td>33182</td>
<td>3.70</td>
</tr>
<tr>
<td>33186</td>
<td>3.70</td>
</tr>
<tr>
<td>33193</td>
<td>3.70</td>
</tr>
<tr>
<td>33196</td>
<td>3.70</td>
</tr>
<tr>
<td>34736</td>
<td>3.70</td>
</tr>
</tbody>
</table>

3.4.2 Resource Use

A total of 40.7% of wholesalers had less than 11 years of experience in Miami-Dade, while another 40.7% had more than 15 years of experience (Table 38).

Table 38. Seafood wholesale experience in Miami-Dade County (n = 27).

<table>
<thead>
<tr>
<th>Years Experience in Miami-Dade</th>
<th>% Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1 year</td>
<td>7.41</td>
</tr>
<tr>
<td>1-5 years</td>
<td>18.5</td>
</tr>
<tr>
<td>6-10 years</td>
<td>14.8</td>
</tr>
<tr>
<td>11-15 years</td>
<td>11.1</td>
</tr>
<tr>
<td>16-20 years</td>
<td>3.70</td>
</tr>
<tr>
<td>&gt;20 years</td>
<td>37.0</td>
</tr>
</tbody>
</table>

Approximately 37.0% of the seafood wholesalers also operated as (at least) part-time commercial fishers. A total of seven part-time commercial fishers/wholesalers were
asked what percent of their sales they catch themselves. The seven part-time commercial fishers reported an average of 37.6% (std. dev. = 44.9%). Overall, participants reported that seafood wholesale activity made up 84.9% of their personal income (n = 23; std. dev. = 31.4%).

Most wholesalers reported sourcing fish from territorial waters from the southern tip of Key Biscayne to the southern tip of Old Rhodes Key (Figure 46).

Figure 46. Current source grounds for seafood wholesalers (n = 14).

Only 18.5% of wholesalers and bait retailers chose to identify historic areas (i.e. areas from which they used to source seafood, either from other commercial fishers or where they fished themselves, but which they no longer utilize). Most of the areas
identified did not overlap (Figure 47; n = 5). The only area of overlap was near Black Point Marina.

![Wholesale Historic Areas](image)

Figure 47. Historic wholesale source grounds by participant count (n = 5).

As demonstrated in Figure 48, a majority of seafood wholesalers reported selling shrimp species (including bait shrimp and food shrimp) and/or baitfish (each 59.3%). Many wholesalers also sold crabs (48.2%), lobsters (40.7%), and/or reef fish (37.0%). Between one-quarter and one-third of wholesalers sold pelagic species (29.6%) and/or mollusks (22.2%). Few wholesalers reported selling “other” species (7.41%), such as cephalopods, and/or coastal species (3.70%).
Figure 48. Species sold by seafood wholesalers (n = 27).

### 3.4.3 Economics

Seafood wholesalers were asked about their suppliers and customer base (Table 39). Participants reported purchasing from an average of 8.48 commercial fishers (n = 25; std. dev. = 13.7) and 0.88 “other” sources (n = 25; std. dev. = 1.13), such as distributors, importers, and/or other wholesalers. More than two-thirds of wholesalers reported selling directly to the public (77.8%; n = 27), indicating that a majority of wholesalers also possessed retail licenses. A minority reported selling to restaurants (22.2%), “other” customers (18.2%; including distributors, resorts, other wholesalers, and exporters), retail markets (14.8%), fish houses (11.1%), and bait shops (11.1%). Each seafood wholesaler employed an average of 12.1 people (n = 25; std. dev. = 15.8).

Table 39. Wholesale customer base (n = 27).

<table>
<thead>
<tr>
<th>Sales</th>
<th>% Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public</td>
<td>77.8</td>
</tr>
<tr>
<td>Bait shops</td>
<td>11.1</td>
</tr>
<tr>
<td>Fish houses</td>
<td>11.1</td>
</tr>
<tr>
<td>Restaurants</td>
<td>22.2</td>
</tr>
<tr>
<td>Retail markets</td>
<td>14.8</td>
</tr>
<tr>
<td>Other</td>
<td>18.5</td>
</tr>
</tbody>
</table>
3.4.4 Perceptions of Water Quality

Finally, seafood wholesalers were asked a series of questions to understand their perceptions of water quality issues in Biscayne Bay. On a scale of very poor to very good (values 0-4), participants indicated that water quality in the bay was between neutral and good (n = 16; mean = 2.31; std. dev. = 0.95). A total of 14.8% of respondents reported water quality to be poor or very poor, while 29.6% of respondents indicated that water quality was good or very good (Figure 49).

On a scale of much worse to much better (values 0-4), seafood wholesalers reported that the bay had gotten slightly worse since they began fishing in the region (n = 23; mean = 1.60; std. dev. = 1.31). A total of 33.3% indicated that water quality had gotten somewhat worse or much worse, while 22.2% stated that water quality had gotten somewhat better or much better (Figure 50).
Figure 50. Changes in water quality condition, as perceived by seafood wholesalers (n = 27).

Figure 51. Observations of water quality improvements by wholesalers (n = 3).
Out of all 27 wholesalers, 25.9% reported noticing improvements in Biscayne bay water quality. About 7.41% noted improvement in seagrass and/or coral health, 11.1% reported a decrease in trash, and 7.41% reported “other” improvements such as more fish. Only 11.1% of seafood wholesalers chose to identify areas where they had observed improved water quality conditions (Figure 51; n = 3). These areas had a large overlap and covered most of the northern bay, particularly the western coast of Miami Beach, Virginia Key, and Key Biscayne.

Conversely, 44.4% of respondents were aware of instances of water quality degradation in the bay. A total of 25.9% reported declines in seagrass and/or coral health, 11.1% a decrease in water clarity, 14.8% increases in levels of trash, and 14.8% increases in algal levels (Figure 52). Approximately 25.9% observed “other” instances of water quality degradation including fewer fish, general pollution, decreased salinity, and increased temperature.

Figure 52. Types of water quality degradation, as perceived by seafood wholesalers (n = 27).
A total of 40.7% of seafood wholesalers chose to identify areas where they had observed water quality degradation (Figure 53; n = 11). Identified areas spanned the entire coast. The highest instances of overlap were inside the bay, particularly in the northern bay and nearshore areas from Black Point Marina to Turkey Point Nuclear Power Plant.

Of the 13 water quality degradation polygons drawn by wholesalers, 46.2% were attributed to sewage and outfalls, 38.5% to runoff, 23.1% to vessel-related pollution and damage, 23.1% to marine litter, 23.1% to land-based trash, and 15.4% to climate change (Figure 54). A total of 53.8% were unattributed.
To close, respondents were asked what they would do if water quality in their current areas were to decline to a point where they could no longer source their current species from current source areas (Figure 55). “Other” responses were most common (59.3%; n = 23) and most frequently included purchasing from distributors. Approximately 40.7% of participants indicated they would source fish from elsewhere, while a handful of participants stated they might stop selling fish (18.5%) and/or would try selling different species (11.1%).
Figure 55. Seafood wholesale adaptation strategies under a degraded water quality scenario (n = 27).

3.5 Recreational Water Operations

3.5.1 Demographics

The most frequently identified age range for recreational water operators was 18 – 30 (36.7%; Table 40), followed by over 31 - 40 (26.7%).

Table 40. Recreational water operator age (n = 30).

<table>
<thead>
<tr>
<th>Age</th>
<th>% Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 18</td>
<td>3.33</td>
</tr>
<tr>
<td>18-30</td>
<td>36.7</td>
</tr>
<tr>
<td>31-40</td>
<td>26.7</td>
</tr>
<tr>
<td>41-50</td>
<td>23.3</td>
</tr>
<tr>
<td>51-60</td>
<td>6.67</td>
</tr>
<tr>
<td>Over 60</td>
<td>3.33</td>
</tr>
</tbody>
</table>

A total of 23 operators were male (76.7%), and 7 (23.3%) were female (Table 41). Half of respondents identified as white and/or Hispanic (each 50.0%, Table 42). Only 3.33% of operators identified as Asian and/or black or African American.

Table 41. Recreational water operator gender (n = 30).

<table>
<thead>
<tr>
<th>Gender</th>
<th>% Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>76.7</td>
</tr>
<tr>
<td>Female</td>
<td>23.3</td>
</tr>
</tbody>
</table>
Table 42. Recreational water operator race (n = 30).

<table>
<thead>
<tr>
<th>Race</th>
<th>% Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hispanic</td>
<td>50.0</td>
</tr>
<tr>
<td>American Indian</td>
<td>0.00</td>
</tr>
<tr>
<td>White</td>
<td>50.0</td>
</tr>
<tr>
<td>Asian</td>
<td>3.33</td>
</tr>
<tr>
<td>Native Hawaiian</td>
<td>0.00</td>
</tr>
<tr>
<td>Black</td>
<td>3.33</td>
</tr>
<tr>
<td>Other</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Recreational water operators were primarily from Miami-Dade County (Table 43; n = 29). Most were from Miami Beach, North Miami Beach, or Coconut Grove. A few were from Opa-Locka, Coral Gables, and Pinecrest. The rest were from Coconut Grove, Cutler Bay, Broward County, or Monroe County.

Table 43. Recreational water operator zip codes (n = 29).

<table>
<thead>
<tr>
<th>Zip</th>
<th>% Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>33010</td>
<td>3.33</td>
</tr>
<tr>
<td>33024</td>
<td>3.33</td>
</tr>
<tr>
<td>33037</td>
<td>3.33</td>
</tr>
<tr>
<td>33130</td>
<td>3.33</td>
</tr>
<tr>
<td>33133</td>
<td>10.0</td>
</tr>
<tr>
<td>33134</td>
<td>3.33</td>
</tr>
<tr>
<td>33139</td>
<td>13.3</td>
</tr>
<tr>
<td>33140</td>
<td>6.67</td>
</tr>
<tr>
<td>33141</td>
<td>6.67</td>
</tr>
<tr>
<td>33146</td>
<td>3.33</td>
</tr>
<tr>
<td>33149</td>
<td>6.67</td>
</tr>
<tr>
<td>33155</td>
<td>3.33</td>
</tr>
<tr>
<td>33156</td>
<td>3.33</td>
</tr>
<tr>
<td>33169</td>
<td>3.33</td>
</tr>
<tr>
<td>33179</td>
<td>3.33</td>
</tr>
<tr>
<td>33181</td>
<td>3.33</td>
</tr>
<tr>
<td>33183</td>
<td>3.33</td>
</tr>
<tr>
<td>33185</td>
<td>3.33</td>
</tr>
<tr>
<td>33316</td>
<td>3.33</td>
</tr>
<tr>
<td>33327</td>
<td>3.33</td>
</tr>
<tr>
<td>36181</td>
<td>3.33</td>
</tr>
</tbody>
</table>
3.5.2 Resource Use

Nearly half of participants had less than six years of experience (46.7%), while 30.0% had more than 15 years of experience (Table 44). Participants were also asked specifically about their experience fishing in Miami-Dade County, which was lower than overall experience, indicating that many recreational water operators had experience outside of Miami-Dade County.

Table 44. General experience in the recreational water operator industry (n = 30) and specifically in Miami-Dade County (n = 30).

<table>
<thead>
<tr>
<th>Years Experience</th>
<th>General</th>
<th>In Miami-Dade</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1 year</td>
<td>23.3</td>
<td>26.7</td>
</tr>
<tr>
<td>1-5 years</td>
<td>23.3</td>
<td>33.3</td>
</tr>
<tr>
<td>6-10 years</td>
<td>23.3</td>
<td>20.0</td>
</tr>
<tr>
<td>11-15 years</td>
<td>0.00</td>
<td>6.67</td>
</tr>
<tr>
<td>16-20 years</td>
<td>10.0</td>
<td>6.67</td>
</tr>
<tr>
<td>&gt;20 years</td>
<td>20.0</td>
<td>6.67</td>
</tr>
</tbody>
</table>

About three-quarters of participants (76.7%) identified as full-time recreational water operators, and participants reported that recreational water operations made up an average of 84.4% of their personal income (n = 27; std. dev. = 29.0%).

Of the provided gear categories, recreational water operators most frequently reported offering kayaks/canoes and stand up paddleboards (SUP) for rent and for use on guided trips (both offered by 56.7%; Figure 56). Less than half of recreational water operators reported offering snorkel (40.0%), SCUBA (30.0%), or spearfishing (20.0%). A majority of operators (60.0%) also offered “other” activities, such as kiteboarding, freediving, surfing, jet skis, etc. These activities ranged dramatically in terms of level of involvement with water quality conditions in Biscayne Bay. For example, freedivers are directly in the water, and their activities may depend on certain conditions. Jet skis and
kiteboards are typically used on the water’s surface and thus typically do not depend on water quality conditions as much as freediving.

