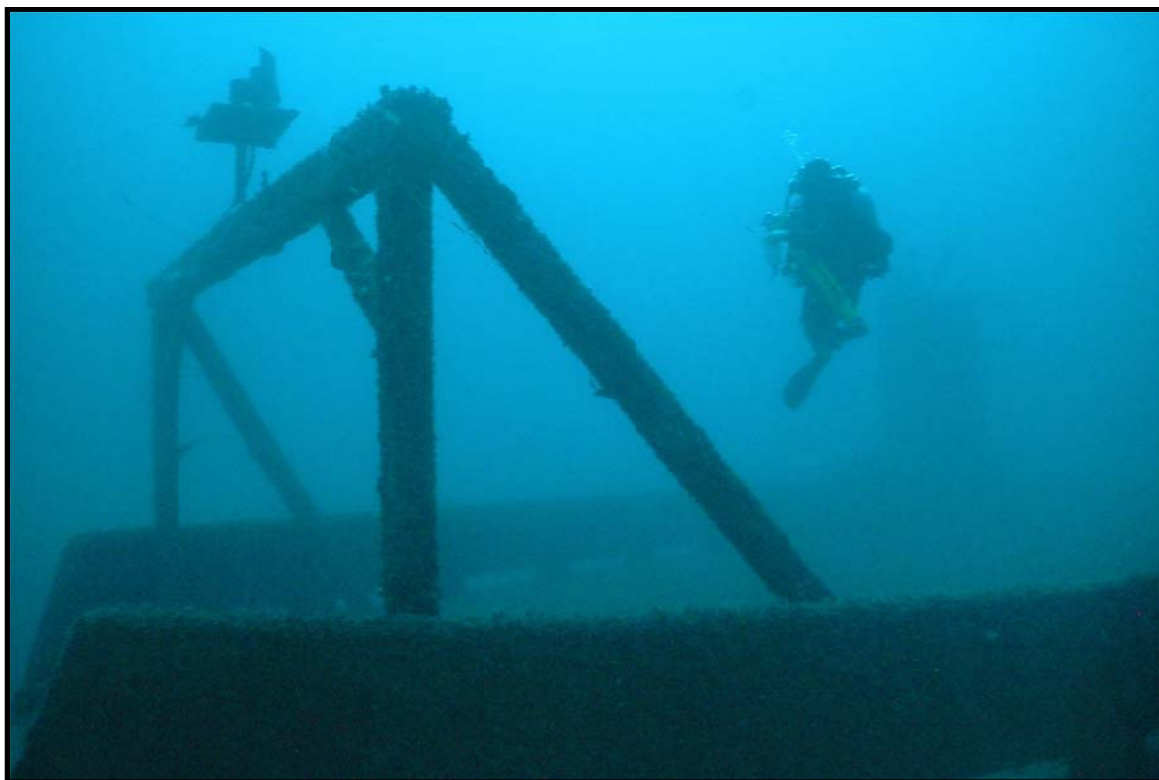


# 2010 ANNUAL MONITORING REPORT

## MARTIN COUNTY ARTIFICIAL REEFS

### *PERFORMED FOR:*

MARTIN COUNTY ENGINEERING DEPARTMENT  
2401 SE MONTEREY ROAD  
STUART, FLORIDA 34996



*(PHOTO OF THE WICKSTROM ARTIFICIAL REEF TAKEN BY W. TURNER)*

### *PREPARED BY:*

MAUREEN WOODS, M.S., P.E.  
MAXWELL MARINE CONSULTING ENGINEERS, INC.  
228 ATLANTIC BLVD. SUITE 200  
KEY LARGO, FL 33037  
786-888-3120

KERRY DILLON  
SEA ROVER SERVICES, INC.  
PO BOX 1206  
PORT SALERNO, FL  
772-263-0307

20 SEPTEMBER 2011

Table of Contents

<b>1.0</b>	<b>Introduction.....</b>	<b>4</b>
<b>2.0</b>	<b>Background .....</b>	<b>5</b>
<b>3.0</b>	<b>Project Objectives .....</b>	<b>10</b>
3.1	Methodology .....	10
3.1.1	Physical Measurements.....	10
3.1.2	Biological Surveys .....	10
3.1.3	Photo/Video Documentation.....	11
3.2	Funding .....	11
<b>4.0</b>	<b>Artificial Reef Locations.....</b>	<b>12</b>
4.1	Donaldson Artificial Reef Site.....	14
4.2	Ernst Artificial Reef Site.....	15
4.3	Sirotkin Artificial Reef Site .....	16
4.4	South County Artificial Reef Site .....	17
<b>5.0</b>	<b>Results .....</b>	<b>18</b>
5.1	Fogel Capital Management Artificial Reef.....	18
5.1.1	History of the Fogel Capital Management Artificial Reef.....	18
5.1.2	Structural Summary .....	19
5.1.3	Biological Survey Results.....	20
5.2	The Heap Artificial Reef.....	22
5.2.1	History of the Heap Artificial Reef.....	22
5.2.2	Structural Summary .....	23
5.2.3	Biological Survey Results.....	23
5.3	American Custom Yachts Tower Reef .....	26
5.3.1	History of the American Custom Yachts Tower Reef .....	26
5.3.2	Structural Summary .....	27
5.3.3	Biological Survey Results.....	28
5.4	Reefmaker Inlet Barge .....	30
5.4.1	History of the Reefmaker Inlet Barge Artificial Reef.....	30
5.4.2	Structural Summary .....	31
5.4.3	Biological Survey Results.....	32
5.5	Donaldson Reefmaker Triangle .....	33
5.5.1	History of the Reefmaker Triangle Artificial Reef .....	33
5.5.2	Structural Summary .....	34
5.5.3	Biological Survey Results.....	34
5.6	Evans Crary Bridge Artificial Reef.....	36
5.6.1	History of the Evans Crary Bridge Artificial Reef .....	36
5.6.2	Structural Summary .....	37
5.6.3	Biological Survey Results.....	38
5.7	Tetrahedron Stack Artificial Reef.....	42
5.7.1	History of the Tetrahedron Stack Artificial Reef.....	42
5.7.2	Structural Summary .....	43
5.7.3	Biological Survey Results.....	43

5.8	Tetrahedron Patch - Yellow & Blue Artificial Reefs.....	46
5.8.1	History of the Tetrahedron Patch - Yellow & Blue Artificial Reefs .....	46
5.8.2	Structural Summary .....	47
5.8.3	Biological Survey Results.....	48
5.9	Ballantrae Anglers Artificial Reef .....	51
5.9.1	History of the Ballantrae Anglers Artificial Reef .....	51
5.9.2	Structural Summary .....	52
5.9.3	Biological Survey Results.....	53
5.10	Pirate's Cove Artificial Reef.....	54
5.10.1	History of the Pirate's Cove Artificial Reef .....	54
5.10.2	Structural Summary .....	55
5.10.3	Biological Survey Results.....	56
5.11	Wickstrom Artificial Reef.....	57
5.11.1	History of the Wickstrom Artificial Reef .....	57
5.11.2	Structural Summary .....	58
5.11.3	Biological Survey Results.....	60

## APPENDICES

### A. 2010 Monitoring Photographs (on CD)

#### List of Tables

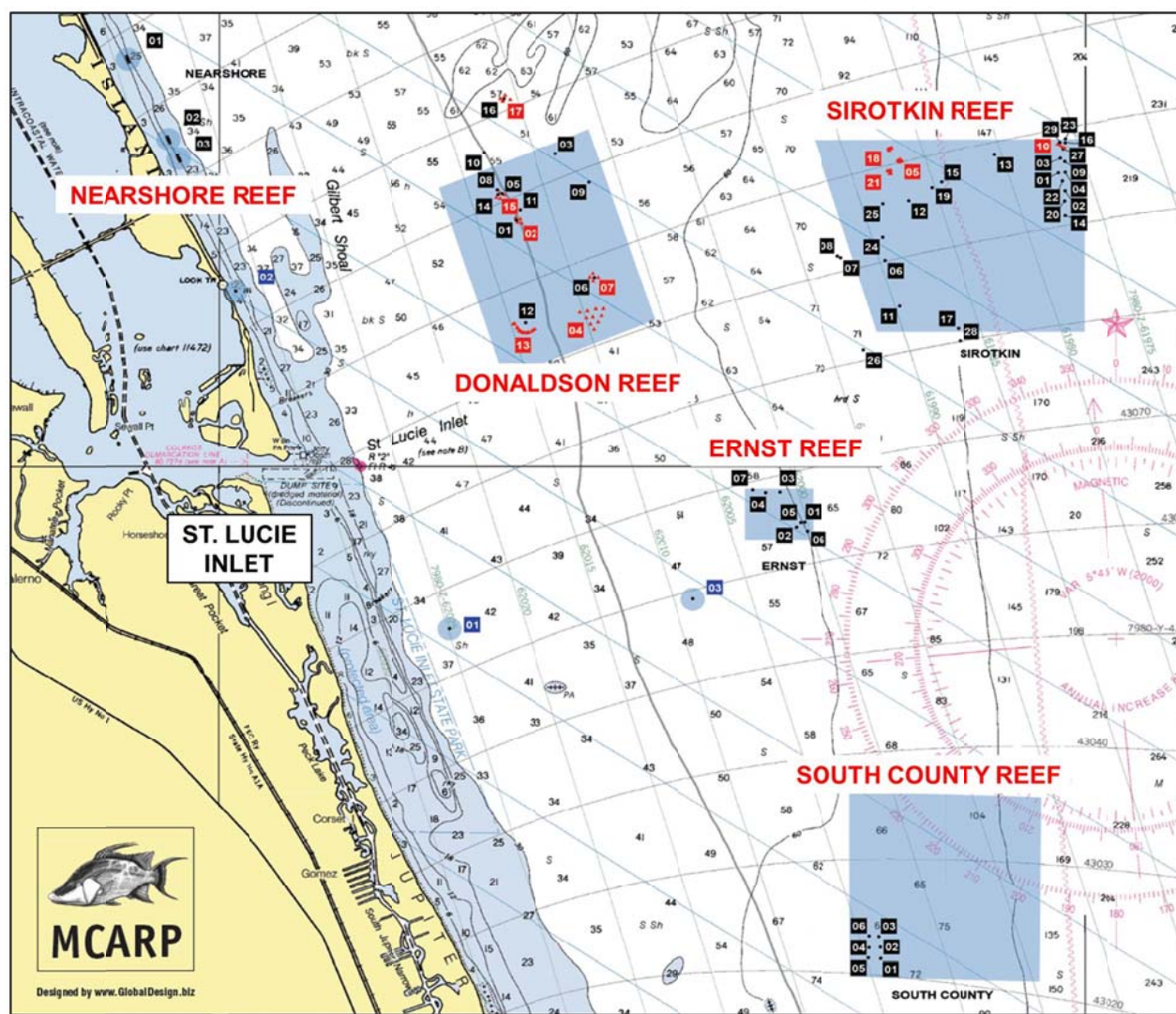
Table 1.	2010 Monitoring Sites. ....	5
Table 2.	Martin County artificial reefs deployed 2000 to 2009.....	5
Table 3.	Locations of Martin County artificial reefs deployed between 2000 to 2009. ....	7
Table 4.	Annual monitoring dates for Martin County artificial reefs. ....	8
Table 5.	List of artificial reefs monitored in 2010. ....	12
Table 6.	Fogel Capital Management Artificial Reef fish species census. ....	20
Table 7.	Fogel Capital Management Artificial Reef benthic species census.....	21
Table 8.	The Heap Artificial Reef fish species census. ....	24
Table 9.	The Heap Artificial Reef benthic species census.....	25
Table 10.	American Custom Yachts Tower Artificial Reef fish species census. ....	28
Table 11.	American Custom Yachts Tower Artificial Reef benthic species census. ....	28
Table 12.	Reefmaker Inlet Barge Artificial Reef fish species census.....	32
Table 13.	Reefmaker Inlet Barge Artificial Reef benthic species census.....	32
Table 14.	Reefmaker Triangle Artificial Reef fish species census.....	35
Table 15.	Donaldson Reefmaker Triangle Artificial Reef benthic species census.....	35
Table 16.	Evans Crary Bridge Artificial Reef fish species census. ....	39
Table 17.	Evans Crary Bridge Artificial Reef benthic species census. ....	41
Table 18.	Tetrahedron Stack Artificial Reef fish species census.....	44
Table 19.	Tetrahedron Stack Artificial Reef benthic species census.....	45
Table 20.	Tetrahedron Patch – Yellow & Blue Artificial Reefs fish species census.....	49
Table 21.	Tetrahedron Patch – Yellow & Blue Artificial Reefs benthic species census.....	50
Table 23.	Ballantrae Anglers Artificial Reef benthic species census. ....	53
Table 25.	Pirate's Cove Artificial Reef benthic species census.....	56
Table 26.	Wickstrom Artificial Reef fish species census. ....	61
Table 27.	Wickstrom Artificial Reef benthic species census. ....	61

### List of Figures

Figure 1. Location of Martin County's Permitted Offshore Reef Sites.....	4
Figure 2. Distances from St. Lucie Inlet sea buoy to the offshore artificial reef sites.....	13
Figure 3. Chart view of the Donaldson Reef site.....	14
Figure 4. Chart view of the Ernst Artificial Reef site.....	15
Figure 5. Chart view of the Sirotkin Artificial Reef site.....	16
Figure 6. Chart view of the South County Artificial Reef area. ....	17
Figure 7. Chart view of the Fogel Capital Mgmt Reef in the S. County Artificial Reef area. ....	18
Figure 8. Fogel Capital Management Artificial Reef 2010 photographs.....	19
Figure 9. Chart view of The Heap in the South County Artificial Reef area. ....	22
Figure 10. The Heap Artificial Reef 2010 photographs. ....	23
Figure 11. Sirotkin Reef sites showing the American Custom Yachts Tower location. ....	26
Figure 12. American Custom Yachts Tower 2009 & 2011 photographs. ....	27
Figure 13. Donaldson Reef site showing the Reefmaker Inlet Barge location.....	30
Figure 14. Reefmaker Inlet Barge Artificial Reef photographs from 2010.....	31
Figure 15. Chart view of the Donaldson Reef site showing the Reefmaker Triangle location. ..	33
Figure 16. Reefmaker Triangle Artificial Reef 2010 photos. ....	34
Figure 17. Chart view of the Evans Crary Bridge Reef within the Ernst Artificial Reef site.....	37
Figure 18. Evans Crary Bridge Reef 2010 photographs. ....	38
Figure 19. Chart view showing the Tetrahedron Stack and Patch reef locations. ....	42
Figure 20. Tetrahedron Stack Artificial Reef 2010 photographs.....	43
Figure 21. Chart view of Tetrahedron Patch - Yellow & Blue Artificial Reefs. ....	47
Figure 22. Tetrahedron Patch Yellow & Blue Artificial Reef 2010 photographs. ....	48
Figure 23. Chart view of Sirotkin Reef showing the Ballantrae Anglers Reef location.....	51
Figure 24. Ballantrae Anglers Reef 2010 photographs.....	52
Figure 25. Chart view of the Sirotkin Reef showing the Pirate's Cove Reef location. ....	54
Figure 26. Pirate's Cove Reef photograph from 2010.....	55
Figure 27. Chart view of Sirotkin Reef showing location of Wickstrom Artificial Reef.....	58
Figure 28. Wickstrom Artificial Reef photographs from 2010.....	59
Figure 29. Wickstrom hull groove cut into the sea floor (Left), Wickstrom superstructure (Right).....	60

## 1.0 Introduction

Martin County has one of the most active and well-developed artificial reef programs in the state of Florida. Since the early 1970s, private and not-for-profit groups have been deploying a wide variety of artificial substrate offshore to enhance local fishing and diving. More recently, the Martin County Coastal Engineering Division began administering a more innovative program that deploys artificial reef projects in cooperation with the Florida Fish and Wildlife Conservation Commission (FWC) and local citizens. Lessons learned from earlier efforts (including those of other groups and agencies) have refined the program significantly. For example, many materials that have historically been used to build artificial reefs are now known to be poor-quality reef substrate. Artificial reef construction is now limited almost exclusively to natural rock, concrete and steel materials. Figure 1 shows the location of the five Martin County permitted offshore reef sites.



**Figure 1. Location of Martin County's Permitted Offshore Reef Sites.**

In July 2010, Maxwell Marine Consulting Engineers, Inc. (MMCE) and Sea Rover Services, Inc.

were authorized by Martin County to perform monitoring services for twelve reef sites, refer to Table 1.

**Table 1. 2010 Monitoring Sites.**

	<b>Reefs to Monitor - 2010</b>	<b>Last Monitoring</b>	<b>Depth</b>	<b>Permit Area</b>	<b>Survey Type</b>
1	Fogel Capital Management	8/31/2009	67	S County	in-water
2	The Heap	10/8/2009	68	S County	in-water
3	American Custom Yachts Tower	10/15/2009	190	Sirotkin	in-water
4	Reefmaker Inlet Barge	6/21/2007	60	Donaldson	in-water
5	Reefmaker Triangle	6/24/2007	50	Donaldson	in-water
6	Evans Crary Bridge	6/17/2005	75	Ernst	in-water
7	Tetrahedron Stack	5/21/2006	100	Sirotkin	in-water
8	Tetrahedron Patch - Yellow	7/18/2007	95	Sirotkin	in-water
9	Tetrahedron Patch - Blue	7/18/2007	95	Sirotkin	in-water
10	Ballantrae Anglers*	none	187	Sirotkin	in-water
11	Pirates Cove Reefs*	none	187	Sirotkin	in-water
12	Wickstrom	9/3/2007	188	Sirotkin	in-water

## 2.0 Background

Martin County has constructed in excess of 60 artificial reefs using discarded concrete and steel bridge components, steel-hulled derelict vessels and natural limestone rock. Within the last decade, dozens of purpose-built artificial reef modules have been deployed in varying arrays offshore to attract popular fish species. As the value and popularity of artificial reefs continue to grow, new strategies and reefing materials may be identified to further enhance local reef habitats. Annual artificial reef monitoring is required for two years following material placement. Refer to Table 2 for a list of all reefs deployed from 2000 to 2009, including the site location, materials and deployment date.

