**OPERATIONAL SCIENCE ADVISORY TEAM**

**SUMMARY REPORT FOR FATE AND EFFECTS OF REMNANT OIL REMAINING IN THE BEACH ENVIRONMENT**

**Annex B: Spatial Oil Distribution**

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## I. Introduction

This document discusses the spatial and temporal distribution of the Mississippi Canyon Block 252 (MC252) oil that reached the shoreline after the Deepwater Horizon oil spill. The oil was weathered substantially (physical and chemical alteration and break down) while at sea for approximately 1 month (Brown et al., 2010). The oil that reached the beaches had very different properties from the oil that was released from the well. The first oiling event of Louisiana beaches occurred on approximately May 15, 2010, and the first oiling of Mississippi, Alabama, and Florida beaches occurred on or about June 1, 2010 (OSAT, 2010). Four representative case studies of sandy beaches, one each from Louisiana, Mississippi, Alabama, and Florida, are presented to illustrate the remaining distribution of oil in three shoreline zones.

## II. Zones of Stranding

Oil was deposited along the shoreline in three zones; the subtidal zone, the intertidal zone, and the supratidal zone (see Figure 1). Oil that remains in the subtidal zone is in the form of submerged oil mats and oil that remains in the supratidal zone is oil that was buried during storm events. Oil remaining in the intertidal, as well as in the supratidal zone, is in the form of small surface residue balls (SSRBs) that are a product of beach cleaning (separating clean sand from oil with sieves) and are the size of the smallest screen used. Refer to Figures 2, 3, and 4 for examples of these three oil types.

One sample of oil deposited in each of the three zones (supratidal, intertidal, and subtidal) at four representative case study sites (Grand Isle, Louisiana; Petit Bois Island, Mississippi; Bon Secour, Alabama; and Fort Pickens, Florida) was analyzed as part of this effort for the oil and sand content. The results of the content analysis enabled a general description of the oil stranded along the beaches from west to east and along a beach profile. Refer to Table 1 for the sand and oil content of samples collected for this analysis.

Oil in the subtidal zone (below the low tide line) was deposited as submerged oil mats (see Figure 2). The matrix of material (oil plus sand) stranded in mats below the low tide line had the greatest percentage of oil compared to sand of the three shoreline zones analyzed. The oil mats analyzed as part of this effort were composed of 83.2 to 90.6 percent sand (9.4 - 16.8 percent oil) by mass, with the highest percentage of oil stranded in mats off beaches closest to the source of the oil spill (see Table 1). Oil mats that have been identified were excavated and removed; however, due to the transient nature of the mats (they break up with storm activity) some pieces may still exist in the environment. One indicator of the presence of submerged oil mats is the transport of tar balls onto the beach, which are used to identify submerged oil mats for subsequent removal.

Bulk oil deposits in the intertidal zone (zone between the low and high tide marks) on all amenity and non-amenity beaches were or are in the process of being removed. The

removal methodology varied on beaches according to the approved Shoreline Treatment Recommendation (STR) for that area. Amenity (man-made public) beaches were subject to excavation and removal of all identified oil to the depth of deposition using mechanical and sifting techniques. The sensitive habitats on National Park Service (NPS) and United States Fish and Wildlife Service (USFWS) beaches (non-amenity beaches) experienced primarily manual surface bulk oil removal, with additional, more invasive oil removal as approved on a case by case basis. Oil residue in the form of small surface residue balls (SSRBs) remained on beaches after the sand was passed through screens to remove bulk oil (sieves were either mechanical or manual) and are the size of the finest screen used (see Figure 3). Refer to Table 2 for the smallest screen size used at the four case study sites. Due to the small size of the SSRBs, these depositions of oil remain on the beaches after the cleaning process. In general, based on STR guidance, SSRBs will cover less than one percent of the beach surface. SSRBs analyzed as part of this effort consisted of 87.2 to 95.8 percent sand (4.2 - 12.8 percent oil) by mass and their outer surface was encrusted in sand (see Table 1). The percentage of oil in the SSRBs decreased along the coastline from Louisiana to Florida.

Oil in the supratidal zone (the zone above the high tide line) was deposited during storm events. As a result of dynamic beach changes, this oil was buried by sand, up to depths of 105 cm (41 inches). Over time as the beach profile changed due to wind and wave action, buried oil was exposed (as sand was blown or washed from the surface during storms) or was reburied (see Figure 4). The supratidal oil deposits contained the least amount of oil of the three forms discussed. These oil deposits were 91.1 to 96.8 percent sand (3.2 - 8.9 percent oil) by mass and were encrusted in a sand outer layer (see Table 1). A worst case scenario estimate of oil currently remaining in the supratidal zone at non-amenity beaches indicates that 2 to 8 percent of the buried oil still remains (see Attachment 1). Any oil that has been buried near vegetation was not removed to prevent damage to plant root systems. SSRBs may also be present in the supratidal zone as a result of sand sieving during beach clean up.

## III. Shoreline Oil Distribution

Shoreline Cleanup and Assessment Technique (SCAT) teams conducted surveys along the beaches to determine the location and severity on oiling of Louisiana, Mississippi, Alabama, and Florida beaches. Houma Branch conducted the surveys of Louisiana beaches and Mobile Branch conducted the surveys along the Mississippi, Alabama, and Florida beaches. SCAT reports submitted by the two branches, that were digitally converted for Geographic Information Systems (GIS) usage and uploaded to the National Oceanic and Atmospheric Administration's (NOAA) Environmental Response Management Application (ERMA) website, were utilized for this analysis. The NOAA ERMA tool is accessible to the public through the GeoPlatform website and may be found at: (http://www.geoplatform.gov/gulfresponse/).

Records of maximum oiling events were compiled for Louisiana, Mississippi, Alabama, and Florida beaches (see Figures 5 and 6). A substantial number of beaches along the

Louisiana coastline had experienced heavy or moderate oiling (see Figure 5). Heaviest oiling was west of the Mississippi River, on the Mississippi Delta, in Barataria Bay, and on the Chandeleur Islands. Light to trace oil was reported behind the Chandeleur Islands.

Some heavy to moderate oiling had occurred on Alabama and Florida beaches (see Figure 6). The heaviest stretch of oiling occurred from Dauphin Island, Alabama, to approximately Gulf Breeze, Florida. Light to trace oil was reported from Gulf Breeze to Panama City, Florida, and along the majority of the Mississippi barrier islands. Areas of heavy / moderate oiling also occurred on Mississippi barrier islands.

Cleanup is ongoing and beaches are continuously changing with weather events. As of January 12, 2011 (the latest sampling date analyzed in this report), a majority of the Louisiana coastline had been cleaned and no oil was reported by SCAT teams (see Figure 7). Very light and light oiling still remains on some of the Louisiana barrier beaches: at the outer edges of the Mississippi Delta, in some of the backbay areas, along the Chandeleur Islands, and some of the marshes in Chandeleur Sound. These areas also still have some reports of heavy and moderate oiling.

As of January 12, 2011, a majority of the Mississippi, Alabama, and Florida coastline had been cleaned and no oil was reported by SCAT teams on many stretches of beach (see Figure 8). Barrier beaches on the Florida panhandle, Alabama coastline, and Mississippi barrier islands still have a trace (<1 percent) remainder of oil on the sand surface. This trace oil is the SSRBs that remain on the sand following sieving processes used to clean the beaches. Light oil still remains on some of the Florida and Alabama state park beaches and the Mississippi barrier islands and there are a few instances of heavy oiling reported on these beaches.

Trenches dug on beaches to investigate subsurface oiling indicated that 67 percent of all the trenches did not contain any observable oil (see Figure 9). A total of 305 trenches out of 11,494 sampled had heavy or moderate oiling, and only 46 of those trenches had continuous (91 – 100 percent) oil cover within the trench. The majority of the heavy / moderate oil did not blanket the beaches. The oil, rather, had broken (51 – 90 percent) and patchy (11 – 50 percent) distribution within the trench. The light and very light oil cover had primarily sporadic (1 – 10 percent) and trace (< 1 percent) cover. Only 105 of the 3,527 light and very lightly oiled trenches had continuous (91 – 100 percent) cover.

## IV. Case Study Sites

Although the SCAT teams surveyed the coastline from Louisiana to Florida, four case study sandy beaches were chosen to analyze in depth (see Figure 10). One sandy beach was chosen in each State, based on increasing distances from the site of the spill, the degree of oiling the beach received relative to surrounding beaches, the presence of supratidal buried oil, the presence of sensitive habitats, and the availability of data on the oil characteristics. A sample of each oil type (submerged oil mat, SSRB, and supratidal

buried oil) was collected at each of the case study sites and analyzed as part of this effort (see Table 1).

Figure 10 indicates the counts of oiled and non-oiled locations along coastal sandy beaches from Louisiana to Florida. The four case study locations (shown in yellow boxes in Figure 10) are compared to beaches surrounding them (black boxes). The oiling that occurred at the Grand Isle, Louisiana, site was similar to the oiling that occurred on surrounding barrier beaches and the beaches in the Mississippi River Delta. Petit Bois Island, Bon Secour, and Fort Pickens all received slightly more oiling than the average of the surrounding beaches, but serve as examples of worse-case scenarios with respect to surrounding beaches.

One important factor in the spatial oil analysis was the impact of stranded oil on sensitive habitat. The NOAA ERMA database (http://www.geoplatform.gov/gulfresponse/), which is available through GeoPlatform, houses a compilation of listed State and Federal species and habitat information. The database was utilized to determine the locations of sensitive habitat along the Louisiana, Mississippi, Alabama, and Florida beaches and in the surrounding shallow water. The data indicated that the sandy shoreline from Louisiana to Florida, including the four case study sites, supported habitat for federally endangered and threatened mammals, birds, and reptiles that utilize these beaches.

## A. Grand Isle, Louisiana

### A.1. Maximum Oiling of Shorelines

Grand Isle was oiled early and repeatedly. The beach experienced the heaviest oiling of the four case study sites, and due to the early timing of oil stranding compared to the other beaches studied, Grand Isle received oil that was weathered at-sea for less time than the other beaches. The maximum oiling of Grand Isle is presented in Figure 11. The entire Gulf-facing beach experienced heavy oiling, except for the western end, which experienced moderate to light oiling. Very light oiling was reported on the breakwaters (offshore rock structures) off the eastern end of the island, eastward of the intersection of State Highway 3151 and Highway 1. The breakwaters west of that intersection had no oil observed on them.

### A.2. Maximum Subsurface Oiling

Subsurface oiling survey results are reported from May 28 to December 9, 2010. Heavy and moderate oiling was reported at the eastern tip of Grand Isle. The bottom of the deepest heavy and moderate oiling layers was observed to a depth of 100 cm (39 inches) below the sand surface (see Table 3). The average penetration of the bottom of the heavy and moderate oiling layers was approximately 60 cm (23.6 inches) and 50 cm (20 inches) below the sand surface, respectively. The thickness of the heavy oil layer ranged from 15 to 49 cm (6 - 19 inches) and averaged 29 cm (11 inches). The thickness of the moderate oil layer ranged from 5 to 31 cm (2 - 12 inches) and averaged 18 cm (7 inches). On

average, the heavy and moderate oil was buried deepest in the supratidal zone. The pores in the sand were fully and partially filled with oil, with a few instances of oil residue in the moderately oiled areas.

The greatest depth of penetration of light and very light oil was 105 cm (41 inches) and 75 cm (29.5 inches), respectively, which occurred at the eastern tip of Grand Isle (see Table 3). Light oil penetrated an average depth of 30 cm (12 inches) below the sand surface and had an average thickness of 7 cm (2.7 inches). Very light oil penetrated an average depth of 28 cm (11 inches) below the sand surface and had an average thickness of 4 cm (1.5 inches). Light and very light oil were also buried deepest in the supratidal zone. Lightly oiled sediment was described as having sand pores partially filled with oil or having an oil residue. Very lightly oiled sediment was described as having sand with oil residue, trace residue, or oil film on the sand grains.

If the distribution of the oil observed in the trenches at Grand Isle is categorized by the severity of the oiling (heavy, moderate, light, etc.) one can see that in the heavy / moderate oiling category, only 20 trenches had the continuous (91 - 100 percent) deposition of oil (see Figure 12). The majority of heavy and moderate oiling was distributed in a broken (51 - 90 percent) cover. The light and very lightly oiled areas only had 6 trenches with continuous cover and 21 trenches with broken cover. The majority of the light and very lightly oiled areas had sporadic (1 - 10 percent) cover. No oil was observed at approximately one third of the trenches dug on Grand Isle in that time period.

### A.3. Shoreline Treatment Recommendations (STRs)

Grand Isle was deep cleaned. The Stage III Shoreline Treatment Recommendation (STR) for Grand Isle State Park (STR# S3-010) recommends that no further cleanup is necessary when there is no visible oil or oiled debris above background level, for both surface and subsurface oil. No depth restriction has been identified for oil removal in the State Park, however, the preservation of clean sand and avoidance of vegetation is recommended. The STR recommends that all surface oil residue mats, balls, and patties in the lower intertidal zone be removed, buried oil be removed with Cherringtons and manual techniques, surface and subsurface oil in tidepools be removed, and riprap on beaches be cleaned so that no oil rubs off on contact. Sand was approved for “sand treatment” at the Grand Isle sand treatment facility and replacement on the State Park beach. This technique was stopped in the beginning of November 2010.

The Stage III STR for the remainder of Grand Isle (STR# S3-011.r.2) recommends that no further treatment is required when no visible oil or oil debris is present above background levels. Background level for surface residue balls (5 cm diameter) is defined as < 50 surface residue balls per 100 m of shoreline. Surface oil residue mats in the lower intertidal zone should be removed at low tide using manual (rakes, shovels) and mechanical (excavator bucket blades) means to scrape the sand surface and remove the oil mat. Supratidal oil and buried oil may be removed using surf washing techniques (moving sand to intertidal zone to be agitated by wave action). No depth restriction has

been identified for oil removal on Grand Isle, however, the preservation of clean sand and avoidance of vegetation is recommended.

### A.4. Small Surface Residue Balls (SSRBs)

Small surface residue balls (SSRBs) are a product of mechanical and manual cleaning and sieving of beach sand. The SSRBs are primarily composed of a mixture of sand and oil. Samples of SSRBs collected from Grand Isle were 87.2 percent sand (12.8 percent oil) by mass (see Table 1).

The SSRBs are the size of the smallest screen used to sieve the oil deposited on the beach from the sand. In general, Grand Isle beach sand was sieved with Cherrington 5000 that had 19 mm (¾ inch) screens and with Barber Sandman 850 that was not equipped with screens. The State Park at Grand Isle was sieved using a Powerscreen Chieftain 1400 with 3 mm (1/8 inch) screens (see Table 2). Therefore, SSRBs are no larger than 19 mm (¾ inch) on Grand Isle, except at the State Park, where they should be no larger than 3 mm (1/8 inch). Because SSRBs are a product of beach cleaning, they will remain on the beaches after the beaches are deemed "clean."

### A.5. Current Shoreline Condition

The Grand Isle shoreline has been cleaned aggressively since the maximum oiling events. SCAT shoreline surveys of Grand Isle on January 12, 2011, indicated that primarily trace (<1 percent) oil deposits remain along the beaches (see Figure 13). No oil was observed at the extreme south end of the island except around the back side of the western tip of the island. Very light oiling was observed on beaches toward the eastern end of the island, just before the entrance to the State Park land. Light oiling remains along a majority of the State Park beach. Sampling along the breakwaters in the State Park on the eastern half of the island revealed the area was very lightly oiled near the eastern tip of the island (see Figure 13). The majority of the breakwaters, however, had no oil observed on them.