![Gear and Activities](image)

**Figure 56.** Gear and activity types offered by recreational water operators (n = 30).

When asked about the types of services they offered, nearly all operators reported offering guided tours (90.0%), 80.0% offered gear rentals, and 50.0% offered lessons and/or certifications (Table 45). About 23.3% noted offering “other” services, such as educational programming and/or opportunities for scientific research.

**Table 45.** Types of services offered by recreational water operators (n = 30).

<table>
<thead>
<tr>
<th>Operations</th>
<th>% Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gear rental</td>
<td>80.0</td>
</tr>
<tr>
<td>Guided tours</td>
<td>90.0</td>
</tr>
<tr>
<td>Lessons/Certifications</td>
<td>50.0</td>
</tr>
<tr>
<td>Other</td>
<td>23.3</td>
</tr>
</tbody>
</table>

The participants who reported renting gear to customers rented to an average of 32.3 customers per day (n = 20; std. dev. = 41.3). Recreational water operators reported taking an average of 1,080 trips per year (n = 26; std. dev. = 2,290). Operators took 14.0 customers on an average trip (n = 24; std. dev. = 12.3). Almost all trips were reported to
take place within the Biscayne Bay region (n = 17; mean = 94.1% of trips; std. dev. = 12.3%).

Recreational water operators launched from a variety of locations throughout the northern half of the county from Oleta River State Park down to the southern tip of Key Biscayne (Figure 57). Some operators launched from Homestead Bayfront Park and from Key Largo.

![Figure 57. Recreational water operator launch points (n = 28).]

Recreational water operations reported highly concentrated operating areas along the reef tract off Miami Beach (Figure 58; n = 28).
Current operating areas for recreational water operators were also displayed by the number of trips per year (Figure 59; n = 26). A heavy concentration of trips was reported to take place off of Miami Beach and Key Biscayne, as well as inside the bay from mid-Miami Beach down to the southern tip of Key Biscayne. A high concentration of trips was also reported to take place outside the region of interest, offshore and to the South of Biscayne Bay (i.e. John Pennekamp State Park in Monroe County).
Finally, current operating areas for recreational water operators were also displayed by the number of gear rentals per day (Figure 60; n = 20). Rentals followed largely the same trend as trips, with a heavier concentration in the northern half of north bay.
Figure 60. Current operating areas for recreational water operators by gear rentals per day (n = 20).

Only 23.3% of recreational water operators chose to identify historic areas (i.e. areas in which they used to rent gear and/or take trips but no longer access). Very few areas overlapped, with the exception of three nearshore areas in separate regions of the bay (Figure 61; n = 7).
3.5.3 Economics

Trip expenses were calculated on a per trip basis separately for operations that used vessels (n = 10; Table 46; Figure 62) and for those that did not (n = 12; Table 47; Figure 63). Recreational water operators that used vessels reported spending the most on “other” expenses, such as dive shop bills and charter expenses. Fuel and oil was estimated to be the second highest trip cost ($54.70 per trip). Air for SCUBA ($29.50) and food and supplies ($21.50) were both significant per trip expenses. Overall, operators that used vessels reported spending dramatically more per trip than those who did not use vessels.
Table 46. Average per trip costs for recreational water operators that used vessels (n = 10).

<table>
<thead>
<tr>
<th>Expense Type</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel and Oil</td>
<td>$54.70</td>
<td>$72.20</td>
</tr>
<tr>
<td>Food and Supplies</td>
<td>$21.50</td>
<td>$32.20</td>
</tr>
<tr>
<td>Air for SCUBA</td>
<td>$29.50</td>
<td>$58.60</td>
</tr>
<tr>
<td>Other</td>
<td>$90.00</td>
<td>$126.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$195.65</strong></td>
<td><strong>$140.00</strong></td>
</tr>
</tbody>
</table>

Figure 62. Average per trip costs for recreational water operators that used vessels (n = 10).

Operators who did not use vessels (Table 47; Figure 63) reported spending much less per trip than those who use vessels. The only expenses reported were food and supplies ($2.50) and fuel and oil ($0.02) used for vehicular transportation to launch sites. This indicates that most recreational water operators who did not use vessels (e.g. coastal kayak rentals, stand up paddleboard rentals, etc.) did not offer lengthy trips or instructional courses with food provided but rather quick rental sessions.

Table 47. Average per trip costs for recreational water operators that didn’t use vessels (n = 12).

<table>
<thead>
<tr>
<th>Expense Type</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel and Oil</td>
<td>$0.02</td>
<td>$0.06</td>
</tr>
<tr>
<td>Food and Supplies</td>
<td>$2.50</td>
<td>$8.66</td>
</tr>
<tr>
<td>Air for SCUBA</td>
<td>$0.00</td>
<td>$0.00</td>
</tr>
<tr>
<td>Other</td>
<td>$0.00</td>
<td>$0.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$2.52</strong></td>
<td><strong>$8.66</strong></td>
</tr>
</tbody>
</table>
Gear value was highly variable amongst recreational water operators (Table 48). SCUBA and snorkel equipment was the most expensive gear type. Kayaks and canoes were about half as valuable as SCUBA/snorkel gear, while stand up paddleboards (SUP) were less than 20% as valuable as SCUBA/snorkel gear. “Other” gear was only reported by two operators and included equipment, such as nets, used by educational operations for scientific expeditions. “Other” gear was only included when the operation’s primary gear type was used directly in the water and did not fall within the provided gear types. Only gear types used for water-based activities with perceived reliance on water quality were included (i.e. gear such as jet skis, kiteboards, parasails, water trampolines were not included).

Table 48. Average operation gear value by gear type (n indicates the number of operators who reported values for each gear type).

<table>
<thead>
<tr>
<th>Item</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kayak/Canoe</td>
<td>$24,900</td>
<td>$8,400</td>
<td>11</td>
</tr>
<tr>
<td>SCUBA/Snorkel</td>
<td>$49,400</td>
<td>$17,500</td>
<td>11</td>
</tr>
<tr>
<td>SUP</td>
<td>$8,740</td>
<td>$3,800</td>
<td>12</td>
</tr>
<tr>
<td>Other*</td>
<td>$1,300</td>
<td>$1,310</td>
<td>2</td>
</tr>
</tbody>
</table>
Recreational water operators frequently did not own vessels, as they either (a) did not offer vessel-related activities or (b) chartered vessels when necessary (e.g. for SCUBA trips). The average vessel value was valued at $139,000 (n = 6; std. dev. = $188,000) and was estimated to be 31.7 feet (n = 7; std. dev. = 11.1) with 309 HP (n = 4; std. dev. = 152). Participants reported owning an average of 0.83 vessels per operation (n = 30; std. dev. = 1.68). Additionally, 23.3% of operators reported docking at marinas, while 3.33% reported using boat ramps. Each recreational water operator employed an average of 11.0 people (n = 29; std. dev. = 16.9).

### 3.5.4 Perceptions of Water Quality

Finally, recreational water operators were asked a series of questions to understand their perceptions of water quality issues in Biscayne Bay. On a scale of very poor to very good (values 0-4), participants indicated that water quality in the bay was neutral (n = 24; mean = 2.04; std. dev. = 1.16). A total of 26.7% of respondents reported water quality to be poor or very poor, 26.7% reported water quality to be neutral, and another 26.7% of respondents indicated that water quality was good or very good (Figure 64).

![Figure 64. Current water quality condition, as perceived by recreational water operators (n = 30).](image)
On a scale of much worse to much better (values 0-4), recreational water operators reported that they bay had gotten slightly worse since they began operating in the region (n = 29; mean = 1.48; std. dev. = 0.78). A total of 46.7% indicated that water quality had gotten somewhat worse or much worse, while only 6.67% stated that water quality had gotten somewhat better or much better (Figure 66).

![Changes in Water Quality Condition](image)

**Figure 65.** Changes in water quality condition, as perceived by recreational water operators (n = 30).

Out of all 30 operators, 23.3% reported noticing improvements in Biscayne bay water quality. About 13.3% noted improvement in seagrass and/or coral health, 10.0% reported a decrease in trash, 3.33% observed improvement in water clarity, and 3.33% witnessed a decrease in algal levels. Approximately 6.67% reported “other” improvements in specific management areas.

Only 13.3% of operators elected to identify areas where they had observed improvements in water quality conditions (Figure 66; n = 4). These areas overlapped in very nearshore areas off Miami Beach, as well as around Virginia Key and Key Biscayne.
Conversely, 44.4% of respondents were aware of instances of water quality degradation in the bay (Figure 67). A total of 43.3% reported declines in seagrass and/or coral health, 36.7% a decrease in water clarity, 50.00% increases in levels of trash, and 26.7% increases in algal levels. Approximately 33.3% observed “other” instances of water quality degradation including fewer fish, turbidity, invasive species, bacteria, and increased temperature.
Figure 67. Types of water quality degradation, as perceived by rec. water operators (n = 30).

Figure 68. Observations of water quality degradation by rec. water operators (n = 20).
Although only 44.4% reported noticing specific water quality degradation factors, a total of 66.7% of operators identified areas where they had observed (at least general) water quality degradation (Figure 68; n = 20). These areas were most concentrated off Miami Beach.

Of the 21 water quality degradation polygons drawn by recreational water operators (Figure 69), 52.4% were attributed to vessel-related pollution and damage, 47.6% to land-based trash, 33.3% to sewage and outfalls, 33.3% to marine litter, 33.3% to climate change, and 28.6% to runoff. A total of 14.3% were unattributed.

![Causes of Water Quality Degradation](image)

Figure 69. Causes of water quality degradation, as perceived by recreational water operators (n = 30).

Finally, participants were asked what they would do if water quality in their current source areas were to decline to a point where they could no longer source their current species. Just under half of participants stated they would try operating elsewhere and/or try “other” options (each 46.7%), such as focusing on retail or offering activities on top of the
water (e.g. cruises). Approximately 23.3% of participants indicated they would stop operating, while 16.7% said they would try offering other water-based activities. Only 10.0% indicated they would offer the same activities but less frequently.

![Contingent Adaptation Strategies](image)

**Figure 70.** Recreational water operator adaptation strategies under a degraded water quality scenario (n = 30).

In the recreational water operations industry, a dichotomy of attitudes was observed between conservationists and non-conservationists. Some operators presented themselves as conservation-minded, classic ecotourism businesses. These operations were run by individuals who were extremely concerned about the state of the bay and who greatly appreciated the ecosystem goods and services it provided. Conservation-oriented operations typically stated that they would be unwilling to transition to different activity types and would shut down if water quality continued to degrade. Other operations seemed to view the bay as a platform for their business but were less interested in the ecological diversity or ecosystem health. These non-conservationist operations were more likely to indicate that they would be willing to transition to activity types that would be less reliant on water quality, such as sunset cruises and parasailing.
Chapter 4

Understanding Stakeholder Perceptions
Policy is influenced by perception. Stakeholders can help establish baselines, and understanding the factors influencing stakeholder perceptions is critical to effective communication, which is necessary to engage stakeholders and to improve environmental management and governance. Many factors, such as previous experience and level of exposure to certain conditions can influence individual perceptions (Bennett 2016).

Baseline data from industry profiles compiled in this study were used to determine if industry and/or tenure could be used to partially explain differences in perceptions amongst stakeholders. Different industry groups had different levels of exposure to the bay and depended on it for different reasons, and thus, it was hypothesized that perceptions of water quality would vary between stakeholder groups. For instance, recreational water operators, many of whom depend on the bay’s health to attract visitors, were expected to view water quality differently compared to seafood wholesalers, who might be more interested in bay products than in bay health or aesthetics. In terms of tenure, stakeholders with more than 20 years of experience would likely have a wide variety of experiences related to the bay, leading to dramatically different perceptions from those who are newer to the region.

4.1 Influence of Industry

There was consensus across all industries that water quality conditions in Biscayne Bay were deteriorating to some extent (Figure 71). However, as demonstrated in Figure 72, the most frequently identified types of degradation varied between industries.
Figure 71. Perceived change in water quality condition by industry on a scale where much worse = 0 and much better = 4. All values fell between “somewhat worse” (1) and “same” (2).

Figure 72. Types of water quality degradation identified by industry.

Anglers, i.e. rec. fishers and for-hire fishing operations, were likely more affected by water clarity than other industries. Those who were engaging in recreational activities, including recreational fishers and recreational water operators, were mostly likely to notice
trash, while those who operated inshore and/or on the reef, including for-hire fishing operations, recreational fishers, and recreational water operations, were most likely to notice declines in seagrass and reef health. Commercial fishers, many of whom were trappers, most frequently reported other changes because they were affected by factors such as freshwater inflows.