**Table 2. Martin County artificial reefs deployed 2000 to 2009.**

<b>Reef Name</b>	<b>Materials</b>	<b>Site</b>	<b>Deployment Dates</b>
Mitigation Site A	bridge pieces	Nearshore	Jul-Sep 2000
Mitigation Site B	bridge pieces	Nearshore	Jul-Sep 2000
Mitigation Site C	bridge pieces	Nearshore	Jul-Sep 2000
Evans Crary Bridge	bridge pieces	Ernst	Summer 2000
Tetrahedron Stack	concrete pyramids	Sirotkin	4,25 Apr 2001
Tetrahedron Patch- Yellow	concrete pyramids	Sirotkin	28 Mar 2002
Tetrahedron Patch-Pink	concrete pyramids	Sirotkin	28 Mar 2002
Tetrahedron Patch-Blue	concrete pyramids	Sirotkin	28 Mar 2002
Tetrahedron Patch-White	concrete pyramids	Sirotkin	28 Jun 2002
Tetrahedron Patch-Black	concrete pyramids	Sirotkin	28 Jun 2002
Tree Barge	140' barge	Sirotkin	19 Apr 2002
Wickstrom	168' cargo ship	Sirotkin	21 Jan 2003

Reef Name	Materials	Site	Deployment Dates
Railroad Tie Stack	concrete RR ties	Sirotkin	Mar-Jun 2003
High Queen and Zeppo	tug & 120' barge	Sirotkin	7 Aug 2003
Five Peaks Patch-Blue	concrete RR ties	Sirotkin	2 Jun 2004
Five Peaks Patch-Orange	concrete RR ties	Sirotkin	2 Jun 2004
Five Peaks Patch-Yellow	concrete RR ties	Sirotkin	28-29 Jun 2004
Five Peaks Patch-Pink	concrete RR ties	Sirotkin	28-29 Jun 2004
Five Peaks Patch-Black	concrete RR ties	Sirotkin	28-29 Jun 2004
Tension Barge	140' barge	Sirotkin	17 Jul 2004
Reefmaker Triangle	concrete & steel units	Donaldson	18 May 2005
Reefmaker Texas	concrete & steel units	Donaldson	20 May 2005
Reefmaker Cement Barge	concrete & steel units	Donaldson	20 May 2005
Reefmaker Traffic Barge	concrete & steel units	Donaldson	20 May 2005
Reefmaker Upside Down Barge	concrete & steel units	Donaldson	20 May 2005
Reefmaker Inlet Barge	concrete & steel units	Donaldson	20 May 2005
Reefmaker Patch N	concrete & steel units	Sirotkin	21 May 2005
Reefmaker Patch C	concrete & steel units	Sirotkin	21 May 2005
Reefmaker Patch S	concrete & steel units	Sirotkin	21 May 2005
Reefmaker Tree Barge	concrete & steel units	Sirotkin	21 May 2005
Clifton Perry Memorial	bridge pieces	Donaldson	Jan-May 2005
Frances Langford Memorial	bridge pieces	Sirotkin	Feb-Aug 2005
PCL Deep	bridge pieces	Sirotkin	Oct 2006
PCL Shallow	bridge pieces	Donaldson	Nov-Dec 2006
PCL River	bridge pieces	IR Lagoon	Nov 2006-Jan 2007
West 400	400 tons concrete	Ernst	15 Jun 2007
Mango	440 tons concrete	Ernst	15,26 Jun 2007
Grand Teton	728 tons concrete	Ernst	26,30 Jun 2007
KD Select	537 tons concrete	Sirotkin	9 Jul 2007
Ann Marie	260 tons concrete	S County	11 Jun 2008
Fogel Capital Management	245 tons concrete	S County	13 Jun 2008
The Heap	268 tons concrete	S County	20 Jun 2008
Jack MacDonald	272 tons concrete	S County	20 Jun 2008
Lentine	240 tons concrete	S County	13 Jun 2008
Shirley	249 tons concrete	S County	11 Jun 2008
American Custom Yachts Tower	Prefab steel tower	Sirotkin	27 Jun 2008
Bausch American Towers Tower	Prefab steel tower	Sirotkin	27 Jun 2008
Baratta Sight-See-er Tower	Prefab steel tower	Sirotkin	27 Jun 2008
Deborah Schmidt Tower	Prefab steel tower	Sirotkin	27 Jun 2008
Pirate's Cove	500 tons concrete	Sirotkin	24 August 2009
Ballantrae Anglers	500 tons concrete	Sirotkin	24 August 2009
Corinthians Yacht Club	500 tons concrete	Sirotkin	24 August 2009

Table 3 presents the locations and water depths for the same artificial reef sites identified in Table 2.

**Table 3. Locations of Martin County artificial reefs deployed between 2000 to 2009.**

<b>Reef Name</b>	<b>Latitude N</b>	<b>Longitude W</b>	<b>Water Depth (ft)</b>	<b>Reef Crest Depth (ft)</b>
Mitigation Site A	27° 14.412'	80° 11.098'	10 to 20	7 to 20
Mitigation Site B	27° 13.553'	80° 10.647'	10 to 20	7 to 20
Mitigation Site C	27° 13.335'	80° 10.513'	10 to 20	7 to 20
Evans Crary Bridge	27° 09.346'	80° 03.368'	75	49
Tetrahedron Stack	27° 12.814'	80° 02.329'	100	91
Tetrahedron Patch (Yellow)	27° 12.486'	80° 02.369'	95	87
Tetrahedron Patch (Pink)	27° 12.465'	80° 02.341'	95	87
Tetrahedron Patch (Blue)	27° 12.479'	80° 02.350'	95	87
Tetrahedron Patch (White)	27° 12.462'	80° 02.323'	98	95
Tetrahedron Patch (Black)	27° 12.432'	80° 02.360'	95	87
Tree Barge	27° 13.419'	80° 00.280'	190	178
Wickstrom Ship	27° 13.492'	80° 00.318'	188	133
Railroad Tie Stack	27° 12.201'	80° 02.310'	93	73
High Queen and Zeppo	27° 13.489'	80° 00.257'	190	175
Five Peaks Patch (Blue)	27° 11.688'	80° 02.120'	99	90
Five Peaks Patch (Orange)	27° 11.670'	80° 02.131'	97	88
Five Peaks Patch (Yellow)	27° 11.701'	80° 02.140'	97	91
Five Peaks Patch (Pink)	27° 11.717'	80° 02.141'	95	86
Five Peaks Patch (Black)	27° 11.707'	80° 02.122'	98	92
Tension Barge	27° 13.527'	80° 00.261'	190	178
Reefmaker Triangle	27° 11.595'	80° 05.716'	50	40
Reefmaker Texas	27° 11.414'	80° 06.523'	50	40
Reefmaker Cement Barge	27° 12.627'	80° 06.597'	60	50
Reefmaker Traffic Barge	27° 12.912'	80° 06.821'	60	50
Reefmaker Upside-Down Barge	27° 13.953'	80° 06.732'	60	50
Reefmaker Inlet Barge	27° 12.022'	80° 05.709'	60	50
Reefmaker Diamond N	27° 13.410'	80° 02.280'	100	90
Reefmaker Diamond C	27° 13.276'	80° 02.165'	105	95
Reefmaker Diamond S	27° 13.166'	80° 02.284'	100	90
Reefmaker Tree Barge	27° 13.425'	80° 00.274'	185	175
Clifton Perry Memorial	27° 13.339'	80° 06.131'	66	40 to 50
Frances Langford Memorial	27° 13.353'	80° 01.046'	150	118
PCL Deep	27° 12.924'	80° 01.774'	122	104
PCL Shallow	27° 13.045'	80° 05.743'	60	41
PCL River	27° 12.771'	80° 11.190'	10 – 17	7 @ MLW
West 400	27° 09.735'	80° 03.856'	62	46
Mango	27° 09.702'	80° 03.702'	61	48
Grand Teton	27° 09.708'	80° 03.535'	62	34
KD Select	27° 11.476'	80° 01.474'	124	113
Ann Marie	27° 04.657'	80° 02.297'	67	59
Fogel Capital Management	27° 04.773'	80° 02.297'	67	60
The Heap	27° 04.888'	80° 02.430'	68	63
Jack MacDonald	27° 04.885'	80° 02.314'	68	59
Lentine	27° 04.769'	80° 02.423'	68	62
Shirley	27° 04.663'	80° 02.440'	66	61



Reef Name	Latitude N	Longitude W	Water Depth (ft)	Reef Crest Depth (ft)
American Custom Yachts Tower	27° 13.148'	80° 00.338'	190	155
Bausch American Towers Tower	27° 13.152'	80° 00.259'	189	154
Baratta Sight-See-Er Tower	27° 13.301'	80° 00.307'	187	172
Deborah Schmidt Tower	27° 13.277'	80° 00.266'	187	152
Pirate's Cove	27° 12.814'	80° 00.289'	187	174
Ballantrae Anglers	27° 12.936'	80° 00.280'	187	181
Corinthians Yacht Club	27° 13.040'	80° 00.306'	185	175

The artificial reef sites in Table 2 and Table 3 required annual monitoring for the first five years following their deployment. The 2009/2010 annual monitoring was performed for the reefs created from 2000 to 2009.

In 2007, four new reefs were deployed using mixed concrete materials, one deeper site in the Sirotkin Reef area and three shallower sites in the Ernst Reef area. These sites are called KD Select, Grand Teton, West 400 and Mango Reef, respectively. In 2008, four steel towers in the Sirotkin Artificial Reef area and six concrete patch reefs in the South County Artificial Reef areas were deployed. In 2009, three more concrete patch reefs were deployed in the Sirotkin Artificial Reef area. Table 4 presents the dates of the annual monitoring performed from 2004 to 2010.

**Table 4. Annual monitoring dates for Martin County artificial reefs.**

Reef Name	2010	2009	2008	2007	2006	2005	2004
Mitigation Site A		no	no	8/18	5/21, 6/30, 12/27	no [1]	6/1
Mitigation Site B		no	no	8/18	5/22	no [1]	5/26 & 29
Mitigation Site C		no	no	7/11	5/21, 12/27	no [1]	5/26 & 30
Evans Crary Bridge	YES	no	no	NA	NA	6/17	5/10,23,30
Tetrahedron Stack	YES	no	no	NA	5/21	6/17	5/21, 6/11
Tetrahedron Patch-Yellow	YES	no	no	7/18	4/26	6/7	5/24, 6/3
Tetrahedron Patch-Pink		no	no	7/18	4/26	6/7	5/24, 6/4
Tetrahedron Patch-Blue	YES	no	no	7/18	4/26	6/7	5/24, 6/5
Tetrahedron Patch-White		no	no	7/18	4/26	6/7	5/24, 6/6
Tetrahedron Patch-Black		no	no	7/18	4/26	6/7	5/24, 6/7
Tree Barge		no	no	9/3	6/3	no [2]	no [2]
Wickstrom Ship	YES	no	no	9/3	6/3	no [2]	8/18
Railroad Tie Stack		no	8/5	6/25	5/23	6/8	5/23 & 29
High Queen and Zeppo		no	no	9/15	no [2]	no [2]	8/27
Five Peaks Patch-Blue		10/2	6/25	7/10	5/27	6/8	deployed
Five Peaks Patch-Orange		10/2	6/25	7/10	5/27	6/8	deployed
Five Peaks Patch-Yellow		10/2	6/25	7/10	5/27	6/8	deployed
Five Peaks Patch-Pink		10/2	6/25	7/10	5/27	6/8	deployed
Five Peaks Patch-Black		10/2	6/25	7/10	5/27	6/8	deployed
Tension Barge		no	no	9/15	no [2]	no [2]	deployed

Reef Name	2010	2009	2008	2007	2006	2005	2004
Reefmaker Triangle	YES	no	no	6/24	5/23	deployed	NA
Reefmaker Texas		no	7/24	6/25	4/21, 6/30	deployed	NA
Reefmaker Cement Barge		no	no	6/22	4/21	deployed	NA
Reefmaker Traffic Barge		no	no	6/21	4/3	deployed	NA
Reefmaker Upside-down Barge		no	no	6/19	no [3]	deployed	NA
Reefmaker Inlet Barge	YES	no	no	6/21	no [3]	deployed	NA
Reefmaker Patch N		no	no	no [3]	3/6	deployed	NA
Reefmaker Patch C		no	no	7/10	no [3]	deployed	NA
Reefmaker Patch S		no	12/21	no [3]	3/6	deployed	NA
Reefmaker Tree Barge		no	no	9/3	6/3	deployed	NA
Clifton Perry Memorial		9/28	7/24	6/24	4/3	deployed	NA
Frances Langford Memorial		10/8	12/21	8/8	6/2	deployed	NA
PCL Deep		10/2	12/20	10/29	deployed	NA	NA
PCL Shallow		9/28	6/25	9/20	deployed	NA	NA
PCL IRL		10/25		deployed	NA	NA	NA
West 400		8/26	6/27	deployed	NA	NA	NA
Mango		10/8	6/27	deployed	NA	NA	NA
Grand Teton		8/26	6/19	deployed	NA	NA	NA
KD Select		10/10	12/20	deployed	NA	NA	NA
Ann Marie		8/31	deployed	NA	NA	NA	NA
Fogel Capital Management	YES	8/31	deployed	NA	NA	NA	NA
The Heap	YES	10/8	deployed	NA	NA	NA	NA
Jack MacDonald		9/1	deployed	NA	NA	NA	NA
Lentine		9/1	deployed	NA	NA	NA	NA
Shirley		10/8	deployed	NA	NA	NA	NA
American Custom Yachts Tower	YES	10/15	deployed	NA	NA	NA	NA
Bausch American Towers Tower		no [3]	deployed	NA	NA	NA	NA
Baratta Sight-See-Er Tower		no [3]	deployed	NA	NA	NA	NA
Deborah Schmidt Tower		no [3]	deployed	NA	NA	NA	NA
Pirate's Cove	YES	deployed	NA	NA	NA	NA	NA
Ballantrae Anglers	YES	deployed	NA	NA	NA	NA	NA
Corinthian Yacht Club		deployed	NA	NA	NA	NA	NA

**Notes:**

1. Mitigation reef monitoring not completed in 2005 due to poor visibility.
2. Annual in-water monitoring is not required for reef sites in water depths greater than 100 feet.
3. Not every Reefmaker unit is monitored every year.

### 3.0 Project Objectives

Artificial reefs are an increasingly valuable amenity for recreational fishing and diving. Florida registers more boats, has more certified scuba divers and more licensed resident and non-resident marine anglers than any other state. For several decades in Martin County, artificial reefs have been enhancing local fishing and diving while alleviating pressure on natural reef systems. While there is no scientific confirmation yet that artificial reefs enhance regional fish populations or reduce human impacts to natural reef and hard-bottom communities, many fisheries biologists believe they do, and regular monitoring may eventually describe their full contribution to the nearshore marine environment.

Annual monitoring of each artificial reef structure for two to five consecutive years, which includes documenting associated flora and fauna, is required by the Florida Fish and Wildlife Conservation Commission (FWC) and the U.S. Army Corps of Engineers. The primary objectives of the monitoring effort are to verify artificial reef locations, document biological activity (benthic flora and invertebrates, demersal and pelagic fish communities) and evaluate engineering performance (stability and condition of the reef materials, scour and settlement). Effective analysis of artificial reef monitoring data may result in a program that optimizes reef placement and engineering in ways that maximize both fisheries and recreational enhancement.

### 3.1 Methodology

The monitoring techniques used to monitor Martin County's artificial reef sites in 2010 were identical to the methodology used by Harris and Dillon in previous annual monitoring efforts. Divers made direct measurements of the reefs, recorded visual observations and collected still photos and video footage to document vital statistics for each artificial reef. Fieldwork was performed by the authors and other qualified divers (engineers and scientists) to ensure that all pertinent engineering and biological data were observed and documented.

#### 3.1.1 Physical Measurements

Divers inspected and measured each artificial reef unit to determine changes in the reef structure, including scour, settlement, and other movement of reef components by repeating survey measurements established during previous monitoring surveys. Reef structure depths were measured using dive computers for measurements of the bottom and both the highest and average depths of the reef materials. Changes in reef heights were used to assess settlement of the materials. The natural bottom depths 10 meters away from the reefs were compared to the maximum depths immediately adjacent to the reefs to assess scour. Measuring tapes and compass readings were used to measure horizontal distances on the reefs, as well as distances and bearings between the patch reefs, where applicable. Divers also used buoys at key locations in order to collect accurate GPS coordinates from the surface.

#### 3.1.2 Biological Surveys

Data collection methods utilized the Roving Diver Technique (RDT) to perform fish counts to assess the diversity and density of demersal and pelagic fishes. Plant and invertebrate assessments were also performed by identifying benthic flora and fauna on and among the artificial reef substrate to the lowest practical taxa.

Monitoring near shore reefs differs greatly from the deepwater offshore sites which are located at the western edge of the Gulf Stream. The Gulf Stream meanders, sometimes daily, by many miles east or west. Generally the Gulf Stream shifts from closer to shore in the summer months to further offshore during the winter months. Many migratory fish species travel north in the summer and south in the winter. This means that on any given day one might see minimal fish species like in this event where only 11 were documented or 20 or more species during a dive on other days.

As well as the Gulf Stream fluctuations, other factors have an effect on how many and which species are seen during a monitoring event. The east central coast of Florida is very close to the continental slope where the relatively gradual sloping continental shelf drops quickly to the abyssal plains of the deep ocean. In the summer months a phenomenon known as cold-water upwelling occurs, most predominately along the east central coast of Florida in the summer months. Cold water upwelling is a phenomenon where normal ocean bottom temperatures will drop to temperatures well below normal for the location and time of year, temperatures as low as 46 degrees F have been documented. The surface temperatures are usually still in the 80s during these events but for divers and fish it can be a traumatic experience. The events usually last from 2 to 6 weeks; June and July are the worst months for these cold-water upwelling events. In some recent years large fish kills have occurred with 1000s of fish dying and either drifting away in the current or washing up on the beaches. These events sometimes bring very deep cold-water species up from the abyss onto the continental shelf. In summation there are many factors that affect the specific numbers and types of fish species documented on the deepwater reefs on any given week throughout the year.

### 3.1.3 Photo/Video Documentation

Underwater still and video cameras were used to document observations during the dives. Photography was used to help confirm identification of flora and fauna and to compare with still and video photographs collected during previous monitoring. Due to varying conditions (especially visibility at the bottom), underwater photographs for some sites or some dates are not of sufficient quality to include in this report. Selected photographs taken in 2010 and early 2011 are included in this report. Copies of all photographs and videos are submitted on compact disk (CD) at the end of this report.

Monitoring reports from prior years were reviewed prior to performing the fieldwork, and dive slates were prepared in advance with sketches of the dive sites and tables for recording measurements and observations. All data taken during each dive was thoroughly reviewed on the boat following each dive, and data were transferred into field journals to assure that correct and complete data were recorded and saved.

## 3.2 Funding

Funding for this program comes from a variety of sources. Martin County allocates a portion of the funding from the Vessel Registration fees into the artificial reef budget on an annual basis. The Martin County Utilities and Solid Waste Department has set aside a staging area in their facility to receive and store recycled concrete material donated by local contractors. The Florida Fish and Wildlife Conservation Commission's Artificial Reef Program has also been a steady

source of fund for the program, Locally, the MCAC Reef Fund, a locally supported Non-profit organization dedicated to supporting the Martin County Artificial Reef Program has provided funds, staged public events, scouted potential reef material and volunteered time to prepare vessels for reefing. They have raised funds by auctioning the naming rights to new reefs being created and have facilitated the construction of many reefs.

#### 4.0 Artificial Reef Locations

A total of 12 individual artificial reef sites were monitored in 2010, scattered among four of the permitted offshore artificial reef sites and one estuary artificial reef site. The specific artificial reef sites listed in Table 5 were monitored, with physical surveys of the reef site and biological inventories performed for each site.

**Table 5. List of artificial reefs monitored in 2010.**

	<b>Reefs to Monitor - 2010</b>	<b>2010 Monitoring Dates</b>	<b>Last Monitoring</b>	<b>Depth</b>	<b>Permit Area</b>	<b>Survey Type</b>
1	Fogel Capital Management	9/10/10	8/31/2009	67	S County	in-water
2	The Heap	9/10/10	10/8/2009	68	S County	in-water
3	American Custom Yachts Tower	2/13/11	10/15/2009	190	Sirotkin	in-water
4	Reefmaker Inlet Barge	12/17/10	6/21/2007	60	Donaldson	in-water
5	Reefmaker Triangle	12/17/10	6/24/2007	50	Donaldson	in-water
6	Evans Crary Bridge	9/11/10	6/17/2005	75	Ernst	in-water
7	Tetrahedron Stack	9/13/10	5/21/2006	100	Sirotkin	in-water
8	Tetrahedron Patch - Yellow	9/13/10	7/18/2007	95	Sirotkin	in-water
9	Tetrahedron Patch - Blue	9/13/10	7/18/2007	95	Sirotkin	in-water
10	Ballantrae Anglers*	9/08/10	none	187	Sirotkin	in-water
11	Pirate's Cove*	9/08/10	none	187	Sirotkin	in-water
12	Wickstrom	9/06/10	9/3/2007	188	Sirotkin	in-water

The following sections provide a summary of the four permitted artificial reef areas offshore of Martin County, which include the Ernst, Donaldson, Sirotkin, and South County areas. The locations of the artificial reefs monitored for this report are shown on those charts, along with other known reef deployments. The permitted reef areas are located in water depths ranging from 50 to 190 feet and include artificial reefs constructed using a variety of man-made and natural materials. The size of the individual artificial reefs is also quite variable due to the type and quantity of materials used.

Figure 2 shows the distances from the St. Lucie Inlet sea buoy to the four primary offshore artificial reef areas, the Ernst, Donaldson, Sirotkin and South County Artificial Reef areas.

