

Osborne Tire Reef Benthic Survey Report



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Florida Department of Environmental Protection



Osborne Tire Reef Benthic Survey Report

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List of Acronyms and Abbreviations

FDEP	Florida Department of Environmental Protection
OTR	Osborne Tire Reef
Olsen	Olsen Associates, Inc.
CSA	CSA Ocean Sciences Inc.
GNSS	global navigation satellite system
GPS	Global Positioning System
M&E	Morgan & Eklund, Inc.

1.0 Overview

Florida's Department of Environmental Protection (FDEP) has contracted the removal of tires from the Osborne Tire Reef (OTR). To date, tire removal has been done utilizing commercial diving methods, but permits are being pursued for other innovative removal techniques (e.g., trawling). Additional surveys of the distribution of tires on the seafloor were needed to both inform feasibility and efficiency of novel removal methods and the potential for unauthorized impacts from those methods to living resources associated with the tires themselves and the surrounding environment.

Beginning in April 2019, CSA Ocean Sciences Inc. (CSA) and Morgan & Eklund Inc. (M&E) worked as a subconsultant to Olsen Associates, Inc. (Olsen) for FDEP to obtain geophysical and observational data on the OTR and adjacent areas in order to evaluate the previously mentioned future tire removal activities. The work was performed under Olsen's FDEP Contract No. CN334. The goal of this scope of work was to collect, analyze, and ground-truth side-scan, multibeam, and video data to produce a georeferenced map showing the current condition of the OTR project area, including:

- The spatial distribution, density, and accessibility of tires;
- Position and description of other (non-tire) man-made seafloor structures (e.g., boulder reefs, vessels, marine debris); and
- Geographic positions and descriptions of natural hardbottom and reef features in and adjacent to the OTR.

2.0 Survey Equipment and Methods

2.1 SIDE-SCAN SONAR AND MULTIBEAM BATHYMETRIC SURVEY (CONTRACT SUBTASK 1A)

The first step in the survey process was to visualize the OTR using side-scan sonar and multibeam techniques. The survey was conducted using side-scan and multibeam simultaneously and covered the OTR project area out to a 300 m buffer rectangle encompassing the OTR boundary (**Figure 1**). The side-scan sonar and multibeam survey was conducted between 25 April and 27 April 2019.

A dual-frequency Klein 3900 side-scan sonar and an R2 Sonic 2024 multibeam echo sounder were used for this phase of the survey. The side-scan sonar was operated at 445 kHz, yielding an effective slant range of 150 m. System components included an in-water towfish, slash-proof transceiver processor unit, and data acquisition computer with software interface. Klein's native SonarPro® interface was used for side-scan sonar data acquisition while real-time navigation and data processing was accomplished using HYPACK Survey and SonarWiz 6 navigation software.

The multibeam system was comprised of a R2 Sonic 2024 echosounder with an integrated surface sound velocity probe and a computer controller unit. The multibeam echosounder was operated at 450 kHz. Side-scan sonar and multibeam bathymetry data were recorded along 24 evenly spaced north– south parallel transect lines. Transect line spacing was 40 m and provided the required 100% side-scan sonar overlap. These surveys occurred between offshore reef features commonly referred to as the Second Reef and Third Reef (**Figure 1**).

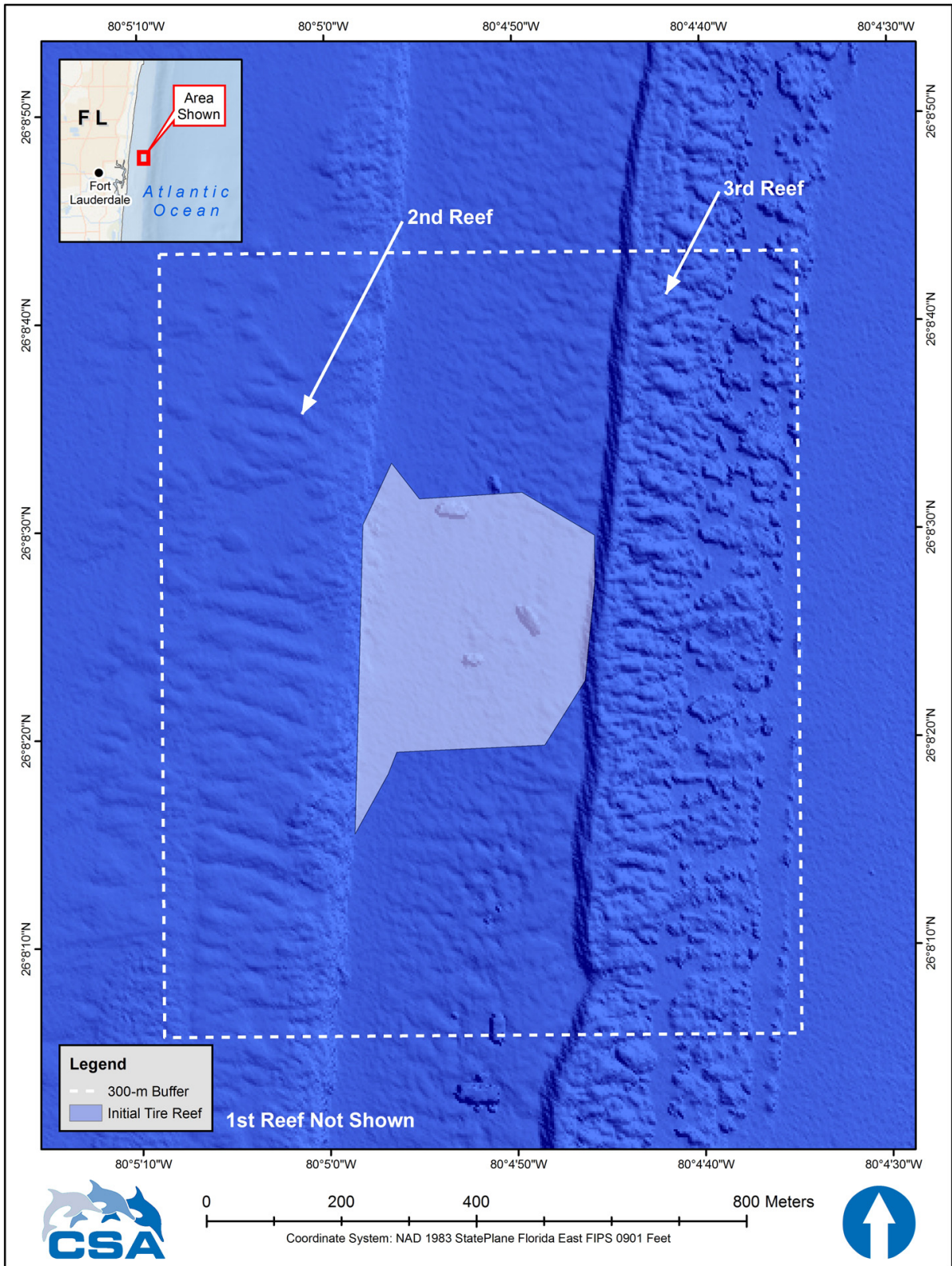


Figure 1. Osborne Tire Reef outline (initial Tire Reef) and the 300-m buffer rectangle. Background source: NOAA NOS Hydrographic Survey H12117, Year: 2008.

An Applanix POS MV Wavemaster (integrated position and motion tracking system) was used to supplement the acoustic hardware and provide motion-corrected location and motion data in real time during multibeam data collection. These components were physically installed on the survey vessel platform (28 ft aluminum hull, twin diesel catamaran equipped with winch, and A-frame) and all spatial offsets between the acoustic and navigation hardware and recording sensors were measured during mobilization. These offsets were then programmed into HYPACK Survey and HYSWEEP (equipment geometry offset solutions) prior to the start of acquisition. Position and heading were provided by the system's global navigation satellite system (GNSS) data and GNSS azimuth measurement system (GAMS); motion is detected and output via an inertial measurement unit (IMU). During the survey, real-time kinematic corrections were incorporated into the navigation system via a Global Positioning System (GPS) base station occupying a survey control point with known coordinates referenced to the Florida State Plane Coordinate System, East Zone, North American Datum of 1983, 2011 adjustment and to the North American Vertical Datum of 1988 (feet). The Surveyors Control Report is located in **Appendix A**.

The speed of sound through the water column was collected at the beginning and the end of each survey day with a Micro X SV Base X2 independent sound velocity profiler. These data were applied during post-processing to refine the soundings taken by the multibeam sonar echo sounder.

The side-scan towfish was deployed on a winch-deployed line via a sheave block mounted on the vessel's stern A-Frame. The sheave block contained an integral cable counter which measured the amount of tow cable paid out during deployment. Settings in the SonarPro interface allowed real-time determination of the towfish position by combining the amount of cable out (layback) with both depth and altitude data captured by sensors on the towfish. The system's TPU applied time-varied gain and slant-range corrections in real time, while a survey technician also monitored real-time deployment to ensure the highest quality imagery acquisition

During this survey (Survey 1, that of the original OTR), it was observed that tires occurred beyond the 300 m buffer rectangle, substantially so to the north and to a lesser extent to the east and south. Olsen communicated these findings to FDEP, which resulted in additional side-scan sonar and multibeam survey efforts (Survey 2) to determine the extent of tire debris accumulations being authorized by FDEP. Survey 2 extended beyond the 300 m buffer rectangle 1,000 m to the north, 500 m to the east, and 500 m to the south. The survey was conducted with the same personnel, vessel, and equipment as the initial survey.

2.2 TOWED VIDEO SURVEY (CONTRACT SUBTASK 1B)

Towed video data were collected to verify objects that were observed in the side-scan sonar and multibeam echosounder survey data during post processing and preliminary map production processes. The towed video platform was comprised of a DeepSea Power & Light Multi SeaCam 2002 underwater video camera/light system and two scaling lasers. The video tow-sled was deployed via the vessel's winch and A-frame, which allowed on-the-fly adjustment in the altitude of the camera system above the seafloor to ensure suitable visualization of seafloor features.

Video was viewed in real-time on board the survey vessel by a CSA marine scientist to ensure that the vessel was towing at an appropriate speed and that the video was of sufficient quality to identify the features. Primary video data were georeferenced and overlain in each frame with UTC time and geographic coordinates along the survey tracks using a Sub C Imaging video annotator. The starting and

ending positions of video transects were obtained from Hypack and were used to define individual transects for reference.

A Sub C Cam 1 Mk6 4K Very High Definition video camera was utilized as a secondary means of video data collection on the towed platform should additional, higher resolution of objects be needed. The very high definition video (4K) was recorded simultaneously on the north–south transects. The 4K video was not overlaid with positioning annotations as the camera is self-contained and records directly to an onboard memory chip. Some representative sections of the towed video transects were also recorded with a GoPro Hero 7 Black camera at 1440p resolution. The GoPro video segments were used to generally identify and characterize seafloor biota. These GoPro video data are not overlaid with positioning annotation due to the same constraints as the 4K video.

2.3 SURVEY DATA PROCESSING AND PRODUCTION OF A PRELIMINARY MAP (CONTRACT SUBTASK 2)

Once processed, Subtasks 1A and 1B plus the additional side-scan sonar and multibeam survey areas (Survey 2, see **Section 2.1**) data products provided a high quality multi-faceted geophysical and visual dataset visualizing the seafloor within the OTR project area, again extending out 1,000 m north, 500 m east, and 500 m south of the 300 m buffer rectangle. Processed and mosaicked side-scan sonar data were combined with bathymetry derived from the multibeam sonar to visualize depth changes, seafloor features, bottom types, and distribution of tires.

During this task, data products from remote sensing acquisition and processing programs were migrated into a project geographic Information system (GIS) database. Sonar files were input in TIFF, ASC, and XYZ formats for analysis. These were overlaid with recorded vessel tracks during acoustic and towed video surveys. Objects of interest and feature identifications/delineations were developed as point, line, and polygon feature classes. All available Subtask 1A and 1B data (side-scan, multibeam, and video) were used to produce a detailed Preliminary Map covering the OTR and extending out to the 300 m buffer rectangle.

Notable features identified within the Preliminary Map included various artificial reef structures, such as sunken barges, reef balls, cube reefs, concrete and metal pipe, hexagonal reef “jacks”, boulders, natural reef structure, and other unidentified objects. Relative tire abundance (“dense” where tires were touching or overlapping and “sparse” where tires were not touching or overlapping) was also plotted from the side-scan data, and ground-truth dive sites were selected within areas of low, medium, and high tire abundance to quantify actual tire density.