![Graph showing causes of water quality degradation by industry.](Image)

**Figure 73.** Causes of water quality degradation identified by industry.

Specific causes of water quality degradation also varied by industry (Figure 73). Those who fished (recreationally, for hire, and/or commercially) noted sewage and outfalls, as well as runoff, as big issues. These two factors are highly connected and have been linked to eutrophication and declines of some species in the bay. Those engaging in recreational activities (including recreational fishers and water operators) often noted land-based trash. These groups were likely to be inshore, and perhaps their recreational enjoyment was hindered by the presence of garbage. Finally, it is interesting that
recreational water operators were most likely to identify vessel pollution and/or damage. Of the groups that directly interact with the bay, recreational water operators were least likely to use vessels, and they were operating in areas of dense recreational and commercial vessel traffic. Overall, industry likely influenced perception due to the needs of each industry group, as well as where industry activity took place.

4.2 Influence of Tenure

Tenure appears to affect perceptions of water quality in the opposite manner. That is, tenure influenced how stakeholders viewed the status of the bay, but not necessarily the likelihood of stakeholders identifying specific types of changes or causes of degradation. Stakeholders with less than ten years of experience were more likely to report that bay conditions were the same as when they began operating, while those with more than ten years of experience indicated that the bay was definitely worse than when they began operating (Figure 74). This suggests that changes may be difficult to observe on shorter timescales and/or that stakeholders who depended on the bay for a longer period of time were more likely to notice changes because they were more invested in the condition of the bay.
There were no notable differences in types of degradation (Figure 75) nor causes of degradation (Figure 76, recreational fishing industry only) when examined by tenure, apart from the fact that the frequency of reporting types of degradation loosely increased with tenure.

Figure 74. Changes in water quality condition as perceived by tenure.

Figure 75. Types of water quality degradation as identified by tenure.
Figure 76. Causes of water quality degradation by tenure on a scale where 0 = not important at all and 4 = very important. This data is representative of the recreational fishing industry only, as other industries were not asked to rank the importance of causes of water quality degradation.

This examination was hindered by the fact that most interview participants and most survey respondents had a significant amount of experience. Future studies should ensure representation from stakeholders newer to Biscayne Bay industries.

4.3 Adaptation Strategies by Industry

Finally, influence of industry on contingent adaptation strategy was investigated (Figure 77). All stakeholder groups most frequently reported that they would attempt to continue their activities elsewhere – just not typically inside the bay. “Elsewhere” was most frequently identified as the Florida Keys.
In terms of target species, recreational fishers and commercial fishers were not likely to target other species, but more than 40% of for-hire fishers said that they would try doing so. In fact, this is already the reality for many for-hire fishers. Most for-hire operations already have some flexibility in terms of species, as they must cater to the preferences of the client. Recreational fishers, on the other hand, only fish what they want to fish, and commercial fishers are limited to those species that can be harvested commercially. Additionally, many commercial fishers have made significant investments in species-specific gear, and thus it would be very difficult to switch target species groups. Finally, recreational water operators could offer different activities; it would be up to the individual operator to decide if they wanted to switch to activities less reliant on water quality. This decision may be influenced by the water operator’s conservationist or non-conservationist attitudes (see Section 3.5.4).

In terms of frequency, recreational fishers were the only group with any real ability to fish or operate less frequently, as they are the only stakeholder group whose livelihoods...
do not depend on the activities in question. Recreational water operators were the only other group to consider operating less frequently, but this was typically only the case if they also operated as gear and/or apparel retailers. In this instance, they would transition most of their business to retail and would operate trips on a less frequent basis.

Finally, commercial fishers were the group most likely to indicate that they would stop operating. This is the group that has invested the most into very niche operations that are completely reliant on Biscayne Bay. This decision would likely trickle down into wholesale, as there was a significant amount of overlap between commercial fishers and seafood wholesalers, especially in bait wholesale. About 23.3% of recreational water operators indicated that they would stop offering activities, but again, these operations typically had a retail component and planned to transition all business to retail if water quality degraded past a certain point.
Chapter 5

Conclusions
5.1 Major Findings and Policy Implications

Overall, all stakeholder groups perceived water quality to be declining in Biscayne Bay. Views on the types of changes occurring and the causes of degradation varied by industry, and those with less experience were less likely to notice declines in water quality than those with more experience. Additionally, adaptation strategies varied by industry, but most participants indicated that they would try to conduct activities elsewhere, most likely in the Florida Keys.

This study presents a wide range of socioeconomic, resource use, and perception-based data for Biscayne Bay water quality-dependent industries. This data can be used in future analyses to determine any major demographic, economic, and resource use shifts. It can also be ground-truthed with water quality measurements for further analysis of factors influencing stakeholder perceptions. More effective educational campaigns can be developed through an understanding of where certain industries operate and how they perceive water quality, and stakeholders with common interests and concerns can be brought together to take political action. This information will help industry participants and policymakers alike to develop new strategies to preserve and improve water quality in Biscayne Bay.

For example, this study determined that recreational water operators were concerned about trash and dead seagrass and corals as forms of water quality degradation and that they blamed vessels and land-based sources of trash for these issues. Policymakers and/or conservation groups could reach out to water operators as potential collaborators in ongoing research examining sources of trash, such as the University of Miami’s Carthe Lab Bay Drift project. Local governments and nonprofit initiatives could also provide
recreational water operators with the resources to get engaged with and/or start their own trash collection efforts, such as beach and mangrove clean-ups. In fact, during the interview process, many water operators asked for assistance in starting long-term clean-up projects. This would be a great opportunity to transition stakeholder perceptions and concerns into actions to improve environmental quality. Additionally, recreational water operators could be encouraged to educate their guests about the impacts of trash on the bay and to discontinue using common environmental pollutants (such as plastic straws and bags, Styrofoam cups, etc.) in their operations.

While recreational water operators were also concerned about dead seagrass and/or corals, they more frequently identified vessels and land-based trash as sources of degradation than runoff or sewage and outfalls, two causes of water quality degradation that are extremely important in terms of seagrass and coral health. This stakeholder group should be very interested in reducing the impacts of runoff and sewage and outfalls from both a sanitary perspective and an ecological perspective. They should want clients to be able to and want to get in the water. Thus, talking to recreational water operators about the impacts of runoff and sewage and outfalls on local ecosystems and on their businesses would likely encourage this stakeholder group to push for more effective water quality management.

Aggregate results from the online surveys and in-person interviews were made publicly available via integration into the study’s online ESRI Story. A “Results” Map Series embedded into the Biscayne Bay Economic and Spatial Study Story Map features spatial use data and perception-based data with respect to water quality degradation. Hopefully, additional data from the NOAA Habitat Blueprint Biscayne Bay Habitat Focus
Area project, such as historic and current measures of water quality, will be incorporated into the “Results” tab.

The mapping portal produced from this research provides endless applications for Biscayne Bay research and policy. This information can be used by industry participants and policymakers alike to push for more effective water quality management strategies to protect Biscayne Bay. Policymakers specifically may use this data to determine how to allocate resources to maximize economic return and to protect the most vulnerable areas. The mapping portal may also be helpful in determining how spatial use patterns influence perceptions of water quality. For instance, stakeholders who primarily utilize certain regions of the bay may be more likely to report water quality degradation, as well as specific types and causes of degradation. Understanding the spatial influence of stakeholder perceptions is critical to developing productive relationships with stakeholders.

Results from this study are critical to the longevity of Biscayne Bay fisheries and recreational water operations, as well as other water quality-dependent industries in the region. Hopefully, the results generated from this research will draw attention to the severity of water pollution and contamination issues in certain regions of the bay and the potential economic consequences of water quality degradation. This project, in combination with data from the SECOORA Data Catalog, FWC, and additional NOAA Habitat Blueprint studies, is designed to serve as a critical component in ensuring the longevity of Biscayne Bay fisheries and recreational water operations, as well as a swimmable, fishable, drinkable bay.
5.2 Future Studies

Future analyses could use the economic data collected in this study to determine the economic value of the focus industries, as well as the potential economic ramifications of water quality degradation. Other studies have used economic modeling tools such as the Capacity Utilization Model and the IMPLAN regional economic input-output model (Hazen and Sawyer 2005). In combination with other readily available economic indicators and statistics, the data presented in the stakeholder industry profiles could be used to conduct updated economic valuations specifically pertaining to water-quality dependent industries.

This study presents a broad range of socioeconomic, resource use, and perception-based data, but the focus industries of this study also contribute to the regional economy in ways that did not fall within the scope of this research. For instance, recreational fishing tournaments happen only intermittently and therefore were outside the scope of this study. However, they may constitute significant contributions to the local economy in terms of recreational fishing expenditures (e.g. bait, chartered boats, ice, etc.), as well as income for the for-hire industry. In-depth, semi-structured interviews with key industry informants provide participants the opportunity to divulge additional information, such as stories and gossip regarding fishing tournaments. More detailed interviews should be conducted with key informants in each industry to get a more detailed understanding of the economic contributions of each industry to the regional economy and how businesses are/may be economically impacted by water quality degradation.

Two specific areas that should be covered for all industries in future analyses are operating costs and contribution to household income. This study asked about trip costs
and some capital investments but did not ask participants to estimate operating costs (e.g. insurance, interest payments, crew payments, vessel maintenance and repair, general maintenance and repair, etc.). Future studies should categorize and estimate all expenses to aid in economic valuation and to understand the full economic contribution of focus industries. Interview participants should also be asked about their contribution to their household income and how many dependents rely on their income. This would help determine how many people immediately depend on money earned in each focus industry and could be used to determine how families would be economically impacted by water quality degradation.

A full census survey of the commercial fishing industry should also be conducted to gain a better understanding of the number of Saltwater Products Licenses that are consistently utilized. While this project presents findings consistent with previous studies, it is possible that there is an untapped community of commercial fishers who have not been interviewed and who may have different resource use practices and/or views on water quality.


Biscayne Bay Aquatic Preserves. 2012. Biscayne Bay Aquatic Preserves Management Plan. Florida Department of Environmental Protection, Coastal and Aquatic Managed Areas.


Chin, D.A. 2015. The Cooling-Canal Sysytem at the FPL Turkey Point Power Station. Miami-Dade County and University of Miami.

Corcoran, E.F., Brown, M.S., Freay, A.D., 1984. The study of trace metals, chlorinated pesticides, polychlorinated biphenyls and phthalic acid esters in sediments of


DERM, 1981. Biscayne Bay Management Plan. Metropolitan Dade County Environmental Resources Management Department and Metropolitan Dade County Planning Department.


Staletovich, J. 2017. Miami’s sewage is supposed to be pumped offshore but the pipe has sprung a leak. Miami Herald.


GIS Data and Tools


A.1.1  Online Survey Request for Consent (English)

Biscayne Bay Economic & Spatial Study

Dear FWC License Holder,

I am a graduate student at the University of Miami conducting very important research about Biscayne Bay, and I would like to invite you to participate. Your participation is essential to protecting Biscayne Bay and its fisheries.

You will be asked to complete a very short (five-minute) survey about your involvement in Biscayne Bay fisheries and your opinions about water quality in the Bay. Your responses will go a long way towards preserving fisheries in the Bay.

Your participation is voluntary, which means you can choose whether or not you want to take part in this study. If you do not wish to answer any or all questions, you may opt out at any time.

You are not expected to have any risks or benefit from being in this research study. Your information will be stored using an anonymous ID in place of your name to maintain confidentiality.

Your participation and completion of this survey indicate your consent.

For more information, please visit:
http://arcg.is/2pZgVYA

Please direct all questions and comments to:
Maria Estevanez and Samantha Dowdell
sdowdell@rsmas.miami.edu
University of Miami
Rosenstiel School of Marine and Atmospheric Science
4600 Rickenbacker Causeway
Miami, FL 33149

If you have any questions about your rights as a research participant, you may contact the University of Miami Human Subjects Research Office at 305-243-3195.
Estudio Económico y Espacial de Biscayne Bay

Estimado titular de la licencia FWC,

Soy una estudiante graduada en la Universidad de Miami realizando investigaciones muy importantes sobre Biscayne Bay, y me gustaría invitarles a participar. Su participación es esencial para proteger la Bahía de Biscayne y sus pesquerías.

Se le pedirá que complete una breve encuesta (de cinco minutos) sobre su participación en las pesquerías de Biscayne Bay y sus opiniones sobre la calidad del agua en la Bahía. Sus respuestas ayudarán mucho a preservar las pesquerías en la Bahía.