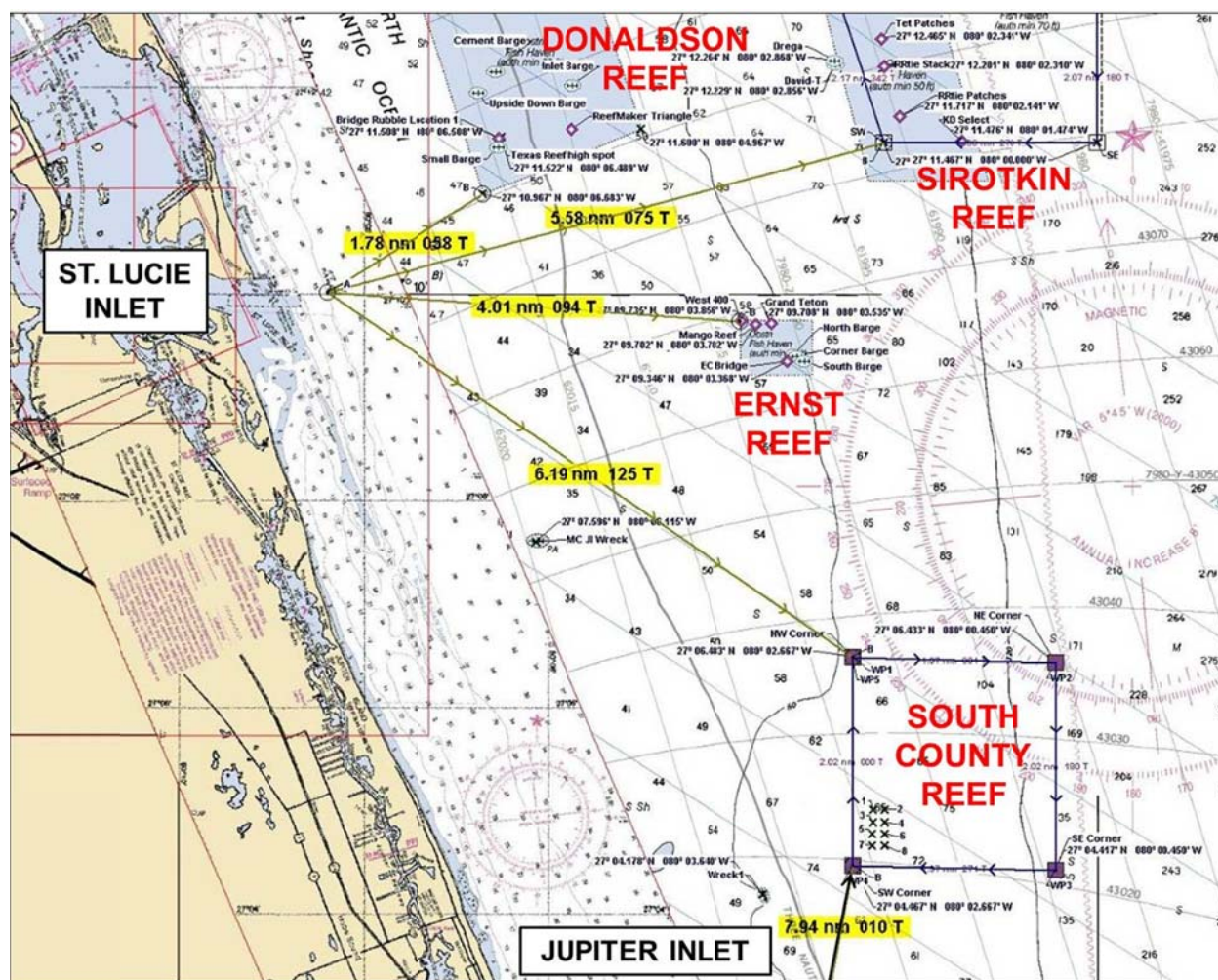


Figure 2. Distances from St. Lucie Inlet sea buoy to the offshore artificial reef sites.

## 4.1 Donaldson Artificial Reef Site

The Donaldson Artificial Reef area, as shown in Figure 3, is located approximately 2 nautical miles NE of the St. Lucie Inlet sea buoy. Water depths vary from 50 to 68 feet within this area and it contains a variety of artificial reef structures, including several older barges, dredged limestone rubble, recycled bridge materials, concrete culverts, boxes and pilings and purpose-built artificial reef modules.

The newest deployment in this site is the PCL Shallow Reef, constructed in 2006 of recycled bridge materials from the dismantled Lyons Bridge. Other notable reef units within the Donaldson Artificial Reef area include the Clifton Perry Memorial Reef and Texas Reef. Fifteen pyramid-shaped Reefmaker artificial reef modules were deployed along the southern edge of Texas Reef. Ten additional Reefmaker modules were deployed within the Donaldson Reef area as a patch reef in the SE portion of the permitted area, indicated as the Reefmaker Triangle in Figure 3. In 2005, sixteen Reefmaker modules were placed around four barges, four units at each, about 100 feet from each side of the barge. Due to its relatively shallow depths and close proximity to St. Lucie inlet, the Donaldson Artificial Reef area is very popular with fishermen and divers.

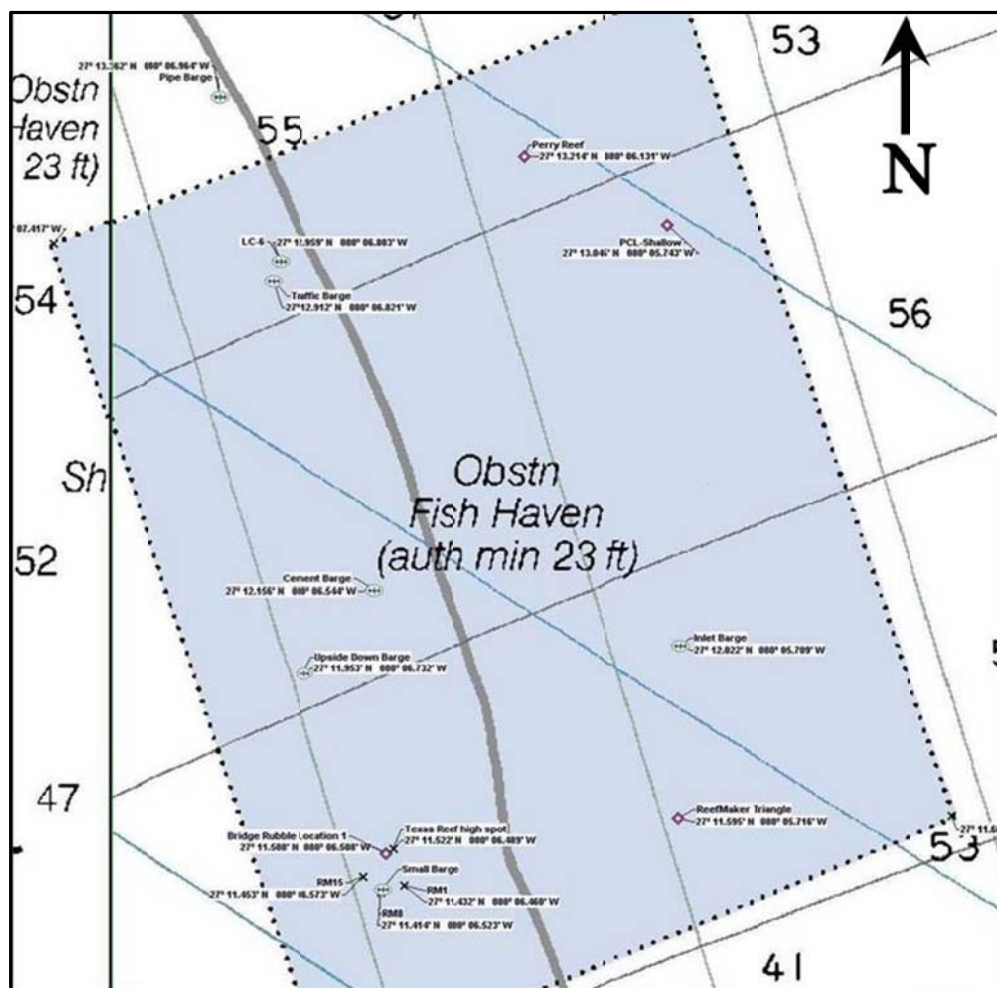


Figure 3. Chart view of the Donaldson Reef site.



## 4.2 Ernst Artificial Reef Site

The Ernst Artificial Reef area (Figure 4) is located about 4 nautical miles due east of the St. Lucie Inlet sea buoy. There are seven known artificial reef sites within this area lying in 60 to 80 feet of water. The newest deployments (2007) in this area are the West 400, Mango, and Grand Teton artificial reefs, all located along the northern boundary of the permitted reef area. Each of these newer artificial reefs was constructed of recycled concrete materials from the Martin County landfill.

Prior deployments to this artificial reef area include the Evans Crary Bridge Reef, an expansive, high relief structure constructed from recycled bridge materials. This artificial reef was deployed in 2000. Other known reefs located within this site include the remnants of three barges, which were deployed in 1972 near the southeast corner of the permitted artificial reef area. All of the artificial reefs in the Ernst Artificial Reef area are very popular with fishermen and scuba divers.



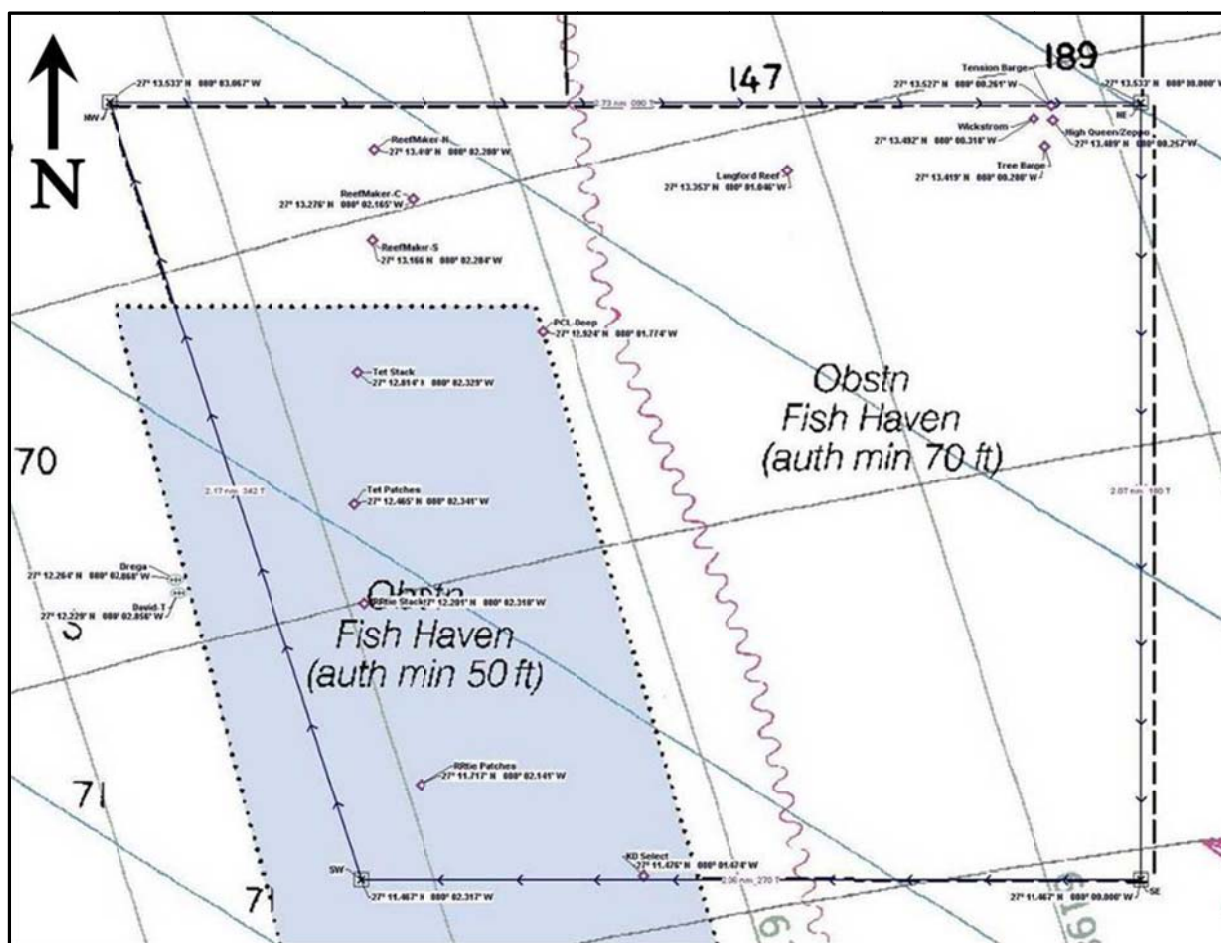
Figure 4. Chart view of the Ernst Artificial Reef site.



### 4.3 Sirotkin Artificial Reef Site

The Sirotkin Artificial Reef site is the largest and deepest of the permitted artificial reef areas offshore of Martin County (Figure 5). The western side has water depths in the 70 foot range, while the eastern border includes water depths of just over 200 feet. Although depths in excess of 130 feet are not recommended for recreational diving, technical divers and offshore sport fishermen utilize the deeper reef sites due to the dramatic underwater scenery and diversity of demersal and pelagic fish species encountered there.

A variety of reefing materials has been deployed within the Sirotkin Artificial Reef area over the past several decades. The more recent deployments have consisted of various concrete rubble, dismantled bridge components, ships, barges and artificial reef modules. One of the newest deployments (2008) in this permitted reef site is the Harbor Branch Towers formation, a group of four steel towers deployed upright in 190 feet of water. Each of the towers measures about 20 feet on a side by 35 feet tall.



**Figure 5. Chart view of the Sirotkin Artificial Reef site.**

Sunken steel vessels such as the Wickstrom, Tree Barge, High Queen/Zeppo, and the Tension Barge have been deployed in the NE corner of the Sirotkin reef site. Four pyramid-shaped Reefmaker artificial reef units were also deployed in the NE corner, between the Tree Barge and

the Wickstrom. Nineteen additional Reefmaker artificial reef units were deployed in 2005 within the Sirotkin Artificial Reef area. Four deployments (one each year from 2001 to 2004) of two different types of concrete shapes (tetrahedrons and railroad ties) were deployed along a N-S axis in the Sirotkin Artificial Reef area, as shown in Figure 5. Concrete tetrahedrons were deployed both as a single stack and as five separate patch reefs. Likewise, the concrete railroad ties were also deployed as a single stack and as five separate patch reefs. Water depths are between 95 and 100 feet at all four of these sites. Approximately 1,500 tons of concrete was deployed at each of the four reef sites in order to determine whether different configurations result in differences in biological colonization rates, species diversity or fish biomass levels among artificial reefs with a constant mass.

#### 4.4 South County Artificial Reef Site

The South County Artificial Reef is the most recently permitted artificial reef site offshore of Martin County and contains depths ranging from 65 to 150 feet. This site is about halfway between St. Lucie and Jupiter Inlets and provides recreational amenities for divers and anglers off the southern portion of Martin County. The site currently contains six separate piles of large concrete and steel materials; all deployed during the same week in June, 2008 in about 70 feet of water (Figure 6). The individual piles are called The Heap, Shirley Reef, Lentine Reef, Fogel Capital Management Reef, Ann Marie Reef and the Jack MacDonald Reef, all named by contributors to the artificial reef program.

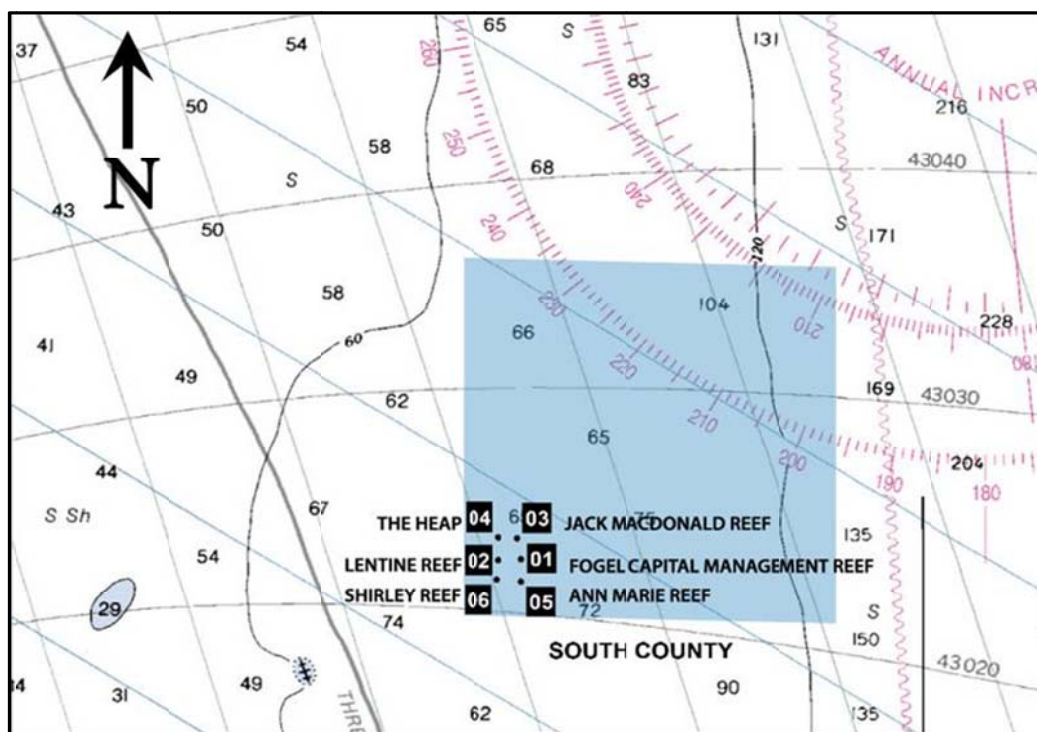


Figure 6. Chart view of the South County Artificial Reef area.

## 5.0 Results

The following sections summarize the monitoring results for each artificial reef monitored in 2010. A brief history and description of each artificial reef is followed by structural details and biological survey results along with selected photographs. Each of the following artificial reefs was monitored by the authors and support staff during 2010 and 2011.

### 5.1 Fogel Capital Management Artificial Reef

- Location: South County Reef
- Materials: Concrete – boxes, culverts, lamp posts, chunks, misc.
- Maximum Depth: 71 feet
- Reef High Point: 60 feet
- Year Created: 2007
- Monitoring Date: 9/10/2010
- Total Cost: \$14,601.50 (FWC 69% and Martin County 31%)

#### 5.1.1 History of the Fogel Capital Management Artificial Reef

In 2007 nearly 2,000 tons of large concrete and steel construction waste was delivered to Harbour Pointe Park in Ft. Pierce and stockpiled prior to deployment offshore of Martin County. In June 2008, the stockpiled material was shipped to the South County Artificial Reef area in three separate barge loads where one half of each barge load of material was deployed on each of the six South County Artificial Reef sites. A total of 245 tons of the material (½ barge load) were dropped in the southwest corner of the reef area from the anchored barge to form the Fogel Capital Management Reef. The material and deployment of the material used to create this reef was funded by the FWC and Martin County for the amount of \$14,601.50. Figure 7 shows a chart with the location of the Fogel Capital Management Reef within the South County Artificial Reef area shaded in light blue.

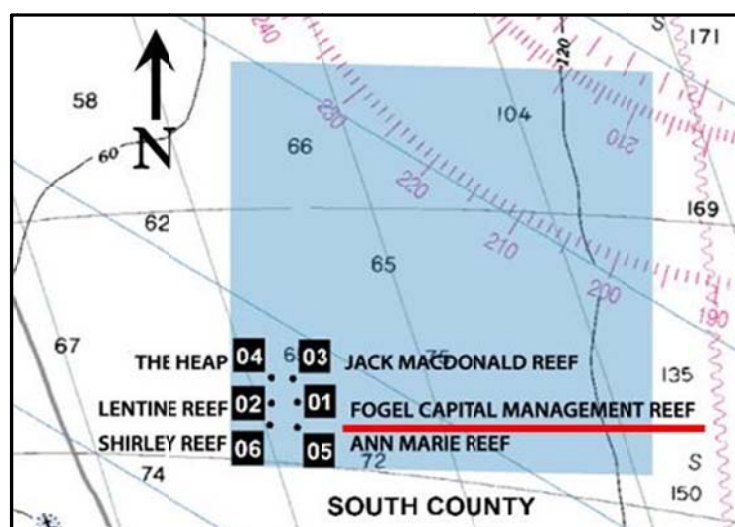


Figure 7. Chart view of the Fogel Capital Mgmt Reef in the S. County Artificial Reef area.