Heavy oiling was still present along the far end and backside of the eastern tip of the island. The heavy oil was initially deposited as pooled or thick oil greater than 1 cm in thickness. There was also some oil and mousse cover in the area that ranged from > 0.1 cm to < 1 cm thick. The eastern tip of Grand Isle appears to have accumulated the heaviest oil deposits. Presently, a biodegradation experiment (described in Annex E – BIO MARUN modeling) is taking place on this strip of beach, and the oil will be removed once the experiment is complete.

Descriptions of the oiled beaches were compiled by the SCAT teams from May 28, 2010, to January 12, 2011, as they surveyed the oiled beaches. The descriptions as of January 12, 2011, are grouped for the lower and mid intertidal zones, upper intertidal zone, and supratidal zone and are summarized below. These descriptions are available through GeoPlatform: (http://www.geoplatform.gov/gulfresponse/).

### A.5.1. Lower and Mid Intertidal Zones

Lower and mid intertidal heavily oiled areas at the eastern end of Grand Isle had pooled or thick oil (> 1 cm thick) or oil cover (> 0.1 cm to < 1 cm thick) of broken (51 - 90 percent) distribution. The light and very lightly oiled areas along the entire island in the middle and lower intertidal zones had a mousse coating (< 0.1 cm) in trace (< 1 percent) to sporadic (1 – 10 percent) distribution. There was also surface residue stain on the sediments in patchy (11 - 50 percent) distribution, trace (<1 percent) highly weathered tar stain, and sporadic (1 - 10 percent) tar balls (< 10 cm in diameter).

### A.5.2. Upper Intertidal Zone

Upper intertidal areas that experienced heavy oiling at the eastern end of the island had oil cover (> 0.1 cm to < 1 cm thick) to pooled or thick oil (> 1 cm thick) of patchy (11 - 50 percent) to broken (51 - 90 percent) distribution. The light and very lightly oiled areas along the entire island in the upper intertidal zone had sporadic (1 - 10 percent) mousse cover (> 0.1 cm to < 1 cm) or coating (< 0.1 cm). There were also sporadic (1 - 10 percent) surface residue and mousse coatings (< 0.1 cm) and tar balls (< 10 cm in diameter).

### A.5.3. Supratidal Zone

The majority of the island showed only trace (<1 percent) to light oil in the supratidal zone, however, heavy oil had been deposited at the eastern tip of the island in the supratidal zone and buried by sand. The light and very lightly oiled areas in the supratidal zone had a sporadic (1 - 10 percent) oil coat (< 1 cm) and trace (<1 percent) to sporadic (1 - 10 percent) tar balls (< 10 cm in diameter). The heavy and moderate oils were deposited in a continuous (91 – 100 percent) to patchy (11 – 50 percent) coverage.

## A.6. Buried Oil Currently Remaining

Subsurface oil, where it was observed, was light along the Gulf-facing beaches on Grand Isle (see Figure 14). The heaviest subsurface oiling occurred along the eastern tip and backside of the eastern tip of the island at the inlet between Grand Isle and Grand Isle Terre. The majority of the oiling was observed between the surface and 60 cm (approximately 24 inches) below the surface (see Figure 15). The deepest oiling occurred at the eastern tip and backside of the eastern tip of the island where the heaviest oiling occurred. Oil was reported to 105 cm (approximately 41 inches) below the surface (see Figure 15 and Table 3). The average maximum depth of oiling for all oil types on Grand Isle was 39 cm below the sand surface.

Supratidal oil collected from Grand Isle indicated that the buried oil deposits were composed of a matrix of sand and oil. The deposits of the supratidal buried oil were 7.7 percent oil (92.3 percent sand) by mass (see Table 1). Because Grand Isle was extensively cleaned to the depth of oil deposition, the worst-case scenario estimates of oil

remaining in NPS and USFWS operated beaches (2 – 8 percent) that were calculated as part of this effort is probably an overestimate for Grand Isle (see Attachment 1).

### A.7. Submerged Oil Mats

Submerged oil mats were found on the Gulf-facing beaches on Grand Isle (see Figure 14). Four oil mats remained on the Gulf-facing beaches as of January 12, 2011, one of which is at the eastern end of the breakwaters in the State Park. Several other oil mats were located at the eastern tip of the State Park where the heaviest oiling on Grand Isle remained. These mats, however, have already been removed. Note that all oil mats that have yet to be removed are slated for removal.

Submerged oil was collected for analysis from Grand Isle. The samples indicated that the deposits were composed of sand and oil. The deposits were 83.2 percent sand (16.8 percent oil) by mass (see Table 1).

### A.8. Current Stage III Shoreline Condition

The SCAT observations were compared to the STR for Grand Isle (STR# S3-011.r.2 and S3-010). As of January 11, 2011, the western quarter of Grand Isle and a stretch of beach west of the entrance of the State Park has been cleaned to Stage III cleanup standards (see Figure 16). The remainder of the island is still being cleaned. The cleaning still in progress is focusing on the removal of submerged oil mats and supratidal buried oil.

### A.9. Oil Remaining in Sensitive Habitat

The areas where known depositions of oil still remain, although they are presently being removed, are located in sensitive habitat (GeoPlatform website: http://www.geoplatform.gov/gulfresponse/). Supratidal buried oil remains in bird and sea turtle habitat, and among the roots of vegetation. Submerged oil mats overlap with bird and sea turtle habitat, as well as aquatic invertebrate habitat and SSRBs remain in bird and sea turtle habitat. All three types of oil are present in human recreational usage areas.

## B. Petit Bois Island, Mississippi

### B.1. Maximum Oiling of Shorelines

The maximum oiling of Petit Bois Island is presented in Figure 17. Heavy oiling occurred along the majority of the Gulf-facing beaches. Light oiling was reported along the backside of the island and along small stretches of the Gulf-side of the island, between the heavily oiled areas.

### B.2. Maximum Subsurface Oiling

The supratidal and upper intertidal subsurface oiling survey for Petit Bois Island is reported from June 15, 2010, through November 6, 2010. The deepest oil was located in the supratidal zone 85 cm (33.5 inches) below the sand surface (see Table 4). The oil was very light, the sand had partially oil filled pores, and the oil was less than 1 cm (0.4 inch) in thickness. The next deepest layers of oil were between 20 cm (8 inches) and 39 cm (15 inches). These layers were in the upper intertidal and supratidal layers. Oiling was either light or very light and oil thickness was 1 – 2 cm (0.4 – 0.8 inch).

The deepest light oil was found 30 cm (12 inches) below the sand surface, although light oil averaged 13.5 cm (5 inches) below the sand surface and 1.4 cm (0.5 inch) in thickness (see Table 4). Supratidal light oil deposits had a deeper average burial depth and layer thickness than upper intertidal oil.

The distribution of the oil observed in the trenches indicates that there were only three heavy / moderately oiled areas that had a continuous (91 - 100 percent) cover of oil (see Figure 18). Light and very light oil depositions were not distributed in continuous cover. This oiling category was primarily distributed in trace (<1 percent) cover. Seventy five percent of the trenches sampled did not have any oil observed.

### B.3. Shoreline Treatment Recommendations (STRs)

Petit Bois Island is a federally designated wilderness area and part of the Gulf Islands National Seashore operated by the NPS. The Stage III Shoreline Treatment Recommendation (STR) for the southern beaches of Petit Bois Island recommends the manual and mechanical (use of two sifter type beach cleaners towed behind tractors) removal of bulk surface oil and shallow subsurface oiling to a maximum depth of 7.5 cm (3 inches) below the sand (or as otherwise directed by the NPS based on the sensitivity of resources at risk) (STR# MS-3-015 and MS-3-033). No oil is to be removed in the vicinity of plant roots. Presently, NPS is considering the manual removal of heavy and moderate subsurface oiling (below the previously removed 3 inches) to a maximum depth of 91 cm (36 inches) on south facing beaches only. Buried oil deposits 3 mm thick or greater in patchy (10 – 50 percent distribution) or greater would be removed, if approved.

The northern facing beaches of Petit Bois Island are to have the bulk surface oil deposits and the residual balls (5 cm or greater in diameter) manually removed (STR# MS-3-007). Oiled debris is also to be manually removed, but buried oil near vegetation is not to be removed. The no further treatment criteria calls for less than 1 percent surface residue distribution and no residue balls with a diameter greater than 5 cm. Because the northern facing beaches are considered a sensitive habitat, the light subsurface oiling is to be left in place and removed by natural processes.

### B.4. Small Surface Residue Balls (SSRBs)

Small surface residue balls (SSRBs) are a product of mechanical and manual cleaning and sieving of beach sand. The SSRBs are a mixture of sand and oil. Samples of SSRBs collected from Petit Bois Island were primarily sand (91.4 percent sand, 8.6 percent oil by mass) (see Table 1).

The SSRBs are the size of the smallest screen used to sieve the oil deposited on the beach from the sand. Petit Bois Island was cleaned using a Beach Tech 2000 and the largest screen size used was 17 mm (2/3 inch) mesh, therefore, SSRBs are no larger than 17 mm (2/3 inch) on Petit Bois Island (see Table 2). Because SSRBs are a product of beach cleaning, they will remain on the beaches after the beaches are deemed "clean" by SCAT teams.

### B.5. Current Shoreline Condition

Petit Bois Island was cleaned after it was oiled. The majority of Petit Bois Island had trace oil (<1 percent) along the beaches on January 12, 2011 (see Figure 19). The back side of the island had a stretch of beach where no oil was observed. A few beaches along the seaward side of the island and the entire eastern tip of the island had lightly oiled beaches.

Descriptions of the oiled beaches were compiled by the SCAT teams from June 15, 2010, to January 12, 2011, as they surveyed the oiled beaches. The descriptions as of January 12, 2011, are grouped for the lower and mid intertidal zones, upper intertidal zone, and supratidal zone and are summarized below. These descriptions are available through the GeoPlatform website: (http://www.geoplatform.gov/gulfresponse/).

#### B.5.1 Lower and Mid Intertidal Zone

Light oil in the middle intertidal zone had a surface oil residue cover (> 0.1 cm to < 1 cm) in trace (< 1 percent) distribution.

#### B.5.2. Upper Intertidal Zone

Light oil in the upper intertidal zone had surface oil residue cover (> 0.1 cm to < 1 cm) in trace (< 1 percent) and sporadic (1 - 10 percent) distribution. Some of this was weathered oil.

#### B.5.3. Supratidal Zone

Heavy oiling that occurred in the supratidal zone had surface oil residue cover (> 0.1 cm to < 1 cm) in patchy (11 - 50 percent distribution). Light oiling in the supratidal zone had surface oil residue cover (> 0.1 cm to < 1 cm) in continuous (91 - 100 percent) and sporadic (1 – 10 percent) distribution. Some of this oil was weathered. Light to

moderate depositions of tar balls (< 10 cm in diameter) were reported on the southern beaches of the south side of the island.

### B.6. Buried Oil Currently Remaining

Subsurface oil sampling in the supratidal zone indicated that very few locations had remaining buried oil (see Figure 20). There were a few light oiling reports below the sand surface toward the west end on the backside of the island. This oil was buried to a maximum depth of 30 cm (12 inches) (see Figure 21). Supratidal and upper intertidal samples indicated that light oil was buried at several locations along the seaward side of the island. The light oiling generally resulted in partially filled sediment pores. The average maximum depth of oiling was 14.5 cm (5.7 inches) on Petit Bois Island.

Heavy oil was observed buried in the supratidal zone on the eastern seaward end of the island. The sediment had oil filled pores and the oil was buried to a depth 15 cm (6 inches) below the sand surface (see Figure 21). Two locations of moderate oiling were also located in the supratidal zone on the seaward side of the island, just west of center (see Figure 20). The oil filled sediment pores had a continuous (91 – 100 percent) distribution and were buried 60 to 100 cm below the sand surface (see Figure 21).

Supratidal oil collected from Petit Bois Island indicated that the buried oil deposits were composed of a matrix of oil and sand. The deposits of the supratidal buried oil were comprised of 8.9 percent oil (91.1 percent sand) by mass (see Table 1).

### B.7. Submerged Oil Mats

Submerged oil mats were located on the backside of Petit Bois Island and at the eastern end (see Figure 20). Some of the oil mats on the backside of the island are located in submerged aquatic vegetation beds (GeoPlatform website: http://www.geoplatform.gov/gulfresponse/). The oil mat at the eastern tip of Petit Bois Island occurred on a sand flat. Observations indicated that there were surface residual balls (1 - 8 cm in diameter) and patties (30 cm in diameter, 10 – 20 percent coverage) at this location. Samples of subtidal oil mats indicated that the deposits were composed of a matrix of sand and oil. The deposits were 90.6 percent sand (9.4 percent oil) by mass (see Table 1).

### B.8. Current Stage III Shoreline Condition

The SCAT current shoreline conditions were compared to the Stage III STR for Petit Bois Island (STR# MS-3-007; MS-3-015; and MS-3-033). As of January 11, 2011, the majority of Petit Bois Island was cleaned to Stage III cleanup standards (see Figure 22). One stretch of beach on the eastern Gulf-facing shoreline was still being cleaned, which was a heavily oiled area in the supratidal zone (see Figure 20). The oil just west of center of the Gulf-facing beach was buried 60 to 100 cm below the sand, which was below the depth permitted in the STR for oil removal, and therefore remains (see Figure 21).

### B.9. Oil Remaining in Sensitive Habitat

The areas where known depositions of oil still remain, either those that are deeper than STR removal depths or those that are presently being removed, are located in sensitive habitat (GeoPlatform website: http://www.geoplatform.gov/gulfresponse/). Supratidal buried oil remains in bird and sea turtle habitat, and among the roots of vegetation. Submerged oil mats overlap with bird and sea turtle habitat, as well as aquatic invertebrate habitat, and areas of submerged aquatic vegetation. SSRBs remain in bird and sea turtle habitat. All three types of oil are present in human recreational usage areas; however, Petit Bois is accessible only by boat, and therefore, human use of the beaches is much less than those beaches that are accessible by vehicle.

## C. Bon Secour, Alabama

### C.1. Maximum Oiling of Shorelines

A majority of the Gulf-facing beaches at Bon Secour experienced heavy oiling (see Figure 23). One small section of the beach had light oiling. The bayside of Bon Secour was reported to only have trace (< 1 percent) oil deposits or no oil was observed at all.

### C.2. Maximum Subsurface Oiling

Subsurface oiling survey results are reported from June 16 to November 15, 2010, and summarized below. Buried heavy oil was reported in the supratidal and upper intertidal zones at Bon Secour. The sediment in which the oil was buried was described as having oil filled pores and partially filled pores. The bottom of the deepest heavy oiling was 80 cm (31 inches) below the sand surface and the average depth of the bottom of the heavy oiled layer was 46 cm (18 inches) below the sand surface (see Table 5). The oil was 65 cm (25.5 inches) thick at the deepest heavy oiling layer, and averaged 39 cm (15 inches) in thickness.

Buried layers of moderate oil were primarily found in the supratidal and upper intertidal zones. The oil in the sediment resulted in oil filled pores, partially filled pores, and oil residue on the sediment. The bottom of the deepest moderate oil layer was 105 cm (14 inches) below the sediment surface and the average bottom of this layer was 32 cm (12.5 inches) below the sand surface (see Table 5). The thickest moderately oiled layer was 47 cm (18.5 inches) and the average thickness of the moderately oiled layer was 16 cm (6 inches).