Su participación es voluntaria, lo que significa que puede elegir si desea o no participar en este estudio. Si no desea responder a ninguna o todas las preguntas, puede optar por salir en cualquier momento.

No se espera que usted tenga ningún riesgo o beneficio de estar en este estudio de investigación. Su información será almacenada usando un ID anónimo en lugar de su nombre para mantener la confidencialidad.

Su participación y la realización de esta encuesta indican su consentimiento.

Para más información por favor visite:

http://arcg.is/2pZgVYA

Por favor dirija todas las preguntas y comentarios a:
Maria Estevanez and Samantha Dowdell
sdowdell@rsmas.miami.edu
University of Miami
Rosenstiel School of Marine and Atmospheric Science
4600 Rickenbacker Causeway
Miami, FL 33149

Si tiene alguna pregunta sobre sus derechos como participante en la investigación, puede comunicarse con la Oficina de Investigación de Sujetos Humanos de la Universidad de Miami a 305-243-3195.
A.1.3 Request for Interview Consent (English)

Biscayne Bay Economic & Spatial Study

Dear Biscayne Bay Stakeholder,

I am a graduate student at the University of Miami conducting very important research about Biscayne Bay, and I would like to invite you to participate. Your participation is essential to protecting Biscayne Bay and its fisheries.

You will be asked to complete a thirty-minute to one-hour interview. You will be asked about your participation and investment in Biscayne Bay fisheries and recreation. Your responses will go a long way towards preserving fisheries and recreation in the Bay.

Your participation is voluntary, which means you can choose whether or not you want to take part in this study. If you do not wish to answer any or all questions, you may opt out at any time. This interview will be audio-taped unless you request otherwise.

You are not expected to have any risks or benefit from being in this research study. Your information will be stored using an anonymous ID in place of your name to maintain confidentiality.

Your participation and completion of this interview indicate your consent.

For more information, please visit:
http://arcg.is/2pZgVYA

Please direct all questions and comments to:
Maria Estevanez and Samantha Dowdell
sdowdell@rsmas.miami.edu
University of Miami
Rosenstiel School of Marine and Atmospheric Science
4600 Rickenbacker Causeway
Miami, FL 33149

If you have any questions about your rights as a research participant, you may contact the University of Miami Human Subjects Research Office at 305-243-3195.
A.1.4 Request for Interview Consent (Spanish)

Estudio Económico y Espacial de Biscayne Bay

Estimado participante de Biscayne Bay,

Soy estudiante graduada en la Universidad de Miami realizando investigaciones muy importantes sobre Biscayne Bay, y me gustaría invitarle a participar. Su participación es esencial para proteger la Bahía de Biscayne y sus pesquerías.

Se le pedirá que complete una entrevista de treinta minutos a una hora. Se le preguntará sobre su participación e inversión en las pesquerías y recreación de Biscayne Bay. Sus respuestas ayudarán mucho a preservar las pesquerías y recreación en la Bahía.

Su participación es voluntaria, lo que significa que puede elegir si desea o no participar en este estudio. Si no desea responder a ninguna o todas las preguntas, puede optar por salir en cualquier momento. Esta entrevista será grabada en audio a menos que usted solicite lo contrario.

No se espera que usted tenga ningún riesgo o beneficio de estar en este estudio de investigación. Su información será almacenada usando un ID anónimo en lugar de su nombre para mantener la confidencialidad.

Su participación y la realización de esta entrevista indican su consentimiento.

Para más información por favor visite:
http://arcg.is/2pZgVYA

Por favor dirija todas las preguntas y comentarios a:
Maria Estevanez and Samantha Dowdell
sdowdell@rsmas.miami.edu
University of Miami
Rosenstiel School of Marine and Atmospheric Science
4600 Rickenbacker Causeway
Miami, FL 33149

Si tiene alguna pregunta sobre sus derechos como participante en la investigación, puede comunicarse con la Oficina de Investigación de Sujetos Humanos de la Universidad de Miami a 305-243-3195.
Appendix 2

Online Surveys
A.2.1 Online Survey (Recreational Fishermen)
(English Only, Spanish Copy Available Upon Request)

SURVEY FLOW

<table>
<thead>
<tr>
<th>Block: Introduction (5 Questions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard: Fishing Trends and Patterns (15 Questions)</td>
</tr>
<tr>
<td>Standard: Economic (6 Questions)</td>
</tr>
<tr>
<td>Standard: Water Quality (16 Questions)</td>
</tr>
<tr>
<td>Standard: Closing (1 Question)</td>
</tr>
</tbody>
</table>

EndSurvey:

INTRODUCTION

Q1.1 Which of the following includes your age?

- ○ under 18 (1)
- ○ 18 - 30 (2)
- ○ 31 - 40 (3)
- ○ 41 - 50 (4)
- ○ 51 - 60 (5)
- ○ over 60 (6)

*Skip To: End of Survey If Q1.1 = under 18 (1)*
Q1.2 Which of the following best describes your race? *Please select all that apply.*

- Hispanic, Latino, or Spanish Origin (7)
- White (1)
- Black or African American (2)
- American Indian or Alaska Native (3)
- Asian (4)
- Native Hawaiian or Pacific Islander (5)
- Some other race (please specify) (6)

Q1.3 Which of the following best describes your gender?

- male (1)
- female (2)

Q1.4 What is your home zip code?
Q1.5 Which of the following represents your primary fishing activity?

- [ ] hook and line / rod and reel (1)
- [ ] spearfishing (2)
- [ ] lobster diving (3)

FISHING TRENDS AND PATTERNS

Q2.1 How long have you been fishing?

- [ ] <1 year (1)
- [ ] 1-5 years (2)
- [ ] 6-10 years (3)
- [ ] 11-15 years (4)
- [ ] 16-20 years (5)
- [ ] >20 years (6)
Q2.2 How long have you been fishing in Miami-Dade County?

- <1 year (1)
- 1-5 years (2)
- 6-10 years (3)
- 11-15 years (4)
- 16-20 years (5)
- >20 years (6)

Q2.3 On average, how many trips do you take per month?

<table>
<thead>
<tr>
<th>trips/month (1)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>
Q2.4 In which of the regions below do you mainly fish? Please select all numbered regions that apply.

- 1. North Bay (1)
- 2. Offshore North Bay (2)
- 3. Central Bay (3)
- 4. Offshore Central Bay (4)
- 5. North Biscayne National Park (5)
- 6. Offshore North Biscayne National Park (6)
- 7. South Biscayne National Park (7)
- 8. Offshore South Biscayne National Park (8)
- 9. Card Sound (9)
- 10. Barnes Sound (10)
- 11. Other (please describe) (11)

Q2.5 The following questions are based on the fishing region(s) you identified. For each identified region, please select your main fishing areas.
Display This Question:

*If in which of the regions below do you mainly fish? Please select all numbered regions that apply.*

<strong>1. North Bay</strong> Is Selected

Q2.6 Please click on the map below to identify your main fishing areas in **Region 1**: North Bay.
Display This Question:

If In which of the regions below do you mainly fish? Please select all numbered regions that apply. 

2. Offshore North Bay is Selected

Q2.7 Please click on the map below to identify your main fishing areas in Region 2: Offshore North Bay.
Display This Question:

If In which of the regions below do you mainly fish? Please select all numbered regions that apply. <strong>3. Central Bay</strong> Is Selected

Q2.8 Please click on the map below to identify your main fishing areas in Region 3: Central Bay.
Q2.9 Please click on the map below to identify your primary fishing areas in **Region 4: Offshore Central Bay**.
Q2.10 Please click on the map below to identify your primary fishing areas in Region 5: North Biscayne National Park.
Q2.11 Please click on the map below to identify your primary fishing areas in **Region 6: Offshore North Biscayne National Park**.
Q2.12 Please click on the map below to identify your primary fishing areas in **Region 7: South Biscayne National Park**.
Display This Question:

If in which of the regions below do you mainly fish? Please select all numbered regions that apply.

,strong>8. Offshore South Biscayne National Park</strong> Is Selected

Q2.13 Please click on the map below to identify your primary fishing areas in Region 8: Offshore South Biscayne National Park.
Q2.14 Please click on the map below to identify your primary fishing areas in Region 9: Card Sound.
Q2.15 Please click on the map below to identify your primary fishing areas in Region 10: Barnes Sound.

ECONOMIC

Q3.1 Do you primarily fish from a boat or from shore?

- from a boat (1)
- from shore (2)
Q3.2 How many boats do you own?

- 0 (2)
- 1 (11)
- 2 (8)
- >2 (9)

Q3.3 From which part of Miami-Dade County do you typically launch your vessel?

- North Miami Beach (1)
- Miami Beach (2)
- Bal Harbour (3)
- Downtown Miami / Miami River (9)
- Key Biscayne (4)
- Coconut Grove (6)
- South Miami / Coral Gables (5)
- Cutler Bay (7)
- Homestead (8)
Display This Question:
If Do you primarily fish from a boat or from shore? from a boat Is Selected

Q46 Do you launch for vessel from a marina, boat ramp, or private dock? Please select all that apply. If marina or boat ramp, please provide the name of the facility.

☐ Marina (1) __________________________________________

☐ Boat Ramp (2) _________________________________________

☐ Private Dock (3)

☐ Other (please describe) (4)
____________________________________________

Q3.5 What species groups did you fish last season? Please select all that apply.

☐ Coastal Species (such as bonefish, pompano, tarpon, snook, permit, etc.) (3)

☐ Reef Fish (such as snapper, grouper, amberjacks, tropical ornamentals, etc.) (4)

☐ Lobsters (5)

☐ Pelagic Species (such as billfish, swordfish, mackerel, dolphinfish, sharks, etc.) (7)

☐ Other (10) ___________________________________________
Q3.6 On a typical trip, what do you spend on the following?

<table>
<thead>
<tr>
<th>Option</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel and oil (1)</td>
<td></td>
</tr>
<tr>
<td>Ice (2)</td>
<td></td>
</tr>
<tr>
<td>Bait (3)</td>
<td></td>
</tr>
<tr>
<td>Food and supplies (4)</td>
<td></td>
</tr>
<tr>
<td>Air for SCUBA tanks (5)</td>
<td></td>
</tr>
<tr>
<td>Other (6)</td>
<td></td>
</tr>
</tbody>
</table>

End of Block

WATER QUALITY

Q4.1 How does water quality in the Bay compare to how it used to be when you first started fishing?

- Much worse (2)
- Somewhat worse (3)
- Same (4)
- Somewhat better (5)
- Much better (6)
- I don’t know (7)
Q4.2 The following questions are based on the fishing region(s) you identified. For each identified region, please identify the areas where you think water quality is poorest.

Display This Question:
If in which of the regions below do you mainly fish? Please select all numbered regions that apply. <strong>1. North Bay</strong> is Selected

Q4.3 Please click on the map below to identify the fishing areas where you think water quality is poorest in Region 1: North Bay.
Q4.4 Please click on the map below to identify the fishing areas where you think water quality is poorest in **Region 2: Offshore North Bay**.
Display This Question:

If in which of the regions below do you mainly fish? Please select all numbered regions that apply. <strong>3. Central Bay</strong> is selected

Q4.5 Please click on the map below to identify the fishing areas where you think water quality is poorest in <strong>Region 3: Central Bay</strong>.
Q4.6 Please click on the map below to identify the fishing areas where you think water quality is poorest in Region 4: Offshore Central Bay.
Q4.7 Please click on the map below to identify the fishing areas where you think water quality is poorest in Region 5: **North Biscayne National Park**.
Display This Question:

If In which of the regions below do you mainly fish? Please select all numbered regions that apply. <strong>6. Offshore North Biscayne National Park</strong> Is Selected

Q4.8 Please click on the map below to identify the fishing areas where you think water quality is poorest in Region 6: Offshore North Biscayne National Park.
If In which of the regions below do you mainly fish? Please select all numbered regions that apply. 
7. South Biscayne National Park Is Selected

Q4.9 Please click on the map below to identify the fishing areas where you think water quality is poorest in Region 7: South Biscayne National Park.
Q4.10 Please click on the map below to identify the fishing areas where you think water quality is poorest in **Region 8: Offshore South Biscayne National Park**.
Display This Question:

If In which of the regions below do you mainly fish? Please select all numbered regions that apply. <strong>9. Card Sound</strong> Is Selected

Q4.11 Please click on the map below to identify the fishing areas where you think water quality is poorest in Region 9: Card Sound.
Q4.12 Please click on the map below to identify the fishing areas where you think water quality is poorest in **Region 10: Barnes Sound**.
Q4.13 What **types of water quality degradation** have you observed in these regions of the Bay? *Please select all that apply.*