Twenty-four dive locations were identified and pre-plotted within the OTR project area for dive team ground-truthing of features and quantification of tire abundance. **Table 1** lists the site numbers and descriptions of targets before the dive survey and following the dives. Eight additional diver transects (T1–T8) were also plotted and swum by divers to confirm the hardbottom/reef sand boundaries within the project area and to collect detailed video (GoPro Hero 7 Black camera with Sola 1200 video lights) within areas of various tire abundance and distribution.

Table 1. Dive sites and transects for diver ground truthing.

Dive Site (D) and Transect (T) numbers	Proposed Target/Task	Diver Ground-truthed Feature	Diver Video No.
D2	Tire density quadrat	Dense loose tires	1, 3
D3	Tire density quadrat	Sand bottom with very few tires	2
D5	Tire density quadrat	Medium density loose tires	3
D6	Unknown feature	Reef balls	4
D7	Unknown feature	Reef balls	4
D8	Wreck? with adjacent tires	Wreck with tires to south	6
D9	Unknown feature	Limestone boulder pile	5
D10	Tire density quadrat	Sand bottom with very few tires	18
D12	Barge	Barge containing tires	4
D13	Long object and bottom targets	Long pipe oriented north-south with loose tires	5, 18
D14	Tire density quadrat	Sand flat east of 3rd reef with abundant loose tires	6
D15	High abundance of tires	Outer reef with abundant tires on sand	14, 19
D16	Unknown feature	Bundles of tires	9
D17	Tire density quadrat	Medium to high density loose tires with bundles	9
D18	Tire density quadrat	Medium to high density loose tires with bundles	7, 8
D19	Tire density quadrat	Occasional tires	8
D20	Unknown feature	Hexapod concrete jacks	9
D21	Unknown feature	Bundles of tires	13
D22	Tire density quadrat/artificial reefs?	Occasional tires and NOVA reef modules	10
D23	Unknown feature, pipe?	Bundles of tires and jacks	11
D24	Tire density quadrat	Low abundance of tires and NOVA reef modules	12
D25	Large pipe sections?	Large concrete pipe sections	11
D26	Tire density quadrat/artificial reefs?	Occasional tires and NOVA reef modules	12
D27	Unidentified debris	Long sections of pipe	13
T1	West-east line in 3rd reef channel	Down sand channel	15
T2	Northerly line across 3rd reef spurs	North Northeast across sand flats and reef areas	14, 15
T3	West-east line along 3rd reef spur	Along reef feature and sand	15
T4	East edge of 2nd reef	East edge of second reef*	16
T5	West edge of 3rd reef	West edge of third reef*	17
T6	North-south transect in area of tires	100-m transect south of D13	18
T7	East-west transect in area of tires	100-m transect to the west of D18	7
T8	Transect at Site D15 (deeper site)	Transect along edge of reef and tires near D15	19

*See **Figure 1** for locations of these reef features. NOVA=Nova Southeastern University.

2.4 IN-SITU DIVER GROUND TRUTHING AND MAP REFINEMENT (CONTRACT SUBTASK 3)

The Preliminary Map was refined (Subtask 3C) using *in situ* data collected during the Diver-verification Survey (Subtask 3A) and the Roving-diver Surveys of Preliminary Map Targets (Subtask 3B). Using the remotely sensed acoustic data (sonar, multibeam) interpreted with respect to the visual data collected by the towed video system, the Preliminary Map detailed prominent benthic features and provided OTR area-wide information on the location, distribution, and approximate extent of tire density and other features of interest.

Diving activities were conducted by a team of four CSA divers over a four-day period from a 28 ft CSA dive vessel equipped with a Hypack navigation system. All dive team members utilized enriched air nitrox mixes to maximize bottom time and decrease required diver surface intervals during the survey. Diver surveys were completed only within the 300 m buffered rectangle project area.

2.4.1 Boundary Delineation (Contract Subtask 3A)

During these reef edge and boundary delineation surveys, one diver operated a Shark Marine Technologies Navigator system while the second diver collected video imagery. The Shark Navigator system combines surficial GPS position tracking with underwater navigation via a diver navigation system that incorporates depth, heading, and acoustic bottom tracking. Pre-programmed waypoints input into the Navigator's diver interface aided in the execution of underwater survey transects and feature location, while the unit's diver tracking system recorded positions for Preliminary Map verification and ultimately the generation of the Diver-Verified Map. The second CSA diver collected video with a hand-held GoPro Hero 7 Black video and still camera with video lights.

2.4.2 Roving Diver Surveys (Contract Subtask 3B)

Following the Boundary Delineation Survey, dive teams transitioned to Roving Diver Surveys to further document seafloor features. Disparate areas within the OTR containing tires, unidentified seafloor targets on the Preliminary Map (e.g., areas with distinctive signatures indicating the presence of structures or other anomalies warranting identification), and natural reef features were surveyed by divers to ensure an accurate interpretation of the side-scan sonar mosaic. To obtain information on relative tire abundance, dive teams counted tires within a fixed area at 11 haphazardly selected, visually representative sites within the survey area. The dive team counted all visible tires falling at least 50% within the boundaries of a 5 m by 5 m square laid out on the bottom at the coordinates of each of the 11 pre-selected sites. Divers did not dig into sediments to count buried tires. Video was collected at each location for context.

At sites selected for feature identification and ground truthing, a weighted buoy was first deployed to mark the site. The dive team then entered the water equipped with the Shark Navigator for underwater navigation and positioning and the GoPro Hero 7 Black video and still camera to collect video and still photos to assist in identification of the features. The dive team obtained oblique video of targeted bottom features at each selected site, and to maximize data collection, then swam transects in the direction of other features near the sites using the Shark to record the dive team's position. This allowed for an additional overview of the seafloor between locations that had widely distributed items with varying side-scan signatures.

At the completion of each field day, all navigation, video, and still photo data were downloaded and reviewed, and then copied onto multiple storage devices for security and redundancy.

2.4.3 Map Refinement (Contract Subtask 3C)

Video data were collected as a series of short recordings for features of interest and secondarily to memorialize the status of the biological habitat and communities. The short recordings from each dive were reviewed and then compiled into a single file for each dive for ease of viewing and data transfer and context. Biologists reviewed the data to assist in providing a general description of the biological habitat and communities. Diver position data from the Shark were input into the GIS project along with the side-scan sonar dataset, and the diver transects were plotted showing diver tracks relative to

specific features in the side-scan imagery. Individual features were identified and then visually compared to the detailed side-scan sonar plots of the project area with the video and photographs obtained at each site.

The Preliminary Map was refined using *in situ* data and a revised geo-referenced map was prepared using the information collected by divers and submitted as an ArcMap Package (here, defined as a Diver-verified Map). This map included the diver-verified boundaries of the OTR (any areas containing tires) and natural reefs (including continuous reef features adjacent to the OTR and the positions of any hardbottom patches within the OTR), as well as the positions of all other notable features (e.g., artificial reefs, other anthropogenic and biogenic features) located within the 300 m buffer surrounding the OTR. The abundance and accessibility (for recovery) of visible tires are displayed on the map. Side-scan sonar and multibeam data associated with the authorized additional survey work are included in the Diver-verified Map.

3.0 Results

3.1 SIDE-SCAN SONAR AND MULTIBEAM

Figure 2 shows the 40 m spaced north–south parallel transect (survey) lines plotted over the multibeam image. In the PDF version of this report, the reader may zoom into the image and observe some of the various larger, more obvious seafloor features and anthropogenic materials.

Figure 3 shows a portion of the side-scan mosaic. The final detailed side-scan sonar mosaic of the site had a resolution of 0.25 ft, and individual exposed tires could be easily identified. The imagery was digitized by GIS staff at 1:300 scale to delineate rough boundaries between areas of visually apparent “dense” or abundant tire abundance (i.e., where adjacent tires were touching or nearly touching, creating greater than approximately 50% cover), and comparatively “sparse” abundance where there were wider gaps between tires (less than approximately 50% cover). **Figure 3** shows a 1:300 scale view with overlying shading depicting the boundaries of the “sparse” and “dense” relative tire abundance. Due to the large size of the area as well as time and budget limitations, the relative abundance shading is only approximate and intended to show representative areas of more abundant tire accumulation.

The Preliminary Map developed from the review of these data was used to plan the diver verification and roving-diver surveys. All unidentified side-scan sonar signature types were selected for diver verification and the final identification is presented in the Target Association Report (**Appendix B**).

The multibeam bathymetric survey data generated the most accurate georeferenced imagery because the DGPS antenna was positioned directly above the vessel-mounted multibeam transducer. Fine-tuned positioning adjustments were made to the side scan sonar data by positioning the side-scan sonar mosaic over the multibeam image, then adjusting the side-scan sonar image until significant features were in alignment.

It should be noted that even under the best circumstances there may be minor misalignment of features due to slight lateral motion of the side scan sonar towfish. When trying to determine the precise location of an object or feature, it is important to recognize that the multibeam imagery is the more accurate.

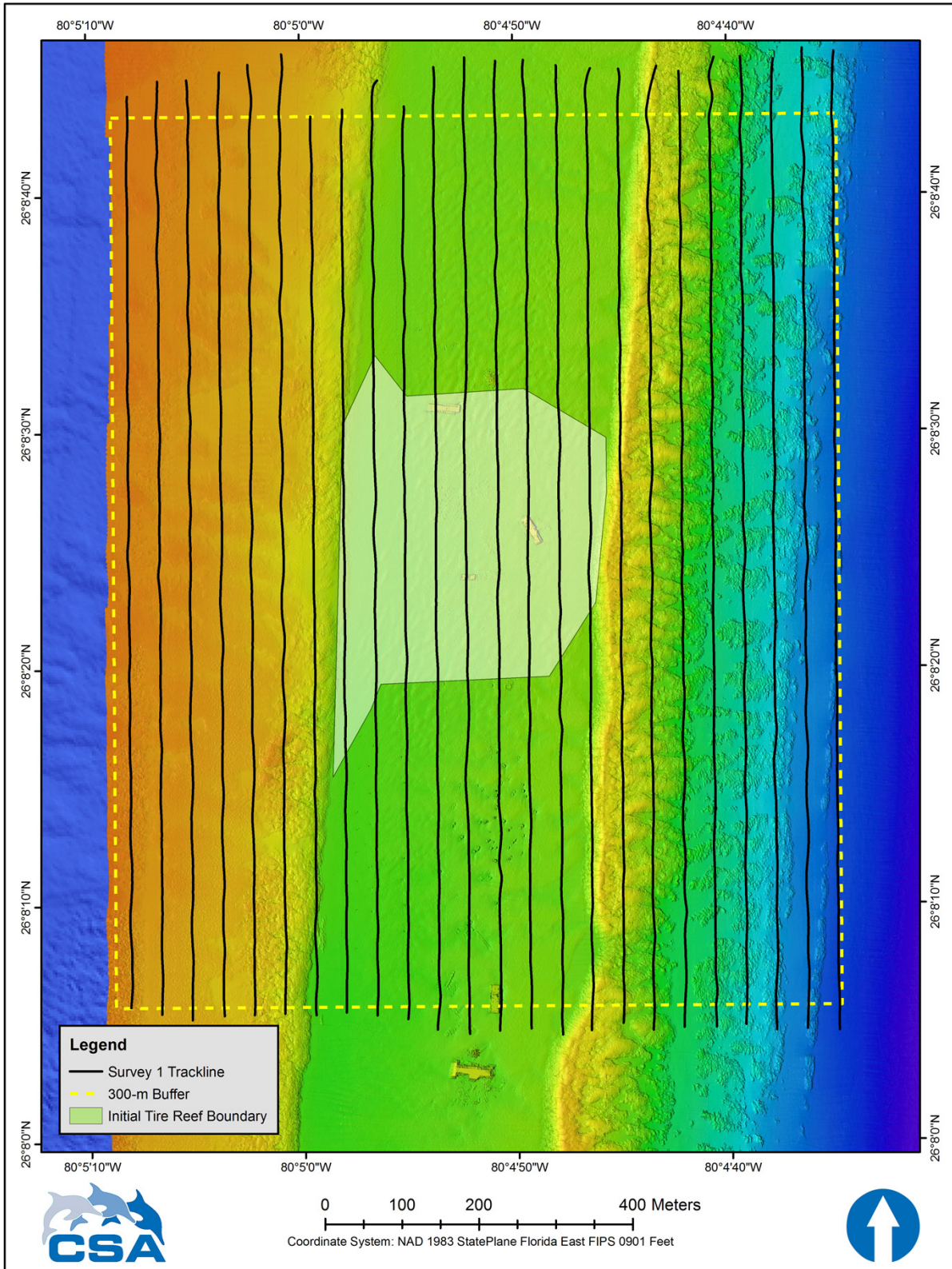


Figure 2. Side-scan sonar and multibeam survey transects across the Osborne Tire Reef project area within the 300-m buffer overlain on the multibeam image. Background source: NOAA NOS Hydrographic Survey H12117, Year: 2008.