Light buried oil was primarily found in the supratidal zone, although some was located in the upper and mid intertidal zones. Light oiling resulted in partially filled sediment pores and oil residue. The bottom of the deepest lightly oiled layer was 86 cm (34 inches) below the sand surface, and the average of the bottom of the lightly oiled layer was 24 cm (9 inches) below the sand surface. The thickest light oil layer was 32 cm (12.5 inches) and the average thickness of the layer is 6 cm (2.5 inches) (see Table 5).

Very light oil was buried primarily in the supratidal zone, with some in the upper and middle intertidal zone. The sediment surrounding this oil had partially filled pores, oil residue, and oil film. The bottom of the deepest very light oil was 82 cm (32 inches) below the sand surface and the average depth was 20 cm (8 inches) below the sea surface. The thickest very light oil layer was 21 cm (8 inches) and the average layer was 4 cm (1.5 inches) thick (see Table 5).

Trenches dug on beaches at Bon Secour indicated that in 475 of the trenches that were sampled, no oil was observed (see Figure 24). A total of 45 trenches out of 1,660 had heavy / to moderate oiling, two of which had continuous (91 – 100 percent) oil distribution. Most of the heavy / moderate trenches had patchy (11 – 50 percent) and broken (51 – 90 percent) distribution. Light and very lightly oiled trenches primarily had sporadic (1 – 10 percent) and patchy (11 – 50 percent) coverage of oil.

### C.3. Shoreline Treatment Recommendations (STRs)

Bon Secour has both amenity beaches and a USFWS National Wildlife Refuge. Specific Shoreline Treatment Recommendations (STRs) were adapted for the sensitive habitat of the wildlife refuge (STR# AL-3-020a; AL-3-023a; and AL-3-035). Mechanical and chemical removal of oil was not authorized at USFWS beaches on Bon Secour. Manual removal of mousse mats, balls, and patties was recommended, followed by sifting of the material through small mesh (that allow sand to pass but not large amounts of oil) screens and natural attenuation of the remainder of the oil. Machines, such as the Beach Tech or Sand Shark, with small screens may be used to supplement manual removal if permitted by the USFWS. Treatment should continue until the amount of non-oiled material exceeds the amount of oiled material removed. Manual crews may follow the machines. The goal is to have less than 1 percent surface distribution of oil remaining on the beach. Oiled debris is also to be removed. No cleanup is permitted in vegetated dune areas because that is the habitat for the endangered Alabama beach mouse.

Areas with subsurface oil that exceeded the cleanup criteria on USFWS beaches may have manual removal of the “hot spots,” mechanical excavation to required depth, side casting of clean material to remove subsurface oil, or tilling / plowing to expose subsurface oil for manual removal (if these techniques are permitted by the USFWS). Subsurface oil that exceeded cleanup criteria will be removed to its depth of penetration, except for oil near plant roots, which will remain untouched. Stained supratidal sands may be wet tilled, raked, relocated, or surf washed to allow for natural attenuation in the surf zone.

The surface and subsurface sand of the amenity beaches at Bon Secour are to be cleaned until there is no visible oil above background levels (STR# AL-3-032a; and AL-3-023a). These beaches require a high degree of treatment, but clean sand removal is to be minimized. Both mechanical and manual techniques are approved for the amenity beaches at Bon Secour. Submerged oil in the intertidal zone, surf zone, and nearshore subtidal zone are to be removed with shovels and nets and hand sifted. Some mechanical

operations may be approved for the intertidal zone. Supratidal oil is to be removed with manual and mechanical techniques and then the sieved sand is to be raked over the beach for natural attenuation. All subsurface oil is to be removed to the depth of oiling through manual or mechanical methods, except in areas near plant roots.

Mechanical equipment is permitted for the removal of oil mats near the waterline on both USFWS and amenity beaches. A tracked backhoe or loader equipped with a bucket lined with a mesh that would allow for the sand and water to return to the beach during the removal process should be used.

### C.4. Small Surface Residue Balls (SSRBs)

Small surface residue balls (SSRBs) are a product of mechanical and manual cleaning and sieving of beach sand. The SSRBs are composed of sand and oil. Samples of SSRBs collected from Bon Secour were primarily sand (92.6 percent sand, 7.4 percent oil by mass) (see Table 1).

The SSRBs are the size of the smallest screen used to sieve the oil deposited on the beach from the sand. The hand screens used on the USFWS beaches were of a small enough size where more oil than sand remained on the screen. Any location where beach machines were permitted to clean the USFWS beaches, SSRBs may be present in the range of 3 mm (1/8 inch) to 17 mm (2/3 inch) (see Table 2). Leeboy Sandsharks typically use a screen size of 3 mm (1/8 inch) and Beach Tech 2000 typically use 6 mm (1/4 inch) and 17 mm (2/3 inch) screen sizes.

The amenity beaches were cleaned with Beach Tech 2000 using a screen size of 6 mm (1/4 inch) and Leeboy Sandsharks with a screen size of 3 mm (1/8 inch) (see Table 2). Amenity beaches, therefore, may have SSRBs in the range of 3 to 6 mm (1/8 to 1/4 inch) in diameter. However, because the STR recommends that screen size be sequentially decreased to reduce size of remnants of oil on the beaches, there may be more 3 mm (1/8 inch) than 6 mm (1/4 inch) SSRBs left on the beaches. Because SSRBs are a product of beach cleaning, they will remain on the beaches after the beaches are deemed “clean.”

### C.5. Current Shoreline Condition

The majority of the backside of the beaches on Bon Secour did not have any oil reported by the SCAT teams as of January 11, 2010 (see Figure 25). There were two small sections of beach that had trace (<1 percent) oil reported by the SCAT teams. The majority of the beaches facing the Gulf of Mexico had trace (<1 percent) oil reported by the SCAT teams as of January 12, 2010. This trace remainder of oil was the SSRBs that were left on the beach after the sand was sieved during the cleaning of the beaches. A few stretches of beach still had light oiling (see Figure 25). These stretches, from west to east, were between: Anderson Street and midway between Vacation Lane and Pontoon Lane; between Surfside Drive and Kiva Way; between Mobile Street to south of Gator Lake and the Bon Secour National Wildlife Refuge; south of the end of Pine Beach Road; and from Starfish Lane to approximately 2 km east of that road. Maps showing the

locations of oil remaining on these beaches in relation to these landmarks are available through the GeoPlatform website: (http://www.geoplatform.gov/gulfresponse/).

Descriptions of the oiled beaches were compiled by the SCAT teams from June 14, 2010, to January 12, 2011, as they surveyed the oiled beaches. The descriptions as of January 12, 2011, are grouped for the lower and mid intertidal zones, upper intertidal zone, and supratidal zone and are summarized below. These descriptions are available through the GeoPlatform website: (http://www.geoplatform.gov/gulfresponse/).

### C.5.1. Lower and Mid Intertidal Zones

A light surface residue oil or mousse cover (> 0.1 cm to < 1 cm) was present in the mid-interidal zone in trace (< 1 percent) distribution. There were also some tar balls in trace (< 1 percent) distribution.

### C.5.2. Upper Intertidal Zone

There was a light surface residue cover of oil or mousse (> 0.1 cm to < 1 cm) in trace (< 1 percent) to sporadic (1 – 10 percent) cover. Some of this oil was weathered. There was also moderate tar ball deposition in trace (< 1 percent) to sporadic (1 – 10 percent) cover.

### C.5.3. Supratidal Zone

There was a light to moderate surface residue cover (> 0.1 cm to < 1 cm) of oil or mousse in trace (< 1 percent) to sporadic (1 – 10 percent) cover. Much of this oil was weathered. There was also light to moderate tar balls in trace (< 1 percent) distribution and heavy weathered tar balls and mousse distributed in trace (< 1 percent) cover on the beach.

## C.6. Buried Oil Currently Remaining

Heavy and moderate buried oil still remains at several locations in the supratidal and upper intertidal zone at Bon Secour (see Figure 26). Concentrations of heavy and moderate buried oil occurring from west to east were: between Pontoon Lane and Privateer Court, Our Road to Gulfway Drive, Beach Club Trail to Martinique Boulevard, south of Ewing Bayou to south of Twin Pines Circle. Light and very light oil was found in trenches along the remainder of the beach. Maps showing the locations of oil remaining on these beaches in relation to these landmarks are available through the GeoPlatform website: (http://www.geoplatform.gov/gulfresponse/).

The deepest buried oil was in the range of 60 - 100 cm below the sand surface (see Figure 27). The majority of the oil, however, was not buried below 60 cm (24 inches). Overall, the heaviest oil deposits were among the deepest buried (see Figures 26 and 27). Supratidal oil collected from Bon Secour indicated that the buried oil deposits were composed of a matrix of oil and sand. The deposits of the supratidal buried oil were 6.5 percent oil (93.5 percent sand) by mass (see Table 1).

### C.7. Submerged Oil Mats

Several submerged oil mats have been located off Bon Secour, none of which have been removed yet (see Figure 26). Subtidal oil samples indicated that these deposits were composed of sand with some oil. The subtidal oil mats were comprised of 89.3 percent sand (10.7 percent oil) by mass (see Table 1). The oil mats are described here from west to east (see Figure 26) and details can be seen on the GeoPlatform website (http://www.geoplatform.gov/gulfresponse/). A moderate submerged oil mat was located 8.5 km from the western tip of Bon Secour. The mat was 15 cm below the sand surface and 10 cm thick. Two moderate submerged oil mats were located south of Plantation Road 20 cm below the sand surface. One mat was 5 – 10 cm thick and the other was 10 – 12 cm thick.

The following submerged oil mats were located on USFWS beaches (see Figure 26). A 10 cm thick light oil mat was located just east of Marigot Promenade 25 cm below the sand surface. Two large oil mats were located near Petty Lane / Moblie Street, one to the west and one to the east. The western oil mat was light to heavy and 2 – 15 cm thick. This mat was buried between 5 and 35 cm below the sand surface. The eastern oil mat was light to heavy, 10 - 15 cm thick, and 25 – 35 cm below the sand surface. Tar balls, which broke off the submerged oil mats, have also been reported on the beach in this area. This area also coincides with locations where supratidal oil was buried deepest (see Figure 27). Two small oil mats were located to the west and east of the eastern end of Pine Beach Road. The western oil mat ranged from light to heavy, had a thickness of 5 – 10 cm, and was buried 25 – 35 cm below the sand surface. The eastern submerged oil mat was moderate to heavy, 5 – 10 cm thick, and buried 25 – 35 cm below the sand surface (GeoPlatform website: http://www.geoplatform.gov/gulfresponse/).

Three submerged oil mats were present along West Beach Boulevard, on the eastern end of Bon Secour (see Figure 26). The western most oil mat ranged from light to heavy, was 5 cm thick, and 25 cm below the sand surface. The middle submerged oil mat was light to heavy, 2 – 10 cm thick, and 25 – 30 cm below the sand surface. The eastern submerged oil mat was medium to heavy, 10 - 20 cm thick, and 15 – 25 cm below the sand surface (GeoPlatform website: http://www.geoplatform.gov/gulfresponse/). This oil mat also coincides with a location of heavy, deeply buried supratidal oil (see Figures 26 and 27).

### C.8. Current Stage III Shoreline Condition

The SCAT observations were compared to the shoreline treatment recommendations for Bon Secour to determine if further work was required along the beaches (STR# AL-3-020a; AL-3-023a; AL-3-032a; and AL-3-035). As of January 11, 2011, the majority of Bon Secour had cleanup in progress or cleanup work was still required according to Stage III cleanup standards (see Figure 28). The areas that still required work or where work was still in progress were areas where there was heavy to moderate buried supratidal oil and submerged oil mats (see Figures 26 and 28). The long stretch of beach where work is in progress is within the USFWS National Wildlife Refuge (where only manual removal

of oil is permitted and large submerged oil mats were present). The remainder of the beaches where work is required is on amenity beaches that are in need of deep cleaning to remove all oil above background concentrations to the depth of penetration. There are also submerged oil mats in these locations.

### C.9. Oil Remaining in Sensitive Habitat

The areas where known depositions of oil still remain, although they are presently being removed, are located in sensitive habitat (GeoPlatform website: http://www.geoplatform.gov/gulfresponse/). Supratidal buried oil remains in bird, sea turtle, and Alabama beach mouse habitat, and among the roots of vegetation. Submerged oil mats overlap with bird and sea turtle habitat, as well as aquatic invertebrate habitat. SSRBs remain in bird, sea turtle, and Alabama beach mouse habitat. All three types of oil are present in human recreational usage areas.

## D. Fort Pickens, Florida

### D.1. Maximum Oiling of Shorelines

Fort Pickens received heavy oiling on a majority of the Gulf-facing beaches (see Figure 29). There was one small section of the beach that had light oiling. The backside of Fort Pickens primarily experienced light oiling, with a few locations where heavy, trace, or no oil was observed.

### D.2. Maximum Subsurface Oiling

Subsurface oiling survey results are reported from June 13 to November 15, 2010, and summarized below. There were only two locations on Fort Pickens where heavy oil was observed, one location in the upper intertidal zone and one location in the middle intertidal zone. Both locations had oil between 5 cm (2 inches) and 20 cm (8 inches) below the sand surface and the sand was described as having oil filled pores (see Table 6).

Moderate oiling was described in the middle and upper intertidal zones and the supratidal zone. All of these locations had oil filled pores. The deepest occurrence of oil was in the supratidal zone and reached to 45 cm (18 inches) below the sand surface. The average moderate oiling depth was 16 cm (6 inches) below the sand surface. The thickest deposit of oil (25 cm; 10 inches) occurred at the location where the oil penetrated the deepest. However, the average thickness of oiling was 2.8 cm (1 inch) (see Table 6).

Light oiling was primarily found in the supratidal zone where the sediment had partially filled pores and oil residue. The deepest oil penetration was 72 cm (28 inches) below the sand surface and the average depth of oiling was 26 cm (10 inches). The maximum thickness of light oil was 25 cm (10 inches), but the average thickness was 6 cm (2.5 inches) (see Table 6).

Very light oil in the supratidal zone resulted in partially filled pores and oil residue. The deepest penetration of very light oil was 48 cm (19 inches), however, this oil averaged a depth of 19 cm (7.5 inches). The thickest very light oil layer was 20 cm (8 inches), and it averaged 5 cm (2 inches) in thickness (see Table 6).

Trenches dug on Fort Pickens beaches indicated that in 536 of the trenches sampled, no heavy or moderate oiling was observed (see Figure 30). These data indicate that all of the located buried heavy and moderately oiled areas were removed as of September 5, 2010. Light and very lightly oiled trenches primarily were distributed in trace (< 1 percent) to patchy (11 – 50 percent) oil coverage. Seventy six percent of the trenches sampled did not reveal oil.

### D.3. Shoreline Treatment Recommendations (STRs)

Fort Pickens is part of the Gulf Islands National Seashore (GUIS) operated by the NPS. The Stage III cleanup standards for the NPS (non-amenity) beaches are: less than 1 percent surface oil and oiled debris and no surface residual balls greater than 2.5 cm (1 inch) in diameter. Subsurface oil removal is not recommended for the NPS beaches and subsurface removal near all plant roots are to be avoided (STR# FL-3-019).

Residual oil in the non-vegetated supratidal zone for the non-amenity beaches should be manually removed, although supplemental machines may be used if permitted by the NPS. If mechanical sifters are used, a screen size of no less than 6 mm may be used and the equipment may not be operated any deeper than 6 inches below the sand surface. Manual crews following mechanical cleanup or working separately will clean the beach until oil remains on less than 1 percent of surface cover and residual balls are no larger than 2.5 cm. No subsurface oil removal is permitted (STR# FL-3-019).