- [ ] Decreased water clarity (cloudier water) (1)
- [ ] Increased trash (2)
- [ ] Areas of dead seagrasses / corals (3)
- [ ] More algae (4)
- [ ] Other (please describe) (5)

Q4.14 What are the main reasons for water quality decline? *Please rank each in terms of its importance.*

<table>
<thead>
<tr>
<th>Reason</th>
<th>Very important (1)</th>
<th>Somewhat important (2)</th>
<th>Not that important (5)</th>
<th>Not important at all (6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural runoff (6)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vessel pollution <em>(such as bilge water, sewage, oil)</em> (5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land-based trash <em>(such as plastics)</em> (2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sewage and outfalls (7)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Climate change (3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Q4.15 If water quality in your fishing areas declined to a point where you could no longer fish your preferred species, what would you do? *Please select all that could apply.*

☐ I would fish elsewhere. (2)

☐ I would target different species. (3)

☐ I would fish less frequently. (7)

☐ I would stop fishing. (1)

☐ Other (please describe) (6)
Display This Question:
If water quality in your fishing areas declined to a point where you could no longer fish your preferred species, what would you do? Please select all that could apply. I would fish elsewhere. Is Selected

Q4.16 Where would you fish? *Please select all regions that could apply.*

- □ 1. North Bay (1)
- □ 2. Offshore North Bay (2)
- □ 3. Central Bay (3)
- □ 4. Offshore Central Bay (4)
- □ 5. North Biscayne National Park (5)
- □ 6. Offshore North Biscayne National Park (6)
- □ 7. South Biscayne National Park (7)
- □ 8. Offshore South Biscayne National Park (8)
- □ 9. Card Sound (9)
- □ 10. Barnes Sound (10)
- □ 11. Other (please describe) (11)

________________________________________________

End of Block

Closing

Q5.1 Please provide any additional comments.
A2.2  Online Survey: Commercial and Charter Fishermen, Seafood Wholesalers  
(English Only, Spanish Copy Available Upon Request)

CONTACT

Q184 If you are interested in participating in an in-person interview for the Biscayne Bay Economic & Spatial Study, please provide your contact information below. Afterwards, please **click the yellow arrow to be directed to the preliminary online survey.** All of your responses will be kept separate from your contact information.

If you do not wish to participate in an in-person interview, please skip this form and **click the yellow arrow to be directed to the preliminary online survey.**

Thank you!

- Name (1) __________________________________________________
- Email Address (3) __________________________________________
- Phone Number (4) __________________________________________

End of Block
### SURVEY FLOW

<table>
<thead>
<tr>
<th>Block: Introduction (5 Questions)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Branch: New Branch</strong></td>
</tr>
<tr>
<td>If Which of the following best describes your fishing activity? commercial fishing Is Selected Or Which of the following best describes your fishing activity? for-hire fishing (includes charter, headboat, flats, and offshore) Is Selected</td>
</tr>
<tr>
<td>Standard: Fishing Trends and Patterns (21 Questions)</td>
</tr>
<tr>
<td>Standard: Fishing Economic (8 Questions)</td>
</tr>
<tr>
<td>Block: Fishing Water Quality (16 Questions)</td>
</tr>
<tr>
<td><strong>Branch: New Branch</strong></td>
</tr>
<tr>
<td>If Which of the following best describes your primary reason for holding a Florida Fish and Wildlife... Seafood Wholesale/Distribution Is Selected</td>
</tr>
<tr>
<td>Standard: Wholesale Trends and Patterns (8 Questions)</td>
</tr>
<tr>
<td>Standard: Wholesale Economic (2 Questions)</td>
</tr>
<tr>
<td>Standard: Wholesale Water Quality (6 Questions)</td>
</tr>
<tr>
<td>Standard: Closing (1 Question)</td>
</tr>
</tbody>
</table>

**EndSurvey:**
INTRODUCTION

Q1.1 Which of the following includes your age?

- under 18 (1)
- 18 - 30 (2)
- 31 - 40 (3)
- 41 - 50 (4)
- 51 - 60 (5)
- over 60 (6)

*Skip To: End of Survey if Q1.1 = under 18 (1)*

Q1.2 Which of the following best describes your race? *Please select all that apply.*

- Hispanic, Latino, or Spanish Origin (7)
- White (1)
- Black or African American (2)
- American Indian or Alaska Native (3)
- Asian (4)
- Native Hawaiian or Pacific Islander (5)
- Some other race (please specify) (6)
Q1.3 Which of the following best describes your gender?

- male (1)
- female (2)

Q1.4 What is your home zip code?

Q1.5 Which of the following best describes your fishing activity?

- commercial fishing (1)
- for-hire fishing (includes charter, headboat, flats, and offshore) (2)
- seafood wholesale (4)

End of Block
FISHING TRENDS AND PATTERNS

Q2.1 How long have you been in the $\{q://QID4/ChoiceGroup/SelectedChoices\}$ industry?

- <1 year (1)
- 1-5 years (2)
- 6-10 years (3)
- 11-15 years (4)
- 16-20 years (5)
- >20 years (6)

Q2.2 How long have you been working in $\{q://QID4/ChoiceGroup/SelectedChoices\}$ in Miami-Dade County?

- <1 year (1)
- 1-5 years (2)
- 6-10 years (3)
- 11-15 years (4)
- 16-20 years (5)
- >20 years (6)

Q2.3 On average, how many trips do you take per month?

trips/month (1)
Q231 How long is an average trip (in days)?

days/trip (1)

Q2.4 What percent of your personal income is derived from $\{q://QID4/ChoiceGroup/SelectedChoices\}? Please provide your best estimate.

% income (1)

Q2.5 What were your total landings last season (in lbs.)? Please provide your best estimate.

______ Total landings (lbs.) (1)

Q2.6 To whom do you sell your catch? Please select all that apply.

☐ I don’t sell my catch. (1)

☐ I sell to bait shops. (2)

☐ I sell to fish houses. (3)

☐ I sell to retail markets. (4)

☐ I sell directly to the public. (5)

☐ Other (please identify) (6)
Q2.7 Do you offer snorkel, kayak, and/or other recreational activities on your for-hire trips?

- Yes (1)
- No (2)

Q232 How many people do you guide on an average trip?

| people/trip (1) |   |
Q2.8 In which of the regions below do you mainly fish? *Please select all numbered regions that apply.*

- [ ] 1. North Bay (1)
- [ ] 2. Offshore North Bay (2)
- [ ] 3. Central Bay (3)
- [ ] 4. Offshore Central Bay (4)
- [ ] 5. North Biscayne National Park (5)
- [ ] 6. Offshore North Biscayne National Park (6)
- [ ] 7. South Biscayne National Park (7)
- [ ] 8. Offshore South Biscayne National Park (8)
- [ ] 9. Card Sound (9)
- [ ] 10. Barnes Sound (10)
- [ ] 11. Other (please describe) (11)

________________________________________________
Q2.9 The following questions are based on the fishing region(s) you identified. For each identified region, please select your main fishing areas.

Display This Question:

If In which of the regions below do you mainly fish? Please select all numbered regions that apply.
<strong>1. North Bay</strong> Is Selected

Q2.10 Please click on the map below to identify your main fishing areas in Region 1: North Bay.
Q2.11 Please click on the map below to identify your main fishing areas in Region 2: Offshore North Bay.
Display This Question:

If In which of the regions below do you mainly fish? Please select all numbered regions that apply.

<strong>3. Central Bay</strong> Is Selected

Q2.12 Please click on the map below to identify your main fishing areas in Region 3: Central Bay.
Q2.13 Please click on the map below to identify your primary fishing areas in Region 4: Offshore Central Bay.
Q2.14 Please click on the map below to identify your primary fishing areas in Region 5: North Biscayne National Park.
Q2.15 Please click on the map below to identify your primary fishing areas in **Region 6: Offshore North Biscayne National Park**.
Display This Question:

If in which of the regions below do you mainly fish? Please select all numbered regions that apply. <strong>Q2.16</strong> 7. South Biscayne National Park</strong> Is Selected

Q2.16 Please click on the map below to identify your primary fishing areas in **Region 7**: South Biscayne National Park.
Q2.17 Please click on the map below to identify your primary fishing areas in **Region 8: Offshore South Biscayne National Park**.
Display This Question:

If in which of the regions below do you mainly fish? Please select all numbered regions that apply. <strong>9. Card Sound</strong> Is Selected

Q2.18 Please click on the map below to identify your primary fishing areas in Region 9: Card Sound.
Q2.19 Please click on the map below to identify your primary fishing areas in Region 10: Barnes Sound.

End of Block

FISHING ECONOMIC

Q3.1 Do you primarily fish from a boat or from shore?

○ from a boat (1)

○ from shore (2)
Display This Question:
If Do you primarily fish from a boat or from shore? from a boat Is Selected

Q3.2 How many boats do you own?

- 0 (2)
- 1 (11)
- 2 (8)
- 3 (9)
- 4 (10)
- 5 (12)
- >5 (13)
Q3.3 From which part of Miami-Dade County do you typically launch your vessel?

- North Miami Beach (1)
- Miami Beach (2)
- Bal Harbour (3)
- Downtown Miami / Miami River (4)
- Key Biscayne (5)
- Coconut Grove (6)
- South Miami / Coral Gables (7)
- Cutler Bay (8)
- Homestead (9)

Q235 Do you launch for vessel from a marina, boat ramp, or private dock? Please select all that apply. If marina or boat ramp, please provide the name of the facility.

- Marina (1) _________________________________
- Boat Ramp (2) _________________________________
- Private Dock (3)
- Other (please describe) (4) _______________________________
Q3.5 What type(s) of fishing gear did you use last season? Please select all that apply.

☐ Stone Crab Traps (1)

☐ Lobster Traps (2)

☐ Nets (3)

☐ SCUBA/Snorkel Gear (5)

☐ Hook & Line (4)

☐ Other gear (please identify) (7)

________________________________________________

Q3.6 How do you get your bait? Please select all that apply.

☐ I fish for my bait. (1)

☐ I purchase my bait. (2)

☐ I don't use bait. (3)
Q3.7 What species groups did you fish last season? Please select all that apply.

- Coastal Species (such as bonefish, pompano, tarpon, snook, permit, etc.) (1)
- Reef Fish (such as snapper, grouper, amberjacks, tropical ornamentals, etc.) (2)
- Lobsters (3)
- Pelagic Species (such as billfish, swordfish, mackerel, dolphinfish, sharks, etc.) (4)
- Crabs (5)
- Baitfish (6)
- Mollusks (such as oysters, clams, scallops, etc.) (7)
- Shrimp (such as bait, brown, pink, and white shrimp) (8)
- Other (9) ________________________________________

Q3.8 On a typical trip, what do you spend on the following?

<table>
<thead>
<tr>
<th>Item</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel and oil (1)</td>
<td></td>
</tr>
<tr>
<td>Ice (2)</td>
<td></td>
</tr>
<tr>
<td>Bait (3)</td>
<td></td>
</tr>
<tr>
<td>Food and supplies (4)</td>
<td></td>
</tr>
<tr>
<td>Air for SCUBA tanks (5)</td>
<td></td>
</tr>
<tr>
<td>Other (6)</td>
<td></td>
</tr>
</tbody>
</table>

End of Block

FISHING WATER QUALITY
Q4.1 How does water quality in the Bay compare to how it used to be when you first started fishing?

- Much worse (2)
- Somewhat worse (3)
- Same (4)
- Somewhat better (5)
- Much better (6)
- I don’t know (7)
Q4.2 The following questions are based on the fishing region(s) you identified. For each identified region, **please identify the areas where you think water quality is poorest.**

Display This Question:

If in which of the regions below do you mainly fish? Please select all numbered regions that apply. <strong>1. North Bay</strong> is Selected

Q4.3 Please click on the map below to identify the fishing areas where you think water quality is poorest in Region 1: North Bay.
Q4.4 Please click on the map below to identify the fishing areas where you think water quality is poorest in **Region 2: Offshore North Bay**.
Display This Question:

If in which of the regions below do you mainly fish? Please select all numbered regions that apply. <strong>3. Central Bay</strong> Is Selected

Q4.5 Please click on the map below to identify the fishing areas where you think water quality is poorest in Region 3: Central Bay.
Q4.6 Please click on the map below to identify the fishing areas where you think water quality is poorest in **Region 4: Offshore Central Bay**.
Q4.7 Please click on the map below to identify the fishing areas where you think water quality is poorest in Region 5: North Biscayne National Park.
Q4.8 Please click on the map below to identify the fishing areas where you think water quality is poorest in **Region 6: Offshore North Biscayne National Park**.
Q4.9 Please click on the map below to identify the fishing areas where you think water quality is poorest in **Region 7: South Biscayne National Park**.
If in which of the regions below do you mainly fish? Please select all numbered regions that apply. <strong>8. Offshore South Biscayne National Park</strong> is selected

Q4.10 Please click on the map below to identify the fishing areas where you think water quality is poorest in Region 8: Offshore South Biscayne National Park.
Display This Question:

If In which of the regions below do you mainly fish? Please select all numbered regions that apply. <strong>9. Card Sound</strong> Is Selected

Q4.11 Please click on the map below to identify the fishing areas where you think water quality is poorest in Region 9: Card Sound.
If In which of the regions below do you mainly fish? Please select all numbered regions that apply.