### 5.1.2 Structural Summary

The maximum depth at this artificial reef site is 71 feet with a maximum relief of about 11 feet. The footprint of the site is oval shaped with a southeast-to-northwest axis and occupies about 0.5 acres of seafloor. The deployment barge was securely moored at two points when the reef materials were dropped and the large concrete components settled in a single pile, although a few pieces settled to the bottom a short distance from the reef pile. Several large culvert sections provide cavernous recesses that are used extensively by large and small fish alike. Many culverts landed in a vertical position and have remained upright since their deployment. Some settling of the materials has occurred and minimal scouring has taken place. The photographs in Figure 8 are from the monitoring dive and show general conditions of the reef and some of the species observed during the dive.



Figure 8. Fogel Capital Management Artificial Reef 2010 photographs.

Identification of species in the photographs shown above in clockwise order from the upper-left photograph are (1) goliath grouper, (2) Sergeant Major & Fogel Capital Management Reef sign, (3) spanish hogfish & tomtates, and (4) various marine plants and algae, no fish.

### 5.1.3 Biological Survey Results

Fish surveys indicate a diverse assemblage of fishes. In 2009 the first year of monitoring occurred and 19 fish species were observed. Seabass, snappers and grunts represented the most numerous species of fishes during that survey. In the 2010 monitoring survey 26 fish species were observed. Of these fish species observed 5 species were in the South Atlantic Grouper/Snapper complex, and one species (snook) is considered an important sport/food fish in Florida waters. Schools of baitfish and predator species were observed in the upper water column above the reef materials, while the demersal species showed an affinity for the reef itself and the numerous crevices and refugia. Plants and invertebrates observed on the artificial reef included red, brown and green algae, sargassum algae, hydroids, sea anemones, sea urchins, barnacles, sea cucumbers, arrow crabs, hermit crabs and encrusting sponges. Table 6 presents the fish species observed during 2010 and Table 7 presents the benthic species observed.

**Table 6. Fogel Capital Management Artificial Reef fish species census.**

Family/Common Name	Species	2010	
		Abundance	Size
<b>Acanthuridae</b>			
Blue Tang	<i>Acanthurus coeruleus</i>	F	A
<b>Carangidae</b>			
Amberjack	<i>Seriola dumerili</i>	M	J
Blue Runner	<i>Caranx crysos</i>	A	A
Round scad	<i>Decapterus punctatus</i>	F	J & A
<b>Centropomidae</b>			
Common snook	<i>Centropomus undecimalis</i>	F	A
<b>Chaetodontidae</b>			
Reef butterflyfish	<i>Chaetodon sedentarius</i>	F	A
<b>Grammatidae</b>			
Whitespotted soapfish	<i>Rypticus maculatus</i>	F	J & A
<b>Haemulidae</b>			
Porkfish	<i>Anisotremus virginicus</i>	M	A
Tomtate	<i>Haemulon aurolineatum</i>	A	J & A
White margate	<i>Haemulon album</i>	F	A
<b>Labridae</b>			
Slippery dick	<i>Halichoeres bivittatus</i>	M	J & A
Spanish hogfish	<i>Bodianus rufus</i>	S	A
<b>Lutjanidae</b>			
Gray snapper	<i>Lutjanus griseus</i>	M	J & A
Yellowtail snapper	<i>Ocyurus chrysurus</i>	F	J & A
<b>Pomacanthidae</b>			
Blue angelfish	<i>Holocanthus bermudensis</i>	F	A
Queen angelfish	<i>Holocanthus ciliaris</i>	S	J
<b>Pomacentridae</b>			
Beaugregory	<i>Pomacentrus leucostictus</i>	F	A
Sergeant major	<i>Abudefduf saxatilis</i>	F	A
Yellowtail reeffish	<i>Chromis enchrysurus</i>	M	J & A
<b>Serranidae</b>			

Family/Common Name	Species	2010	
		Abundance	Size
Belted sandfish	<i>Serranus subligarius</i>	M	A
Goliath grouper	<i>Epinephelus itajara</i>	F (8)	A
Scamp	<i>Mycteroperca phenax</i>	F	J
Gag grouper	<i>Mycteroperca microlepis</i>	F	J
<b>Sparidae</b>			
Sheepshead	<i>Archosargus probatocephalus</i>	F	A
Sheepshead porgy	<i>Calamus penna</i>	F	A
<b>Tetraodontidae</b>			
Sharpnose puffer	<i>Canthigaster rostrata</i>	S	J
<b>Total</b>		<b>26</b>	

Abundance Key: S=single, F=few (2-10), M=many (11-100), A=abundant (>100)

Size Key: A=adult, J=juvenile, A/J=intermediate

**Table 7. Fogel Capital Management Artificial Reef benthic species census.**

	Common Name	Scientific Name
<b>Echinoderms</b>	Common arbacia sea urchin	<i>Arbacia punctulata</i>
	Sea Cucumber	Unidentified species
<b>Cnidarians</b>	Algae Hydroid	<i>Thyrosocyphus ramosus</i>
	Hydroids	Unidentified species
	Unidentified solitary octocoral	<i>Octocorallia</i>
	Sea Anemones	Unidentified species
<b>Ascidians</b>	Overgrowing Tunicates	<i>Didemnidae</i>
	Mottled Encrusting Tunicate	<i>Distaplia bermudensis</i>
<b>Poriferans</b>	Encrusting Sponge	Unidentified species
<b>Crustaceans</b>	Yellowline Arrow Crab	<i>Stenorhynchus seticornis</i>
	Hermit Crab	Unidentified species
	Sessile barnacles	<i>Balanus trigonus</i>
<b>Other</b>	Red, Brown & Green Algae	Unidentified species
	Sargassum Algae	Unidentified species

## 5.2 The Heap Artificial Reef

- Location: South County Reef
- Materials: Concrete – culverts, lamp posts, chunks, misc.
- Maximum Depth: 64 feet
- Reef High Point: 60 feet
- Year Created: 2007
- Monitoring Date: 9/10/2010
- Total Cost: \$14,601.50 (FWC 69% and Martin County 31%)

### 5.2.1 History of the Heap Artificial Reef

Nearly 2,000 tons of large concrete and steel construction waste was delivered to Harbour Pointe Park in Ft. Pierce in 2007 and early 2008 and stockpiled prior to deployment offshore of Martin County. In June 2008, the stockpiled material was shipped to the South County Artificial Reef area in three separate barge loads where one half of each barge load of material was deployed on each of the six South County Artificial Reef sites. A total of 268 tons (½ barge load) of these materials were dropped in the southwest corner of the reef area from the anchored barge to form The Heap artificial reef. The material and deployment of the material used to create this reef was funded by the FWC and Martin County for the amount of \$14,601.50. Figure 9 shows a chart with the location of The Heap.

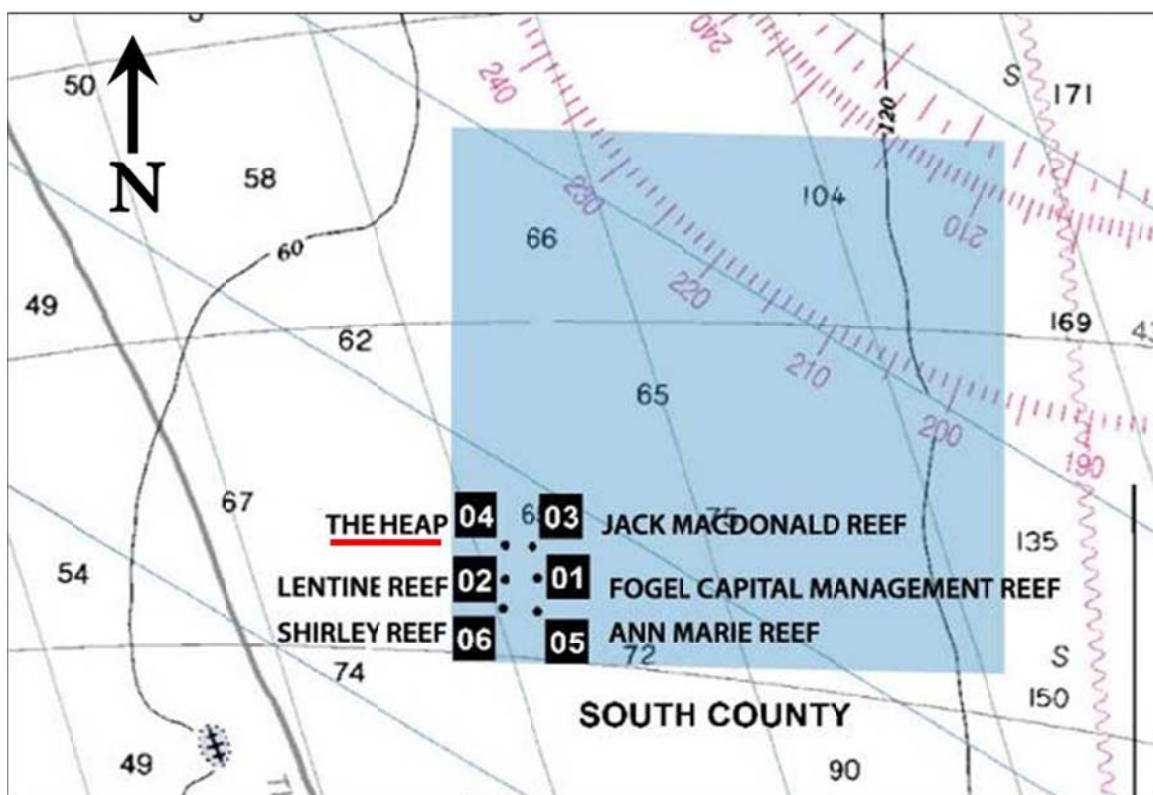


Figure 9. Chart view of The Heap in the South County Artificial Reef area.



### 5.2.2 Structural Summary

The maximum depth at this artificial reef site is about 64 feet with a maximum relief of about 4 feet. The footprint of the site is generally round with an irregular margin and occupies about 0.4 acres of seafloor. The deployment barge was securely moored at two points when the reef materials were deployed, this particular barge load had many smaller pieces than others and much scattering of the materials occurred resulting in a lower profile reef site. Many low profile concrete slabs were deployed here as well. The seafloor at this site is comprised of a shell/sand mixture and appears to have provided a marginally solid base for the heavy concrete and steel pieces. More scouring has occurred at this site, up to 3 feet, typically between 1 to 2 feet; therefore the overall profile is the lowest of the six South County artificial reef sites. The photographs in Figure 10 are from the monitoring dive and show general conditions of the reef and some of the species observed during the dive.



Figure 10. The Heap Artificial Reef 2010 photographs.

Identification of species in the photographs shown above in clockwise order from the upper-left photograph are (1) tomtates and ocean trigger fish, (2) juvenile black grouper and beaugregory, (3) lionfish, and (4) sheepshead.

### 5.2.3 Biological Survey Results

Fish surveys indicate and observed 27 species a diverse assemblage of fishes; 2010 was the second year of monitoring since deployment. Jacks, snappers, grunts and damselfish represented the most numerous species of fishes. As at most of the South County artificial reef sites, vast



schools of adult round scad were observed around and above the reef crest. Plants and invertebrates observed on the artificial reef included red, brown, green and sargassum alga, hydroids, tunicates, sea anemones, sea urchins, sea stars, sea cucumbers, arrow crabs, spiny lobsters, hermit crabs, rock snails, and encrusting sponges. Table 8 presents the fish species observed during 2010 and Table 9 presents the benthic species observed.

**Table 8. The Heap Artificial Reef fish species census.**

Family / Common Name	Species	2010	
		Abundance	Size
<b>Acanthuridae</b>			
Doctorfish	<i>Acanthurus chirurgus</i>	F	A
<b>Apogonidae</b>			
Twospot cardinalfish	<i>Apogon pseudomaculatus</i>	F	A
<b>Balistidae</b>			
Ocean triggerfish	<i>Canthidermis sufflamen</i>	M	A
<b>Carangidae</b>			
Amber jack	<i>Seriola dumerili</i>	M	J & A
Round scad	<i>Decapterus punctatus</i>	A	A
<b>Centropomidae</b>			
Common snook	<i>Centropomus undecimalis</i>	F	A
<b>Haemulidae</b>			
Black margate	<i>Anisotremus surinamensis</i>	F	A
Porkfish	<i>Anisotremus virginicus</i>	F	A
Tomtate	<i>Haemulon aurolineatum</i>	A	J & A
<b>Labridae</b>			
Bluehead wrasse	<i>Thalassoma bifasciatum</i>	M	J & A
Spanish hogfish	<i>Bodianus rufus</i>	S	J
Spotfin hogfish	<i>Bodianus pulchellus</i>	S	J
<b>Lutjanidae</b>			
Gray snapper	<i>Lutjanus griseus</i>	M	J & A
Lane snapper	<i>Lutjanus synagris</i>	F	A
Yellowtail snapper	<i>Ocyurus chrysurus</i>	F	J
<b>Pomacanthidae</b>			
Queen angelfish	<i>Holocanthus ciliaris</i>	S	J
<b>Pomacentridae</b>			
Beaugregory	<i>Pomacentrus leucostictus</i>	M	J & A
Blue chromis	<i>Chromis cyaneus</i>	S	A
Sergeant major	<i>Abudefduf saxatilis</i>	F	J & A
Yellowtail reeffish	<i>Chromis enchrysurus</i>	M	J & A
<b>Sciaenidae</b>			
Cubby	<i>Equetus umbrosus</i>	F	J & A
<b>Scorpaenidae</b>			
Red Lionfish	<i>Pterois volitans</i>	F (3)	A(2), J(1)
Spotted scorpionfish	<i>Scorpaena plumeiri</i>	S	A
<b>Serranidae</b>			
Belted sandfish	<i>Serranus subligarius</i>	F	J & A
Goliath grouper	<i>Epinephelus itajara</i>	S	A

Scamp	<i>Mycteroperca phenax</i>	F	J
<b>Sparidae</b>			
Sheepshead porgy	<i>Calamus penna</i>	F	A
	<b>Total</b>	<b>27</b>	

Abundance Key: S=single, F=few (2-10), M=many (11-100), A=abundant (>100)

Size Key: A=adult, J=juvenile, A/J=intermediate

**Table 9. The Heap Artificial Reef benthic species census.**

	<b>Common Name</b>	<b>Scientific Name</b>
<b>Echinoderms</b>	Rock Boring Urchin	<i>Echinometra lucunter</i>
<b>Cnidarians</b>	Algae Hydroid Hydroids	<i>Thyrosocyphus ramosus</i> Unidentified species
<b>Ascidians</b>	Overgrowing Tunicates Mottled Encrusting Tunicate Giant Tunicates	<i>Didemnidae</i> <i>Distaplia bermudensis</i> <i>Polycarpa spongiabilis</i>
<b>Poriferans</b>	Encrusting Sponge Brown Variable Sponge White Lumpy Sponge	Unidentified species <i>Anthosigmella varians</i> <i>Ptilocaulis sp.</i>

### 5.3 American Custom Yachts Tower Reef

- Location: Sirotkin Reef
- Materials: Steel
- Maximum Depth: 187 feet
- Reef High Point: 152 feet
- Year Created: 2008
- Monitoring Date: 02/13/2011
- Total Cost: \$4,500 (MCAC 50% and Martin County 50%)

#### 5.3.1 History of the American Custom Yachts Tower Reef

This artificial reef is one of four almost identical steel towers that were constructed by Harbor Branch Oceanographic Institution for the United States Navy. The Navy planned to deploy these towers in an unspecified location and use them for submarine acoustic and navigation exercises. However, the towers were never used for their originally intended purpose and became available for Martin County's artificial reef program. Funding was provided by Martin County and the Martin County Anglers Club in the amount of \$4,500 for the deployment of each tower. The deployment of the tower was performed using a barge that was securely moored at two points to ensure the tower was located at its permitted coordinates within the Sirotkin reef site. Figure 11 shows the location of the American Custom Yachts Tower in the Sirotkin Artificial Reef area.

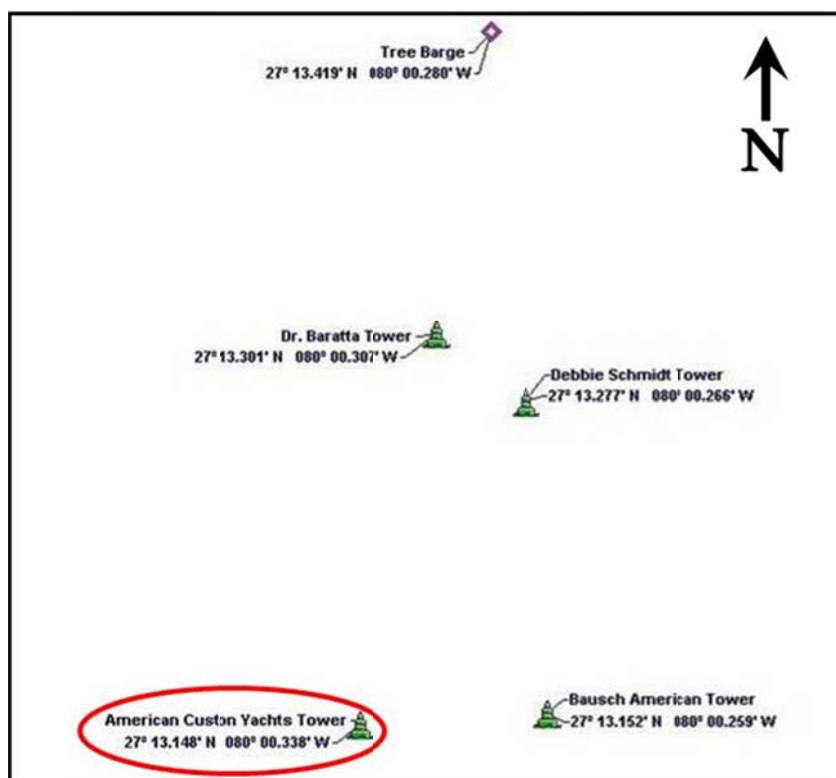


Figure 11. Sirotkin Reef sites showing the American Custom Yachts Tower location.

### 5.3.2 Structural Summary

The maximum seafloor depth at this artificial reef site is about 187 feet and the tower is 35 feet tall. The rope and barrels float upward about 90 feet from the top of the tower and may be as little as 70 feet beneath the surface in a mild current. The seafloor at this site is quite firm and composed of a shell/coarse sand mixture and appears to provide a solid base for the heavy tower, as scouring is not significant around the tower's three feet. The photographs in Figure 12 are from the monitoring dive and show general conditions of the reef and some of the species observed during the dive.



Figure 12. American Custom Yachts Tower 2009 & 2011 photographs.

Identification of species in the photographs shown above in clockwise order from the upper-left photograph are (1) greater amberjacks, (2) greater amberjack, (3) black & bank seabass and juvenile snowy grouper, and (4) Rich Meeker with black seabass around brackets.

### 5.3.3 Biological Survey Results

A total of 8 fish species were observed and consisted mainly of seabass and jacks. Black and bank seabass were common around the tower feet and greater amberjacks patrolled the tower legs and mast. Vast schools of unicorn filefish were observed around the rope and barrels above the tower. Invertebrate biomass on the artificial reef was already well established with barnacles, hydroids, tunicates, tube worms and numerous small colonies of *Oculina* coral. Table 10 and Table 11 present the fish and benthic species observed during 2010.