Fort Pickens also has amenity beaches. The Stage III cleanup standards for amenity beaches are: no visible surface oil above background levels, no oiled debris, and no visible subsurface oil above background levels, except in areas with vegetation, where buried oil is to remain in order to prevent damage to plant roots. Mechanical sand sifters are permitted on amenity beaches, but the screen size must be no smaller than 6 mm and they may not be operated to a depth beyond 18 inches (STR# FL-3-019).

### D.4. Small Surface Residue Balls (SSRBs)

Small surface residue balls (SSRBs) are a product of mechanical and manual cleaning and sieving of beach sand. The SSRBs are composed of sand and oil. Samples of SSRBs collected from Fort Pickens were primarily sand (95.8 percent sand, 4.2 percent oil, by mass) (see Table 1).

The SSRBs are the size of the smallest screen used to sieve the oil deposited on the beach from the sand. The smallest screen size permitted at Fort Pickens was 6 mm (1/4 inch), and therefore, SSRBs may be 6 mm (1/4 inch) in diameter at Fort Pickens. Because

SSRBs are a product of beach cleaning, they will remain on the beaches after the beaches are deemed "clean."

SSRBs that have been reported at Fort Pickens in areas where "No Further Treatment" was recommended (SCAT verified the beach was cleaned to the STR) averaged 14 SSRBs per meter (1,361 per 100 m or 8,459 per mile). Considering that the average width of beach surveyed was 9.3 m, there was an estimated 1.5 SSRBs left per square meter of beach. The SSRBs averaged 0.5 cm (0.2 inch), which is concurrent with the smallest screen size permitted for use at Fort Pickens.

### D.5. Current Shoreline Conditions

Fort Pickens had primarily trace oil (<1 percent) remaining on the beaches (SSRBs) after the cleaning process was completed (see Figure 31). There were also a few stretches of beach at the west end and on the backside of the peninsula where no oil was observed by the SCAT teams.

Descriptions of the oiled beaches were compiled by the SCAT teams from June 13, 2010, to January 12, 2011, as they surveyed the oiled beaches. The descriptions as of January 12, 2011, are grouped for the lower and mid intertidal zones, upper intertidal zone, and supratidal zone and are summarized below. These descriptions are available through the GeoPlatform website: (http://www.geoplatform.gov/gulfresponse/).

#### D.5.1. Lower and Mid Intertidal Zones

The middle intertidal zone had a few heavy to moderately oiled locations with oil filled pores.

#### D.5.2. Upper Intertidal Zone

The upper intertidal zone had a few heavy to moderately oiled locations with oil filled pores. There were also some lightly oiled locations with partially filled pores in a patchy (11 – 50 percent) distribution.

#### D.5.3. Supratidal Zone

The supratidal zone had very light oil residue to partially filled pores with trace (< 1 percent) to sporadic (< 1 – 10 percent) oil distribution. There was also light oil residue to partially filled pores in a trace (< 1 percent) to broken (51 – 90 percent) distribution. One trench had light oil that had a continuous (91 – 100 percent) distribution resulting in partially filled pores. There was also some buried sediment with moderate oil residue to oil filled pores found in the supratidal zone.

### D.6. Buried Oil Currently Remaining

Several locations of moderate oiling occurred in the supratidal and middle to upper intertidal zone along the entire beach at Fort Pickens (see Figure 32). Oil was buried deepest in the supratidal zone. The deepest buried oil was in the range of 60 - 100 cm (24 – 39 inches) below the sand surface (see Figure 33). The majority of the oil, however, was not buried below 30 cm (12 inches). Overall, the heaviest oil deposits were amongst the deepest buried (see Figures 32 and 33). Supratidal oil collected from Fort Pickens indicated that the buried oil deposits were composed of a mixture of oil and sand. The deposits of the supratidal buried oil were 3.2 percent oil (96.8 percent sand) by mass (see Table 1).

### D.7. Submerged Oil Mats

No submerged oil mats were reported in the area of interest at Fort Pickens (see Figure 32). However, tar balls have washed up on the beach to the east of the case study area. Subtidal oil and tar balls from the eastern subtidal oil indicated that the deposits were composed of sand and oil. The deposits were 90.0 percent sand (10.0 percent oil) by mass (see Table 1).

### D.8. Current Stage III Shoreline Conditions

The amenity beaches at Fort Pickens are those where work is still in progress (see Figure 34). The amenity beaches have a shoreline treatment recommendation that calls for no visible surface oil above background levels, no oiled debris, and no visible subsurface oil above background levels, to a maximum depth of 18 inches below the sand surface. The removal of the subsurface oil is still in progress (STR# FL-3-019).

The non-amenity NPS beaches have been verified by SCAT teams as cleaned to the STR, which does not allow subsurface oil removal and only permits bulk oil removal to a depth of 6 inches below the sand surface. Therefore, there may be oil present below the cleaned surface 6 inches, but this oil is to remain in place according to the STR (STR# FL-3-019).

### D.9. Oil Remaining in Sensitive Habitat

The areas where known depositions of oil still remain, either those that are deeper than STR removal depths or those that are presently being removed, are located in sensitive habitat (GeoPlatform website: http://www.geoplatform.gov/gulfresponse/). Supratidal buried oil remains in bird and sea turtle habitat, and among the roots of vegetation. Submerged oil mats overlap with bird and sea turtle habitat, as well as aquatic invertebrate habitat and SSRBs remain in bird and sea turtle habitat. All three types of oil are present in human recreational usage areas.

## V. Anticipated Routes of Exposure of Oil to Organisms

The buried oil remaining on the beaches may impact nesting turtles if they lay their eggs in areas where oil is buried below the sand surface. If the buried oil becomes exposed with changes in the beach profile, driven by storms, it may impact nesting or feeding birds through egg contact or ingestion. Oil that becomes unburied may also impact humans who utilize the beach recreationally with potential exposure occurring through dermal contact or ingestion. Submerged oil mats are not anticipated to impact sea turtles or birds because neither of these groups of organisms nest or feed in the nearshore surf zone. The submerged oil mats, however, may impact aquatic invertebrates through physical and chemical exposure and may impact humans through dermal contact. Incidences of exposure to SSRBs may include ingestion by foraging birds and dermal contact and ingestion by humans utilizing a beach. The anticipated impacts of the remaining oil on the beaches (based on available data and literature searches) was used in a Net Environmental Benefit Analysis (NEBA) to determine if the remaining oil on the NPS and USFWS beaches should be cleaned up or left in place to naturally attenuate.

## VI. References

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STR# AL-3-023a. October 20, 2010. Ft. Morgan to Gulf S.

STR# AL-3-032a. October 27, 2010. Ft. Morgan – Amenity.

STR# AL-3-035. October 20, 2010. Bon Secour National.

STR# FL-3-019. October 23, 2010. Fort Pickens GUIS.

**FIGURES**

**TABLES**

**and**

**ATTACHMENTS**

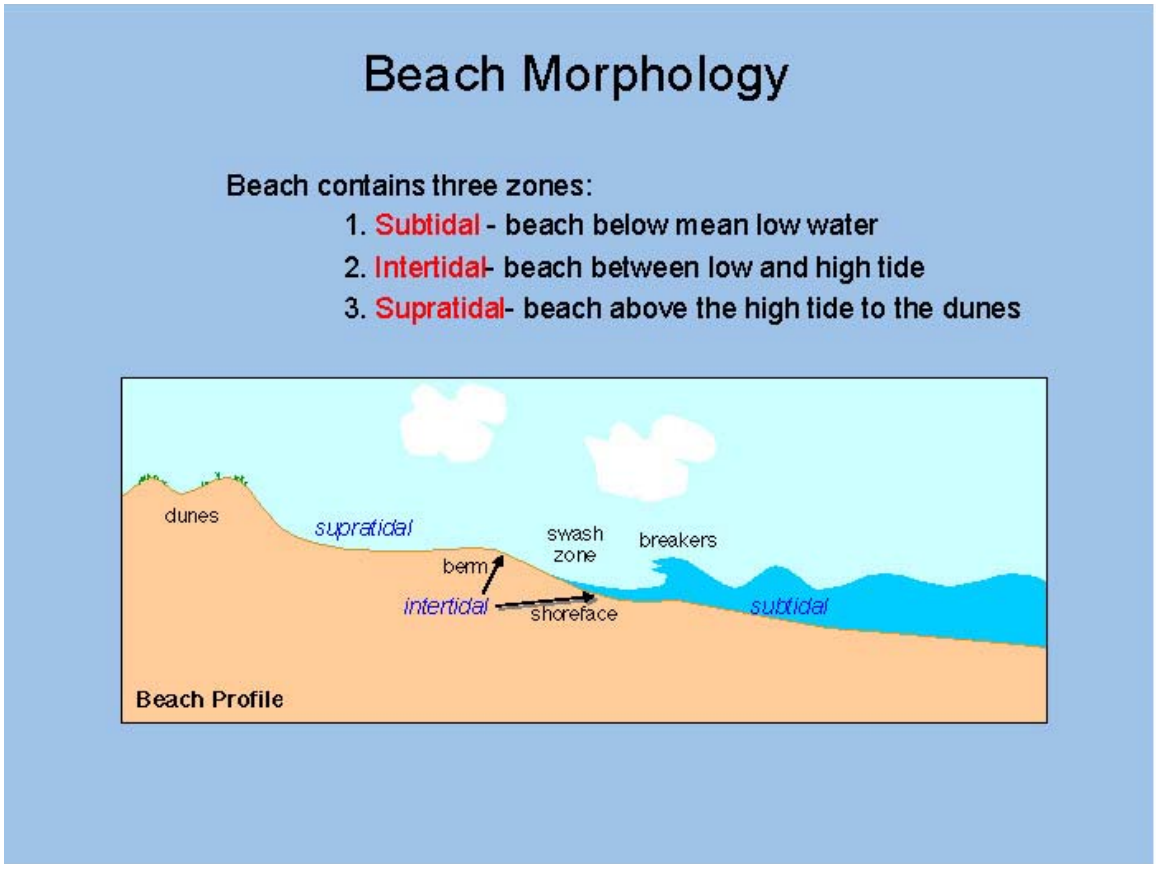


Figure 1. Shoreline zones (J. Michel, Research Planning Inc., pers. comm., 2010).

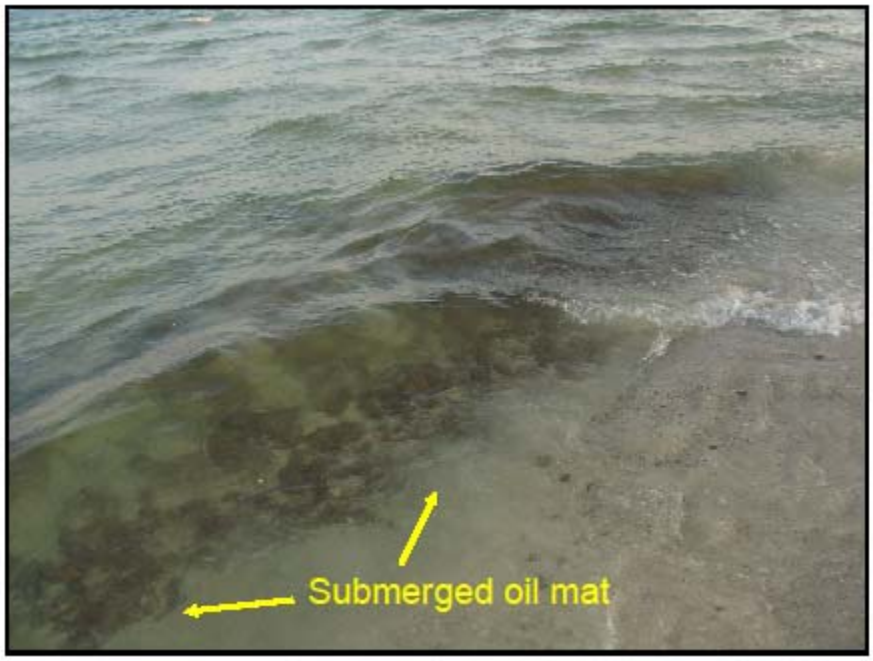


Figure 2. Submerged oil mat.

Figure 3. Small Surface Residue Balls (SSRBs); a product of beach cleaning.

Figure 4. Supratial buried oil that is buried and exposed with changes in beach profile.

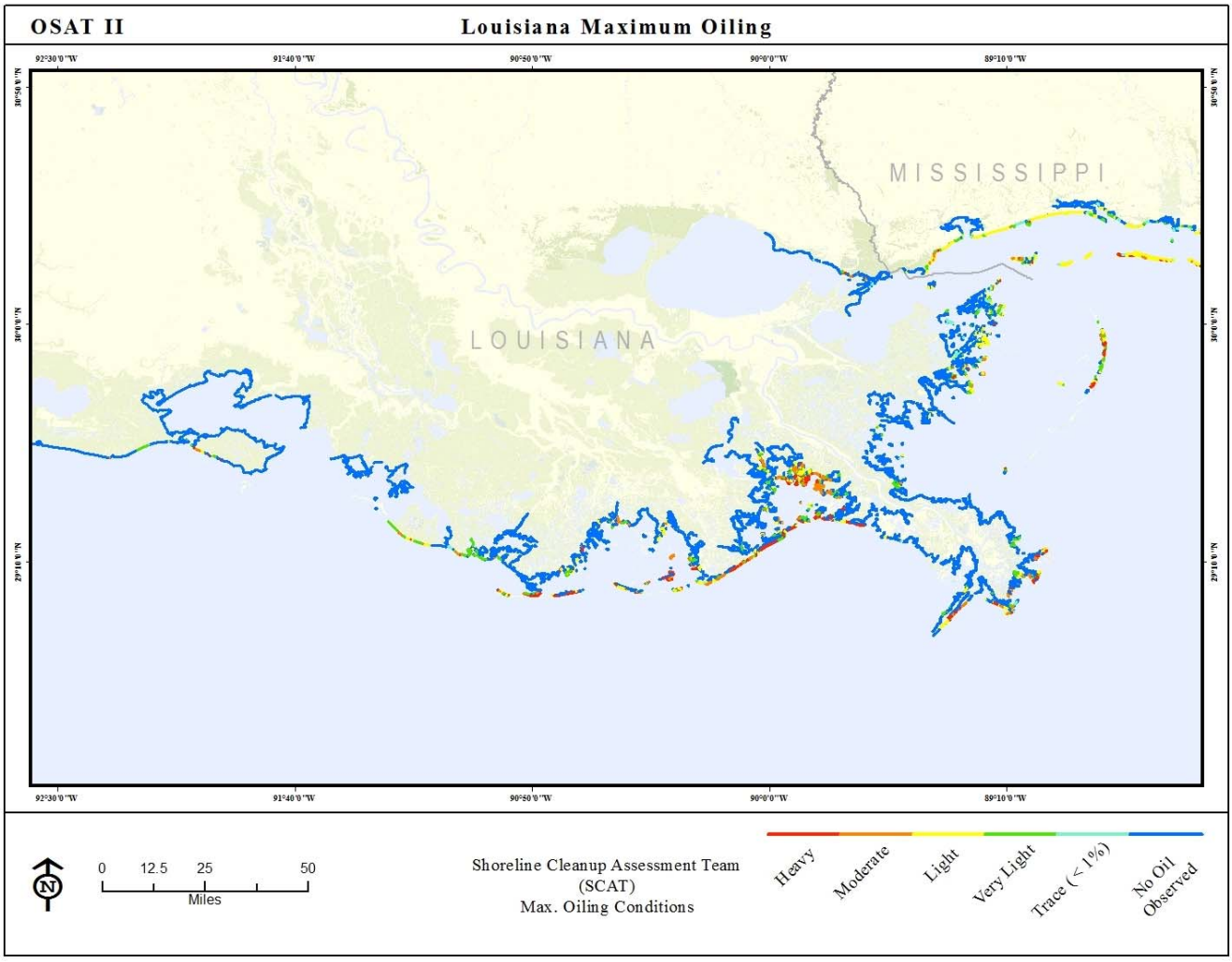


Figure 5. Maximum oiling of Louisiana beaches.