Q4.12 Please click on the map below to identify the fishing areas where you think water quality is poorest in Region 10: Barnes Sound.
Q4.13 What **types of water quality degradation** have you observed in these regions of the Bay? *Please select all that apply.*

- [ ] Decreased water clarity (cloudier water) (1)
- [ ] Increased trash (2)
- [ ] Areas of dead seagrasses / corals (3)
- [ ] More algae (4)
- [ ] Other (please describe) (5)

Q4.14 What are the main reasons for water quality decline? *Please rank each in terms of its importance.*

<table>
<thead>
<tr>
<th>Reason</th>
<th>Very important (1)</th>
<th>Somewhat important (2)</th>
<th>Not that important (5)</th>
<th>Not important at all (6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural runoff (6)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vessel pollution <em>(such as bilge water, sewage, oil)</em> (5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land-based trash <em>(such as plastics)</em> (2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sewage and outfalls (7)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Climate change (3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Q4.15 If water quality in your fishing areas declined to a point where you could no longer fish your preferred species, what would you do? Please select all that could apply.

☐ I would fish elsewhere. (2)

☐ I would target different species. (3)

☐ I would fish less frequently. (7)

☐ I would stop fishing. (1)

☐ Other (please describe) (6)

___________________________________________
Display This Question:

If if water quality in your fishing areas declined to a point where you could no longer fish your pr... I would fish elsewhere. Is Selected

Q4.16 Where would you fish? *Please select all regions that could apply.*

- [ ] 1. North Bay (1)
- [ ] 2. Offshore North Bay (2)
- [ ] 3. Central Bay (3)
- [ ] 4. Offshore Central Bay (4)
- [ ] 5. North Biscayne National Park (5)
- [ ] 6. Offshore North Biscayne National Park (6)
- [ ] 7. South Biscayne National Park (7)
- [ ] 8. Offshore South Biscayne National Park (8)
- [ ] 9. Card Sound (9)
- [ ] 10. Barnes Sound (10)
- [ ] 11. Other (please describe) (11)

End of Block
WHOLESALE TRENDS AND PATTERNS

Q5.1 How long have you been in the ${q://QID4/ChoiceGroup/SelectedChoices}$ industry?

- <1 year (1)
- 1-5 years (2)
- 6-10 years (3)
- 11-15 years (4)
- 16-20 years (5)
- >20 years (6)

Q5.2 How long have you been working in ${q://QID4/ChoiceGroup/SelectedChoices}$ in Miami-Dade County?

- <1 year (1)
- 1-5 years (2)
- 6-10 years (3)
- 11-15 years (4)
- 16-20 years (5)
- >20 years (6)
Q5.3 How would you describe your ${q://QID4/ChoiceGroup/SelectedChoices} activity?

- Full-time (1)
- Part-time (2)

Q5.4 What percent of your personal income is derived from ${q://QID4/ChoiceGroup/SelectedChoices}? Please provide your best estimate.

% of income (1)

Q5.5 What were your sales last year (in lbs.)? Please provide your best estimate.

_______ Total sales (in lbs.) (1)

Q5.6 Do you catch your own fish to sell?

- Yes (4)
- No (5)
Q5.7 To whom do you sell your seafood products? Please select all that apply.

☐ ☑ I don't sell my seafood products. (1)

☐ I sell to bait shops. (2)

☐ I sell to fish houses. (3)

☐ I sell to retail markets. (4)

☐ I sell to restaurants. (7)

☐ I sell directly to the public. (5)

☐ Other (please identify) (6)

________________________________________________________________________
Q5.8 From which of the regions below do you mainly buy fish? Please select all numbered regions that apply.

- 1. North Bay (1)
- 2. Offshore North Bay (2)
- 3. Central Bay (3)
- 4. Offshore Central Bay (4)
- 5. North Biscayne National Park (5)
- 6. Offshore North Biscayne National Park (6)
- 7. South Biscayne National Park (7)
- 8. Offshore South Biscayne National Park (8)
- 9. Card Sound (9)
- 10. Barnes Sound (10)
- 11. Other (please describe) (11)
- I don't know (12)

End of Block

WHOLESALE ECONOMIC

Q6.1 Do you sell bait?

- Yes (1)
- No (2)
Q6.2 What species groups did you sell last season? Please select all that apply.

- Coastal Species (such as bonefish, pompano, tarpon, snook, permit, etc.) (1)
- Reef Fish (such as snapper, grouper, amberjacks, tropical ornamentals, etc.) (2)
- Lobsters (3)
- Pelagic Species (such as billfish, swordfish, mackerel, dolphinfish, sharks, etc.) (4)
- Crabs (5)
- Baitfish (6)
- Mollusks (such as oysters, clams, scallops, etc.) (7)
- Shrimp (such as bait, brown, pink, and white shrimp) (8)
- Other (9) ________________________________

WHOLESALE WATER QUALITY

Q7.1 How does water quality in the Bay compare to how it used to be when you first started selling fish?

- Much worse (2)
- Somewhat worse (3)
- Same (4)
- Somewhat better (5)
- Much better (6)
- I don’t know (7)
Q7.2 Where you believe water quality has degraded the most? *Please select all regions that apply.*

- [ ] 1. North Bay (1)
- [ ] 2. Offshore North Bay (2)
- [ ] 3. Central Bay (3)
- [ ] 4. Offshore Central Bay (4)
- [ ] 5. North Biscayne National Park (5)
- [ ] 6. Offshore North Biscayne National Park (6)
- [ ] 7. South Biscayne National Park (7)
- [ ] 8. Offshore South Biscayne National Park (8)
- [ ] 9. Card Sound (9)
- [ ] 10. Barnes Sound (10)
- [ ] 11. Other *(please describe)* (11)

________________________________________________
Q7.3 What **types of water quality degradation** have you observed in these regions of the Bay? *Please select all that apply.*

- [ ] Decreased water clarity (cloudier water) (1)
- [ ] Increased trash (2)
- [ ] Areas of dead seagrasses / corals (3)
- [ ] More algae (4)
- [ ] Other (please describe) (5)

Q7.4 What are the main reasons for water quality decline? *Please rank each in terms of its importance.*

<table>
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<td></td>
</tr>
<tr>
<td>Climate change (4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Q7.5 If water quality in the areas from which you buy fish declined to a point where you could no longer buy your preferred species, what would you do? Please select all that could apply.

☐ I would buy fish elsewhere. (7)

☐ I would buy different species. (3)

☐ I would buy seafood less frequently. (2)

☐ I would stop buying seafood. (1)

☐ Other (please describe) (6)

________________________________________________
Q7.6 Where would you buy fish? *Please select all regions that apply.*

- [ ] 1. North Bay (1)
- [ ] 2. Offshore North Bay (2)
- [ ] 3. Central Bay (3)
- [ ] 4. Offshore Central Bay (4)
- [ ] 5. North Biscayne National Park (5)
- [ ] 6. Offshore North Biscayne National Park (6)
- [ ] 7. South Biscayne National Park (7)
- [ ] 8. Offshore South Biscayne National Park (8)
- [ ] 9. Card Sound (9)
- [ ] 10. Barnes Sound (10)
- [ ] 11. Other (please describe) (11)

End of Block

CLOSING

Q8.1 Please provide any additional comments.

End of Block
Appendix 3

In-Person Interviews
### A.3.1 In-Person Interview: Qualtrics

(English Only, Spanish Copy Available Upon Request)

#### SURVEY FLOW

| Standard: INTERVIEW - DO NOT ASK (4 Questions) |
| Block: Introduction (3 Questions) |

| Branch: New Branch |
| If |
| If Which of the following best describes your fishing activity? commercial fishing Is Selected |
| Or Which of the following best describes your fishing activity? for-hire fishing (includes charter, headboat, flats, and offshore) Is Selected |

| Standard: Fishing Trends and Patterns (12 Questions) |
| Standard: Fishing Economic (20 Questions) |
| Standard: Fishermen - Water Quality (8 Questions) |

| Branch: New Branch |
| If |
| If Which of the following best describes your primary reason for holding a Florida Fish and Wildlife... Seafood Wholesale/Distribution Is Selected |

| Standard: Wholesale Trend and Patterns (7 Questions) |
| Standard: Wholesale Economic (5 Questions) |

| Branch: New Branch |
| If |
| If Do you catch your own fish to sell? Yes Is Selected |

| Block: Fishing Trends and Patterns (12 Questions) |
| Block: Fishing Economic (20 Questions) |

| Standard: Wholesale Water Quality (8 Questions) |

| Branch: New Branch |
| If |
| If Industry recreational water operations Is Selected |

| Standard: Rec. Water Ops. Trends and Patterns (10 Questions) |
| Standard: Rec. Water Ops. Water Quality (7 Questions) |

| Standard: Closing (2 Questions) |

EndSurvey:
INTERVIEW - DO NOT ASK

Q1.1 Interview ID Number

Q1.2 Date of Interview
Month (1)
Day (2)
Year (3)

Q1.3 Industry
☐ commercial fishing (1)
☐ for-hire fishing (includes charter, headboat, flats, and offshore) (2)
☐ seafood wholesale (4)
☐ recreational water operations (5)

Q1.4 Gender of Participant
☐ male (1)
☐ female (2)

End of Block
INTRODUCTION

Q2.1 Which of the following includes your age?

- under 18 (1)
- 18 - 30 (2)
- 31 - 40 (3)
- 41 - 50 (4)
- 51 - 60 (5)
- over 60 (6)

Q2.2 Which of the following best describes your race? Please select all that apply.

- Hispanic, Latino, or Spanish Origin (7)
- White (1)
- Black or African American (2)
- American Indian or Alaska Native (3)
- Asian (4)
- Native Hawaiian or Pacific Islander (5)
- Some other race (please specify) (6)
Q2.3 What is your home zip code?

FISHING TRENDS AND PATTERNS

Q3.1 How long have you been in the commercial/charter industry?

- <1 year (1)
- 1-5 years (2)
- 6-10 years (3)
- 11-15 years (4)
- 16-20 years (5)
- >20 years (6)

Q3.2 How long have you been in the commercial/charter industry in Miami-Dade County?

- <1 year (1)
- 1-5 years (2)
- 6-10 years (3)
- 11-15 years (4)
- 16-20 years (5)
- >20 years (6)
Q3.3 How would you describe your commercial/charter fishing?

- full-time (1)
- part-time (2)

Q3.4 On average, how many trips do you take per month?

- trips/month (1) ________________________________

Q3.5 How long is an average trip (in hours or days)?

- trip length (1) ________________________________

Q3.6 What percent of your personal income is derived from commercial/charter fishing? Please provide your best estimate.

- % income (1) ________________________________

Display This Question:
If Industry for-hire fishing (includes charter, headboat, flats, and offshore) Is Selected

Q3.7 Do you offer recreational activities such as SCUBA, snorkel, or kayak on your for-hire fishing trips?

- Yes (1)
- No (2)

Display This Question:
If Industry for-hire fishing (includes charter, headboat, flats, and offshore) Is Selected
Q3.8 How many people do you guide on an average trip?

☐ people/trip (1) ____________________________________________

Q3.9 To whom do you sell your catch? Please select all that apply.

☐ I don't sell my catch. (1)

☐ I sell to bait shops. (2)

☐ I sell to fish houses. (3)

☐ I sell to retail markets. (4)

☐ I sell directly to the public. (5)

☐ Other (please identify) (6)

__________________________________________________________________

Q3.10 What percent of your catch do you sell?

☐ % of catch sold (1) ____________________________________________

Q3.11 What percent of your catch do you keep?

☐ % of catch sold (1) ____________________________________________

Q3.12 How many people do you employ in your operation?
FISHING ECONOMIC

Q4.1 How many boats do you own?

- 0 (2)
- 1 (11)
- 2 (8)
- 3 (9)
- 4 (10)
- 5 (12)
- >5 (13)

Skip To: Q4.8 If Q4.1 = 0 (2)

Display This Question:
If How many boats do you own? 1 Is Selected

Q4.2 What is the total value of your boat in its present condition? Please provide your best estimate in US Dollars.