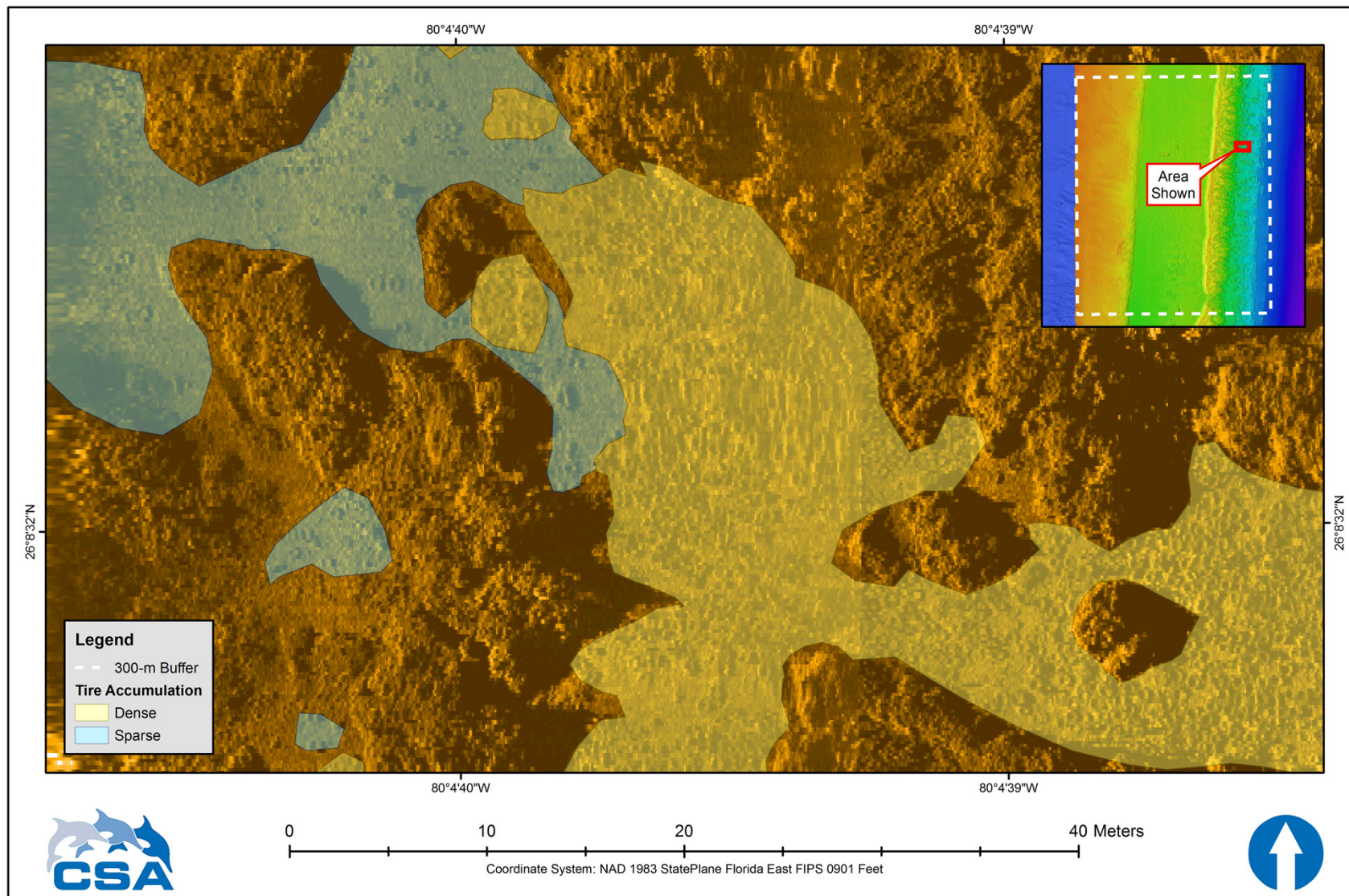


Figure 3. Side scan-sonar mosaic from outside third reef showing example of tire accumulation classification. Background Source: Side-scan sonar mosaic. Inset source: NOAA NOS Hydrographic Survey H12117, Year: 2008.

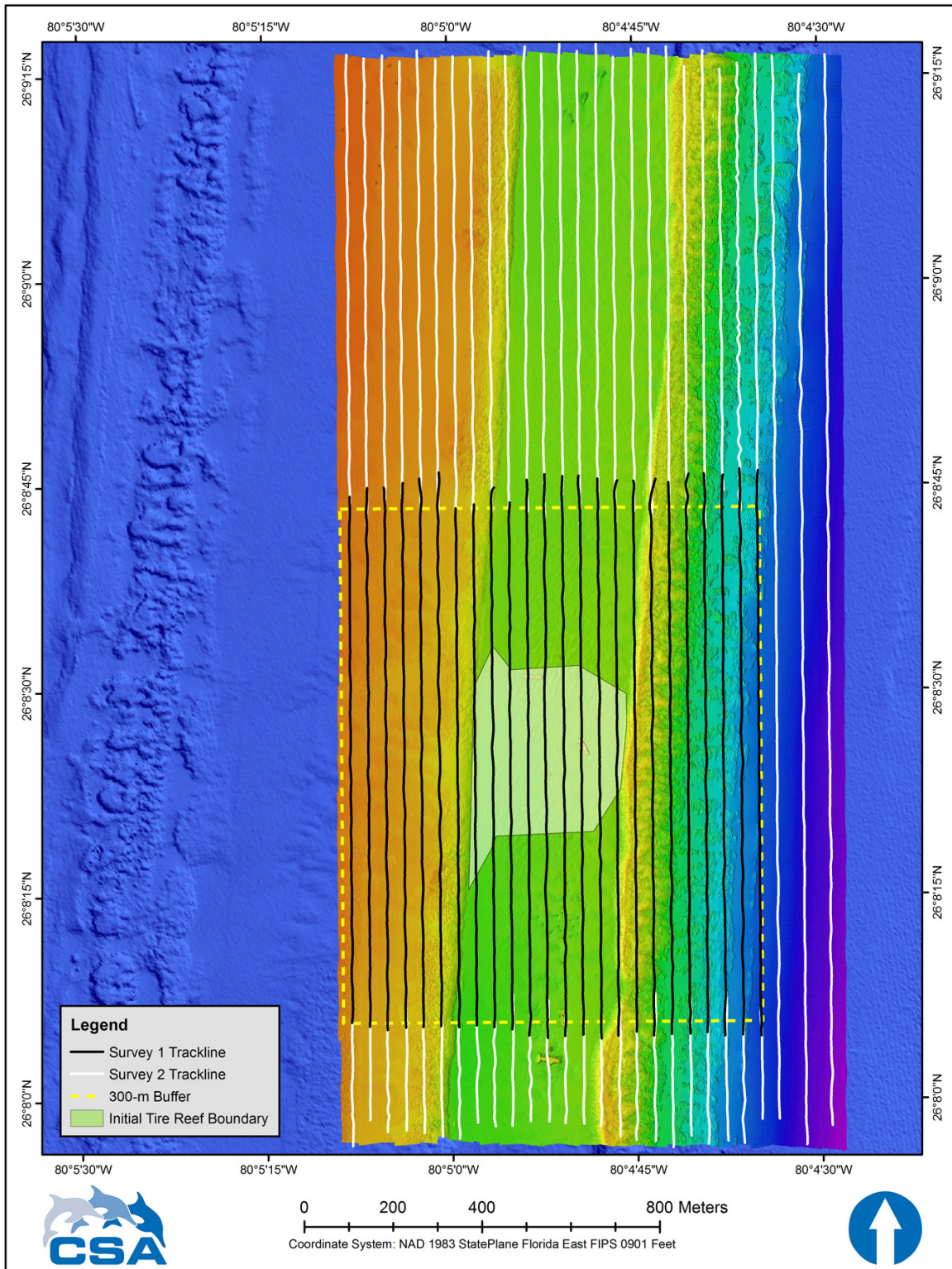


Figure 4. Side-scan sonar and multibeam survey transect plots including the expanded survey area (Survey 2) north, east and south of the original Osborne Tire Reef project area within the 300-m buffer (Survey 1). Background source: NOAA NOS Hydrographic Survey H12117, Year: 2008.

3.2 TOWED VIDEO

A total of 14 towed video transects were run, six transects in the east–west direction and eight transects in the north–south direction. The line spacing for the east–west transects was 200 m and line spacing for the north–south transects was 100 m. Towed video data were collected during two separate field efforts (previously described Surveys 1 and 2). **Figure 5** depicts the actual (post-plot) towed video track lines from both surveys that fell within the 300 m buffer.

Towed video data were reviewed to define the relative abundance of tires as well as reef edge boundaries and other features falling along the video transects. The data were used to confirm side-scan sonar targets where possible, although due to the relatively narrow field-of-view very few specific targets other than barges were observed along video tow lines.

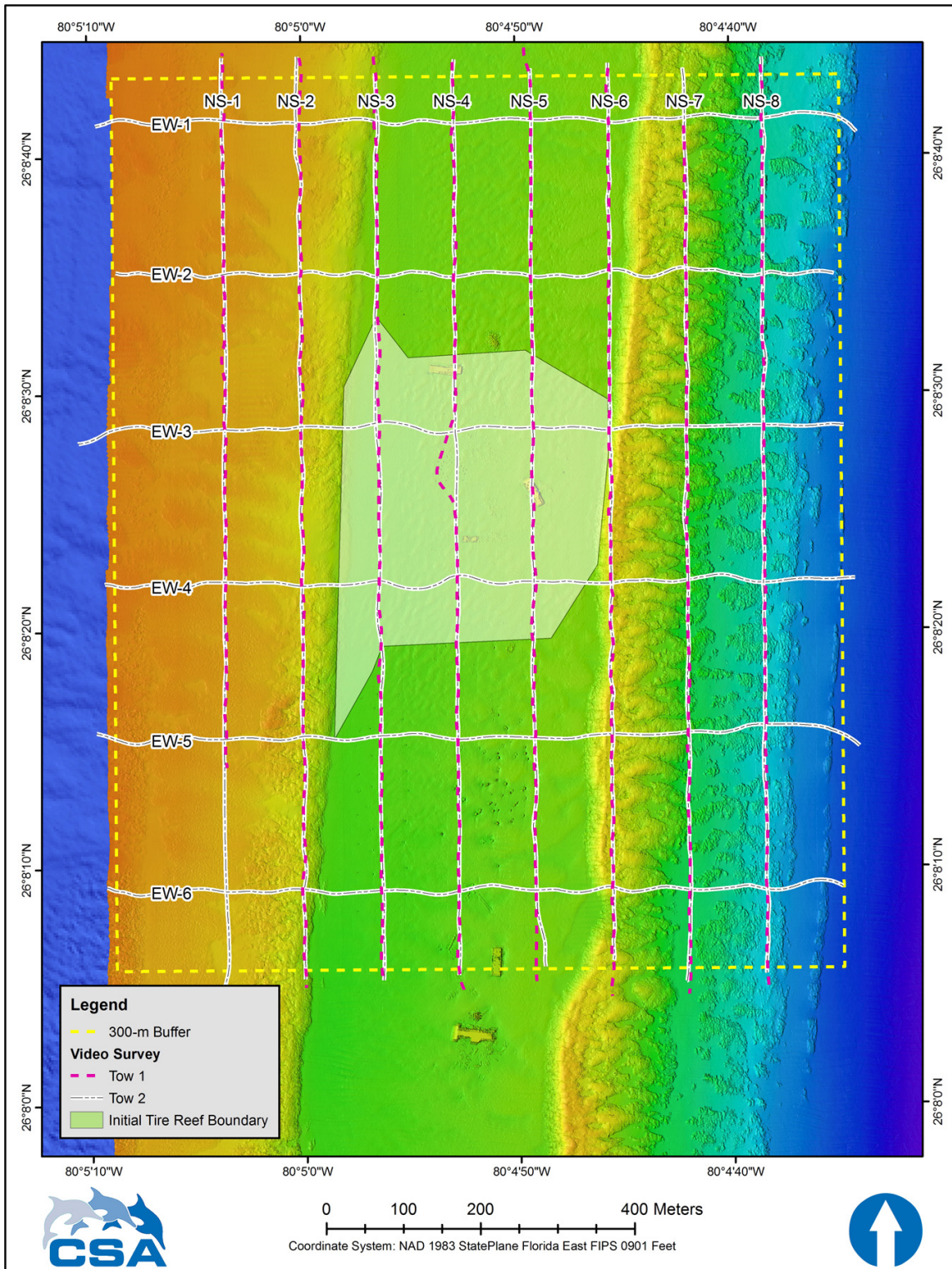


Figure 5. Post-plots and numbering of towed video survey lines within the project area. EW=East-West; NS=North-South. Tow 1 refers to the NS axis tows (performed twice), Tow 2 refers to EW axis tows. Background source: NOAA NOS Hydrographic Survey H12117, Year: 2008.