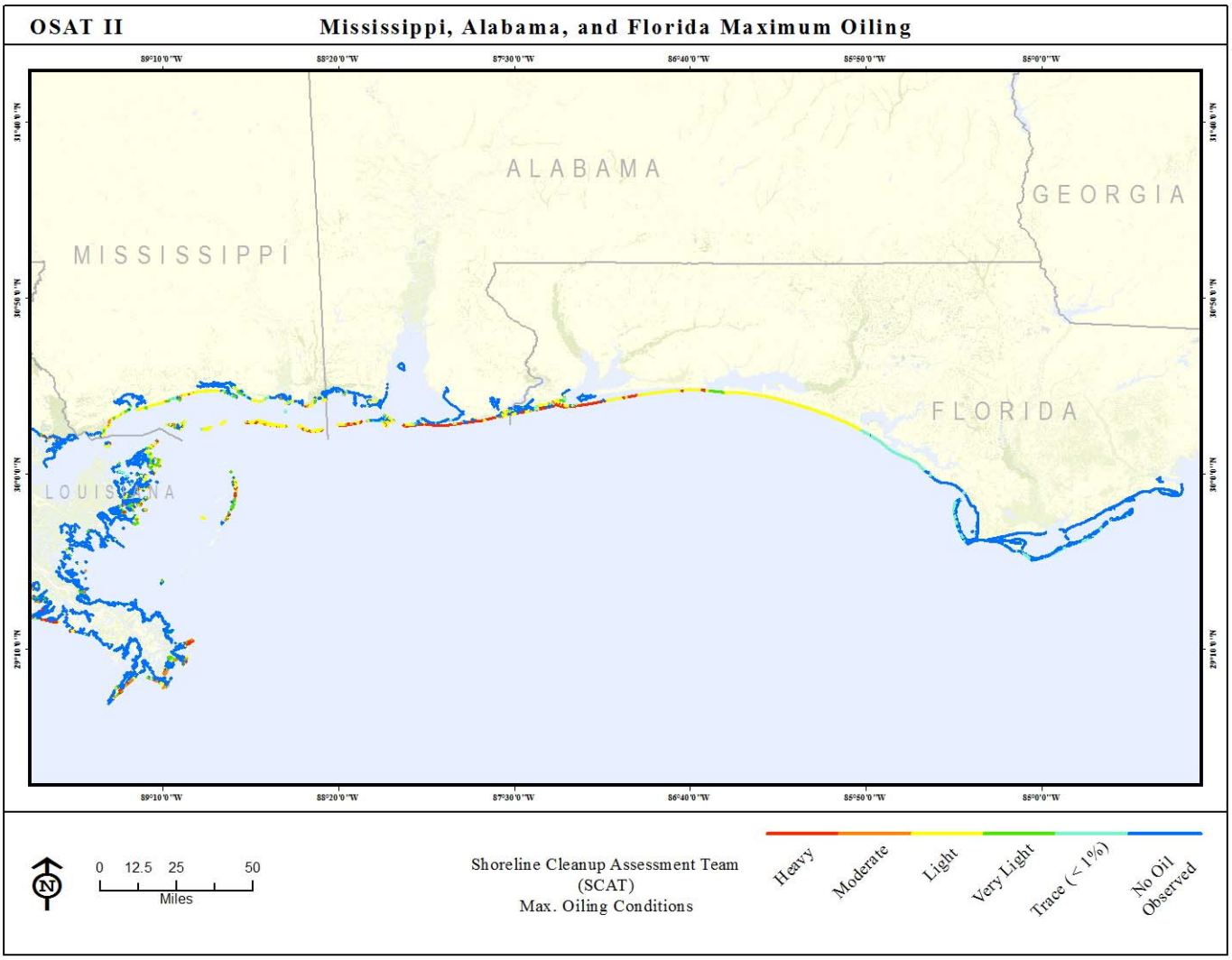


Figure 6. Maximum oiling of Mississippi, Alabama, and Florida beaches.

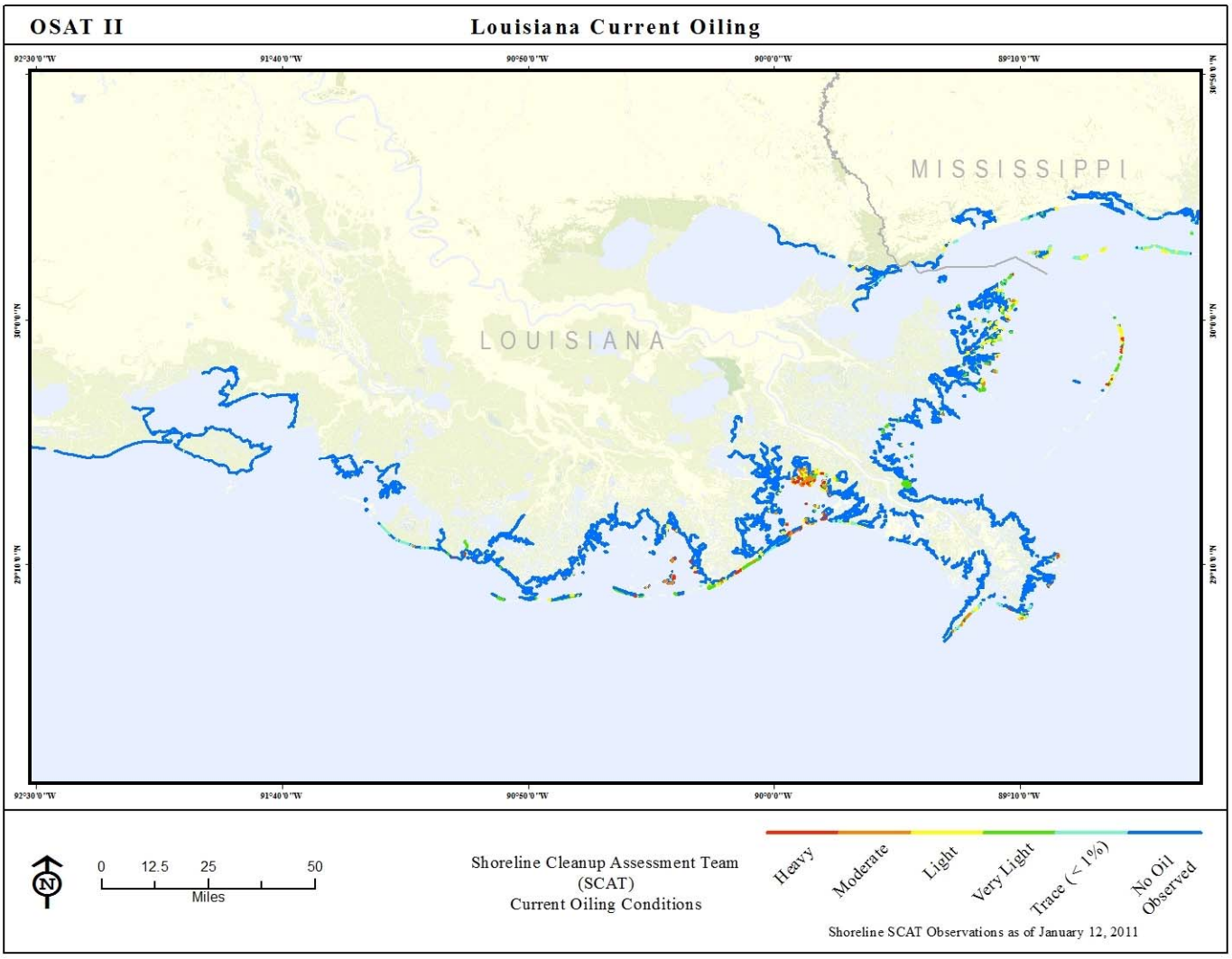


Figure 7. Current shoreline SCAT observations on Louisiana beaches. January 12, 2011.

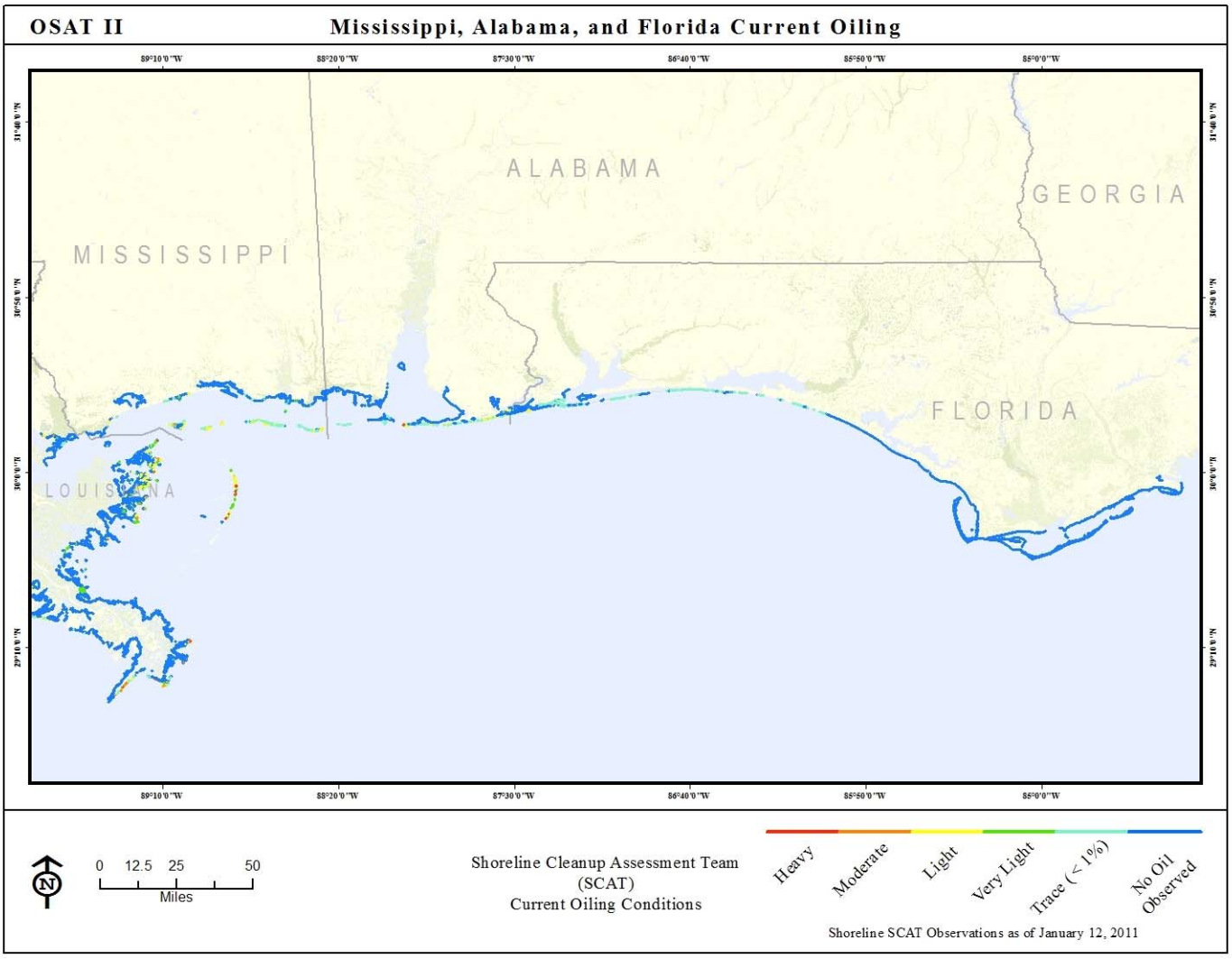


Figure 8. Current shoreline SCAT observations on Mississippi, Alabama, and Florida beaches. January 12, 2011.

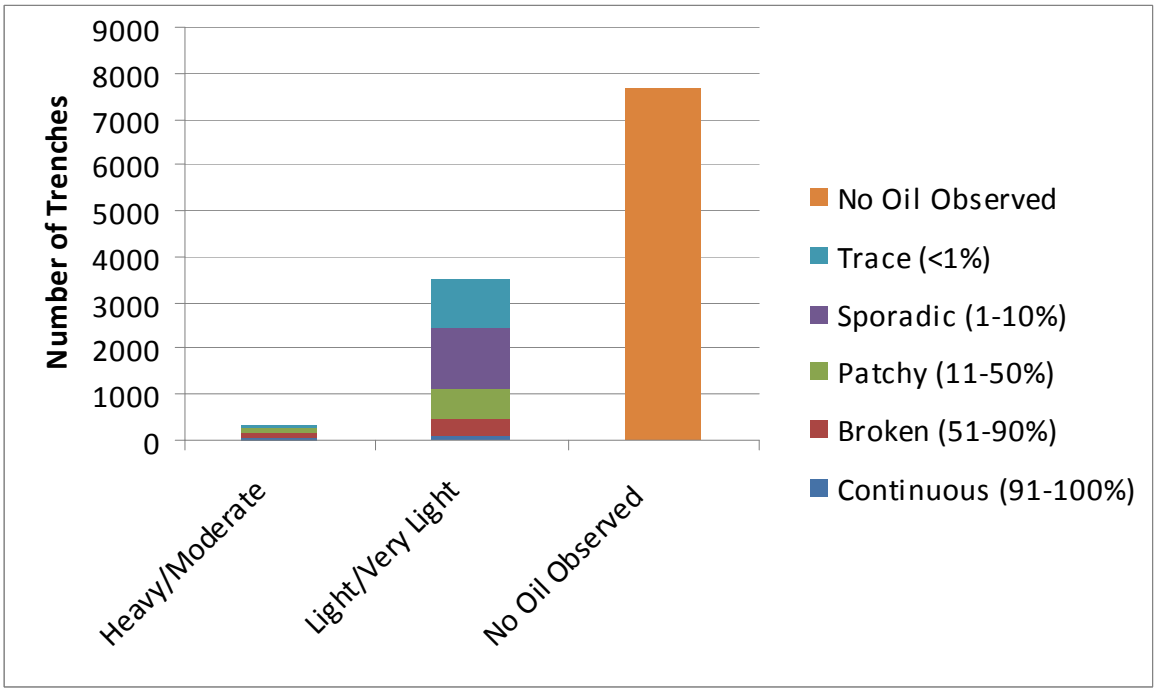


Figure 9. Distribution of oil in all trenches.