Display This Question:
If How many boats do you own? 1 Is Selected

Q4.3 How long is your boat (in ft)?

Display This Question:
If How many boats do you own? 1 Is Selected
Q4.4 What is the horsepower on your boat?

Q4.5 What is the total value of each of your boats in their present condition? Please provide your best estimate in US Dollars.

- Vessel 1 (1) _____________________________________________
- Vessel 2 (2) _____________________________________________
- Vessel 3 (3) _____________________________________________
- Vessel 4 (4) _____________________________________________
- Vessel 5 (5) _____________________________________________
- Additional (6) ___________________________________________
Q4.6 What is the length of your vessels (in ft)?

- Vessel 1 (1) ________________________________
- Vessel 2 (2) ________________________________
- Vessel 3 (3) ________________________________
- Vessel 4 (4) ________________________________
- Vessel 5 (5) ________________________________
- Additional (6) ______________________________

Display This Question:
If How many boats do you own? 0 Is Not Selected
Or How many boats do you own? 1 Is Not Selected

Carry Forward Entered Choices - Entered Text from "What is the length of your vessels (in ft)?" [ Q4.6 ]

X→

Q4.7 What is the horsepower of your vessels?

- Vessel 1 (1) ________________________________
- Vessel 2 (2) ________________________________
- Vessel 3 (3) ________________________________
- Vessel 4 (4) ________________________________
- Vessel 5 (5) ________________________________
- Additional (6) ______________________________
Q4.8 What type(s) of fishing gear did you use last season? *Please select all that apply.*

- [ ] Stone Crab Traps (1)
- [ ] Lobster Traps (2)
- [ ] Nets (3)
- [ ] SCUBA/Snorkel Gear (5)
- [ ] Hook & Line (4)
- [ ] Other gear (please identify) (7)

________________________________________________

Display This Question:
If What type(s) of fishing gear did you use last season? Please select all that apply. Other gear (please identify) Is Selected

Q4.9 What is your "other gear" worth in its present condition? *Please provide your best estimate in US Dollars.*

Display This Question:
If What type(s) of gear did you use last season? Please select all that apply. Stone crab traps Is Selected

Q4.10 How many stone crab traps did you use last season? *Please provide your best estimate.*

_____ Plastic Stone Crab Traps (1)
_____ Wood Stone Crab Traps (2)
_____ Wire Stone Crab Traps (3)
Q4.11 How many lobster traps did you use last season? *Please provide your best estimate.*

- [ ] Plastic Lobster Traps (1)
- [ ] Wood Lobster Traps (2)
- [ ] Wire Lobster Traps (3)

Q4.12 How many nets did you use last season? *Please provide your best estimate.*

- [ ] Lampara Nets (1)
- [ ] Butterfly (Wing) Nets (2)
- [ ] Pound Nets (3)
- [ ] Other (please identify) (4)

Q4.13 What is the **total value** of your SCUBA/snorkel fishing gear in its present condition (including regulators, masks, fins, spears, slings, etc.)? *Please provide your best estimate in US Dollars.*
Q4.14 What is your hook & line gear worth in its current condition? Please provide your best estimate in US Dollars for any gears types you used last season.

- Rod and Reel (1)
- Hand Reel (2)
- Troll Lines (3)
- Other (please identify) (4)

Q4.15 How do you get your bait? Please select all that apply.

- I fish for my bait. (1)
- I purchase my bait. (2)
- I don’t use bait. (3)

Q4.16 What species groups did you fish last season? Please select all that apply.

- Coastal Species (such as bonefish, pompano, tarpon, snook, permit, etc.) (1)
- Reef Fish (such as snapper, grouper, amberjacks, tropical ornamentals, etc.) (2)
- Lobsters (3)
- Pelagic Species (such as billfish, swordfish, mackerel, dolphinfish, sharks, etc.) (4)
- Crabs (5)
- Baitfish (6)
- Mollusks (such as oysters, clams, scallops, etc.) (7)
- Shrimp (such as bait, brown, pink, and white shrimp) (8)
- Other (9) ________________________________________________
Q4.17 What were your **landings last season** (in lbs.) for each species group you fished? *Charter: number of heads, not in lbs.*

- **Coastal Species** *(such as bonefish, pompano, tarpon, snook, permit, etc.)* (1)
- **Reef Fish** *(such as snapper, grouper, amberjacks, tropical ornamentals, etc.)* (2)
- **Lobsters** (3)
- **Pelagic Species** *(such as billfish, swordfish, mackerel, dolphins, sharks, etc.)* (4)
- **Crabs** (5)
- **Baitfish** (6)
- **Mollusks** *(such as oysters, clams, scallops, etc.)* (7)
- **Shrimp** *(such as bait, brown, pink, and white shrimp)* (8)
- **Other** (9)
Q4.18 How many trips did you take last season for each species group you fished?

- Coastal Species (such as bonefish, pompano, tarpon, snook, permit, etc.) (1)
  
- Reef Fish (such as snapper, grouper, amberjacks, tropical ornamentals, etc.) (2)
  
- Lobsters (3)
  
- Pelagic Species (such as billfish, swordfish, mackerel, dolphinfish, sharks, etc.) (4)
  
- Crabs (5)
  
- Baitfish (6)
  
- Mollusks (such as oysters, clams, scallops, etc.) (7)
  
- Shrimp (such as bait, brown, pink, and white shrimp) (8)
  
- Other (9)
Q4.19 On a typical trip, what do you spend on the following?

- Fuel and oil (1) __________________________________________________
- Ice (2) _______________________________________________________
- Bait (3) _______________________________________________________
- Food and supplies (4) ___________________________________________
- Air for SCUBA tanks (5) _________________________________________
- Other (6) _____________________________________________________

*If Which of the following represents your primary fishing activity? hook and line / rod and reel Is Not Selected*

Q4.20 REFER TO MAP TO ENTER MARINAS, CURRENT AND HISTORIC FISHING AREAS.

---

**FISHERMEN - WATER QUALITY**

Q277 Based on your knowledge of Biscayne Bay, how would you describe overall water quality in the Bay today?

- Very poor (1)
- Poor (2)
- Neutral (3)
- Good (4)
- Very Good (5)
Q5.1 Based on your knowledge of Biscayne Bay, how does the **overall water quality** in the Bay today compare to when you started fishing?

- [ ] Much worse (2)
- [ ] Somewhat worse (3)
- [ ] Same (4)
- [ ] Somewhat better (5)
- [ ] Much better (6)
- [ ] I don't know (7)

---

Q270 Have you noticed any of the following improvements? *Please select all that apply.*

- [ ] Areas of increased water clarity (1)
- [ ] Decreased trash (2)
- [ ] Areas of improved seagrass/coral health (3)
- [ ] Less algae (4)
- [ ] Other (5) _________________________________
Q271 Have you noticed any of the following signs of degradation? *Please select all that apply.*

- [ ] Areas of decreased water clarity (1)
- [ ] Increased trash (2)
- [ ] Areas of dead seagrasses/corals (3)
- [ ] More algae (4)
- [ ] Other (5) ____________________________________________________________________

Q5.2 REFER TO MAP TO ENTER POSITIVE AND NEGATIVE WATER QUALITY AREAS.

Q5.3 If water quality in your fishing areas declined to a point where you could no longer fish your preferred species, what would you do? *Please select all that could apply.*

- [ ] I would fish elsewhere. (3)
- [ ] I would target different species. (2)
- [ ] I would fish less frequently. (1)
- [ ] I would stop fishing. (7)
- [ ] Other (please describe) (6) ____________________________________________________________________
Q5.4 What species group(s) would you target? Please select all that apply.

- Coastal Species *(such as bonefish, pompano, tarpon, snook, permit, etc.)* (1)
- Reef Fish *(such as snapper, grouper, amberjacks, tropical ornamentals, etc.)* (2)
- Lobsters (3)
- Pelagic Species *(such as billfish, swordfish, mackerel, dolphinfish, sharks, etc.)* (4)
- Crabs (5)
- Baitfish (6)
- Mollusks *(such as oysters, clams, scallops, etc.)* (7)
- Shrimp *(such as bait, brown, pink, and white shrimp)* (8)
- Other (9) ____________________________________________________________

Q5.5 REFER TO MAP TO ENTER POTENTIAL FISHING AREAS.
WHOLESALE TREND AND PATTERNS

Q6.1 For how many years have you bought and sold seafood products on a commercial scale in Miami-Dade County?

- <1 year (1)
- 1-5 years (2)
- 6-10 years (3)
- 11-15 years (4)
- 16-20 years (5)
- >20 years (6)

Q6.2 What percent of your personal income is derived from seafood wholesale? Please provide your best estimate.

- % of income (1) ________________________________

Q6.3 What were your sales last year (in $ or lbs)? Please provide your best estimate.

Q6.4 Do you catch your own fish to sell?

- Yes (4)
- No (5)
Q276 What percent of the seafood you sell do you catch yourself?

☐ % of sales (1) ____________________________________________

Q6.5 To whom do you sell your seafood products? Please select all that apply.

☐ ☒ I don't sell my seafood products. (1)

☐ I sell to bait shops. (2)

☐ I sell to fish houses. (3)

☐ I sell to retail markets. (4)

☐ I sell to restaurants. (7)

☐ I sell directly to the public. (5)

☐ Other (please identify) (6) ____________________________________________

Q6.6 How many people do you employ?

WHOLESALE ECONOMIC

Q7.1 How many fishermen do you purchase from?

_____ Commercial (1)

_____ Charter (2)

_____ Recreational (3)

_____ Unidentified/Other (4)
Q7.2 Do you sell bait?

- Yes (1)
- No (2)

Q7.3 What **species groups** did you buy and sell last season? *Please select all that apply.*

- Coastal Species (*such as bonefish, pompano, tarpon, snook, permit, etc.*) (1)
- Reef Fish (*such as snapper, grouper, amberjacks, tropical ornamentals, etc.*) (2)
- Lobsters (3)
- Pelagic Species (*such as billfish, swordfish, mackerel, dolphinfish, sharks, etc.*) (4)
- Crabs (5)
- Baitfish (6)
- Mollusks (*such as oysters, clams, scallops, etc.*) (7)
- Shrimp (*such as bait, brown, pink, and white shrimp*) (8)
- Other (9) __________________________

*Carry Forward All Choices - Displayed & Hidden from "What species groups did you buy and sell last season? Please select all that apply." [Q7.3]*
Q7.4 How many pounds of each species group did you purchase from local fishermen last season?

- **Coastal Species** *(such as bonefish, pompano, tarpon, snook, permit, etc.)* (1)

- **Reef Fish** *(such as snapper, grouper, amberjacks, tropical ornamentals, etc.)* (2)

- **Lobsters** (3)

- **Pelagic Species** *(such as billfish, swordfish, mackerel, dolphinfish, sharks, etc.)* (4)

- **Crabs** (5)

- **Baitfish** (6)

- **Mollusks** *(such as oysters, clams, scallops, etc.)* (7)

- **Shrimp** *(such as bait, brown, pink, and white shrimp)* (8)

- **Other** (9)

Q7.5 REFER TO MAP TO ENTER **CURRENT AND HISTORIC SOURCE AREAS.** ENTER **MARINAS** if catch own fish to sell.
WHOLESALE WATER QUALITY

Q278 Based on your knowledge of Biscayne Bay, how would you describe **overall water quality** in the Bay today?

- Very poor (1)
- Poor (2)
- Neutral (3)
- Good (4)
- Very Good (5)

Q8.1 Based on your knowledge of Biscayne Bay, how does the **overall water quality** in the Bay today compare to when you started buying and selling seafood products?

- Much worse (2)
- Somewhat worse (3)
- Same (4)
- Somewhat better (5)
- Much better (6)
- I don’t know (7)
Q274 Have you noticed any of the following improvements? *Please select all that apply.*

- [ ] Areas of increased water clarity (1)
- [ ] Decreased trash (2)
- [ ] Areas of improved seagrass/coral health (3)
- [ ] Less algae (4)
- [ ] Other (5) ____________________________

Q275 Have you noticed any of the following signs of degradation? *Please select all that apply.*

- [ ] Areas of decreased water clarity (1)
- [ ] Increased trash (2)
- [ ] Areas of dead seagrasses/corals (3)
- [ ] More algae (4)
- [ ] Other (5) ____________________________

Q8.2 REFER TO MAP TO ENTER POSITIVE AND NEGATIVE WATER QUALITY AREAS.
Q8.3 If water quality in your fishing areas declined to a point where you could no longer fish your preferred species, what would you do? Please select all that could apply.