3.3 DIVER VERIFICATION

A total of 24 specific dive locations and targets were surveyed during the diver verification operations. **Figure 6** shows pre-plotted diver ground-truthing sites and **Figure 7** shows post-plotted positions of the actual diver tracks during the survey relative to bottom features (In the PDF version of this report, the reader may zoom into the image and observe some of the various larger, more obvious seafloor features and anthropogenic materials). Photographs of identified targets and features are exhibited in **Appendix C** and brief dive descriptions are in **Appendix D**. Targets of dives included various concentrations, orientations, and groupings of tires, ranging from single tires nearly completely buried in sandy areas to sites with large accumulations of exposed tires with abundances of more than 3 tires per m² (**Photo C-1**), along with still-intact bundles (**Photo C-2**). Small bundles of what appeared to be vertical stacks of motorcycle tires were identified (**Photo C-3**) as well as partially buried and intact large tire bundles colonized with sponges, octocorals, and stony corals (**Photo C-4**). Other accumulations of tires were also noted near the center of the site where commercial divers have created upright rows and bundles of tires for removal (**Photos C-5 and C-6**).

Additional identified features included a large carbonate boulder pile (**Photo C-7**), various distributions of hexagonal concrete jacks (typically used in breakwaters) (**Photos C-8 and C-9**), a long concrete girder or beam (**Photo C-10**), a long metal barge spud (**Photo 11**), various sized sections of metal and concrete pipe (**Photos C-12 and C-13**), three barges (at least one filled with tires) (**Photos C-14 and C-15**), a sunken vessel, various groupings of reef balls (**Photos C-16 and C-17**), and nearly 30 “cube-shaped” artificial reef modules (**Photo C-18**). All these specific features were plotted and appear to closely match (visually) with features and their positions shown in the side scan sonar mosaic.

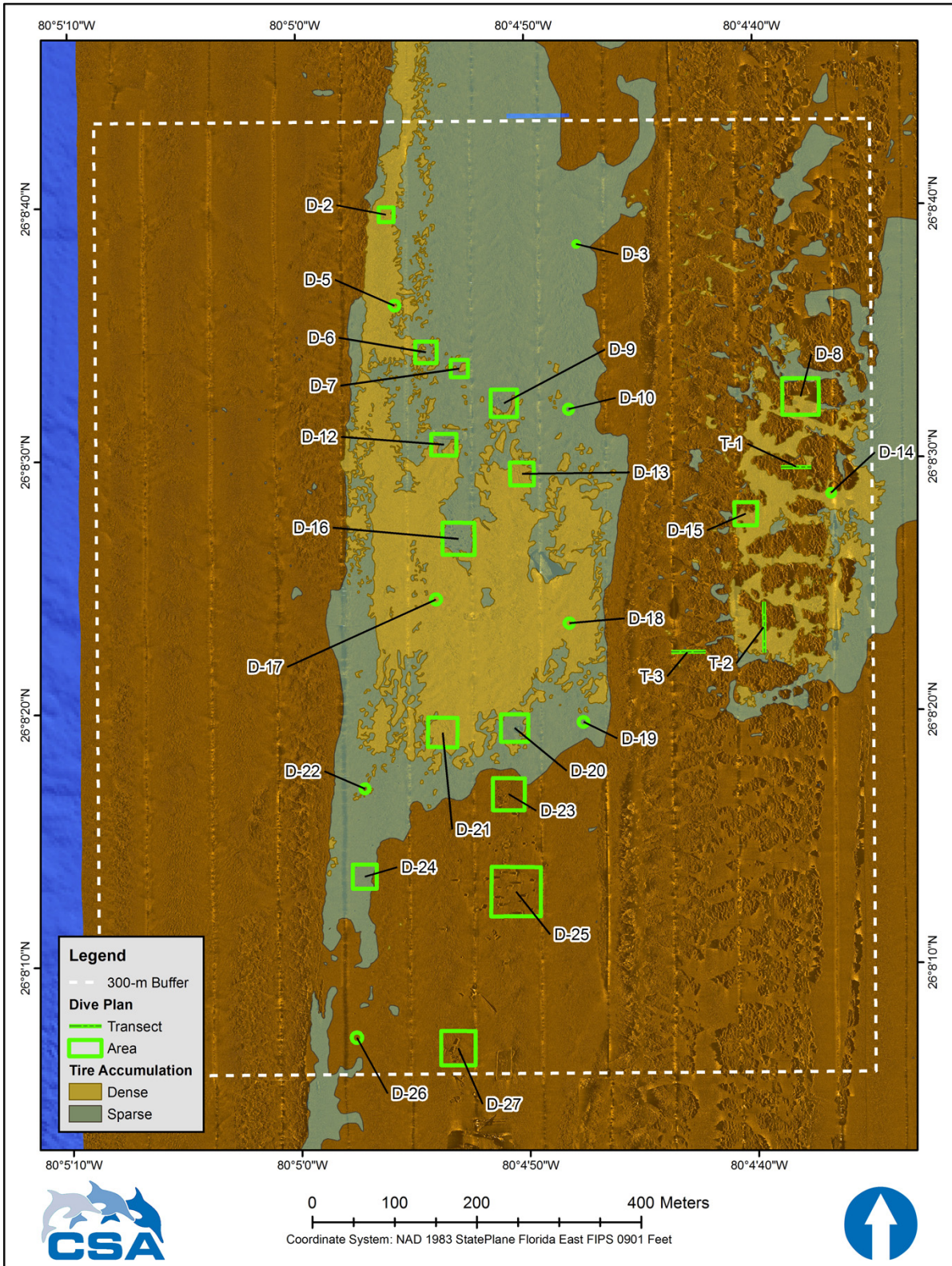


Figure 6. Pre-plotted locations for diver ground-truthing of features within the project area. Background source: Side-scan sonar mosaic.

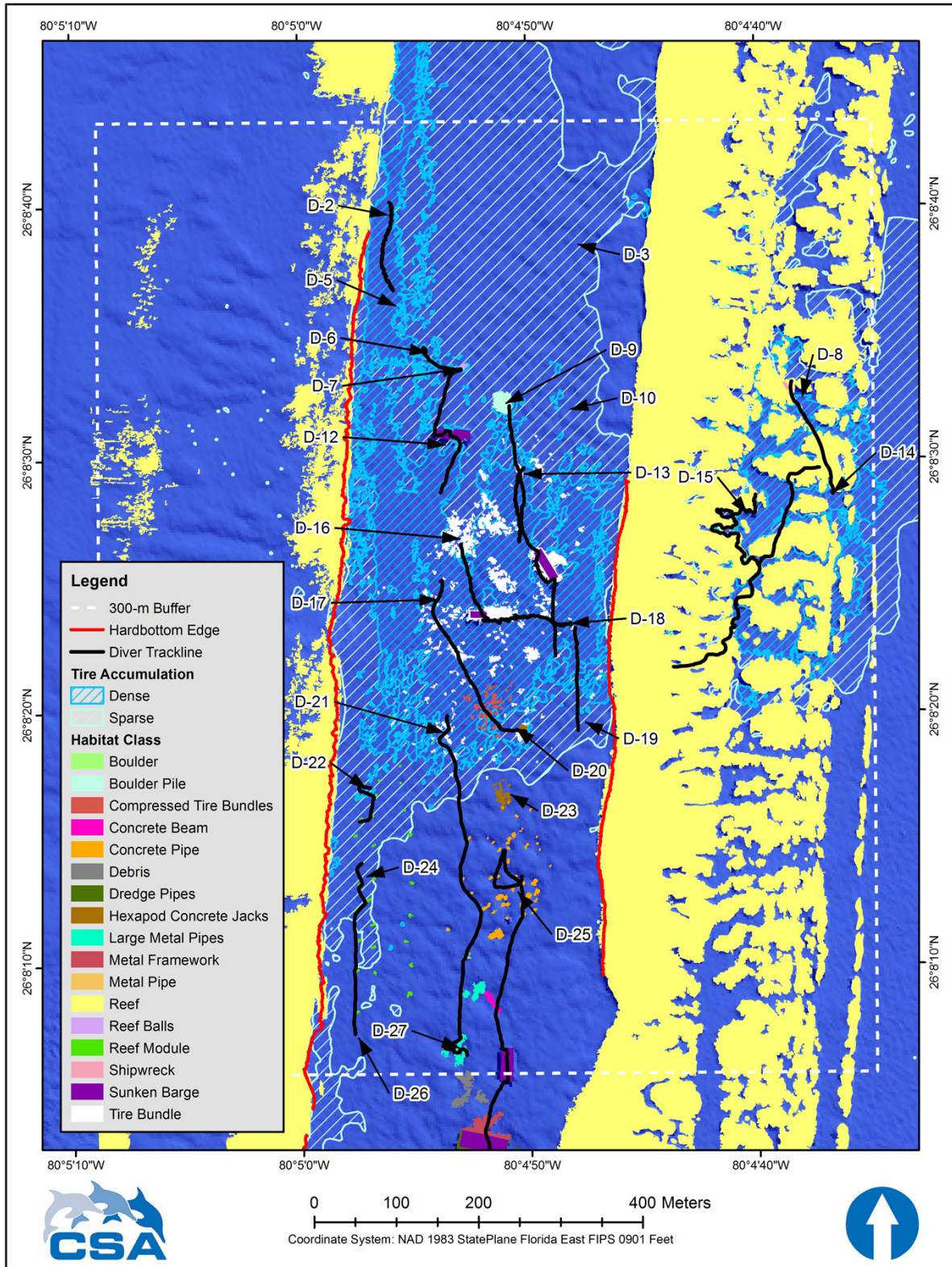


Figure 7. Post-survey diver track positions relative to identified bottom features within the project area. Background source: Background source: NOAA NOS Hydrographic Survey H12117, Year: 2008.

Counts of tires made within 5 m × 5 m grids at each of the 11 quadrat sites ranged from 0 up to 88 tires per 25 m² grid (3.5 tires m⁻²) with five of the sites having more than 1 tire m⁻² (**Table 2**). It became evident during the diver survey that many of the tires located within the OTR site were nearly or completely buried, and as such would have minimal to no side-scan sonar return, rendering them invisible in the side-scan sonar plots. This burial was observed during the review of diver video collected at several of the sites where large scale sand waves up to 0.5 m height were evident, half covering bundles of tires and nearly totally covering loose tires. This is also evidenced in **Photos C-19 to C-23** and can be detected by zooming in on the side scan sonar plots from areas just to the north of Site D21 (**Figure 8**) and to the south of Site D12 where alternating bands of sand waves and exposed tires can be observed.

Table 2. Tire density at selected locations within survey area.

Site	Tires per 25 m ²	Tires per m ²
D2	88	3.5
D3	0	0.0
D5	28	1.1
D10	0	0.0
D14	57	2.3
D17	52	2.1
D18	44	1.8
D19	5	0.2
D22	6	0.2
D24	15	0.6
D26	3	0.1

While the Scope of Work referenced “assemblages of tires stacked vertically, cemented into a concrete anchor,” dive teams did not observe features precisely fitting this description. However, intact bundles of 6 to 10 motorcycle (or small width) tires containing what appeared to be cement (**Photos C-3 and C-24**) were observed, primarily in an area to the northwest of the circle of hexagonal concrete jacks (Site D20); these may be the referenced structures but they were not cemented into a visibly apparent anchor. These exhibited a relatively distinct side scan sonar return (**Figure 9**).