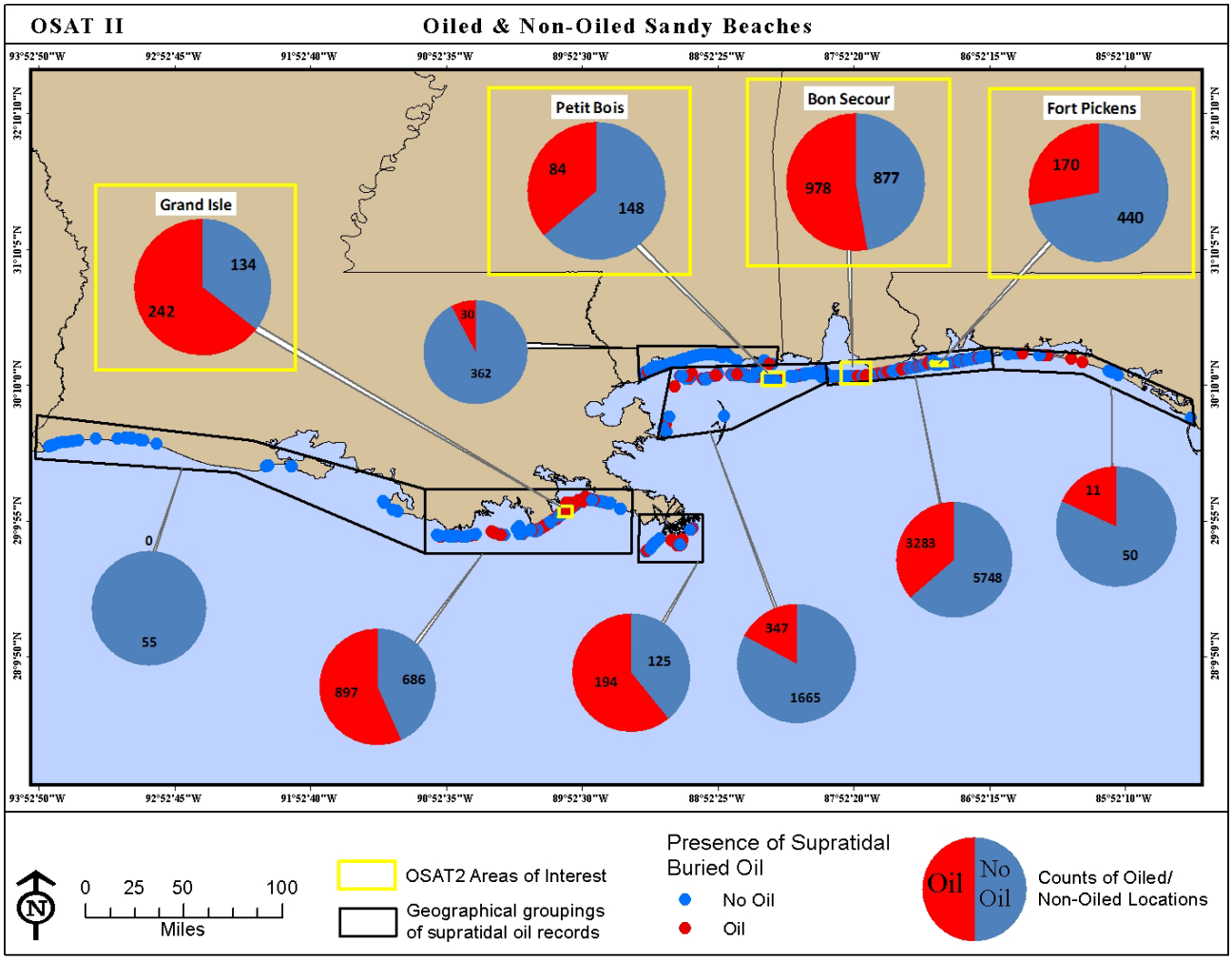


Figure 10. Location of four case study beaches from west to east: Grand Isle, Louisiana; Petit Bois Island, Mississippi; Bon Secour, Alabama; and Fort Pickens, Florida showing the number of oiled and non-oiled sandy beaches.

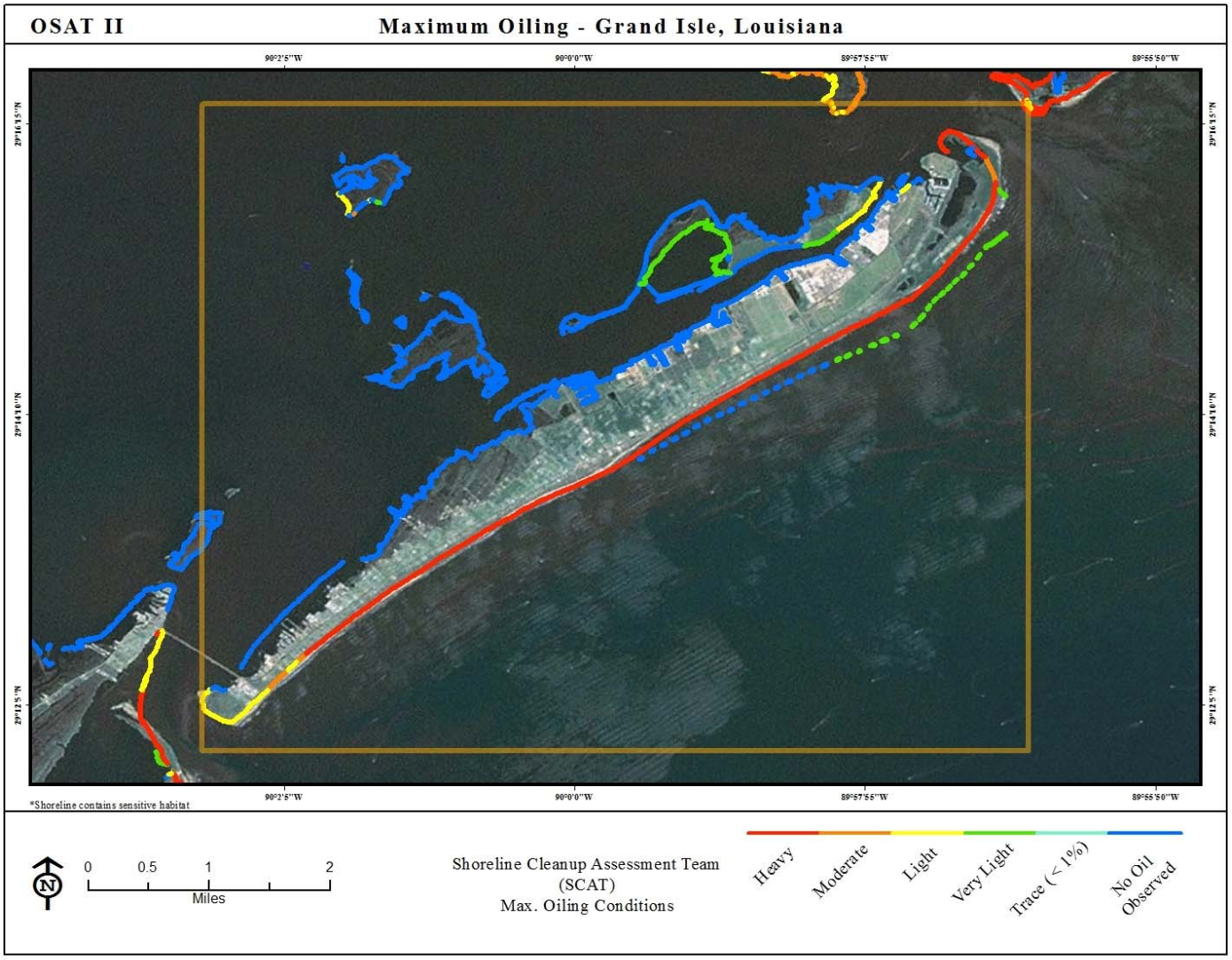


Figure 11. Maximum oiling of Grand Isle.

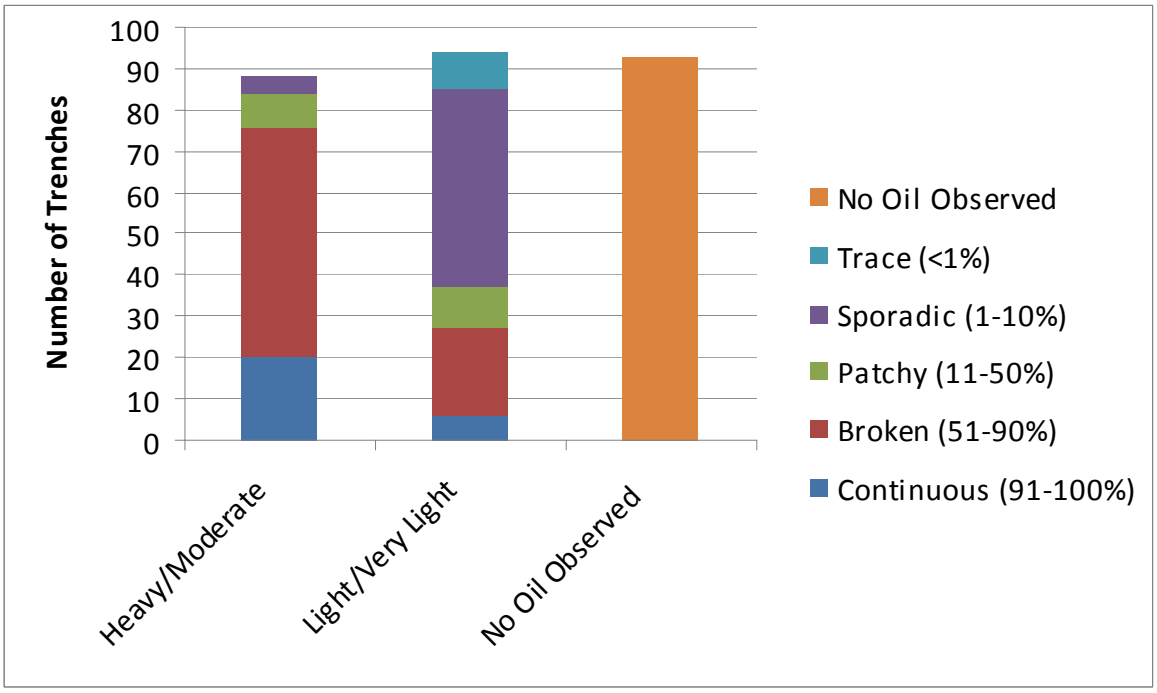


Figure 12. Distribution of oil in trenches from beaches on Grand Isle.

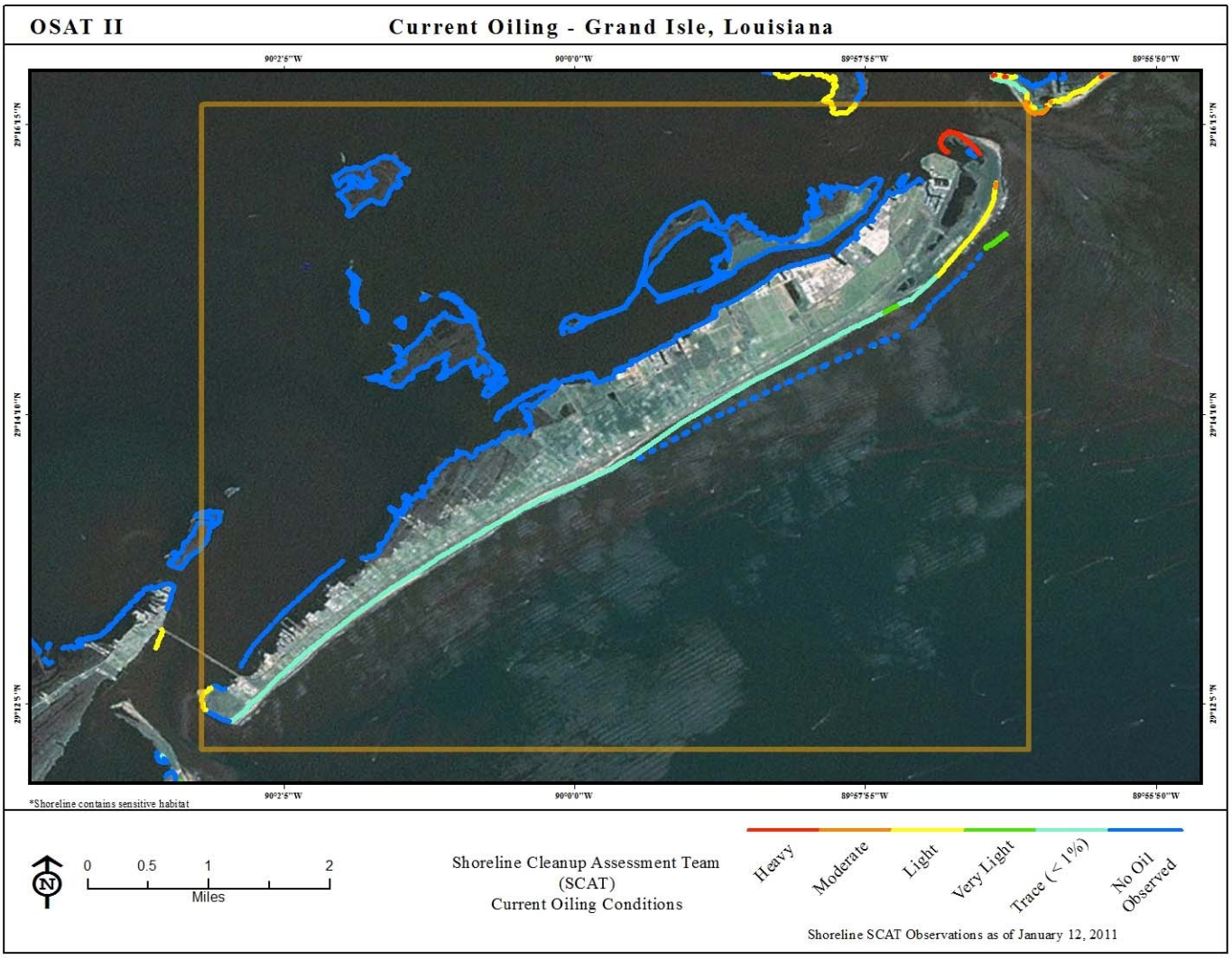


Figure 13. Current shoreline SCAT observations on Grand Isle. January 12, 2011.