- [ ] I would source fish from elsewhere. (3)
- [ ] I would buy/sell different species. (2)
- [ ] I would buy/sell fish less frequently. (1)
- [ ] I would not buy/sell fish. (7)
- [ ] Other (please describe) (6)

Display This Question:
If I would buy/sell different species. Is Selected

Carry Forward All Choices - Displayed & Hidden from "What species groups did you fish last season? Please select all that apply." [ Q4.16 ]
Q8.4 **What species group(s) would you target? Please select all that apply.**

- Coastal Species *(such as bonefish, pompano, tarpon, snook, permit, etc.)* (1)
- Reef Fish *(such as snapper, grouper, amberjacks, tropical ornamentals, etc.)* (2)
- Lobsters (3)
- Pelagic Species *(such as billfish, swordfish, mackerel, dolphinfish, sharks, etc.)* (4)
- Crabs (5)
- Baitfish (6)
- Mollusks *(such as oysters, clams, scallops, etc.)* (7)
- Shrimp *(such as bait, brown, pink, and white shrimp)* (8)
- Other (9) ____________________________________________

**Display This Question:**

*If I would source fish from elsewhere. Is Selected*

Q8.5 **REFER TO MAP TO ENTER POTENTIAL SOURCE AREAS.**

End of Block
REC. WATER OPS. TRENDS AND PATTERNS

Q9.1 How long have you been in the \$\{q://QID4/ChoiceGroup/SelectedChoices\} industry?

- <1 year (1)
- 1-5 years (2)
- 6-10 years (3)
- 11-15 years (4)
- 16-20 years (5)
- >20 years (6)

Q9.2 How long have you been in the \$\{q://QID4/ChoiceGroup/SelectedChoices\} industry in Miami-Dade County?

- <1 year (1)
- 1-5 years (2)
- 6-10 years (3)
- 11-15 years (4)
- 16-20 years (5)
- >20 years (6)
Q9.3 How would you describe your occupation?

- full-time (1)
- part-time (2)

Q9.4 What percent of your personal income is derived from? *Please provide your best estimate.*

- % income (1) ________________________________

Q9.5 What types of gear and/or trips do you offer?

- SCUBA (1)
- Snorkel (2)
- Kayak/Canoe (3)
- Stand Up Paddleboard (4)
- Spearfishing (6)
- Other (5) ________________________________
Q9.6 How would you describe your operations? Please select all that apply.

- Guided tours (1)
- Gear rental (2)
- Lessons/Certifications (4)
- Other (3) ____________________________________________

Display This Question: 
If How would you describe your operations? Please select all that apply. Gear rental Is Selected

Q9.7 How many customers do you rent to per day?

- customers/day (1) ________________________________

Display This Question: 
If How would you describe your operations? Please select all that apply. Guided tours Is Selected

Q9.8 On average, how many trips do you take per month?

- trips/month (1) ________________________________

Display This Question: 
If How would you describe your operations? Please select all that apply. Guided tours Is Selected

Q9.9 How many people do you guide on an average trip?

- people/trip (1) ________________________________

Q9.10 How many people do you employ?
REC. WATER OPS. ECONOMIC

Q10.1 How many vessels do you own?

- 0 (2)
- 1 (11)
- 2 (8)
- 3 (9)
- 4 (10)
- 5 (12)
- >5 (13)

*Skip To: Q10.8 if Q10.1 = 0 (2)*

**Display This Question:**

*If How many vessels do you own? 1 Is Selected*

Q10.2 What is the total value of your vessel in its present condition? *Please provide your best estimate in US Dollars.*

**Display This Question:**

*If How many vessels do you own? 1 Is Selected*

Q10.3 How long is your vessel (in ft)?
Q10.4 What is the horsepower on your vessel?

Q10.5 What is the total value of each of your boats in their present condition?  
Please provide your best estimate in US Dollars.

- Vessel 1 (1) ________________________________
- Vessel 2 (2) ________________________________
- Vessel 3 (3) ________________________________
- Vessel 4 (4) ________________________________
- Vessel 5 (5) ________________________________
- Additional (6) ________________________________

Display This Question:
If How many vessels do you own? 0 Is Not Selected
Or How many vessels do you own? 1 Is Not Selected

Carry Forward All Choices - Entered Text from "What is the total value of each of your boats in their present condition? Please provide your best estimate in US Dollars." [ Q10.5 ]
Q10.6 What is the length of each of your vessels (in ft)?

- Vessel 1 (1) ________________________________
- Vessel 2 (2) ________________________________
- Vessel 3 (3) ________________________________
- Vessel 4 (4) ________________________________
- Vessel 5 (5) ________________________________
- Additional (6) ________________________________

Display This Question:

If How many vessels do you own? 0 Is Not Selected
Or How many vessels do you own? 1 Is Not Selected

Carry Forward All Choices - Entered Text from "What is the length of each of your vessels (in ft)?" [ Q10.6 ]

Q10.7 What is the horsepower of each of your vessels?

- Vessel 1 (1) ________________________________
- Vessel 2 (2) ________________________________
- Vessel 3 (3) ________________________________
- Vessel 4 (4) ________________________________
- Vessel 5 (5) ________________________________
- Additional (6) ________________________________
Q10.8 What types of gear do you rent and/or use on your recreational trips?  
*Please select all that apply.*

- [ ] SCUBA / snorkel (1)
- [ ] Canoes / kayaks (2)
- [ ] Paddleboards (3)
- [ ] Spearfishing (5)
- [ ] Other *(please describe)* (4)

---

*Carry Forward Selected Choices from "What types of gear do you rent and/or use on your recreational trips? Please select all that apply." [Q10.8]*

---

Q10.9 What is the **total value** of each type of gear you use (in present condition)?  
*Please provide your best estimate in US Dollars.*

- [ ] SCUBA / snorkel (1) ________________________________
- [ ] Canoes / kayaks (2) ________________________________
- [ ] Paddleboards (3) ________________________________
- [ ] Spearfishing (4) ________________________________
- [ ] Other *(please describe)* (5)

______________________________
Q10.10 On a typical trip, what do you spend on the following?

- Fuel and oil (1) ________________________________
- Food and supplies (4) ________________________________
- Air for SCUBA tanks (5) ________________________________
- Other (6) ________________________________

Q10.11 REFER TO MAP TO ENTER MARINAS, CURRENT AND HISTORIC OPERATING AREAS.

REC. WATER OPS. WATER QUALITY

Q279 Based on your knowledge of Biscayne Bay, how would you describe overall water quality in the Bay today?

- Very poor (1)
- Poor (2)
- Neutral (3)
- Good (4)
- Very Good (5)
Q11.1 Based on your knowledge of Biscayne Bay, how does the overall water quality in the Bay today compare to when you started your operation?

- Much worse (2)
- Somewhat worse (3)
- Same (4)
- Somewhat better (5)
- Much better (6)
- I don't know (7)

Q272 Have you noticed any of the following improvements? Please select all that apply.

- Areas of increased water clarity (1)
- Decreased trash (2)
- Areas of improved seagrass/coral health (3)
- Less algae (4)
- Other (5) ____________________________________________
Q273 Have you noticed any of the following signs of degradation? Please select all that apply.

☐ Areas of decreased water clarity (1)

☐ Increased trash (2)

☐ Areas of dead seagrasses/corals (3)

☐ More algae (4)

☐ Other (5) ________________________________

Q11.2 If water quality in your operating areas declined to a point where you could no longer offer your preferred activity type, what would you do? Please select all that could apply.

☐ I would offer activities elsewhere. (2)

☐ I would offer different activity types. (3)

☐ I would offer activities less frequently. (1)

☐ I would no longer offer activities. (7)

☐ Other (please describe) (6)

______________________________

Display This Question:
If If water quality in your operating areas declined to a point where you could no longer offer your preferred activity type, what would you do? Please select all that could apply. I would offer different activity types. Is Selected

Q11.3 What types of activities would you offer?

______________________________
Display This Question:

If if water quality in your operating areas declined to a point where you could no longer offer your preferred activity type, what would you do? Please select all that could apply. I would offer activities elsewhere. Is Selected

Q11.4 REFER TO MAP TO ENTER POTENTIAL AREAS.

End of Block

CLOSING

Q12.1 Do you know of any charter fishermen, commercial fishermen, seafood wholesalers, or recreational water operators (SCUBA, snorkel, kayak, etc.) who may be interested in speaking with us? If so, please provide any available contact information.

Q12.2 Please provide any additional comments.

End of Block
A.3.2 In-Person Interview: SeaSketch

Interview ID: ____________
Interview ID Number

Industry
Click to select one or more options
• Commercial Fishing
• Charter Fishing
• Seafood Wholesale
• Recreational Water Ops.

Marina/Boat Ramp
Fishermen and Water Ops.: Please identify the location and name (if applicable) of your primary marina, boat ramp, private dock, or other launch site.

Select one of the following:
• Boat Ramp
• Marina
• Other

Current Areas
Fishermen: Please identify your current fishing areas.
Seafood Wholesale: Please identify where the fish you buy/sell are caught.
Recreational Water Ops.: Please identify the areas you visit on recreational trips.

Percent: ____________
For fishermen: What percent of your trips go here? What percent of your landings come from here?
For Wholesalers: What percent of your supply comes from here?
For Rec. Water Ops.: What percent of your trips go here?

What types of fish do you target here?
Click to select one or more options.
• Coastal Fish
• Reef Fish
• Lobsters
• Crabs
• Pelagic Species
• Baitfish
• Shrimp
• Mollusks
• Other
What species do you target here?

**Historic Areas**
Fishermen: Please identify any areas you used to fish but no longer use.
Seafood Wholesale: Please identify any area that you used to source fish from but no longer source from.
Recreational Water Ops.: Please identify any areas you used to visit on recreational trips but no longer use.

Why did you discontinue fishing/sourcing/operating this area?

What types of fish did you target here?
*Click to select one or more options.*
- Coastal Fish
- Reef Fish
- Lobsters
- Crabs
- Pelagic Species
- Baitfish
- Shrimp
- Mollusks
- Other
- N/A

What species did you target here?

**Positive Water Quality Changes**
Please identify any areas in which you have noticed positive water quality changes.

What types of water quality improvements have you noticed in these areas?
*e.g. increased water clarity, less trash, areas of thriving seagrasses/corals, less algae, etc.*

What environmental factors do you think are responsible for these changes?
*e.g. less agricultural runoff, less vessel pollution, less land-based trash, fewer input from sewage/outfalls, etc.*

Why do you think these environmental factors occurred/are occurring?
*e.g. decreased vessel traffic, better regulation/enforcement, etc.*

**Negative Water Quality Changes**
Please identify any areas in which you have noticed negative water quality changes.

What types of water quality degradation have you observed here?
Click to select one or more options.

- Decreased water clarity
- Increased trash
- Areas of dead seagrasses/corals
- More algae
- Other

Which of the following do you attribute to these changes?
Select all that apply.

- Runoff (such as agricultural, stormwater, etc.)
- Vessel Traffic/Pollution (such as bilge water, oil, anchoring)
- Land-Based Trash (such as plastics)
- Marine Litter
- Sewage and Outfalls
- Climate Change

Which is the worst?

- Runoff (such as agricultural, stormwater, etc.)
- Vessel Traffic/Pollution (such as bilge water, oil, anchoring)
- Land-Based Trash (such as plastics)
- Marine Litter
- Sewage and Outfalls
- Climate Change

Why do you think these environmental factors occurred/are occurring?

* e.g. increased vessel traffic, construction of specific structures, coastal development, lack of regulation and/or enforcement, etc.

**Potential Areas**

If water quality in your fishing areas declined to a point where you could no longer fish/source your preferred species/perform your preferred activity, and you chose to operate somewhere else, what are some alternative areas?
VITA

Samantha Clair Dowdell was born in Arlington, Virginia, on July 10, 1992. Her parents are Lisa Ann Dowdell and Thomas Edward Dowdell. She received her elementary education at Arlington Traditional School and her secondary education at Williamsburg Middle School and Yorktown High School. In September 2010, she entered Dartmouth College from which she was graduated with the B.A. degree in June 2014. She worked as an intern at the National Marine Sanctuary Foundation and on the Biodiversity and Wildlife Solutions team at Resolve in Washington, D.C. from January through June 2015. During the summer of 2015, she worked as an intern in the Oceans Program at Conservation Law Foundation in Boston, Massachusetts. In August 2015, she was admitted to the Rosenstiel School of Marine and Atmospheric Science Graduate School of the University of Miami, where she was granted an M.S. degree in December 2017.