Towed video and diver video and observations indicated tires occurred in the OTR area as well as north, east, and south of the OTR area. Large concentrations of tires were visible and exposed along the eastern margin of the second reef (see **Figure 1** for reef locations), extending several hundred meters north of the defined OTR boundary (**Photo C-25**). Large accumulations of tires were also observed in the offshore (eastern) portions of sand channels across the third reef (**Photos C-26 and C-27**) as well as in adjacent sandy low relief areas east of the third reef and the OTR boundary. These tires were nearly totally exposed and covered wide expanses of the sand and rubble flats between reef structures (**Photos C-28 and C-29**). Despite the high abundance of tires east of the third reef, very few tires were observed on elevated reef areas, and where present they were generally in sand-filled depressions (**Photos C-30 and C-31**). Diver and towed video observations also confirmed that very few tires were present on elevated sections of the second and third reefs.

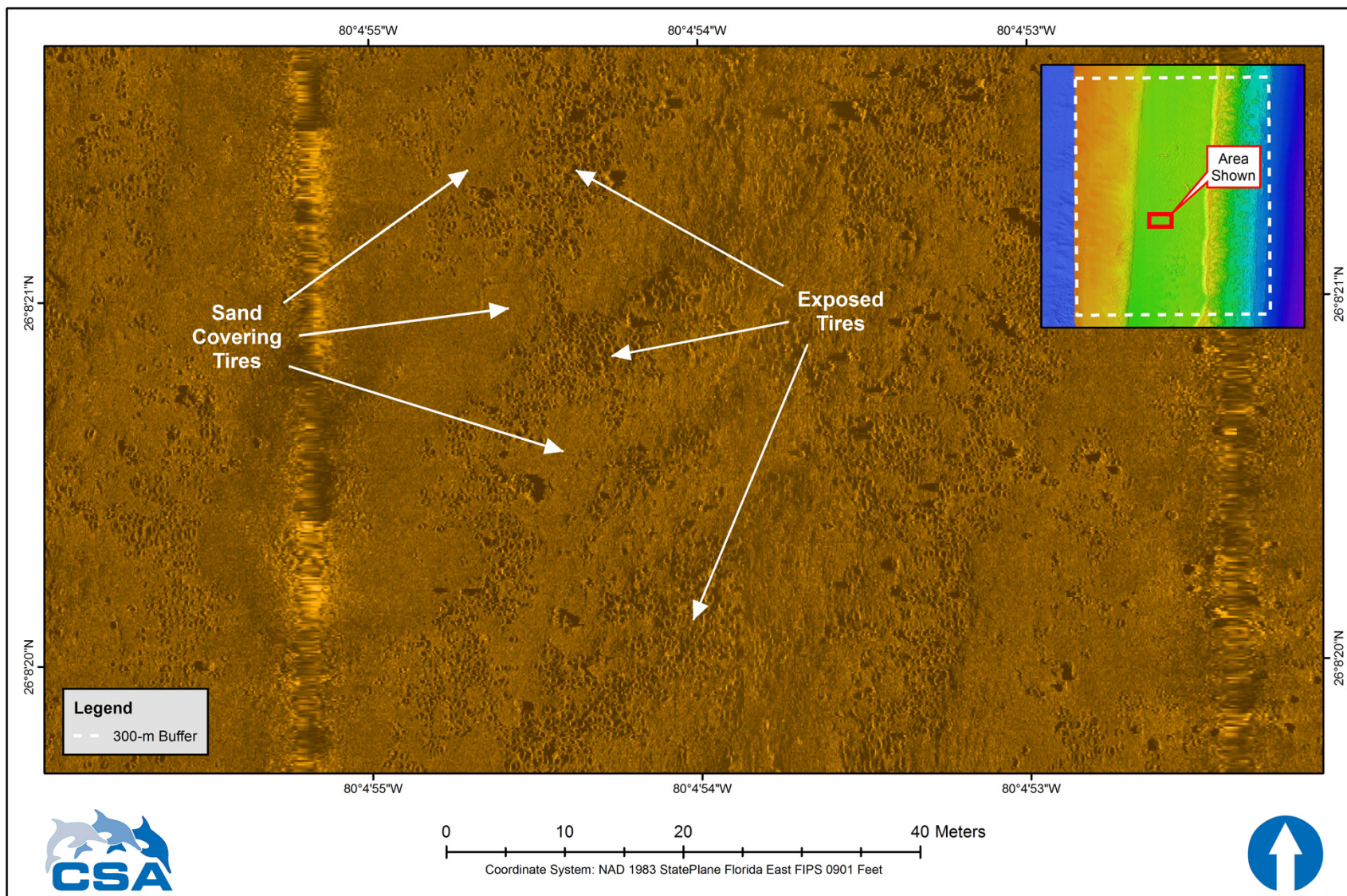


Figure 8. Bands of wide sand wave features with exposed tires in troughs north of Site D21. Background source: Side-scan sonar mosaic. Inset source: NOAA NOS Hydrographic Survey H12117, Year: 2008.

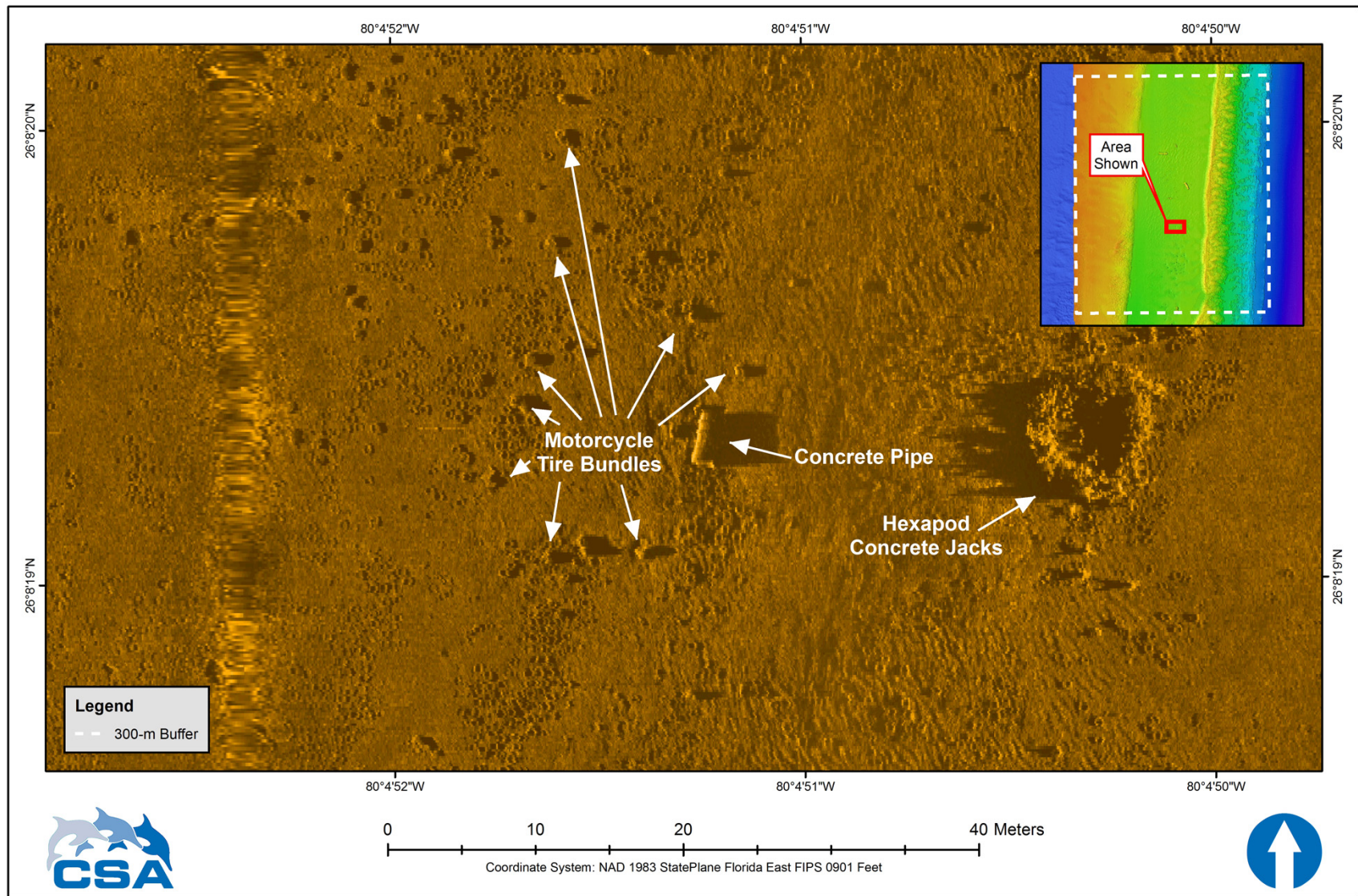


Figure 9. Intact bundles of motorcycle tires appearing to be filled with cement, to the west and northwest of the hexagonal concrete jacks at Site D20. Background source: Side-scan sonar mosaic. Inset source: NOAA NOS Hydrographic Survey H12117, Year: 2008.

Epifaunal presence and abundance on tires was highly dependent upon the orientation of the tire and amount of tire exposed above the seafloor. Many loose tires lying in sand between the second and third reefs had very little attached fauna, presumably due to the constant sand scouring of exposed surfaces. Occasional octocorals were noted as well as the rare observation of a stony coral on loose tires between the reef lines. Loose tires east of the third reef were usually in areas of apparently lower amounts of sediment and were typically more exposed above the sediment. Here, small stony coral colonies were attached to many of these tires with divers observing up to 5 coral colonies recruited to individual tires. Although the number of intact bundles of tires was low, the few remaining bundles often had high amounts of epifaunal growth, including sponges, octocorals, and stony corals up to more than 30 cm diameter. **Table 3** lists identified species associated with tires in the project area as well as common epifauna noted on natural reef structures.

Table 3. Presence (x) of sessile species by substrate at selected locations within survey area.

Classification	Taxa	On Tires	On Reef
Octocoral	<i>Briareum abestinium</i>		X
Octocoral	<i>Erythropodium caribaeorum</i>	X	X
Octocoral	<i>Eunicea flexuosa</i>		X
Octocoral	<i>Eunicea</i> spp.	X	X
Octocoral	<i>Gorgonia ventalina</i>		X
Octocoral	<i>Iciligorgia shrammi</i>	X	X
Octocoral	<i>Muricea</i> spp.		X
Octocoral	<i>Plexaura</i> spp.		X
Octocoral	<i>Pseudoplexaura porosa</i>	X	X
Octocoral	<i>Pseudoplexaura</i> sp.	X	X
Octocoral	<i>Pseudopterogorgia</i> spp.	X	X
Octocoral	<i>Antipathes</i> sp.		X
Sponge	<i>Agelas clathrodes</i>		X
Sponge	<i>Agelas tubulata</i>		X
Sponge	<i>Aplysina cauliformis</i>	X	X
Sponge	<i>Callyspongia vaginalis</i>		X
Sponge	<i>Halisarca</i> sp.	X	X
Sponge	<i>Holopsamma helwigi</i>	X	
Sponge	<i>Iotrochota birotulata</i>	X	X
Sponge	<i>Ircinia strobilina</i>	X	X
Sponge	<i>Monanchora unguifera</i>	X	X
Sponge	<i>Niphates digitalis</i>	X	X
Sponge	<i>Niphates erecta</i>	X	X
Sponge	<i>Ptilocaulis</i> sp.	X	X
Sponge	<i>Xestospongia muta</i>	X*	X
Stony Coral	<i>Agaricia lamarcki</i>		X
Stony Coral	<i>Agaricia</i> spp.	X	X
Stony Coral	<i>Diploria labyrinthiformes</i>		X
Stony Coral	<i>Diploria</i> spp.		X
Stony Coral	<i>Diploria strigosa</i>	X	X
Stony Coral	<i>Madracis decactis</i>		X
Stony Coral	<i>Millepora alcicornis</i>	X	X
Stony Coral	<i>Montastrea cavernosa</i>	X	X

Table 3. (Continued).

Classification	Taxa	On Tires	On Reef
Stony Coral	<i>Mycetophyllia aliciae</i>		X
Stony Coral	<i>Orbicella faveolata</i>		X
Stony Coral	<i>Orbicella</i> spp.		X
Stony Coral	<i>Porites astreoides</i>	X	X
Stony Coral	<i>Porites porites</i>	X	X
Stony Coral	<i>Siderastrea siderea</i>	X	X
Stony Coral	<i>Solenastrea bournoni</i>	X	X
Stony Coral	<i>Stephanocoenia intersepta</i>	X	X

*Observed growing through centers of tires at reef edges.