**Table 10. American Custom Yachts Tower Artificial Reef fish species census.**

Family/Common Name	Species	2010		2009	
		Abundance	Size	Abundance	Size
<b>Serranidae</b>					
Bank seabass	<i>Centropomus ocyurus</i>	M	J & A	M	A
Black seabass	<i>Centropomus striata</i>	M	J & A	M	A
Snowy grouper	<i>Epinephelus niveatus</i>	S	J	S	J
<b>Carangidae</b>					
Almaco jack	<i>Seriola rivoliana</i>			M	A
Amberjack	<i>Seriola dumerili</i>	M	J & A	M	A
<b>Chaetodontidae</b>					
Bank butterflyfish	<i>Chaetodon</i>			F	A
<b>Balistidae</b>					
Unicorn filefish	<i>Aluterus monoceros</i>			M	A
Gray triggerfish	<i>Balistes capris</i>	F	A		
<b>Ephippidae</b>					
Atlantic spadefish	<i>Chaetodipterus faber</i>	M	A		
<b>Sparidae</b>					
Sheepshead porgy	<i>Calamus penna</i>	F	A		
<b>Bothidae</b>					
Gulf flounder	<i>Paralichthys albigutta</i>	S	A		
	<b>Total</b>	<b>8</b>		<b>7</b>	

Abundance Key: S=single, F=few (2-10), M=many (11-100), A=abundant (>100)

Size Key: A=adult, J=juvenile, A/J=intermediate

**Table 11. American Custom Yachts Tower Artificial Reef benthic species census.**

Common Name		Scientific Name
<b>Echinoderms</b>	Common arbutia sea urchin	<i>Arbutia punctulata</i>
<b>Cnidarians</b>	Hydroids	Unidentified species
<b>Ascidians</b>	Overgrowing Tunicates	<i>Didemnidae</i>
	Mottled Encrusting Tunicate	<i>Distaplia bermudensis</i>

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<b>Annelida</b>	Tube worm	Unidentified species
<b>Scleractinia</b>	Large ivory coral	<i>Oculina varicosa</i>
<b>Crustaceans</b>	Sessile barnacles	<i>Balanus trigonus</i>
<b>Mollusca</b>	Octopus (either common or Caribbean)	<i>Octopus sp.</i>

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## 5.4 Reefmaker Inlet Barge

- Location: Donaldson Reef
- Materials: Concrete, steel
- Maximum Depth: 55 feet
- Reef High Point: 46 feet
- Year Created: 2005
- Monitoring Date: 12/17/2010
- Total Cost: \$3,180 (FWC 89% and Martin County 11%)

### 5.4.1 History of the Reefmaker Inlet Barge Artificial Reef

In 2005 Martin County received a \$47,700 grant from FWC to enhance existing artificial reef sites by deploying sixty Reefmaker “Florida Special” units adjacent to existing reef materials in the Donaldson and Sirotkin reef sites. These modules are large three-sided pyramids fabricated using concrete and steel. Four of the Reefmaker artificial reef modules were deployed within the Donaldson Reef Site around the four sides of the Inlet Barge for \$3,180 from the FWC grant and monies from Martin County.

The Inlet Barge was deployed in the 1980’s. It was noticed that some of the older barges deployed in the 1970’s and 1980’s were partially collapsed and settled deeply into the sand substrate. It was expected that by placing the four Reefmaker Units around the Inlet barge as well as other sites would result in increased complexity and biodiversity at the artificial reef sites. Figure 13 shows the location of the Reefmaker Inlet Barge (near the center of the map) in the Donaldson Artificial Reef area.

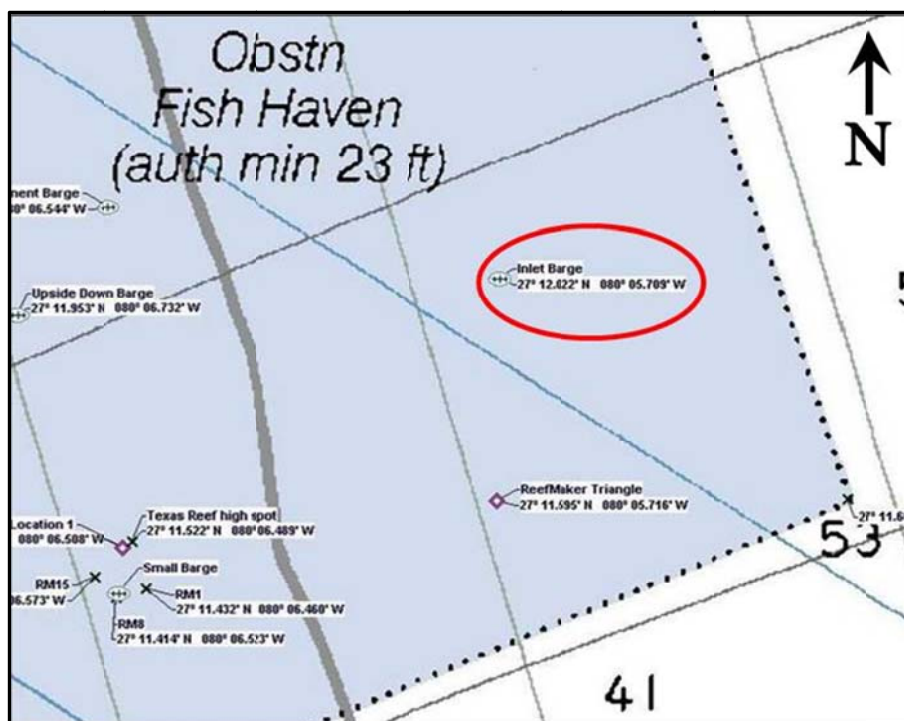
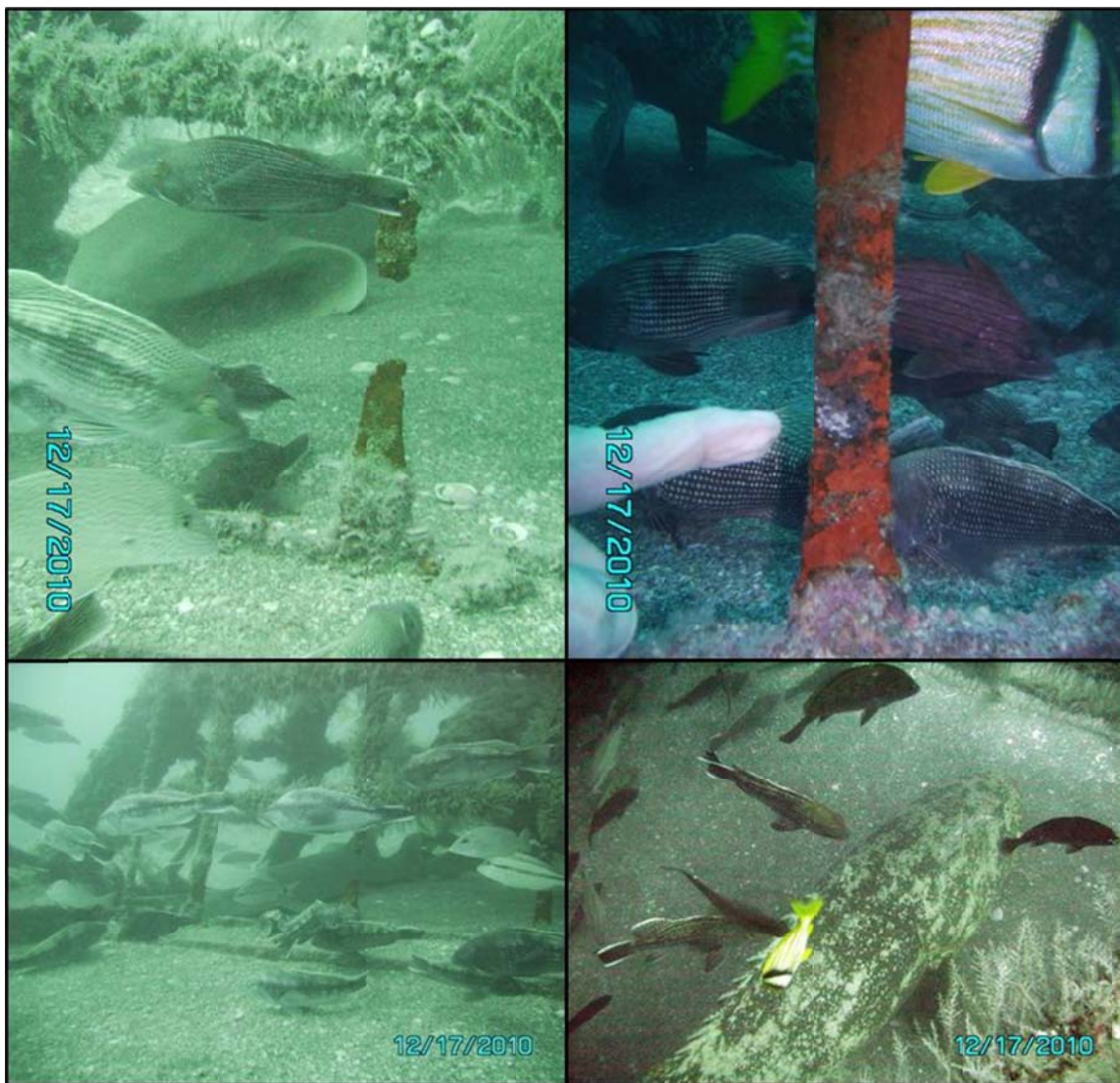


Figure 13. Donaldson Reef site showing the Reefmaker Inlet Barge location.

### 5.4.2 Structural Summary

Underwater measurements at each of the four units were performed; minimal settling of 1 ft has occurred and is typical of other Reefmaker Unit sites deployed by Martin County. The bases of all the units were buried resulting in increased stability. Figure 14 shows representative photographs of the Reefmaker units at the Inlet Barge site. All four of the Reefmaker units are intact and standing upright. Some of the steel bars near the base of the units have eroded/corroded through with some section loss evident as shown in the photographs of the Reefmaker steel damage; over time this erosion/corrosion is expected to worsen. In addition to showing the conditions of the reef, the photographs in Figure 14 show some of the species observed during the monitoring dive.



**Figure 14. Reefmaker Inlet Barge Artificial Reef photographs from 2010.**

Identification of species in the photographs shown above in clockwise order from the upper-left photograph are (1) black seabass & nurse shark, (2) goliath grouper, porkfish, black seabass, and cubbyu, (3) goliath grouper, porkfish, and black seabass, and (4) black seabass and tomtates.



### 5.4.3 Biological Survey Results

Fish surveys indicate an increasing trend in species diversity since 2005 and identified a total of 11 species. During the survey large schools of atlantic silversides (1½ to 2 in. long) and unidentified fry (¼ in. long) were observed above and around the reef site. Benthic species observed on and around the Reefmaker Units included sea urchins, encrusting sponges, barnacles and hydroids. Table 12 and Table 13 present the fish and benthic species observed during 2010.

**Table 12. Reefmaker Inlet Barge Artificial Reef fish species census.**

Family/Common Name	Species	2010	
		Abundance	Size
<b>Serranidae</b>			
Gag grouper	<i>Mycteroperca microlepis</i>	F	J
Goliath grouper	<i>Epinephelus itajara</i>	S	A
Whitespotted soapfish	<i>Rypticus maculatus</i>	F	A
<b>Scorpaenidae</b>			
Spotted scorpionfish	<i>Scorpaena plumeiri</i>	S	J/A
<b>Atherinopsidae</b>			
Atlantic Silverside	<i>Menidia menidia</i>	A	J & A
<b>Sparidae</b>			
Sheepshead porgy	<i>Calamus penna</i>	F	A
<b>Haemulidae</b>			
Porkfish	<i>Anisotremus virginicus</i>	M	J & A
Tomtate	<i>Haemulon aurolineatum</i>	A	J & A
Black margate	<i>Anisotremus surinamensis</i>	F	A
<b>Sciaenidae</b>			
Cubbyu	<i>Equetus umbrosus</i>	M	A
<b>Centropomidae</b>			
Common snook	<i>Centropomus undecimalis</i>	F	A
	<b>Total</b>	<b>11</b>	

Abundance Key: S=single, F=few (2-10), M=many (11-100), A=abundant (>100)

Size Key: A=adult, J=juvenile, A/J=intermediate

**Table 13. Reefmaker Inlet Barge Artificial Reef benthic species census.**

	Common Name	Scientific Name
<b>Echinoderms</b>	Common arbacia sea urchin	<i>Arbacia punctulata</i>
<b>Cnidarians</b>	Algae Hydroid Hydroids	<i>Thyrosocyphus ramosus</i> Unidentified species
<b>Crustaceans</b>	Sessile barnacles	<i>Balanus trigonus</i>
<b>Poriferans</b>	Encrusting Sponge	Unidentified species

## 5.5 Donaldson Reefmaker Triangle

- Location: Donaldson Reef
- Materials: Reef modules (steel and concrete)
- Maximum Depth: 55 feet
- Reef High Point: 43 feet
- Year Created: 2005
- Monitoring Date: 12/17/2010
- Total Cost: \$7,950.00 (FWC 89% and Martin County 11%)

### 5.5.1 History of the Reefmaker Triangle Artificial Reef

Martin County received a \$47,700 grant in 2005 from the FWC to enhance existing artificial reef sites by deploying sixty Reefmaker “Florida Special” artificial reef modules adjacent to existing reef materials in the Donaldson and Sirotkin reef sites and four stand-alone sites. These modules are large three-sided pyramids fabricated using concrete and steel. A portion of the grant in the amount of \$7,950 was used to deploy ten additional Reefmaker modules within the Donaldson Reef area as a patch reef in the SE portion of the permitted area, indicated as the Reefmaker Triangle. A chart showing the location of the Reefmaker Triangle location is shown in Figure 15.

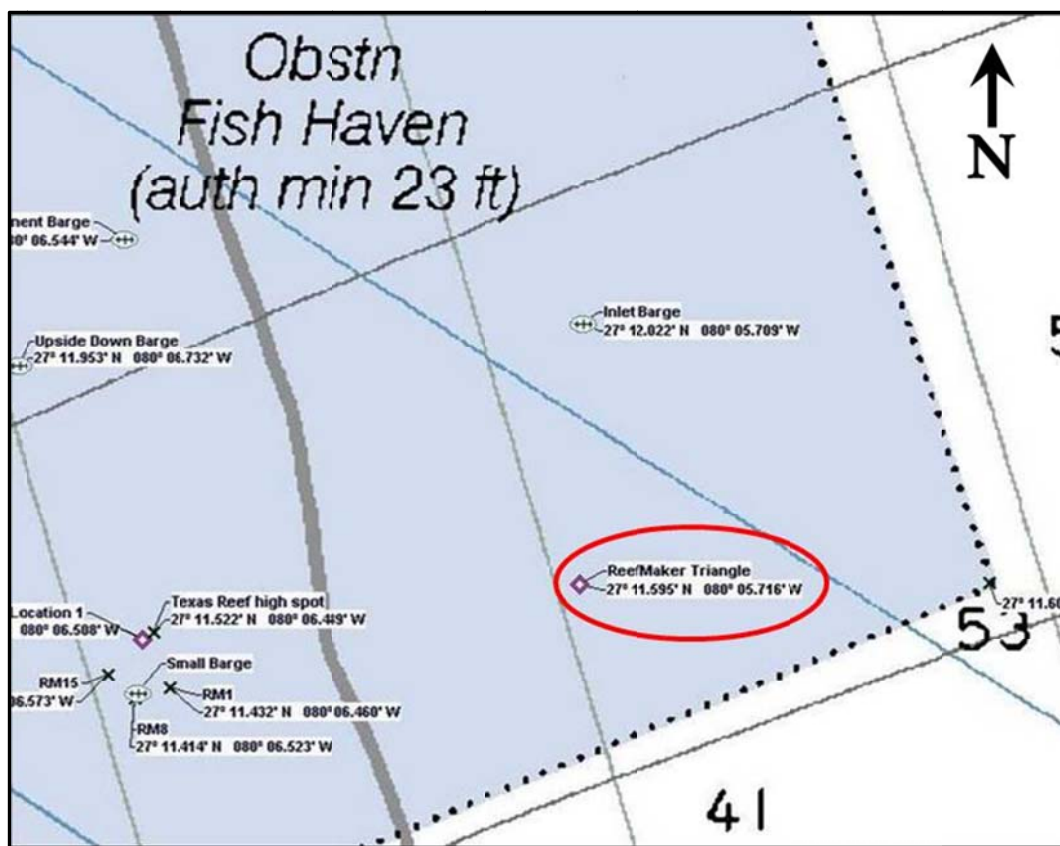


Figure 15. Chart view of the Donaldson Reef site showing the Reefmaker Triangle location.

### 5.5.2 Structural Summary

Each of the modules at the Reefmaker Triangle location was observed and found to be standing upright, stable and in their original positions. Settlement of approximately 1 foot was noted around the base of one module although it appeared very stable. The concrete components of the modules were intact however several steel components (typically near the base of the units) were observed to be corroded/eroded severely as shown in the photographs below. The photographs in Figure 16 are from the monitoring dive and show general conditions of the reef and some of the species observed during the dive.



**Figure 16. Reefmaker Triangle Artificial Reef 2010 photos.**

Identification of species in the photographs shown above in clockwise order from the upper-left photograph are (1) atlantic spadefish, (2) various marine benthic growth, (3) Unknown fish egg masses, and (4) black seabass.

### 5.5.3 Biological Survey Results

Fish surveys identified 14 species and indicated an increasing trend in species diversity since 2005. With black seabass and jacks representing the most numerous species in 2010, although grunts and snappers were also common. Invertebrate biomass on the artificial reef also appeared to have increased since deployment. Some of the most common species included sea urchins, seastars, encrusting sponges, spiny file clams and red netted barnacles. Table 14 and Table 15 present the fish and benthic species observed during 2010.

Table 14. Reefmaker Triangle Artificial Reef fish species census.

Family/Common Name	Species	2010	
		Abundance	Size
<b>Serranidae</b>			
Black seabass	<i>Centropristis striata</i>	A	J & A
Goliath grouper	<i>Epinephelus itajara</i>	S	A
Whitespotted soapfish	<i>Rypticus maculatus</i>	F	A
<b>Carangidae</b>			
Yellow Jack	<i>Caranx bartholomaei</i>	A	J & A
Atlantic bumper	<i>Chloroscombrus chrysurus</i>	A	A
<b>Lutjanidae</b>			
Lane snapper	<i>Lutjanus synagris</i>	F	A
Vermilion snapper	<i>Rhomboplites aurorubens</i>	A	J
<b>Haemulidae</b>			
Porkfish	<i>Anisotremus virginicus</i>	F	A
Tomtate	<i>Haemulon aurolineatum</i>	M	J & A
Pigfish	<i>Orthopristis chrysoptera</i>	A	A
<b>Sciaenidae</b>			
Cubbyu	<i>Equetus umbrosus</i>	M	A & J
Spot	<i>Leiostomus xanthurus</i>	F	A
<b>Ephippidae</b>			
Atlantic spadefish	<i>Chaetodipterus faber</i>	M	J
<b>Rhincodontidae (Carpet Sharks)</b>			
Nurse shark	<i>Ginglymostoma cirratum</i>	S	A
	<b>Total</b>	<b>14</b>	

Abundance Key: S=single, F=few (2-10), M=many (11-100), A=abundant (&gt;100)

Size Key: A=adult, J=juvenile, A/J=intermediate

Table 15. Donaldson Reefmaker Triangle Artificial Reef benthic species census.

	Common Name	Scientific Name
<b>Echinoderms</b>	Variegated sea urchin	<i>Lytechinus variegates</i>
	Beaded Seastar	<i>Astropecten articulatus</i>
<b>Mollusca</b>	Spiny Fileclam	<i>Lima lima</i>
<b>Crustaceans</b>	Red-netted barnacles	<i>Megabalanus sp.</i>
<b>Others</b>	Unidentified type of sponge	

## 5.6 Evans Crary Bridge Artificial Reef

- Location: Ernst Reef
- Materials: Concrete, steel, cast iron, PVC
- Maximum Depth: 75 feet
- Reef High Point: 49 feet
- Year Created: 2000
- Monitoring Date: 9/11/2010
- Total Cost: There was no cost to Martin County

### 5.6.1 History of the Evans Crary Bridge Artificial Reef

As part of the contract with the Florida Department of Transportation to construct the new Evans Crary Bridge (completed in 2000) in Stuart, Florida, the contractor was required to dismantle and dispose of the old bridge components. The contractor was required to transport the steel and concrete bridge components offshore to construct an artificial reef. Some of the smaller bridge components were used to create three nearshore shallow water mitigation reefs close to the Stuart and Jensen Beach shorelines in water depths of 10-20 feet, while the larger bridge sections and the majority of the materials were deployed in the Ernst permitted reef site in water depths of 60-70 feet.

In the summer of 2000 approximately 24 barge loads of old bridge components were deployed at the Ernst offshore site, these deployments consisted of the following:

- concrete piles from 20 – 40 ft. long each
- concrete pile caps approx. 30 ft. x 4 ft. x 5 ft. each
- steel/concrete roadway sections approx. 40 ft. x 5 ft. x 4 ft. each
- pieces of the bascule piers various sizes up to 10 ft. x 8 ft. x 4 ft.
- sections of the steel drawbridge leafs up to 30 ft. x 12 ft. x 10 ft.
- large steel gears from the drawbridge lifting mechanisms
- cast iron & PVC water main piping
- steel & aluminum electrical conduit
- concrete handrail & sidewalk sections

Each barge load of these materials was deployed from one of two temporary mooring buoys placed approximately 100 to 200 yards west of three sunken barges previously sunk for artificial reef development in 1972. Because the contractor moored the barge each time to the same buoys, the materials settled on the bottom in a tightly grouped pile. This pile is roughly elliptical and measures approximately 280 feet long x 80 feet wide x 26 feet high, with the major axis in an east/west orientation.