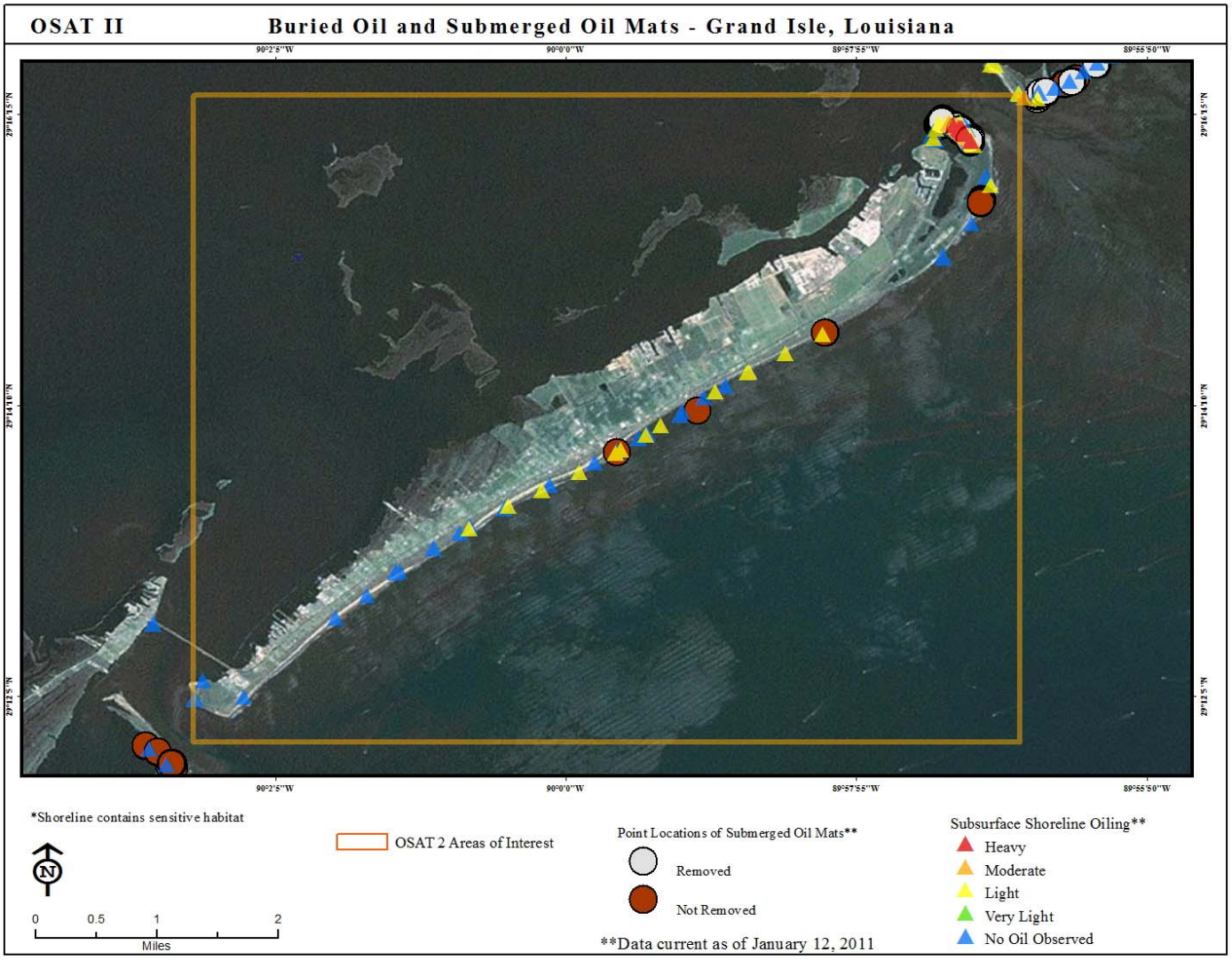


Figure 14. Buried oil locations and submerged oil mats on Grand Isle. January 12, 2011.

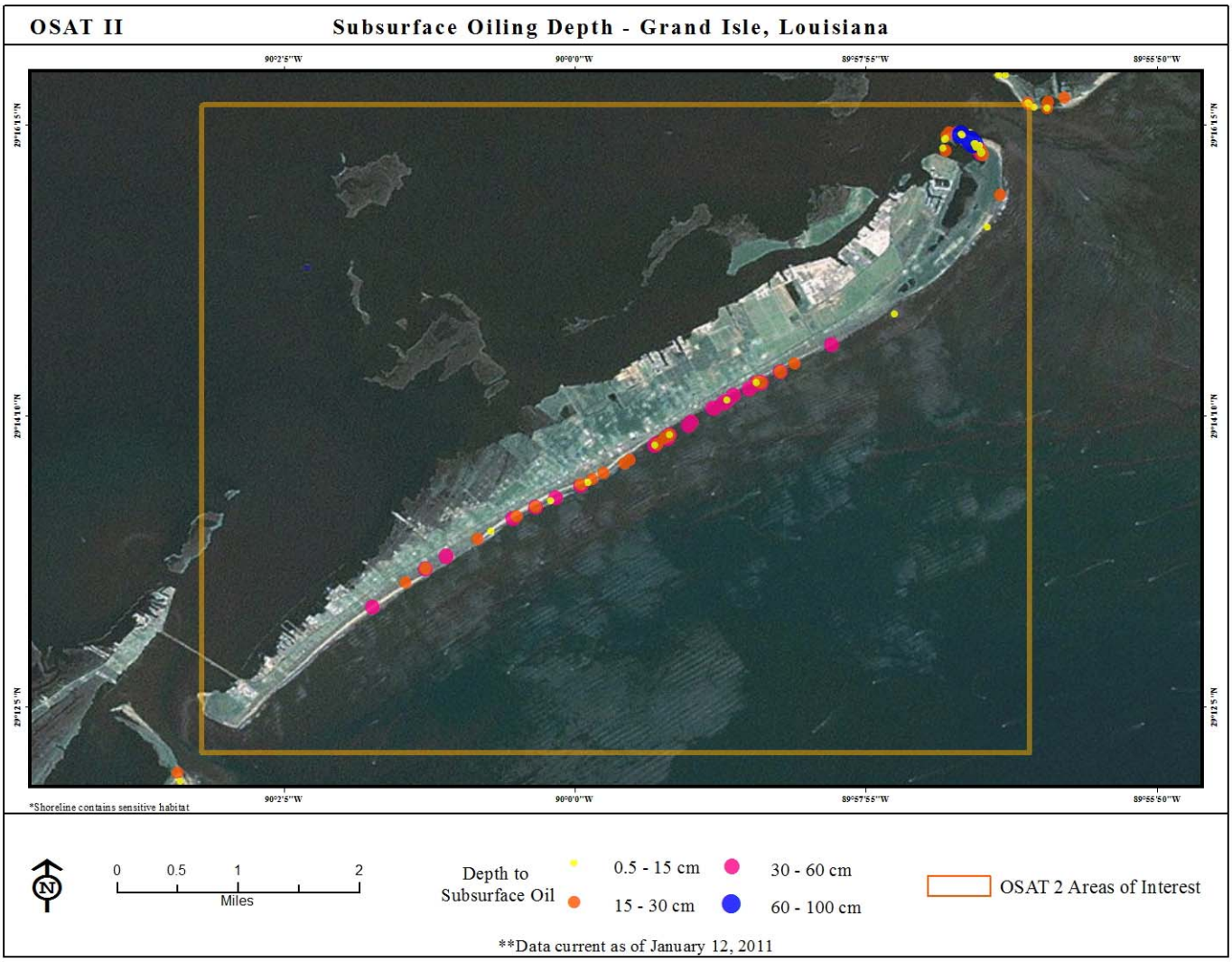


Figure 15. Buried oil depth on Grand Isle. January 12, 2011.

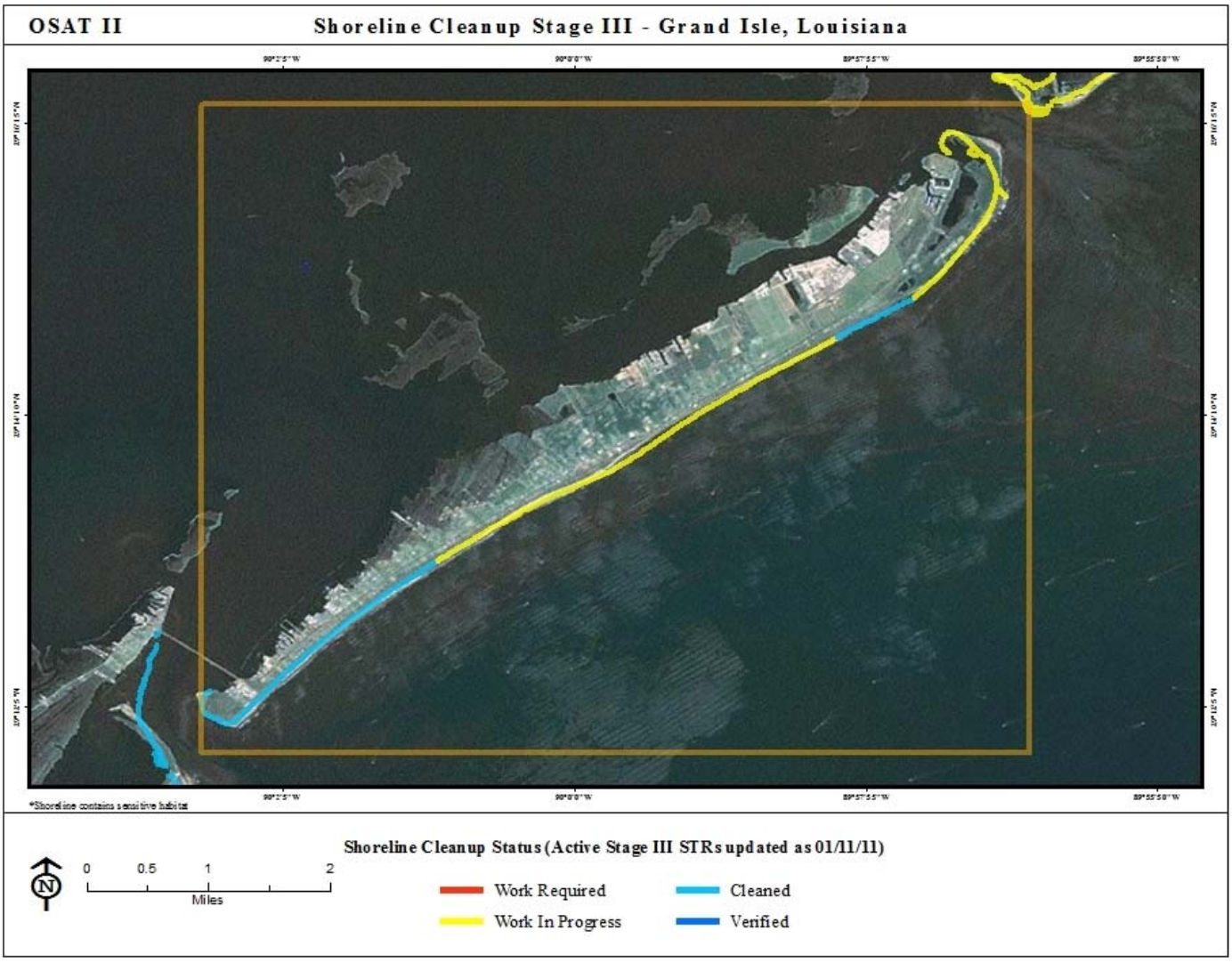


Figure 16. Current Stage III cleanup of Grand Isle. January 11, 2011.


Figure 17. Maximum oiling of Petit Bois Island.

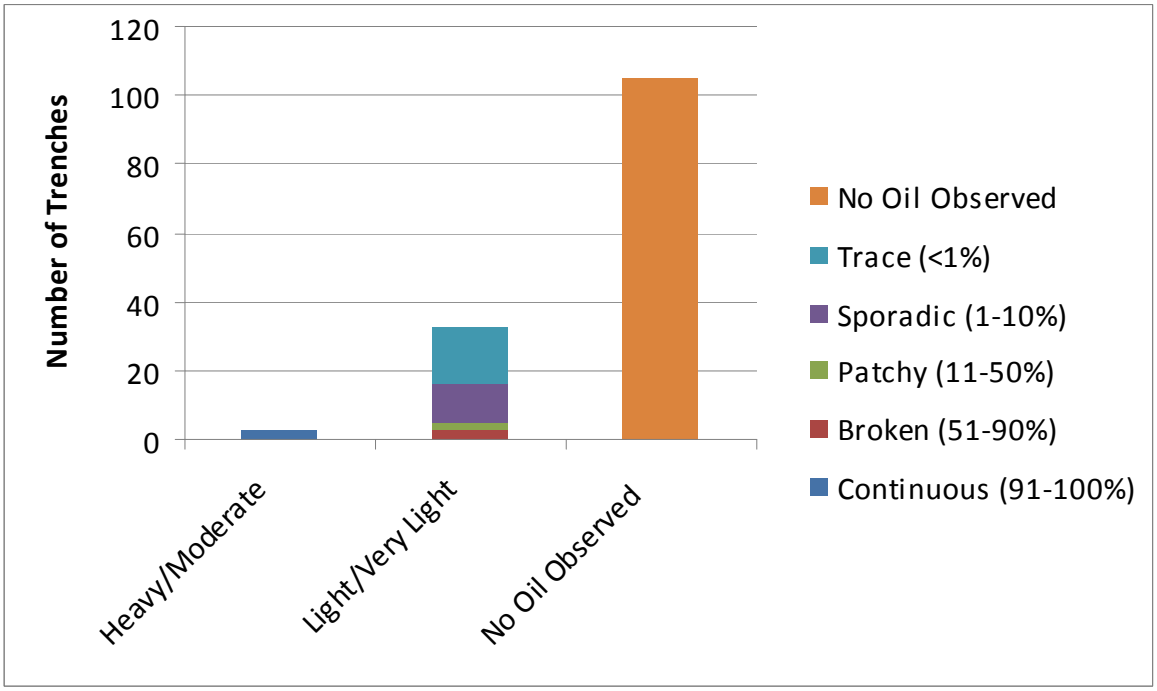


Figure 18. Distribution of oil in trenches from beaches on Petit Bois Island.


Figure 19. Current shoreline SCAT observations on Petit Bois Island. January 12, 2011.


Figure 20. Buried oil locations and submerged oil mats on Petit Bois Island. January 12, 2011.


Figure 21. Buried oil depth on Petit Bois Island. January 12, 2011.

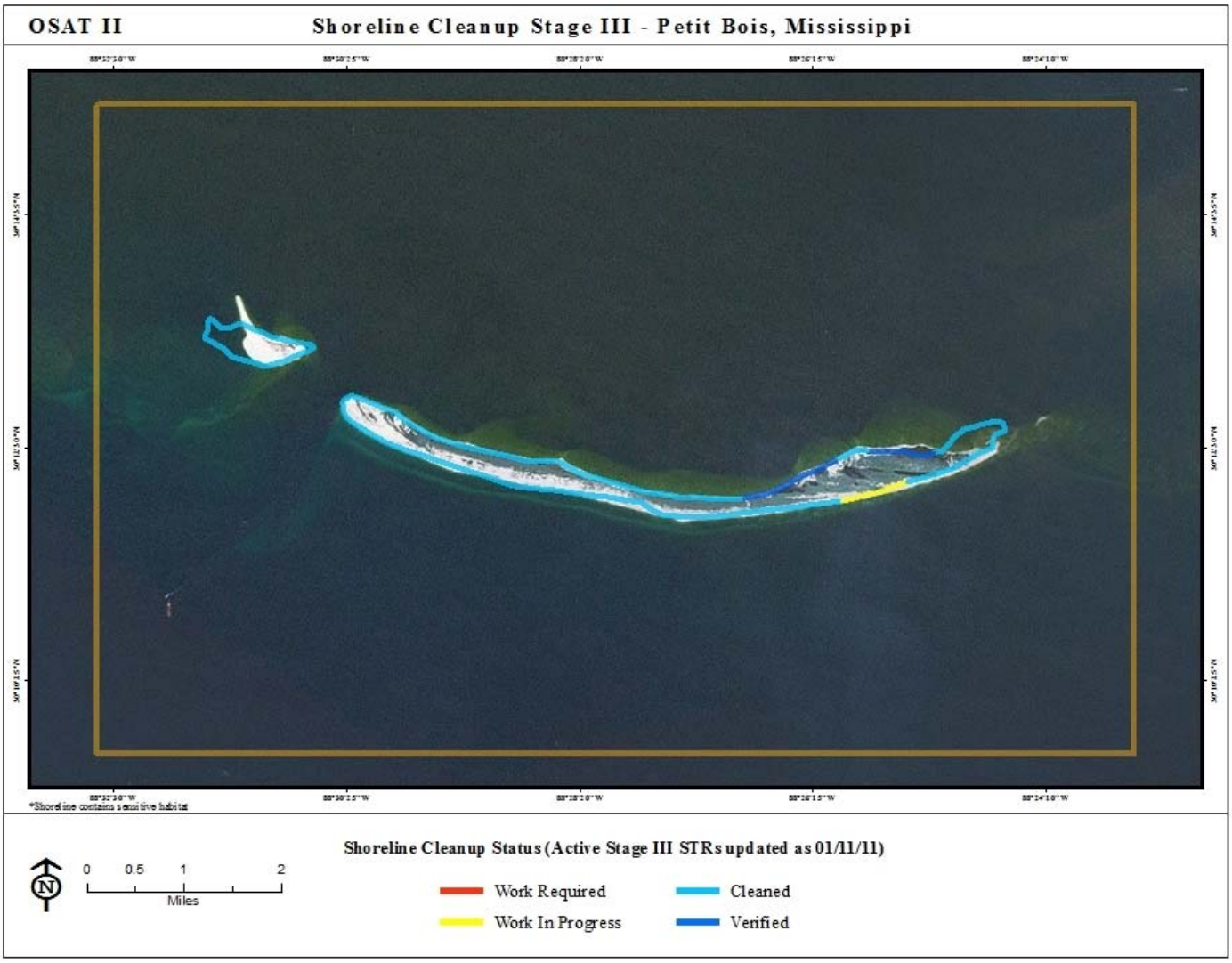


Figure 22. Current Stage III cleanup of Petit Bois Island. January 11, 2011.