4.0 Data Storage

Data collected by the survey teams were daily put on external storage devices (portable hard drives) and transferred to CSA corporate headquarters in Stuart, Florida. Data were then copied to a data storage server. The copied and original data were compared to ensure the copy was complete. These data were then copied to the two external hard drives delivered to the FDEP via Olsen Associates, Inc. **Figure 10** shows the data structure utilized to organize survey data on the two external hard drive deliverable.

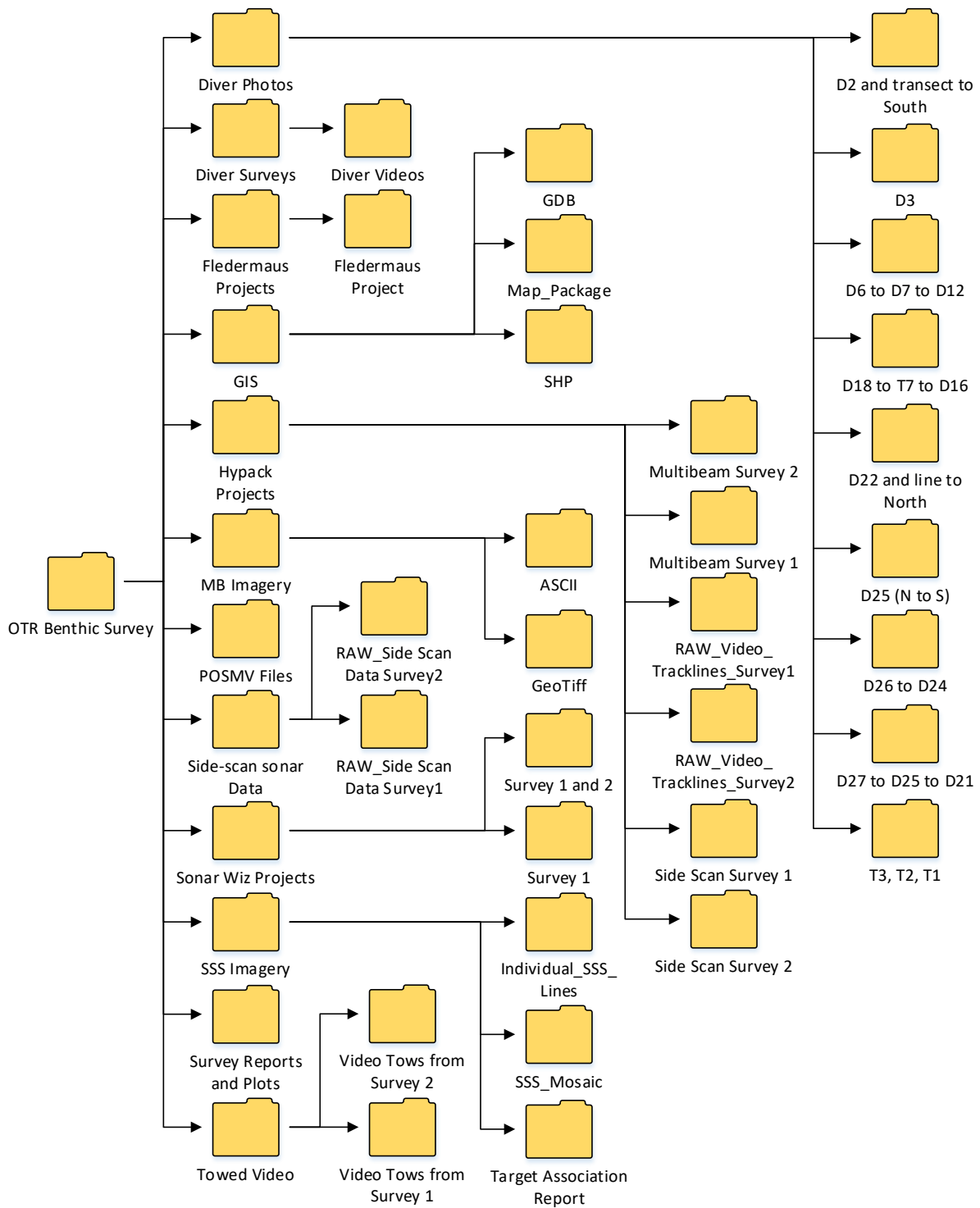


Figure 10. The general organizational directory structure for data collected in the field. Arrow direction demonstrates the folder opening sequence.

Appendices

(All appendices are provided in electronic format only)

Appendix A

Surveyors Control Report

SURVEYOR CONTROL REPORT

Hydrographic Survey: Multi-beam Bathymetry and Side-scan Sonar
Survey of the Osborne Tire Reef
Broward County, Florida

Prepared for:

CSA Ocean Sciences, Inc.

Prepared by:

Morgan & Eklund, Inc.

Professional Survey Consultants

4909 U.S. Highway 1
Vero Beach, Florida 32967
Phone: (772) 388-5364
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Licensed Business (L.B.) 4298

Morgan & Eklund, Inc. Project Number 35711-1

Report Date: June 11, 2019

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Intended Purpose of Control

This control was established for the purpose of providing horizontal and vertical positioning, via RTK GPS, for a hydrographic survey (multi-beam bathymetry and sidescan sonar) of the Osborne Tire Reef.

Project Location

The reef is located off Hugh Taylor Birch State Park, in Ft. Lauderdale, Florida. (Shown below)



Project Data

The horizontal datum for this project is the North American Datum of 1983, NGS adjustment of 1990 (NAD 83/90), and the vertical datum for this project is the North American Vertical Datum of 1988 (NAVD 88).

Establish Horizontal Control

Florida Department of Environmental Protection published control monumentation was used as primary control for this project. A 5/8" rebar & cap (#401) and a PK nail and disk (# 402) were set as secondary control in the vicinity of the Florida Department of Natural Resources (FDNR) concrete monument "86 92 DA18". A Trimble R-7 RTK base station was set on FDNR concrete monument "R 62 BROWARD CO 74", and a Trimble 5700 RTK rover was used to horizontally position points 401 and 402. Check measurements were also taken to FDNR monuments "86 92 DA18" and "R-59 BROW 1993"

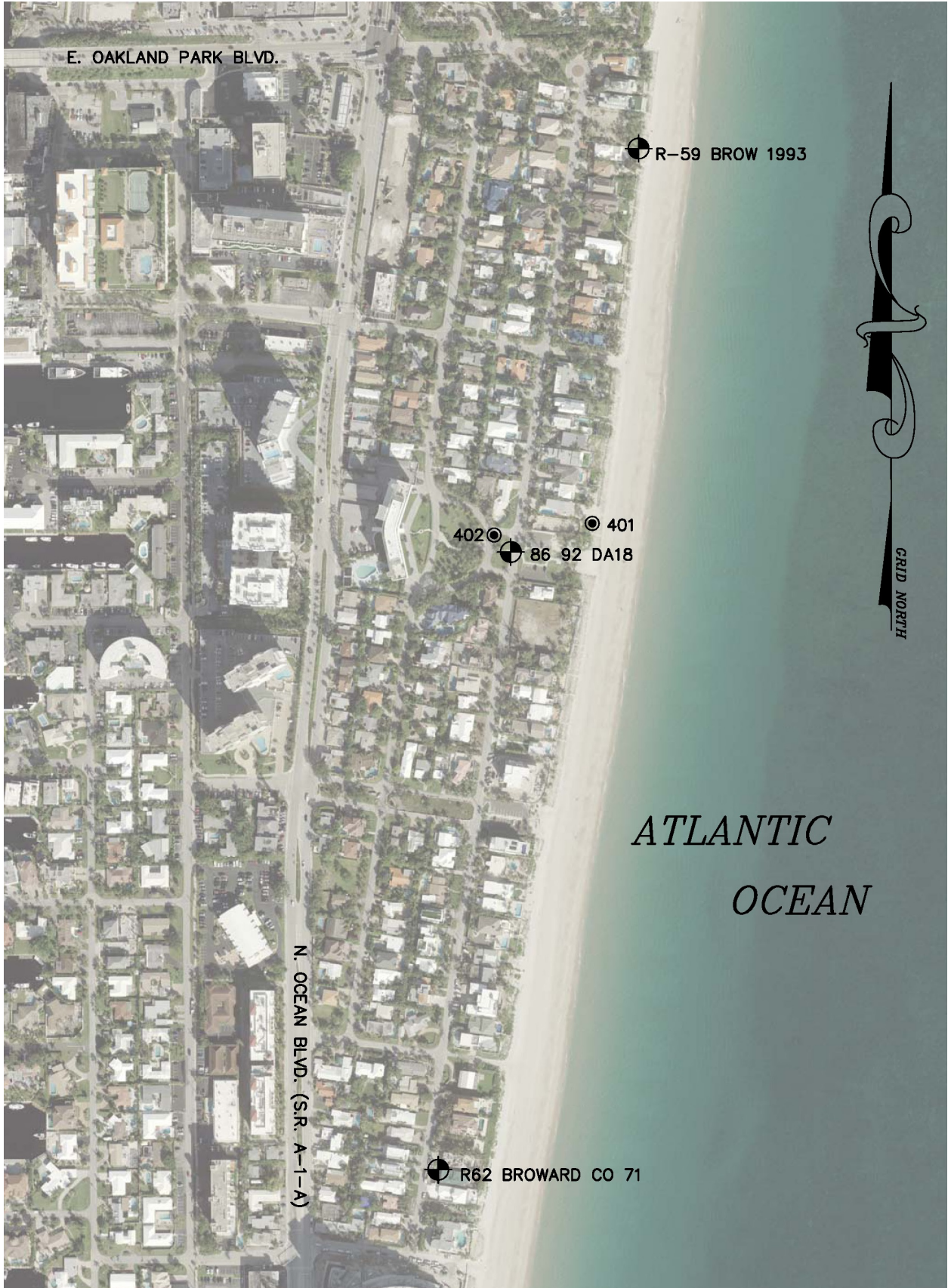
Establish Vertical Control

Differential leveling, off of FDEP published control points, using a Wild NA-1 automatic level, was utilized to determine the elevations of the secondary control points.

A level run commenced at the FDNR disk in concrete stamped "86 92 DA18", was run through points 401 and 402, and closed on the FDNR concrete monument "R-59 BROW 1993"

Control Tabulation

	NAD 83/90	SPCS 0901	NAVD 88	US SURVEY FEET
MONUMENT	NORTHING	EASTING	ELEVATION	STAMPING
DA-18	666145.77	951601.19	9.84	86 92 DA18
R-59	667324.91	951973.96	9.13	R-59 BROW 1993
R-62	664340.35	951389.41	9.73	R 62 BROWARD CO 74
401	666229.37	951838.85	7.16	REBAR & CAP #401
402	666195.18	951552.42	9.45	NAIL & DISK #402



Appendix B

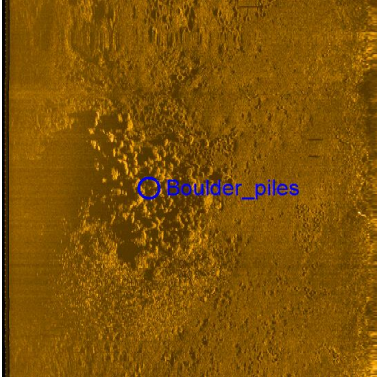
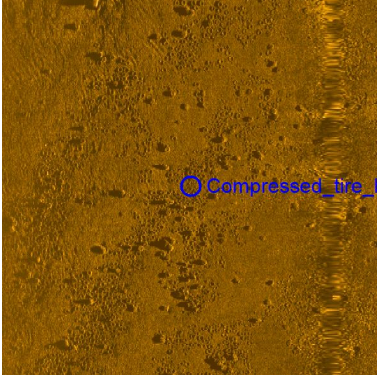