The Evans Crary Bridge pile has become a thriving reef community with substantial populations of pelagic and benthic species. At the surface above the reef, baitfish by the 1000's are often seen at this site. This artificial reef site has become one of, if not the most visited artificial reef sites in Martin County for saltwater anglers, charter sport fishing boats, and recreational divers. Figure 17 shows the location of the Evans Crary Bridge Artificial Reef.





Figure 17. Chart view of the Evans Crary Bridge Reef within the Ernst Artificial Reef site.

### 5.6.2 Structural Summary

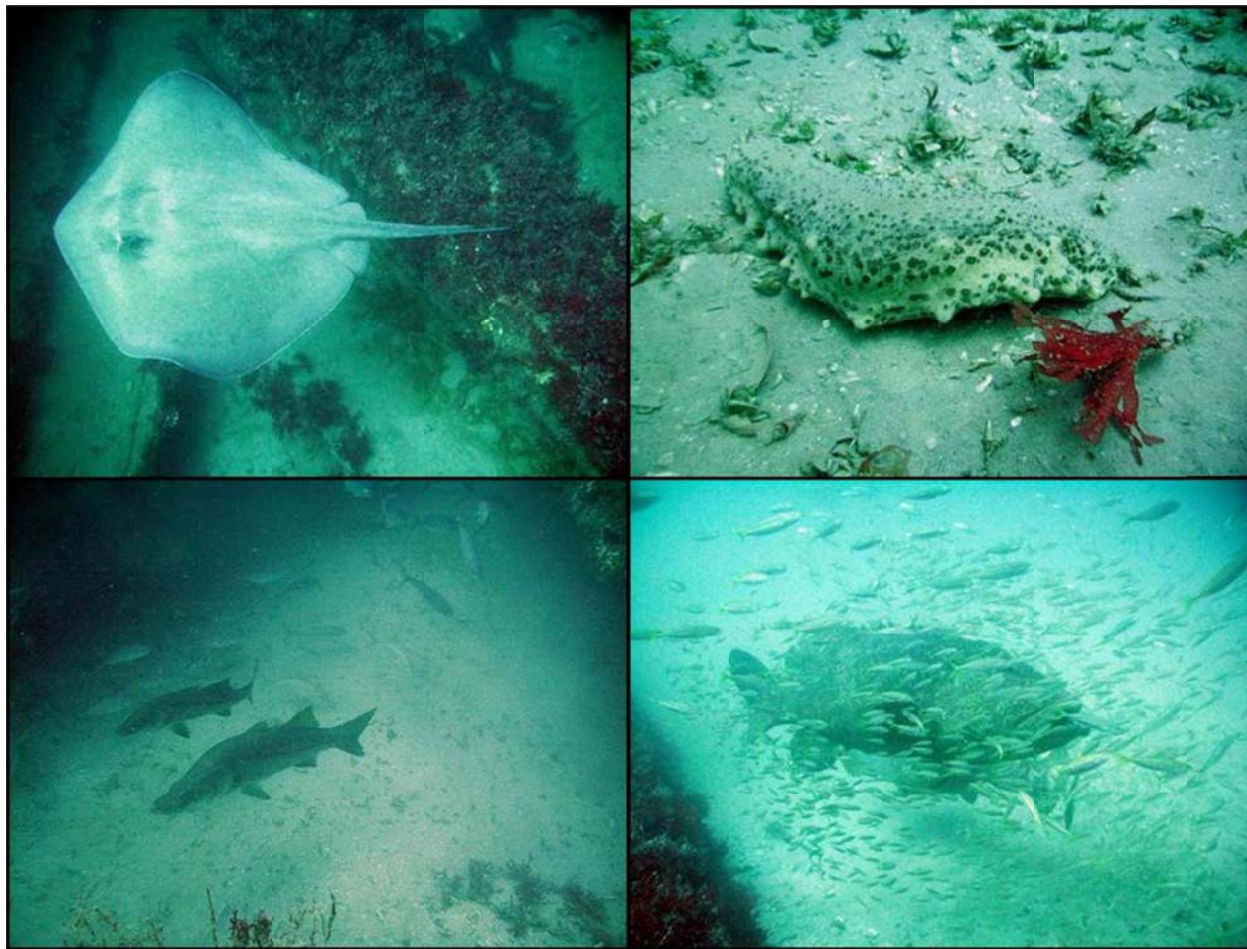
The Evans Crary Bridge Reef site was monitored with much frequency during construction in 2000, and then annually between 2001 and 2006. This site is likely the most popular fishing and dive sites of all the 60+ Martin County reef sites. This is due to its relatively shallow depth 65 to 75 feet and relative closeness to Martin County's sole ocean access inlet. It has the most total tonnage of any artificial reefs to date, over 20 barge loads of steel & concrete materials were placed here in the spring/summer of 2000.

Between 2004 & 2005 this large reef was hit by three hurricanes - Frances, Jeanne, & Wilma. Although these hurricanes rearranged the materials and took approx. 10 ft off the total profile, the reef site still has an impressive 26 foot profile with max depth of 75 ft and a reef crest depth of 49 ft. The overall footprint on the seafloor is approximately the size of a football field measuring 280 ft x 80 ft.

Although the footprint has increased slightly in the past 10 years it is still a very stable reef site with 100s of components interlocked with one another. Some scouring (3-4 feet) has occurred around the base of the reef. As a result of the scouring 100s of automobile, truck and airplane tires have emerged from the substrate (as was previously reported). In 2000, when the reef was

built it was not known a tire reef had been placed nearby in the 1970s. Over time the “tire reef” settled into the sands and began reappearing in 2001 after the placement of the material at the Evans Crary reef site. These tires, although not an ideal reef material, have become a part of the Evans Crary Bridge reef site and do provide habitat for mostly crustaceans and other demersal species.

The overall structural stability of this site appears very good and should continue to be an excellent artificial reef site for many decades to come. The photographs in Figure 18 are from the monitoring dive and show general conditions of the reef and some of the species observed during the dive.



**Figure 18. Evans Crary Bridge Reef 2010 photographs.**

Identification of species in the photographs shown above in clockwise order from the upper-left photograph are (1) southern stingray, (2) variegated sea cucumber, (3) goliath grouper and round scad, and (4) common snook and tomtates.

### 5.6.3 Biological Survey Results

Total invertebrate biomass on the artificial reef has observably increased since deployment of the Evan Crary Bridge Reef in 2000 with 34 fish species present. Most common species included spiny lobsters, hermit crabs, sea urchins, encrusting sponges, tunicates and sea cucumbers. Due

to the high profile of the site increasing the amount of sunlight reaching parts of the structure corals, tunicates, gorgonians, alga and other marine plants thrive at this site.

The Evans Crary Bridge Reef also had the highest fish species diversity of all the sites monitored during 2010 with a total of 34 for fish species observed and two non-fish species, bottlenose dolphin and a loggerhead turtle. Over the years of monitoring the Martin County artificial reefs it has been observed that the reefs typically reach a threshold of 40 fish species on the shallow artificial reef sites and around 20 fish species on the artificial reef sites deeper than 130 ft.

During the 10 years of monitoring and diving the artificial reef sites off of Martin County the Evans Crary Bridge Reef site is often the most biologically complete artificial reef site in Martin County's inventory of over 60 artificial reef sites. All of the major fish types are seen at this site on almost every dive. Typical species include reef grazers such as butterflyfish, damsels, angelfishes, and sheephead to predator species such as snappers, groupers, rays, barracudas, and snook. As well, there are usually pelagic species observed at this site such as sharks, kingfish, eagle & manta rays, little tunny, and dolphin. Marine mammal species such as bottlenose dolphin (seen during the 2010 monitoring dive) and spotted dolphin have also been observed at this artificial reef site. Two species of marine reptiles, loggerhead and leatherback sea turtles, are often seen in the spring as they ready to lay their eggs on the beaches 4 miles to the west on Jupiter and Hutchinson Islands.

Because of its overall size, high profile, complex array of steel & concrete materials and ideal location the Evans Crary Bridge Artificial Reef has been the benchmark for what a successful shallow water artificial reef should look like. Table 16 presents the fish species observed and Table 17 presents the invertebrate data collected from 2010.

**Table 16. Evans Crary Bridge Artificial Reef fish species census.**

Family/Common Name	Species	2010		
		Abundance	Size	Comments
<b>Apogonidae</b>				
Twospot cardinalfish	<i>Apogon pseudomaculatus</i>	F	A	
<b>Carangidae</b>				
Blue runner	<i>Caranx chrysos</i>	A	A	
Rainbow runner	<i>Elafatis bipinnulata</i>	M	A	
Round scad	<i>Decapterus punctatus</i>	M	J & A	
<b>Centropomidae</b>				
Common snook	<i>Centropomus undecimalis</i>	F	A	
<b>Chaetodontidae</b>				
Reef butterflyfish	<i>Chaetodon sedentarius</i>	M	A	
Spotfin butterflyfish	<i>Chaetodon ocellatus</i>	S	A	
<b>Delphinidae</b>				
Bottlenose dolphin	<i>Tursiops truncatus</i>	M (13)	J & A	
<b>Elasmobranchs</b>				
Southern stingray	<i>Dasyatis Americana</i>	F (2)	A	(1) = 5' Dia
<b>Ephippidae</b>				
Atlantic spadefish	<i>Chaetodipterus faber</i>	A	A	



Family/Common Name	Species	2010		
		Abundance	Size	Comments
<b>Grammistidae</b>				
Whitespottedsoapfish	<i>Rypticus maculatus</i>	F	A	
<b>Haemulidae</b>				
Black margate	<i>Anisotremus surinamensis</i>	M	A	
Cottonwick	<i>Haemulon melanurum</i>	F	J & A	
Pigfish	<i>Orthopristis chrysoptera</i>	M	J & A	
Porkfish	<i>Anisotremus virginicus</i>	F	J & A	
Tomtate	<i>Haemulon aurolineatum</i>	A	J & A	
<b>Labridae</b>				
Spanish hogfish	<i>Bodianus rufus</i>	M	J & A	
<b>Lutjanidae</b>				
Gray snapper	<i>Lutjanus griseus</i>	M	J & A	
Yellowtail snapper	<i>Ocyurus chrysurus</i>	F	J & A	
<b>Pomacanthidae</b>				
Blue angelfish	<i>Holocanthus bermudensis</i>	F	A	
<b>Pomacentridae</b>				
Beaugregory	<i>Pomacentrus leucostictus</i>	F	A	
Blue chromis	<i>Chromis cyanea</i>	M	A	
Cocoa damselfish	<i>Stegastes variabilis</i>	S	A	
Sergeant major	<i>Abudefduf saxatilis</i>	M	J & A	
Yellowtail reeffish	<i>Chromis enchrysurus</i>	M	J & A	
<b>Priacanthidae</b>				
Bigeye	<i>Priacanthus arenatus</i>	S	A	
<b>Sciaenidae</b>				
Cubbyu	<i>Equetus umbrosus</i>	F	A	
<b>Scorpaenidae</b>				
Spotted scorpionfish	<i>Scorpaena plumeiri</i>	F	A	
<b>Serranidae</b>				
Belted sandfish	<i>Serranus subligarius</i>	M	J & A	
Gag grouper	<i>Mycteroperca microlepis</i>	S	A	
Goliath grouper	<i>Epinephelus itajara</i>	M (18)	A	200-400 lbs
Scamp	<i>Mycteroperca phenax</i>	M	J	
<b>Sparidae</b>				
Sheepshead	<i>Archosargus probatocephalus</i>	M	J & A	
Sheepshead porgy	<i>Calamus penna</i>	F	A	
<b>Tetraodontidae</b>				
Bandtail puffer	<i>Sphoeroides spengleri</i>	F	J & A	
	<b>Total</b>	<b>35</b>		

Abundance Key: S=single, F=few (2-10), M=many (11-100), A=abundant (>100)

Size Key: A=adult, J=juvenile, A/J=intermediate

Table 17. Evans Crary Bridge Artificial Reef benthic species census.

	Common Name	Scientific Name
<b>Echinoderms</b>	Common arbutia sea urchin	<i>Arbutia punctulata</i>
	Variegated Sea Cucumber	Unidentified species
<b>Cnidarians</b>	Algae Hydroid	<i>Thyrosocyphus ramosus</i>
	Hydroids	Unidentified species
<b>Ascidians</b>	Overgrowing Tunicates	<i>Didemnidae</i>
	Mottled Encrusting Tunicate	<i>Distaplia bermudensis</i>
<b>Poriferans</b>	Encrusting Sponge	Unidentified species
<b>Crustaceans</b>	Spiny Lobster	<i>Panulirus argus</i>
	Hermit Crabs	Unidentified species
<b>Anthozoa</b>	Gorgonians – several species	<i>Holaxonia</i>
<b>Other</b>	Red, Brown & Green Algae	Unidentified species

## 5.7 Tetrahedron Stack Artificial Reef

- Location: Sirotkin Reef
- Materials: Concrete
- Maximum Depth: 100 feet
- Reef High Point: 92 feet
- Year Created: 2001
- Monitoring Date: 9/13/2010
- Total Cost: \$35,766 (FWC & Martin County)

### 5.7.1 History of the Tetrahedron Stack Artificial Reef

As part of a Florida Fish & Wildlife Conservation Commission construction grant (FWC Grant # 13821 for \$25,000) and with additional funding from Martin County in the amount of \$10,766, a single stacked concrete tetrahedron reef was constructed in April of 2001. To date, this is the deepest (statewide) that such a reef has been built made of concrete tetrahedrons. The materials utilized were 5-and 6-foot solid concrete tetrahedrons with a cast in place lifting eye of steel rebar. The reef was constructed on April 4 & April 25, 2001 utilizing two barge loads of concrete modules. A total of 430 units were placed from an anchored barge, with approximately 215 units deployed on each date. The deployment resulted in a single reef with an elliptical shape oriented in a general northeast/southwest direction. When diving this site one cannot determine any separation of the first deployment's modules from the second.

These units are designed to interlock together and “stack” on top of each other to form many crevices, voids, and hiding places for fish, crustaceans, and other marine life. While some modules settled on their bases without stacking on top of other modules, approximately 40% landed on top of others. The large surface area of each module also provides habitat for benthic organisms to attach themselves. Figure 19 shows the configuration of the Tetrahedron Stack and Tetrahedron Patches Artificial Reefs.

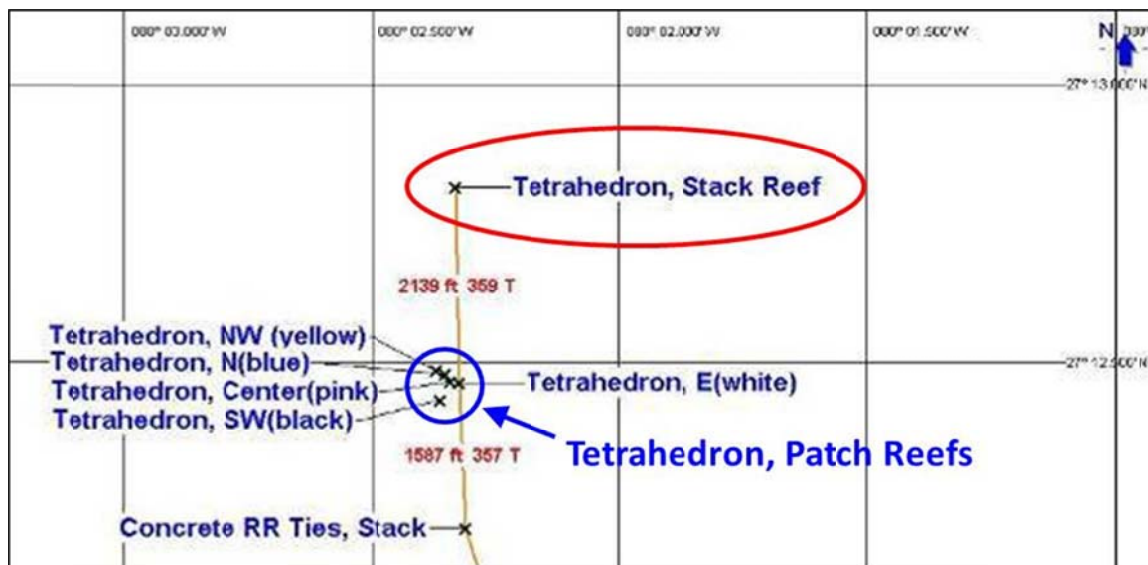


Figure 19. Chart view showing the Tetrahedron Stack and Patch reef locations.

### 5.7.2 Structural Summary

After initially diving this site in 2001 during the post-deployment surveys, and monitoring the site many times during the years 2001 – 2006; very little has changed as far as structural integrity and module positioning is concerned. A slight visual settling of the modules has occurred of maybe 1 foot but with depth gages and dive computers of plus/minus 1-foot accuracy it is hard to quantify. Overall assessment is that the reefs structural stability is good and little changes have occurred since deployment in 2001, despite the several hurricanes experienced in the area during 2004 and 2005. The photographs in Figure 20 are from the monitoring dive and show general conditions of the reef and some of the species observed during the dive.



**Figure 20. Tetrahedron Stack Artificial Reef 2010 photographs.**

Identification of species in the photographs shown above in clockwise order from the upper-left photograph are (1) no fish in this photo, (2) sea urchin, (3) variegated sea cucumber, and (4) marine benthic growth.

### 5.7.3 Biological Survey Results

Fish surveys found 18 fish species and indicated a generally increasing trend in fish species diversity since 2001. Vast schools of round scad, pigfish and tomtates were observed around and above the reef crest. It is obvious this reef has matured successfully in its 10 years of existence as every surface, crevice, void, cavern, overhang, and habitat created by the modules and vast

benthic attached marine growth is filled with marine species. Table 18 presents the fish species observed in 2010 and Table 19 presents the benthic species observed. Especially notable at this site is the amount of attached sargassum algae on the concrete modules. Long strands of the algae are everywhere some reaching 6 feet in length. Although the total biomass is more now than in previous years, this condition has been noted in other monitoring reports as well. For whatever reason whether depth, location, or types of modules this has been noticed mostly on the tetrahedron modules here at the Stack Reef and at the Tetrahedron Patch Reef ½ mile to the south.

**Table 18. Tetrahedron Stack Artificial Reef fish species census.**

Family/Common Name	Species	2010	
		Abundance	Size
<b>Carangidae</b>			
Amberjack	<i>Seriola dumerili</i>	M	A
Round scad	<i>Decapterus punctatus</i>	A	J & A
<b>Centropomidae</b>			
Common snook	<i>Centropomus undecimalis</i>	F	A
<b>Grammistidae</b>			
Whitespotted soapfish	<i>Rypticus maculatus</i>	F	J & A
<b>Haemulidae</b>			
Cottonwick	<i>Haemulon melanurum</i>	F	A
Pigfish	<i>Orthopristis chrysoptera</i>	A	A
Tomtate	<i>Haemulon aurolineatum</i>	A	J & A
<b>Labridae</b>			
Hogfish	<i>Lachnolaimus maximus</i>	S	J / A
Slippery dick	<i>Halichoeres bivittatus</i>	F	J / A
<b>Ostraciidae</b>			
Scrawled cowfish	<i>Acanthostracion quadricornis</i>	S	A
<b>Pomacentridae</b>			
Yellowtail reeffish	<i>Chromis enchrysurus</i>	F	J
<b>Sciaenidae</b>			
Cubby	<i>Equetus umbrosus</i>	M	J & A
<b>Scorpaenidae</b>			
Spotted scorpionfish	<i>Scorpaena plumeiri</i>	M	J & A
<b>Serranidae</b>			
Belted sandfish	<i>Serranus subligarius</i>	M	J & A
Black seabass	<i>Centropristis striata</i>	M	J & A
Snowy grouper	<i>Epinephelus niveatus</i>	S	J
<b>Sparidae</b>			
Sheepshead	<i>Archosargus probatocephalus</i>	M	A
Sheepshead porgy	<i>Calamus penna</i>	M	A
	<b>Total</b>	<b>18</b>	

Abundance Key: S=single, F=few (2-10), M=many (11-100), A=abundant (>100)

Size Key: A=adult, J=juvenile, A/J=intermediate



Table 19. Tetrahedron Stack Artificial Reef benthic species census.

	Common Name	Scientific Name
<b>Echinoderms</b>	Rock Boring Urchin	<i>Echinometra lucunter</i>
	3 Rowed Sea Cucumber	<i>Isostichopus badionotus</i>
	Conical Spined Sea Star	<i>Echinaster sentus</i>
<b>Cnidarians</b>	Algae Hydroid	<i>Thyroscyphus ramosus</i>
	Feather Plume Hydroid	<i>Aglaophenia latecarinata</i>
	Hydroids	Unidentified species
<b>Ascidians</b>	Overgrowing Tunicates	Didemnidae
	Bulb/ Painted Tunicates	<i>Clavelina sp.</i>
	Giant Tunicates	<i>Polycarpa spongiabilis</i>
<b>Other</b>	Sea Slug	Unidentified nudibranch
	Brown Variable Sponge	<i>Anthosigmella varians</i>
	White Lumpy Sponge	<i>Ptilocaulis sp.</i>
	Large amounts of Sargassum Algae	Unidentified species



## 5.8 Tetrahedron Patch - Yellow & Blue Artificial Reefs

- Location: Sirotkin Reef
- Materials: Concrete pyramids
- Maximum Depth: 102 feet
- Reef High Point: 94 feet
- Year Created: 2002
- Monitoring Date: 9/13/2010
- Total Cost: \$20,400 (FWC & Martin County)

### 5.8.1 History of the Tetrahedron Patch - Yellow & Blue Artificial Reefs

As part of a Florida Fish & Wildlife Conservation Commission construction grant (FWC Grant #00190 for \$15,000) and with additional funding from Martin County, five patch reefs using concrete tetrahedron modules were constructed in March and June 2002. The funding provided a total of \$20,400 (\$10,200 each) for both the Yellow and Blue Tetrahedron Patch reefs. The materials utilized were 4 feet and 5 feet solid concrete tetrahedrons with a steel rebar lifting eye.

This reef is approximately ½ mile south of an existing tetrahedron stack reef constructed in April 2001. The patch reef were built with the same total tonnage as the stack reef, and are located in similar water depth and same distance offshore of the Martin County shoreline (6.5 miles). The tetrahedron patch reefs were built on March 28 & June 28, 2002 utilizing one barge load of concrete modules for each deployment. A total of approximately 460 units were placed from an anchored barge, approximately 230 units each deployment. There are five patches or “clusters” on the reef, each separated by a sand/shell seafloor. Distances vary between the clusters and are a nominal 80 to 100 feet from outer edges of each cluster. Color-coded tie wraps were added to tetrahedron modules in each of the patch areas to aid future monitoring efforts. Sub-surface buoys also were added in 2003 at each patch to aid in monitoring. Figure 21 shows the location of Tetrahedron Patch Yellow and Blue reef sites within the overall Tetrahedron Patch reefs.

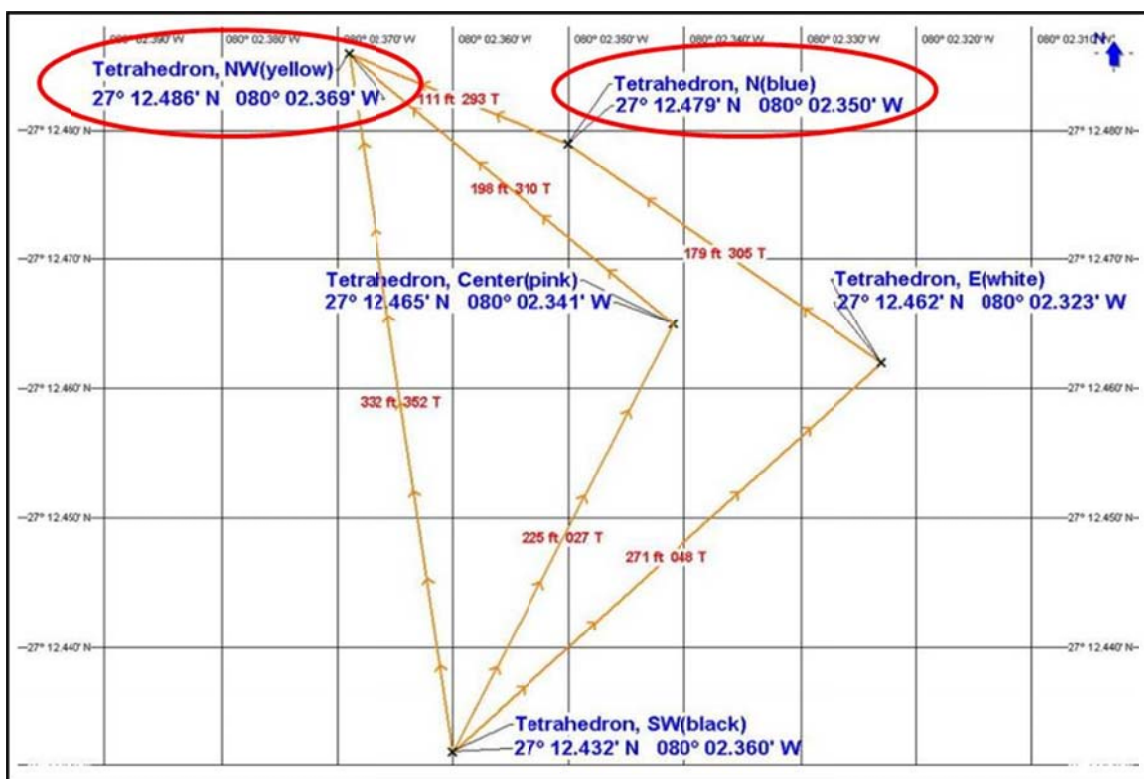


Figure 21. Chart view of Tetrahedron Patch - Yellow & Blue Artificial Reefs.

### 5.8.2 Structural Summary

This site was first monitored in 2002 during the post-deployment surveys and then for 5 years as a part of the 2003 – 2007 annual monitoring events. As was seen at the Tetrahedron Stack Reef, very little has changed as far as structural integrity and positioning/location of the modules is concerned. Minimal amount of settlement of the modules has been observed during the surveys, approximately 1 to 2 feet, but with depth gages and dive computers of plus/minus 1-foot accuracy it is hard to quantify. The overall assessment is that the reefs structural stability is good and little changes have occurred since the deployment in 2002, despite the 3 hurricanes experienced during 2004 and 2005. The photographs in Figure 22 are from the monitoring dive and show general conditions of the reef and some of the species observed during the dive.



**Figure 22. Tetrahedron Patch Yellow & Blue Artificial Reef 2010 photographs.**

Identification of species in the photographs shown above in clockwise order from the upper-left photograph are (1) no fish in this photo, (2) lionfish, (3) unidentified species of jellyfish, and (4) sea star.

### 5.8.3 Biological Survey Results

During the 2010 monitoring 22 finfish species were documented. As is seen at many Martin County artificial reef sites, tomtates and black seabass were the most prevalent finfish species recorded at this site. Many herbivore fish species are present as a result of the large quantity of attached sargassum algae and other benthic plant species. Hundreds of individual fish can be seen constantly grazing the reef's abundant marine vegetation. The predator species seem to hover over the modules and swim around the outer edges waiting for the opportunity to strike their prey. The most common benthic species included sea urchins, hydroids, tunicates, tube worms, barnacles, encrusting sponges and sea cucumbers. Fire worms, sea anemones and various crabs were also observed. Table 20 presents the demersal fish species observed during 2010 and Table 21 presents the benthic species observed.

Table 20. Tetrahedron Patch – Yellow &amp; Blue Artificial Reefs fish species census.

Family/Common Name	Species	2010	
		Abundance	Size
<b>Carangidae</b>			
Amberjack	<i>Seriola dumerili</i>	M	J
<b>Gobiidae</b>			
White-eye goby	<i>Bollmannia boqueronensis</i>	F	J & A
<b>Grammistidae</b>			
Whitespottedsoapfish	<i>Rypticus maculatus</i>	F	A
<b>Haemulidae</b>			
Tomtate	<i>Haemulon aurolineatum</i>	A	J & A
<b>Labridae</b>			
Slippery dick	<i>Halichoeres bivittatus</i>	S	J / A
<b>Lutjanidae</b>			
Land snapper	<i>Lutjanus synagris</i>	F	A
<b>Ogcocephalidae</b>			
Shortnose batfish	<i>Ogcocephalus nasutus</i>	S	J / A
<b>Ostraciidae</b>			
Scrawled cowfish	<i>Acanthostracion quadricornis</i>	S	A
<b>Pomacanthidae</b>			
Blue angelfish	<i>Holocanthus bermudensis</i>	F	A
<b>Pomacentridae</b>			
Yellowtail reeffish	<i>Chromis enchrysurus</i>	M	J
<b>Rachycentridae</b>			
Cobia	<i>Rachycentron canadum</i>	F (4)	J / A
<b>Sciaenidae</b>			
Cubbyu	<i>Equetus umbrosus</i>	M	J & A
<b>Scorpaenidae</b>			
Red Lionfish	<i>Pterois volitans</i>	S	A
Spotted scorpionfish	<i>Scorpaena plumeiri</i>	M	J & A
<b>Serranidae</b>			
Bank seabass	<i>Centropristis ocyurus</i>	M	A
Black seabass	<i>Centropristis striata</i>	A	J & A
Scamp	<i>Mycteroperca phenax</i>	F	J
<b>Sparidae</b>			
Pigfish	<i>Orthopristis chrysoptera</i>	F	A
Pinfish	<i>Lagodon rhomboides</i>	F	J / A
Sheepshead	<i>Archosargus probatocephalus</i>	F	A
Sheepshead porgy	<i>Calamus penna</i>	F	A
<b>Tetraodontidae</b>			
Bandtail puffer	<i>Sphoeroides spengleri</i>	F	J
	<b>Total</b>	<b>22</b>	

Abundance Key: S=single, F=few (2-10), M=many (11-100), A=abundant (&gt;100)

Size Key: A=adult, J=juvenile, A/J=intermediate

Table 21. Tetrahedron Patch – Yellow &amp; Blue Artificial Reefs benthic species census.

	Common Name	Scientific Name
<b>Echinoderms</b>	Rock Boring Urchin	<i>Echinometra lucunter</i>
	3 Rowed Sea Cucumber	<i>Isostichopus badionotus</i>
	Conical Spined Sea Star	<i>Echinaster sentus</i>
<b>Cnidarians</b>	Unidentified upside-down jellyfish	<i>Cassiopea</i>
	Algae Hydroid	<i>Thyroscyphus ramosus</i>
	Feather Plume Hydroid	<i>Aglaophenia latecarinata</i>
	Sea anemones	Unidentified species
<b>Crustaceans</b>	Unidentified Small Crabs	<i>Brachyura</i>
	Sessile barnacles	<i>Balanus trigonus</i>
<b>Ascidians</b>	Tunicates	Unidentified species
<b>Annelida</b>	Bearded Fireworm	<i>Hermodice carunculata</i>
	Tube worm	Unidentified species
<b>Poriferans</b>	Encrusting Sponge	Unidentified species



## 5.9 Ballantrae Anglers Artificial Reef

- Location: Sirotkin Reef – NE Quadrant
- Materials: Concrete box culverts, jersey barriers, bridge pilings, misc. chunks
- Maximum Depth: 187 feet
- Reef High Point: 181 feet
- Year Created: 2009
- Monitoring Date: 9/8/2010
- Total Cost: \$21,125 (FWC 87% & Martin County 13%)

### 5.9.1 History of the Ballantrae Anglers Artificial Reef

In March of 2008 Sea Rover Services was hired to perform an initial site bathymetric and dive survey of several areas in the NE corner of the Sirotkin Reef Site to gather data needed to apply for a FWC construction grant for deepwater artificial reefs. This \$60,000 Grant was awarded to Martin County's Engineering Department in the Fall of 2008. The funds allocated for the Ballantrae Anglers Club Reef from the FWC grant in addition to monies from Martin County totaled \$21,125. Materials of opportunity were collected and stored and planning of deployment of the new concrete reefs continued until summer of 2009. The materials were deployed during three separate deployments between August 18<sup>th</sup> and August 24<sup>th</sup>. During three deployments over 1,500 tons of material was loaded onto a large ABS certified barge operated by McCulley Marine Service and placed within the Sirotkin permitted artificial reef area. Of the 1,500 tons approximately 500+ tons (1 barge load) were utilized to construct the Ballantrae Anglers Club Reef. Figure 23 shows the location of the Ballantrae Anglers Reef in the Sirotkin permitted artificial reef area.

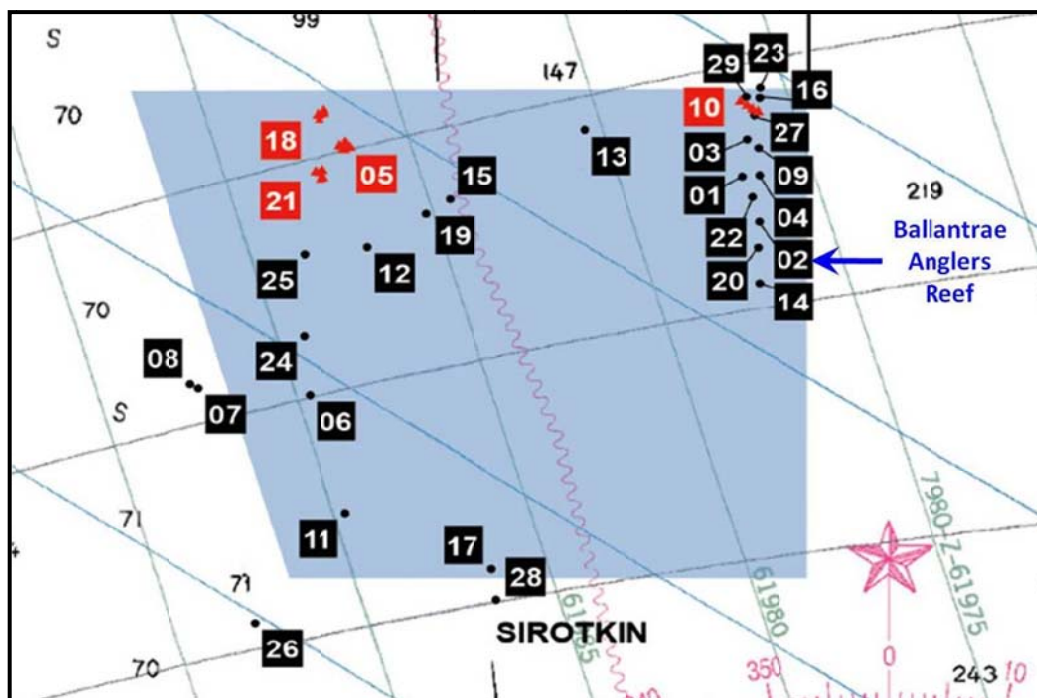


Figure 23. Chart view of Sirotkin Reef showing the Ballantrae Anglers Reef location.

### 5.9.2 Structural Summary

This reef is comprised of several hundred pieces of concrete, railroad ties, box culverts, pilings, bridge railings, jersey traffic barriers, slabs, and smaller concrete chunks. When deeper reefs are built from deploying from the surface from an anchored barge some scattering occurs. The longer piling type shapes, on occasion, sail through the water column as they sink rapidly towards the seafloor. Therefore, there are some pieces laying on the seafloor a short distance (less than 75 ft away) from the main mound.

At this depth scouring is not a problem because of all the firm stable substrate and minimal effect from wave energy found here. However During the deployment many of the pieces did land on top of each other and formed a low mound with an approximate 6 ft profile. No settling or loose components were observed. The photographs in are from the monitoring dive and show general conditions of the reef and some of the species observed during the dive.



**Figure 24. Ballantrae Anglers Reef 2010 photographs.**

Identification of species in the photographs shown above in clockwise order from the upper-left photograph are (1) no fish in this photo, (2) Kerry Dillon collecting data, (3) warsaw grouper, and (4) bank seabass.

### 5.9.3 Biological Survey Results

Fish species consisted mainly of seabass and amberjacks. Numerous black and bank sea bass and Greater Amberjack were observed around the reefs components. A large (approx. 70 lb) Warsaw Grouper was observed and photo documented on the site and seemed very curious with the divers monitoring efforts. Table 22 and Table 23 present the fish and benthic species observed during 2010.

**Table 22. Ballantrae Anglers Artificial Reef fish species census.**

Family/Common Name	Species	2010		
		Abundance	Size	Comments
<b>Carangidae</b>				
Amberjack	<i>Seriola dumerili</i>	M	A	
<b>Serranidae</b>				
Bank seabass	<i>Centropristis ocyurus</i>	M	A	
Black seabass	<i>Centropristis striata</i>	A	J & A	
Warsaw grouper	<i>Epinephelus nigritus</i>	S	A	~70 lb
<b>Sparidae</b>				
Sheepshead porgy	<i>Calamus penna</i>	F	A	
	<b>Total</b>	<b>5</b>		

Abundance Key: S=single, F=few (2-10), M=many (11-100), A=abundant (>100)

Size Key: A=adult, J=juvenile, A/J=intermediate

**Table 23. Ballantrae Anglers Artificial Reef benthic species census.**

	Common Name	Scientific Name
<b>Echinoderms</b>	Rock Boring Urchin	<i>Echinometra lucunter</i>
<b>Crustaceans</b>	Sessile barnacles	<i>Balanus trigonus</i> .
<b>Others</b>	Unidentified type of sponge	

## 5.10 Pirate's Cove Artificial Reef

- Location: Sirotkin Reef
- Materials: Conc. boxes, pipe sections, bridge railings, culverts, slabs, pilings
- Maximum Depth: 187 feet
- Reef High Point: 172 feet
- Year Created: 2009
- Monitoring Date: 9/8/2010
- Total Cost: \$21,125.00 (FWC 87% & Martin County 13%)

### 5.10.1 History of the Pirate's Cove Artificial Reef

In the fall of 2008 the FWC awarded a \$62,068 grant to Martin County's Engineering Department. Materials of opportunity were collected and stored until summer of 2009. Three bargeloads of material, approximately 500 tons each, were deployed on the Sirotkin site to create 3 new reefs. One of these reefs was the Pirate's Cove reef. The funds allocated for the Pirate's Cove Reef from the FWC grant in addition to monies from Martin County totaled \$21,125. On August 24, 2009 the Pirates Cove Reef was built successfully in 187 ft of water and since has become another fine deepwater artificial reef offshore Martin County, Florida. On Sept. 8, 2010 a large steel sign with concrete bases was placed on the reef with the name Pirate's Cove Reef.

Pirate's Cove Resort & Marina is a locally operated facility in the Manatee Pocket section of Port Salerno, Florida. Many of the guests at the resort and sport fishing fleet in the marina have fished the waters of Martin County for decades. A generous donation to support the efforts of both the MCAC fund and the Martin County Artificial Reef Program was received by Pirate's Cove in exchange for the naming rights to the new reef. Figure 25 shows a chart with the location of the Pirate's Cove Reef.