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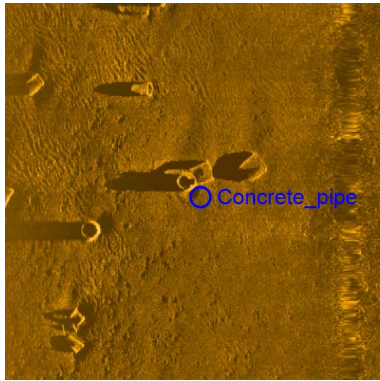
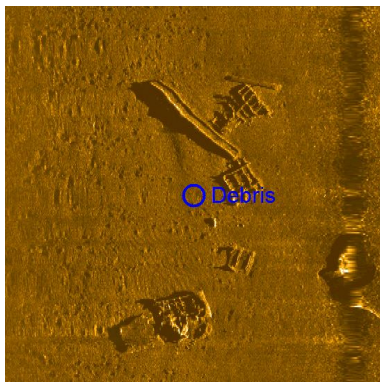
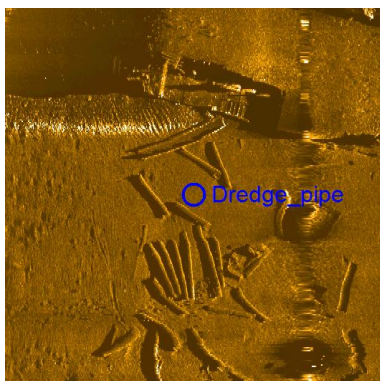
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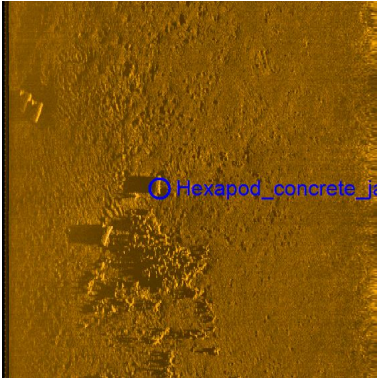
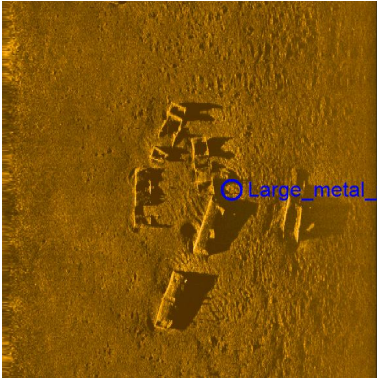
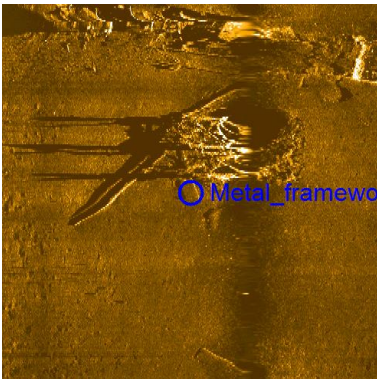
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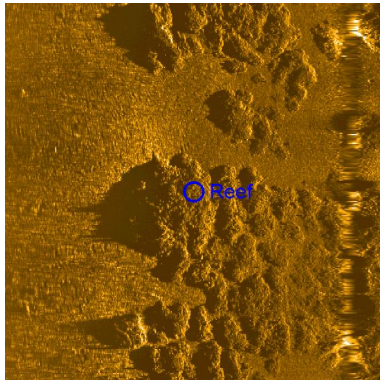
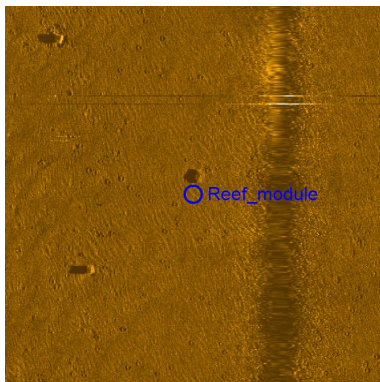
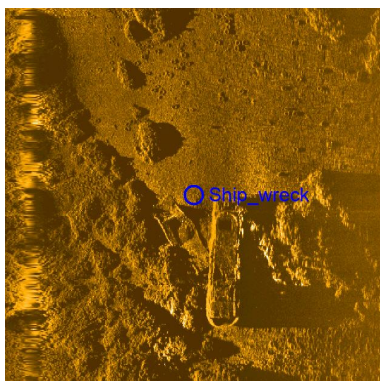
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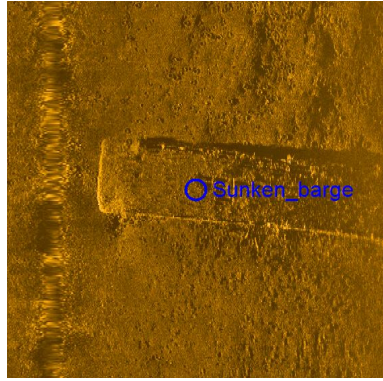
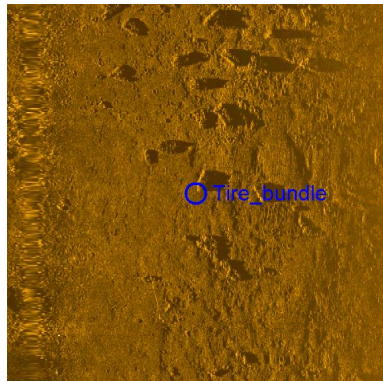

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Concrete pipe	4/27/2019 8:04:12 AM	26.1370941299	-80.0810419483
Debris	5/7/2019 12:55:05 PM	26.1347920758	-80.0814373769
Dredge pipe	5/7/2019 12:54:35 PM	26.1339953987	-80.0813501407
Hexapod concrete jack	4/27/2019 8:03:40 AM	26.1378495588	-80.0809477279
Large metal pipes	4/27/2019 8:05:35 AM	26.1351500285	-80.0815371040
Metal framework	4/27/2019 11:22:19 AM	26.1343637533	-80.0811230122
Reef	5/7/2019 12:07:40 PM	26.1343471155	-80.0781934350
Reef module	4/27/2019 7:21:57 AM	26.1367419341	-80.0827008306
Ship wreck	4/27/2019 9:40:08 AM	26.1425059972	-80.0774117080
Sunken barge	4/27/2019 8:00:48 AM	26.1419383649	-80.0814287984
Tire bundle	4/27/2019 8:01:26 AM	26.1410206194	-80.0814556804
Reef balls	4/27/2019 8:00:16 AM	26.1427058979	-80.0813693663
Pipe	4/27/2019 8:24:44 AM	26.1414634526	-80.0806366821

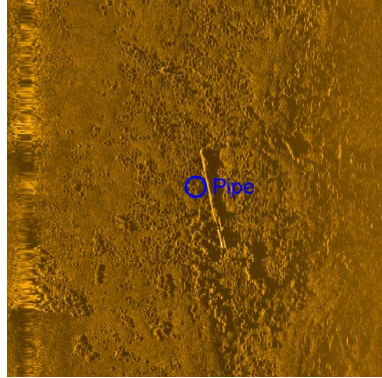
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	<p>Compressed tire bundles</p> <ul style="list-style-type: none"> • Sonar Time at Target: 4/27/2019 8:02:54 AM • Click Position 26.1389285772 -80.0810498269 (WGS84) (X) 957648.11 (Y) 657250.56 (Projected Coordinates) • Map Projection: FL83-EF • Acoustic Source File: I:\3425_Olsen_Tire_Reef_SS_Data\Olsen190427075800.xtf • Ping Number: 73671 • Range to target: 61.70 US ft • Fish Height: 21.22 US ft • Heading: 178.560 Degrees • Event Number: (-1) • Line Name: Olsen190427075800 • Water Depth: 0.00 US ft 	<p>Dimensions and attributes</p> <ul style="list-style-type: none"> • Target Width: 0.00 US ft • Target Height: 0.00 US ft • Target Length: 0.00 US ft • Target Shadow: 0.00 US ft • Classification1: • Classification2: • Area: • Block: • Description:
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	<p>Concrete pipe</p> <ul style="list-style-type: none"> • Sonar Time at Target: 4/27/2019 8:04:12 AM • Click Position 26.1370941299 -80.0810419483 (WGS84) (X) 957655.40 (Y) 656583.78 (Projected Coordinates) • Map Projection: FL83-EF • Acoustic Source File: I:\3425_Olsen_Tire_Reef_SS_Data\Olsen190427075800.xtf • Ping Number: 74824 • Range to target: 62.83 US ft • Fish Height: 18.67 US ft • Heading: 179.780 Degrees • Event Number: (-1) • Line Name: Olsen190427075800 • Water Depth: 0.00 US ft 	<p>Dimensions and attributes</p> <ul style="list-style-type: none"> • Target Width: 5.25 US ft • Target Height: 3.82 US ft • Target Length: 7.00 US ft • Target Shadow: 16.87 US ft • Classification1: • Classification2: • Area: • Block: • Description:
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	<p>Hexapod concrete jack</p> <ul style="list-style-type: none"> • Sonar Time at Target: 4/27/2019 8:03:40 AM • Click Position 26.1378495588 -80.0809477279 (WGS84) (X) 957684.37 (Y) 656858.59 (Projected Coordinates) • Map Projection: FL83-EF • Acoustic Source File: I:\3425_Olsen_Tire_Reef_SS_Data\Olsen190427075800.xtf • Ping Number: 74354 • Range to target: 95.57 US ft • Fish Height: 18.27 US ft • Heading: 180.150 Degrees • Event Number: (-1) • Line Name: Olsen190427075800 • Water Depth: 0.00 US ft 	<p>Dimensions and attributes</p> <ul style="list-style-type: none"> • Target Width: 0.00 US ft • Target Height: 0.00 US ft • Target Length: 0.00 US ft • Target Shadow: 0.00 US ft • Classification1: • Classification2: • Area: • Block: • Description:
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	<p>Metal framework</p> <ul style="list-style-type: none"> • Sonar Time at Target: 4/27/2019 11:22:19 AM • Click Position 26.1343637533 -80.0811230122 (WGS84) (X) 957635.82 (Y) 655591.12 (Projected Coordinates) • Map Projection: FL83-EF • Acoustic Source File: I:\3425_Olsen_Tire_Reef_SS_Data\Olsen190427110800.xtf • Ping Number: 250470 • Range to target: 24.83 US ft • Fish Height: 21.80 US ft • Heading: 178.430 Degrees • Event Number: (-1) • Line Name: Olsen190427110800 • Water Depth: 0.00 US ft 	<p>Dimensions and attributes</p> <ul style="list-style-type: none"> • Target Width: 30.50 US ft • Target Height: 0.00 US ft • Target Length: 55.73 US ft • Target Shadow: 0.00 US ft • Classification1: • Classification2: • Area: • Block: • Description:

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	<p>Reef module</p> <ul style="list-style-type: none"> • Sonar Time at Target: 4/27/2019 7:21:57 AM • Click Position 26.1367419341 -80.0827008306 (WGS84) (X) 957112.04 (Y) 656451.91 (Projected Coordinates) • Map Projection: FL83-EF • Acoustic Source File: I:\3425_Olsen_Tire_Reef_SS_Data\Olsen190427071500.xtf • Ping Number: 37374 • Range to target: 37.62 US ft • Fish Height: 31.25 US ft • Heading: 179.420 Degrees • Event Number: (-1) • Line Name: Olsen190427071500 • Water Depth: 0.00 US ft 	<p>Dimensions and attributes</p> <ul style="list-style-type: none"> • Target Width: 0.00 US ft • Target Height: 0.00 US ft • Target Length: 0.00 US ft • Target Shadow: 0.00 US ft • Classification1: • Classification2: • Area: • Block: • Description:
	<p>Ship wreck</p> <ul style="list-style-type: none"> • Sonar Time at Target: 4/27/2019 9:40:08 AM • Click Position 26.1425059972 -80.0774117080 (WGS84) (X) 958832.51 (Y) 658559.38 (Projected Coordinates) • Map Projection: FL83-EF • Acoustic Source File: I:\3425_Olsen_Tire_Reef_SS_Data\Olsen190427093400.xtf • Ping Number: 159886 • Range to target: 70.73 US ft • Fish Height: 17.74 US ft • Heading: 0.510 Degrees • Event Number: (-1) • Line Name: Olsen190427093400 • Water Depth: 0.00 US ft 	<p>Dimensions and attributes</p> <ul style="list-style-type: none"> • Target Width: 13.19 US ft • Target Height: 7.02 US ft • Target Length: 55.31 US ft • Target Shadow: 47.74 US ft • Classification1: • Classification2: • Area: • Block: • Description:

	<p>Sunken barge</p> <ul style="list-style-type: none"> • Sonar Time at Target: 4/27/2019 8:00:48 AM • Click Position 26.1419383649 -80.0814287984 (WGS84) (X) 957516.04 (Y) 658343.72 (Projected Coordinates) • Map Projection: FL83-EF • Acoustic Source File: I:\3425_Olsen_Tire_Reef_SS_Data\Olsen190427075800.xtf • Ping Number: 71807 • Range to target: 62.46 US ft • Fish Height: 20.27 US ft • Heading: 181.210 Degrees • Event Number: (-1) • Line Name: Olsen190427075800 • Water Depth: 0.00 US ft 	<p>Dimensions and attributes</p> <ul style="list-style-type: none"> • Target Width: 31.59 US ft • Target Height: 0.00 US ft • Target Length: 126.71 US ft • Target Shadow: 0.00 US ft • Classification1: • Classification2: • Area: • Block: • Description:
	<p>Tire bundle</p> <ul style="list-style-type: none"> • Sonar Time at Target: 4/27/2019 8:01:26 AM • Click Position 26.1410206194 -80.0814556804 (WGS84) (X) 957509.58 (Y) 658010.06 (Projected Coordinates) • Map Projection: FL83-EF • Acoustic Source File: I:\3425_Olsen_Tire_Reef_SS_Data\Olsen190427075800.xtf • Ping Number: 72370 • Range to target: 71.49 US ft • Fish Height: 20.02 US ft • Heading: 179.820 Degrees • Event Number: (-1) • Line Name: Olsen190427075800 • Water Depth: 0.00 US ft 	<p>Dimensions and attributes</p> <ul style="list-style-type: none"> • Target Width: 0.00 US ft • Target Height: 0.00 US ft • Target Length: 9.44 US ft • Target Shadow: 0.00 US ft • Classification1: • Classification2: • Area: • Block: • Description:
	<p>Reef balls</p> <ul style="list-style-type: none"> • Sonar Time at Target: 4/27/2019 8:00:16 AM • Click Position 26.1427058979 -80.0813693663 (WGS84) (X) 957533.57 (Y) 658622.85 (Projected Coordinates) • Map Projection: FL83-EF • Acoustic Source File: I:\3425_Olsen_Tire_Reef_SS_Data\Olsen190427075800.xtf • Ping Number: 71338 • Range to target: 43.64 US ft • Fish Height: 18.98 US ft • Heading: 180.150 Degrees • Event Number: (-1) • Line Name: Olsen190427075800 • Water Depth: 0.00 US ft 	<p>Dimensions and attributes</p> <ul style="list-style-type: none"> • Target Width: 4.11 US ft • Target Height: 2.08 US ft • Target Length: 4.69 US ft • Target Shadow: 5.86 US ft • Classification1: • Classification2: • Area: • Block: • Description:

	<p>Pipe</p> <ul style="list-style-type: none"> • Sonar Time at Target: 4/27/2019 8:24:44 AM • Click Position 26.1414634526 -80.0806366821 (WGS84) (X) 957777.14 (Y) 658172.93 (Projected Coordinates) • Map Projection: FL83-EF • Acoustic Source File: I:\3425_Olsen_Tire_Reef_SS_Data\Olsen190427082200.xtf • Ping Number: 93035 • Range to target: 74.12 US ft • Fish Height: 15.66 US ft • Heading: 179.480 Degrees • Event Number: (-1) • Line Name: Olsen190427082200 • Water Depth: 0.00 US ft 	<p>Dimensions and attributes</p> <ul style="list-style-type: none"> • Target Width: 1.74 US ft • Target Height: 0.85 US ft • Target Length: 44.57 US ft • Target Shadow: 4.35 US ft • Classification1: • Classification2: • Area: • Block: • Description:
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Appendix C

Photos



Photo C-1. Area of dense tire accumulation at Site D2.



Photo C-2. Intact bundles of tires with attached stony corals and octocorals at Site D21.



Photo C-3. Bundle of motorcycle tires near large section of concrete pipe west of D20.



Photo C-4. Partially intact bundles of tires with octocorals and stony corals (*Montastrea cavernosa* and *Porites astreoides*) at Site D 16.



Photo C-5. Tires gathered for removal by commercial divers near site D16.



Photo C-6. Recently stacked tires east of second reef and south of Site D5.



Photo C-7. Boulder reef at Site D9.



Photo C-8. Hexagonal concrete jacks near Site D20.

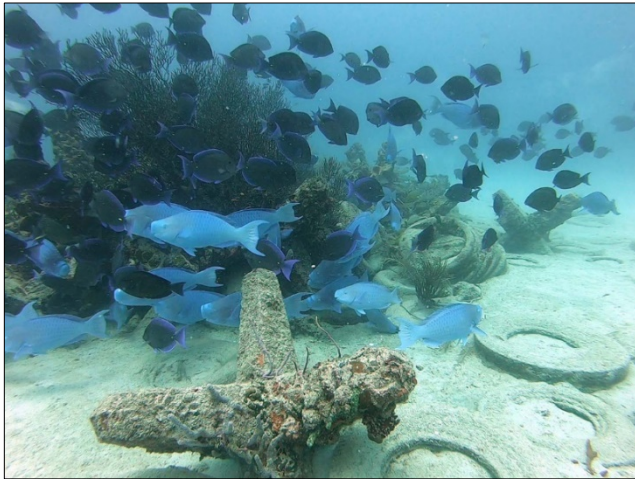


Photo C-9. Edge of large ring of hexagonal concrete jacks at Site D20.

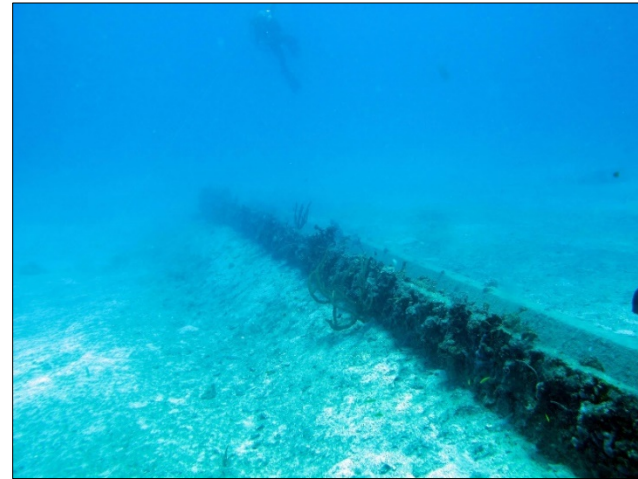


Photo C-10. Concrete girder on seafloor near south margin of 300-m buffer.



Photo C-11. Corroded barge spud in area of tires at Site D13.



Photo C-12. Large flattened metal tubing/pipe south of Site D25.



Photo C-13. Large diameter concrete pipe at Site D25.



Photo C-14. Deck of barge immediately north of Site D12.



Photo C-15. Bundles of tires south of “upside down” barge near center of Osborne Tire Reef site.



Photo C-16. Reef balls with attached octocorals, sponges, and stony corals at Site D6.



Photo C-17. Grouping of reef balls near loose tires at Site D7.



Photo C-18. NOVA reef module in southwest portion of project area.



Photo C-19. Outlines of buried tires at Site D17.



Photo C-20. Partially buried tires and stacks of tires being removed at Site D16.



Photo C-21. Partially buried intact bundles of tires south of Site D16.



Photo C-22. Area of buried tires south of Site D16.



Photo C-23. Buried tires and reef ball south of Site D26.



Photo C-24. Short bundles of motorcycle tires among other loose tires northwest of Site D20.



Photo C-25. Large concentration of loose tires near Site D2, north of Osborne Tire Reef northern boundary.



Photo C-26. Scattered tires in sand channel across third reef along Transect T1.



Photo C-27. Tires south of Site D15 in sand channel east of third reef.



Photo C-28. Loose tires covering bottom of sand flat east of third reef on Transect T2.



Photo C-29. Tires lying against third reef edge near Site D15.



Photo C-30. Tires in elevated sand-filled depression on reef on Transect T2.

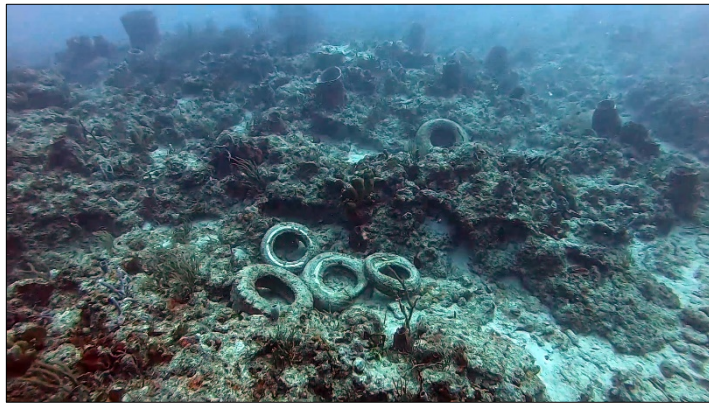


Photo C-31. Tires in cut across reef along Transect T2.

Appendix D

Dive Description Table

Table D-1. Brief dive descriptions.

Date	Diver Video No.	Sites	Description
28-May	16	Transect T4 (N to S)	Demarcation of eastern edge of second reef along entire length of 200-m buffer area.
	17	Transect T5 (N to S)	Demarcation of western edge of third reef along majority of length of 200-m buffer area.
	11	D25 (N to S)	Diver transect from large diameter concrete pipes at D25 to the south over long concrete beam, 2 barges, large metal framework, and metal dredge pipes.
	5	D9 to D13 to barge	Diver transect from large boulder pile at D9 south to long metal pipe (barge spud) in area of broken bundles of tires and on to large overturned barge. Many bundles of tires at south end of barge.
	4	D6 to D7 to D12	Diver transect from D6 to D7 (both clusters of reef balls) and south to barge containing tires north of D12.
29-May	15	Transects T3, T2, and T1	Diver transect west to east on Line T3, then NNE along T2 to Line T-1. Dive progressed along sand channels and across reef and sand flats with tires.
	13	D27 to west of D25 to D21	Diver transect started at large flattened metal pontoons/tubes at D27. Intersected large concrete pipes west of D25, then through area of loose and bundled tires near D21. Original tire bundles with some fairly large attached corals observed.
	12	D26 to D24	Diver transect from D26 north to D24. Very few loose tires at D26, occasional 1m cube reefs with attached epifauna at regular spacing moving toward D24. Loose tire abundance was slightly higher at D24 but still relatively sparse.
	8	D19	Few tires at D19 (5 noted in a single bundle containing cement).
	7, 8	D18	Loose tires were relatively abundant with a few bundles.
	9	D20 to D17 to D16	D20 was large ring of hexagonal concrete jacks with large schools of blue parrotfish and blue tangs, and various grunts. Large concrete pipe immediately to the west. Short bundles of motorcycle tires containing cement in area. Tire abundance increased as divers swam to the north with bundles also present. Large amounts of sand covering loose tires with only upper half of bundled tires exposed in many areas. Stony corals <i>Siderastrea siderea</i> , <i>Solenastrea bournoni</i> , <i>Stephanocoenia michelini</i> , <i>Porites astreoides</i> , <i>Montastrea cavernosa</i> , <i>Agaricia</i> sp., and <i>Colpophyllia natans</i> observed growing on tops of bundles.
30-May	3	D5 to D2	Transect from D5 north to D2. D5 had medium density tires and abundance increased greatly toward D2 with 2 to 3 layers of loose tires exposed at D2.
	14	Transect T2 to D15	Medium to high abundance of loose tires in sandy areas between reef structures along transect and at D15.
	6	D14 to D8	High abundance of tires noted in vicinity of D14 adjacent to reef. Medium to high tire abundance noted in sandy areas between reef structures during transit to D8 (wreck).

Date	Diver Video No.	Sites	Description
30-May (cont'd)	7	D18, Transect T7, and to D16	Medium abundance of loose tires at D18 with a few bundles. High tire abundance along 100-m transect T7 immediately to the west with large numbers of loose tires and more bundles. Areas observed where sediments were covering loose tires. Small barge further to the west had significant amount of tires to west, northeast, and east. Larger numbers of half buried old bundles and newly formed groupings of tires for removal observed toward D16 to the north.
	18	Transect T6 (100-m line north to D13) and D10	High abundance of tires noted along 100-m transect T6 which extended to the north ending at a long pipe (barge spud) at D13. No tires at D10 quadrat, although a few were scattered in the area.
31-May	19	Transect T8	Dive along edge of reef and area of loose tires near Site D15. Tires were noted in sand channels and cuts in reef but very few were up on elevated areas of reef.
	2	Site D3 bounce dive	A few scattered tires and one small clump of about 8 tires noted. Sand bottom.
	1	Site D2 and transect to south	Dense tires noted at D2 with abundance decreasing as divers swam to the south.
	10	Site D22 and transect to north	Low density of loose tires noted at D22. 1-m cube artificial reef modules were spaced at regular intervals on the seafloor to the north and south of D22.