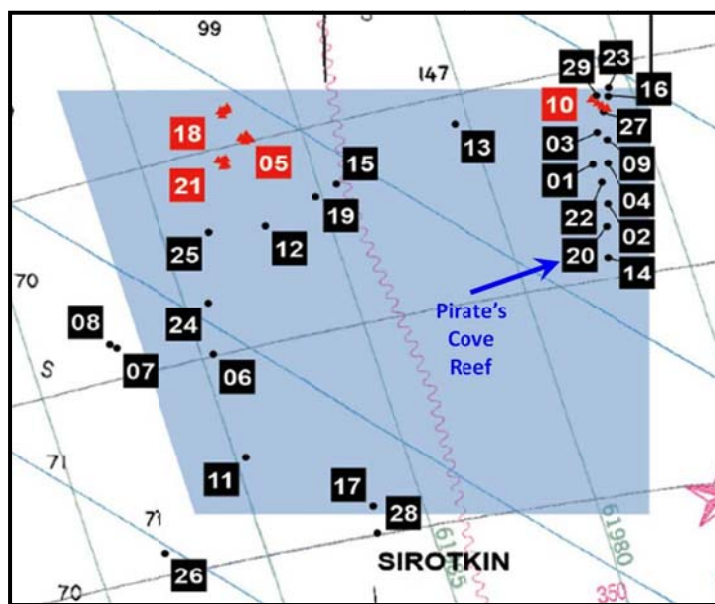
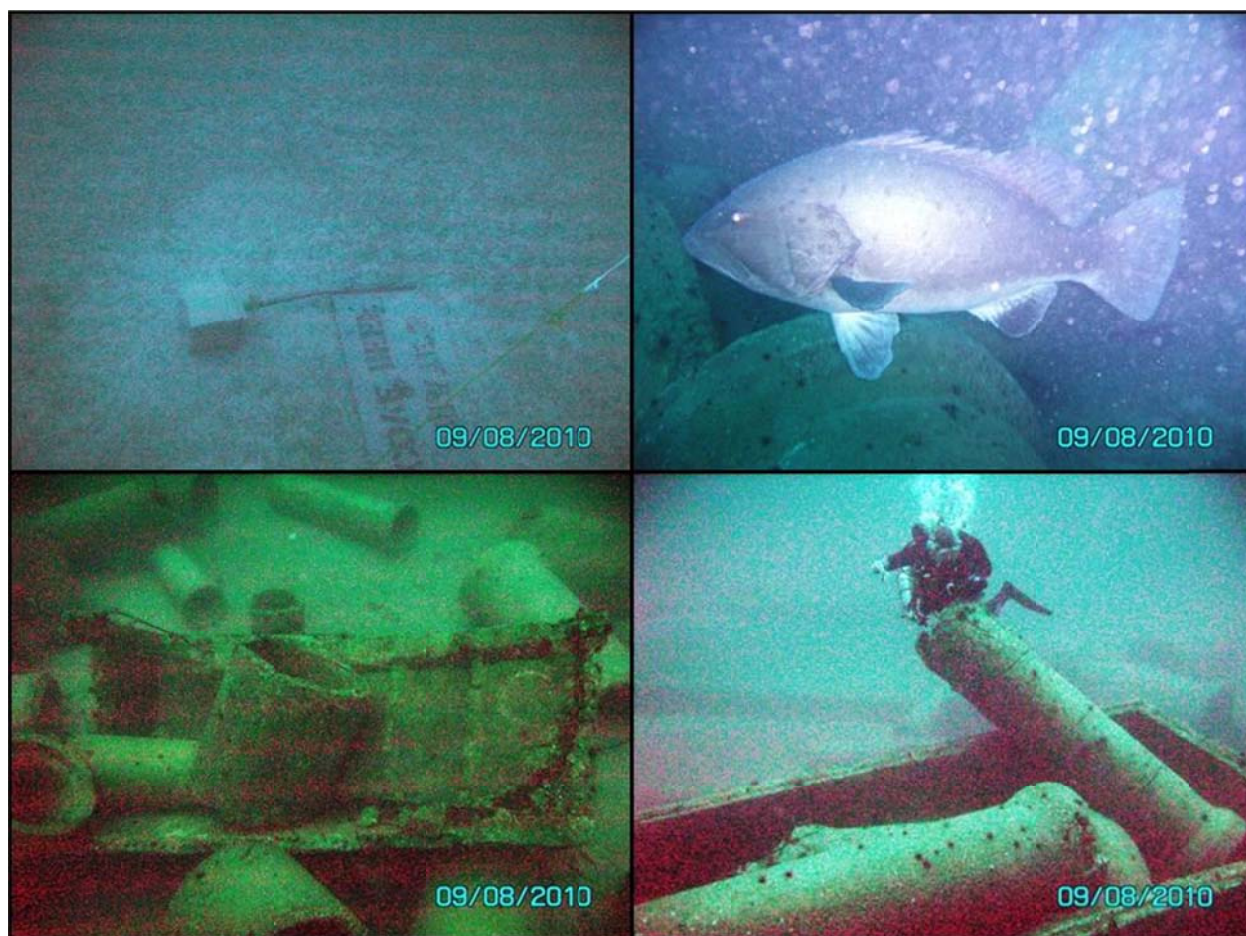


Figure 25. Chart view of the Sirotkin Reef showing the Pirate's Cove Reef location.



### 5.10.2 Structural Summary

This reef is comprised of several hundred pieces of concrete: large baffle boxes, pilings, bridge railings, culverts, slabs and smaller concrete chunks. During the deployment several of the large baffle boxes landed on top of each other greatly increasing the overall profile of the reef. Many other components landed in a similar fashion and resulted in a high mound with a 15 ft profile. When deeper reefs are built from deploying from an anchored barge some scattering occurs. This seemed not to be the case with this reef, although there are a few pieces laying on the seafloor a short distance (< 50 ft) from the main mound. The footprint of the site is generally round and occupies about ½ acre of seafloor. At this depth, 187 ft, scouring is not a problem because of all the firm stable substrate and minimal wave energy at these depths. No settling or loose components were observed. The photographs in are from the monitoring dive and show general conditions of the reef and some of the species observed during the dive.



**Figure 26. Pirate's Cove Reef photograph from 2010.**

Identification of species in the photographs shown above in clockwise order from the upper-left photograph are (1) no fish in this photo, (2) warsaw grouper (estimated >60lbs), (3) sea urchins and Kerry Dillon, and (4) no fish in this photo.



### 5.10.3 Biological Survey Results

Nine fish species were noted and consisted mainly of sea basses, pinfish, yellowtail reeffish and amberjacks. As on the Ballantrae Reef a Warsaw grouper was identified during monitoring. This Warsaw grouper was approx. 60 lb. As typical of this species around divers it was very curious with our activities and would approach closely within 5 ft. of us during the dive. Table 24 and Table 25 present all the fish and benthic species observed during 2010 at this site. As is often seen on the deeper than 130 ft deep sites less total species are documented but more quantities of each species is evident. The deeper sites still have 100s to 1000s of individual fish just less species diversification than at the shallower artificial reef sites.

**Table 24. Pirate's Cove Artificial Reef fish species census.**

Family/Common Name	Species	2010		
		Abundance	Size	Comments
<b>Carangidae</b>				
Amber jack	<i>Seriola dumerili</i>	M	A	
<b>Elasmobranchs</b>				
Dusky shark	<i>Carcharhinus obscurus</i>	S	A	6 ft @ 70 ft depth
<b>Pomacentridae</b>				
Yellowtail reeffish	<i>Chromis enchrysurus</i>	M	J & A	
<b>Serranidae</b>				
Bank seabass	<i>Centropristis ocyurus</i>	M	A	
Black seabass	<i>Centropristis striata</i>	A	J & A	
Snowy grouper	<i>Epinephelus niveatus</i>	S	J / A	
Warsaw grouper	<i>Epinephelus nigritus</i>	S	A	~60 lb
<b>Sparidae</b>				
Pinfish	<i>Lagodon rhomboides</i>	M	A	
Sheepshead porgy	<i>Calamus penna</i>	F	A	
	<b>Total</b>	<b>9</b>		

Abundance Key: S=single, F=few (2-10), M=many (11-100), A=abundant (>100)

Size Key: A=adult, J=juvenile, A/J=intermediate

**Table 25. Pirate's Cove Artificial Reef benthic species census.**

	Common Name	Scientific Name
<b>Echinoderms</b>	Rock Boring Urchin	<i>Echinometra lucunter</i>
<b>Poriferans</b>	Encrusting Sponge	Unidentified species
<b>Crustaceans</b>	Sessile barnacles	<i>Balanus trigonus</i> .
<b>Other</b>	Encrusting Bryozoans	Unidentified Species

## 5.11 Wickstrom Artificial Reef

- Location: Sirotkin Reef – NE Quadrant
- Materials: Steel Ship (Coastal Freighter)
- Maximum Depth: 193 ft (in scour trench)
- Max. Seafloor Depth: 189 ft (on seafloor next to ship on east side)
- Reef High Point: 130 ft (on top of bridge mast support column)
- Profile Height: 59 ft (from seafloor to top of bridge mast support column)
- Year Created: 2003
- Monitoring Date: 9/6/2010
- Total Cost: \$17,000 (Martin County)

### 5.11.1 History of the Wickstrom Artificial Reef

The Wickstrom was previously known as the Lady Lora, Tauros, and US Army FS 553. The ship is a 168-ft. long coastal freighter that had been sitting idle in the Miami River for about 4 years. The funding source for the creation of the reef was provided by Martin County in the amount of \$17,000. A cooperative union of many groups made the acquisition, transport, and deployment possible beginning in the spring of 2002. Some of the groups include: Martin County's Engineering Department, Florida Sportsman Magazine, Martin County Anglers Club (MCAC), Florida Oceanographic Society (FOS), McCulley Marine Services, Jones Shipyard, and the FOS Reef Research Dive Team.

The vessel was purchased from Jones shipyard in Miami, Florida with funds from Karl Wickstrom, the founder and chief editor of Florida Sportsman magazine, and the MCAC Reef Fund. Martin County's Board of County Commissioners' Artificial Reef Program funded the transport, administrative, deployment and annual monitoring costs of the project.

On Tuesday January 21, 2003 the "Wickstrom" was intentionally sunk in 188 feet of water in the northeast quadrant of the Sirotkin permitted artificial reef area. The ship was deployed resting perfectly upright located approximately 400 feet north of the previously sunk "Tree Barge". Figure 27 shows a chart with the location of the Wickstrom Artificial Reef.

This deepwater offshore site has become a very popular destination for many private and charter sport fishing captains as well as some commercial fishing businesses. However, because of the depth, technical training, experience, and equipment necessary to dive this site very few sport divers have visited the site.

In Sept. 2004 Martin County was hit by two major hurricanes (Frances, Category 2 & Jeanne, Category 3) followed by Hurricane Wilma in 2005; these hurricanes had great impacts on the Wickstrom, which are addressed, in the Structural Summary section below.

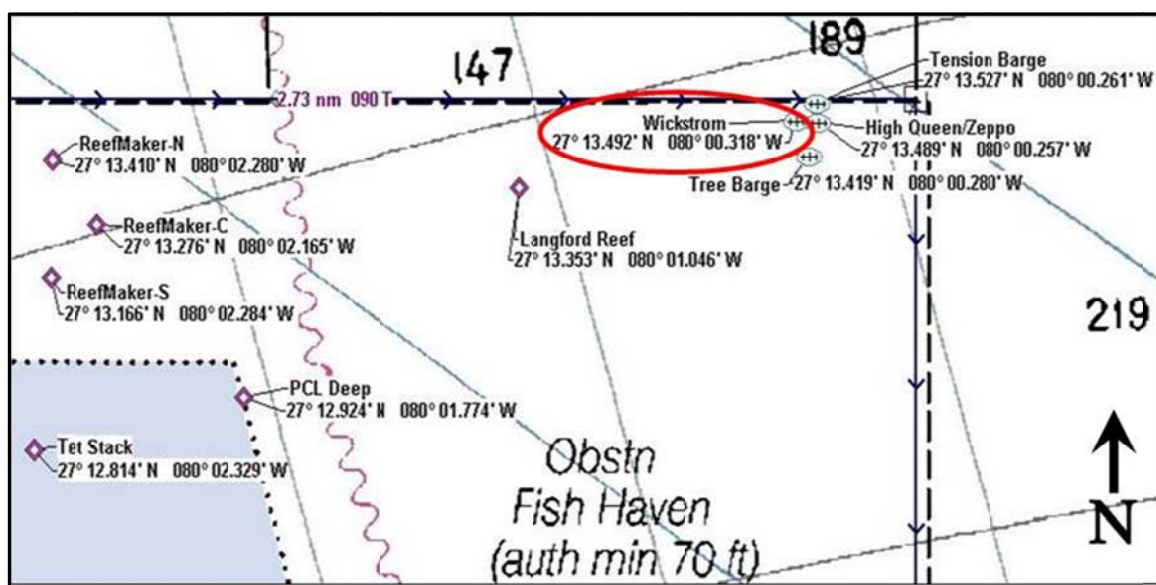


Figure 27. Chart view of Sirotkin Reef showing location of Wickstrom Artificial Reef.

### 5.11.2 Structural Summary

Until 2004 the changes mainly included a general increase in total biomass in, around and attached to the ship. In Sept. 2004 the Martin County area was impacted by two major hurricanes within a month's time (Frances Category 2 & Jeanne Category 3) both of which made landfall at the same spot on shore in South Hutchinson Island. The tracks of both hurricanes passed directly over the Wickstrom just prior to making landfall. Kerry Dillon of Sea Rover Services made the following post hurricanes observations in the fall of 2004:

- The Wickstrom was broken in two sections just aft of the main superstructure.
- The two sections were separated by approx. 15 to 30 ft in a jagged separation
- The stern section shifted further to the east and now faces NE instead of north as when it was deployed
- The bow section is still facing slightly east of due south as it was when deployed
- The entire bow section hull has sawed itself into the seafloor below the sand and into the limestone substrate by 4 ft creating a smooth walled trench with limestone on one side and the steel hull plates on the other (See Figure 29, Left side)
- Cracks exist on other areas of the ship from either the initial deployment impact or the hurricanes or both
- The DGPS derived Lat/Long coordinates of the site have not changed at all
- The overall top depths of the ship is slightly deeper than when first deployed as a result of the settling into the seafloor

Since 2005 no further structural changes have been located during annual monitoring efforts. Figure 28 and Figure 29 display photographs taken during the 2010 monitoring survey showing the Wickstrom's superstructure, *Oculina* corals growing, large schools of fish surrounding the reef and the general conditions of the reef observed during the dive.



**Figure 28. Wickstrom Artificial Reef photographs from 2010.**

Identification of species in the photographs shown above in clockwise order from the upper-left photograph are (1) *oculina varicosa* coral, (2) greater amberjacks, (3) yellowline arrow crab and *oculina varicosa* coral on hull, (4) sea urchin and 8-legged sea star, (5) *oculina varicosa* coral on reefmaker unit, and (6) unidentified school of baitfish.

As mentioned above, Figure 29 shows the trench (left photo) carved into the bottom by the ship as a result of repetitive motion of the ship's hull on the bottom substrate. The photograph on the right shows 1000's of baitfish schooling around the smoke stack funnel of the Wickstrom.



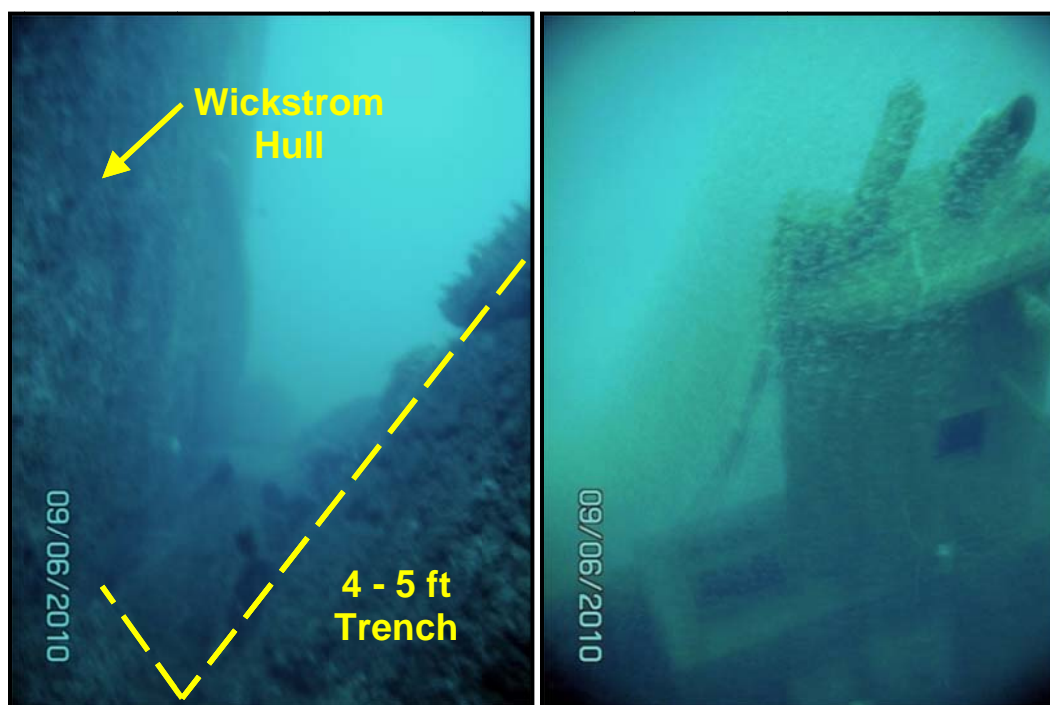


Figure 29. Wickstrom hull groove cut into the sea floor (Left), Wickstrom superstructure (Right).

### 5.11.3 Biological Survey Results

On this monitoring event only 11 fish species were identified. As experienced on previously monitored deepwater artificial reef sites, the specific fish census fluctuates greatly dependent on current, water temp, meteorological seasons, breeding seasons, and other factors. During other events in previous years many more species were seen. Baitfishes are another type of fish species that come and go to a specific site randomly. There have been other dives on the Wickstrom where 1000s of baitfish in large schools are seen darting all around the site and many fish feeding upon them. This day large baitfish schools were seen. Large Goliath Grouper of over 500 lbs. have been documented on this site many times before yet on this day none were seen.

Invertebrate biomass on the artificial reef has increased substantially in the last several years at this site. On deep sites this is an important first step in the food chain because it takes longer to establish than on shallower sites due to the limited amount of sunlight that reaches the deep-water surfaces. This sunlight is important for the photosynthesis process, which supports the large number of algae species. Even though it takes a few more years to establish, once established the growth continues to take hold of every surface on the metal ship. Even inside the ship where no or very little sunlight washes the surfaces benthic growth exists. The Federally protected deepwater stony coral species *Oculina varicosa* is now found on the outside of the hull's vertical surfaces as well as deep inside the ships engine room and other compartments. This species unlike most shallow water coral species does not need light to survive; rather it is a filter feeder. Over time it is hoped the entire wreck will become white with the beautiful coral branches of this important coral species. Table 26 below presents the finfish species documented and Table 27 presents the benthic species observed.



Table 26. Wickstrom Artificial Reef fish species census.

Family/ Common Name	Species	2010	
		Abundance	Size
<b>Serranidae</b>			
Black seabass	<i>Centropristis striata</i>	M	A
Bank seabass	<i>Centropristis ocyurus</i>	M	A
Yellowmouth grouper	<i>Mycteroperca interstitialis</i>	S	A
Roughtongue seabass	<i>Pronotogrammus martinicensis</i>	F	J & A
Scamp	<i>Mycteroperca phenax</i>	F	A
Black Grouper	<i>Mycteroperca bonaci</i>	F	A
<b>Carangidae</b>			
Amberjack	<i>Seriola dumerili</i>	A	A
<b>Lutjanidae</b>			
Red snapper	<i>Lutjanus campechanus</i>	F	A
<b>Sparidae</b>			
Sheepshead porgy	<i>Calamus penna</i>	M	A
<b>Sciaenidae</b>			
Cubbyu	<i>Equetus umbrosus</i>	F	A
<b>Ephippidae</b>			
Atlantic spadefish	<i>Chaetodipterus faber</i>	M	A
<b>Total</b>		<b>11</b>	

Abundance Key: S=single, F=few (2-10), M=many (11-100), A=abundant (>100)

Size Key: A=adult, J=juvenile, A/J=intermediate

Table 27. Wickstrom Artificial Reef benthic species census.

Common Name		Scientific Name
<b>Echinoderms</b>	Common Arbacia Urchin	<i>Arbacia punctulata</i>
	Variegated Urchin	<i>Lytechinus variegatus</i>
	2 -spined Sea Star	<i>Astropecten duplicatus</i>
	8-legged Sea Star	Unidentified species
<b>Cnidarians</b>	Hydroids	Unidentified species
<b>Scleractinia</b>	Large ivory coral	<i>Oculina varicosa</i>
<b>Ascidians</b>	Tunicates	Many unidentified species
<b>Crustaceans</b>	Yellowline Arrow Crab	<i>Stenorhynchus seticornis</i>
	Sessile barnacles	<i>Balanus trigonus</i>
<b>Other</b>	Encrusting Bryozoans	Unidentified Species
	Encrusting Sponges	Many unidentified Species