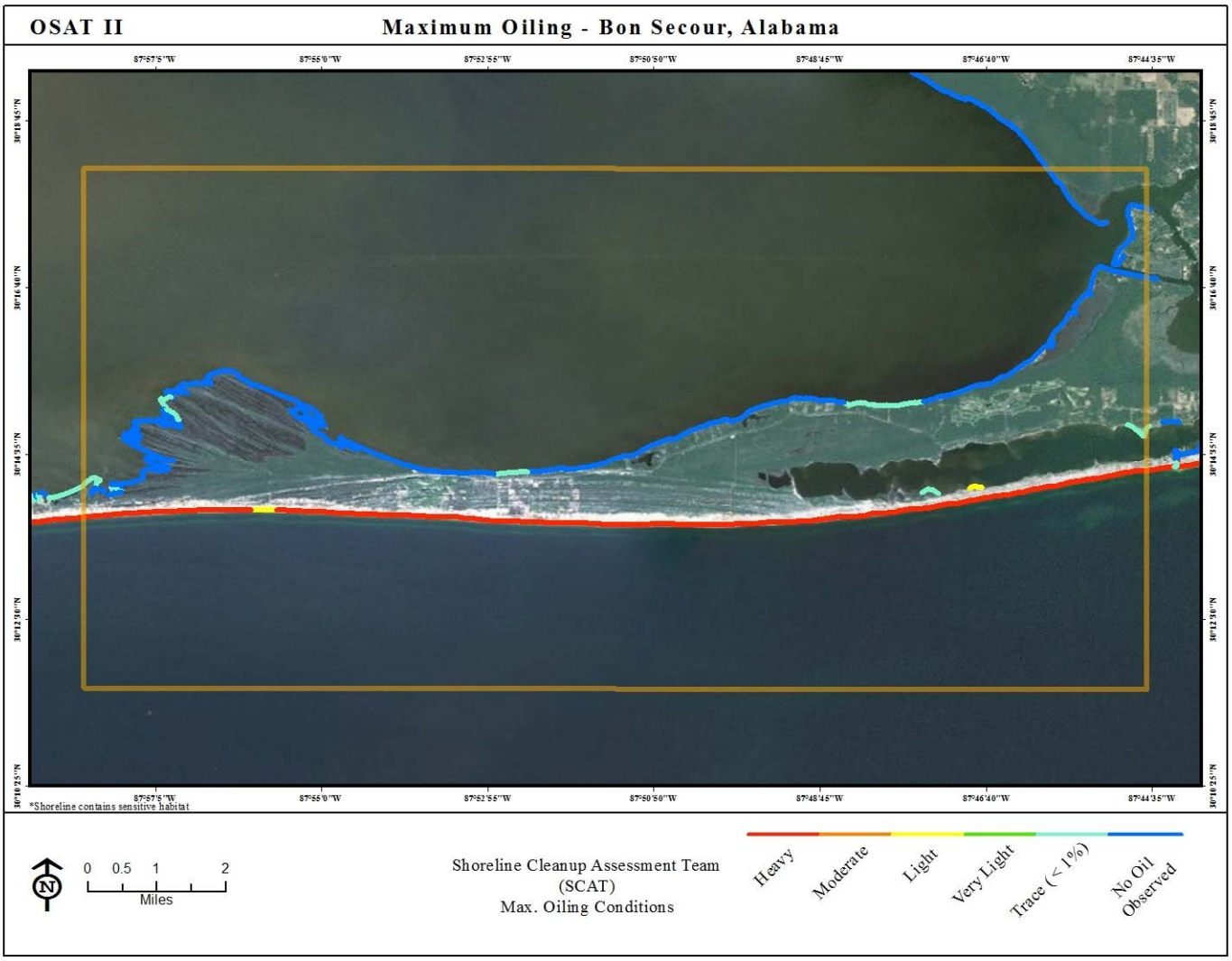


Figure 23. Maximum oiling at Bon Secour.

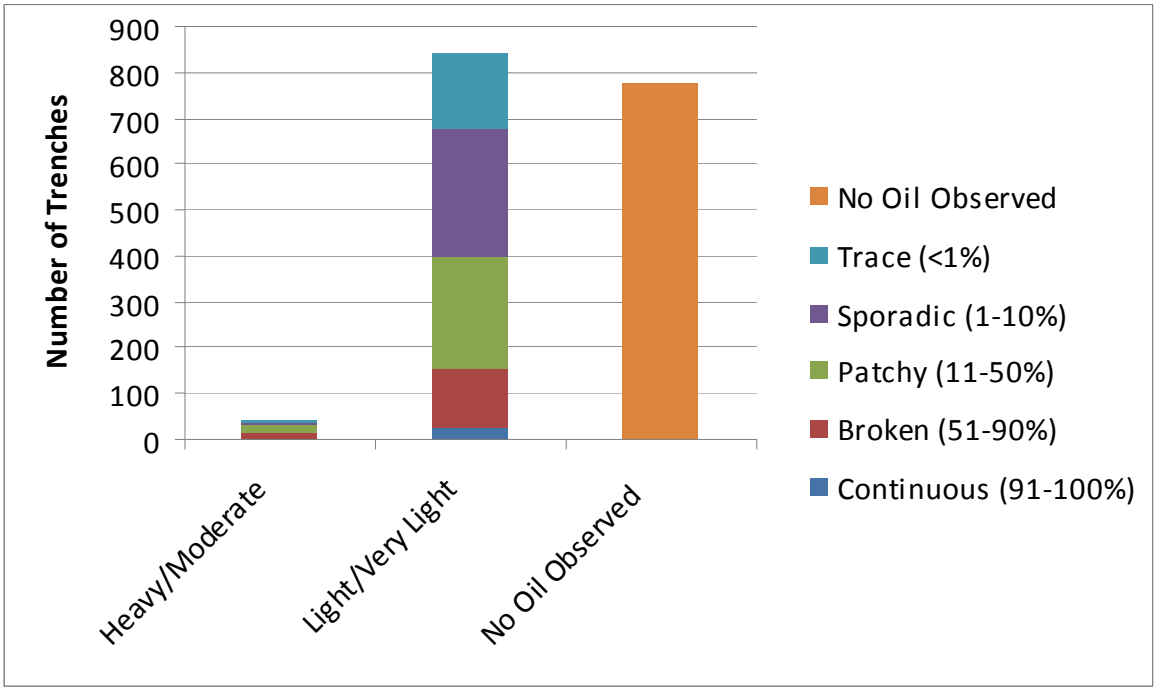


Figure 24. Distribution of oil in trenches from beaches at Bon Secour.


Figure 25. Current shoreline SCAT observations at Bon Secour. January 12, 2011.


Figure 26. Buried oil locations and submerged oil mats at Bon Secour. January 12, 2011.

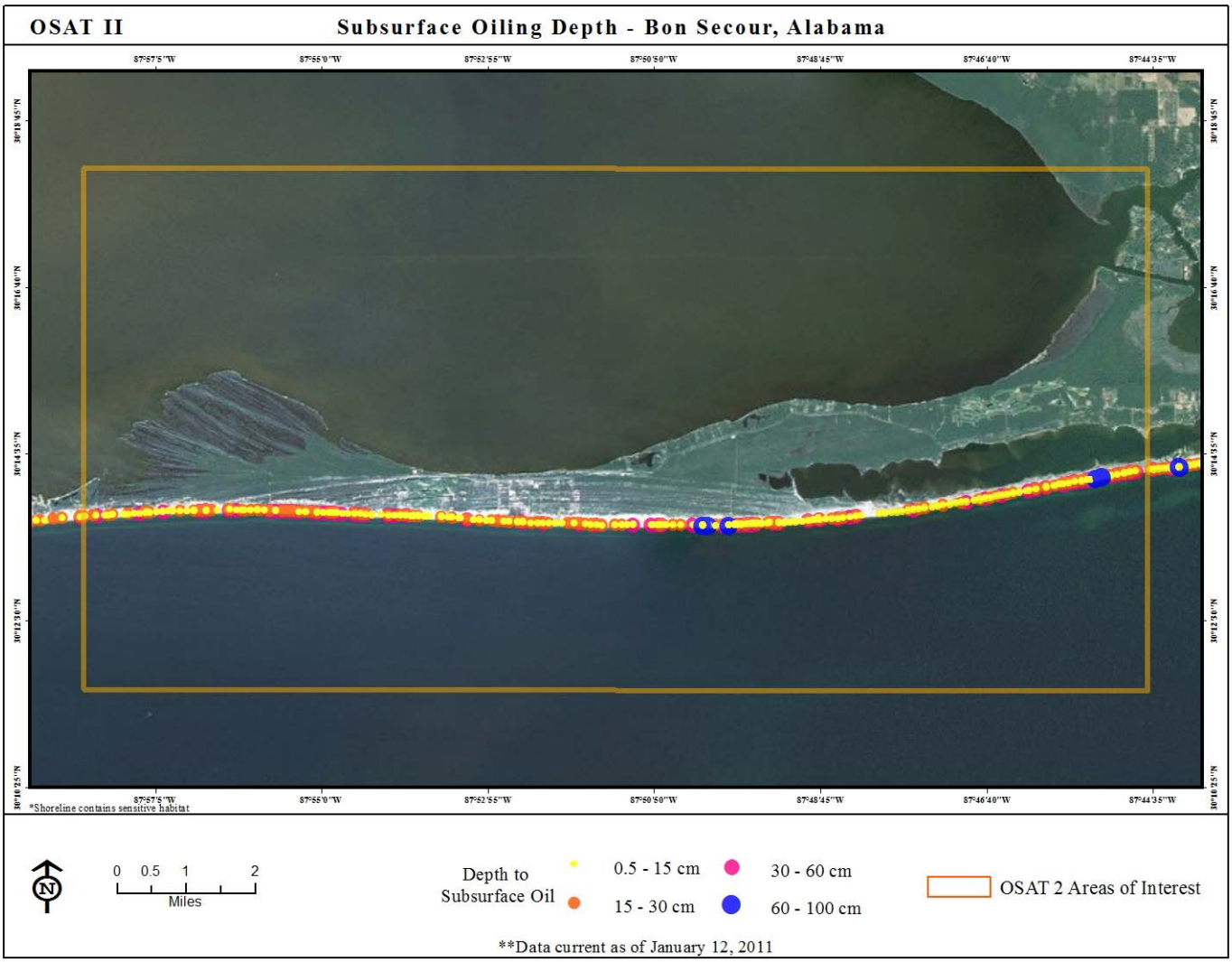


Figure 27. Buried oil depth at Bon Secour. January 12, 2011.

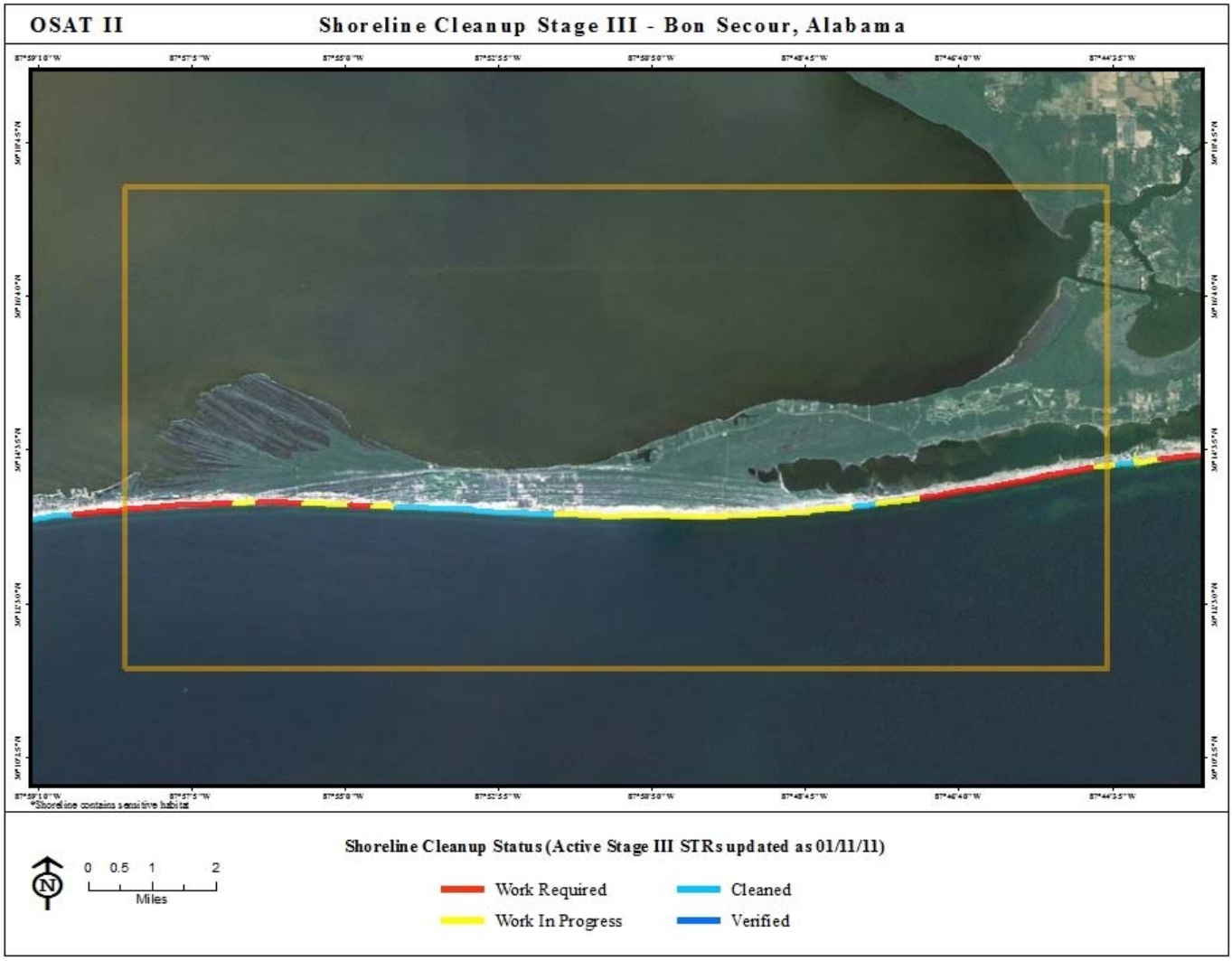


Figure 28. Current Stage III cleanup of Bon Secour. January 11, 2011.

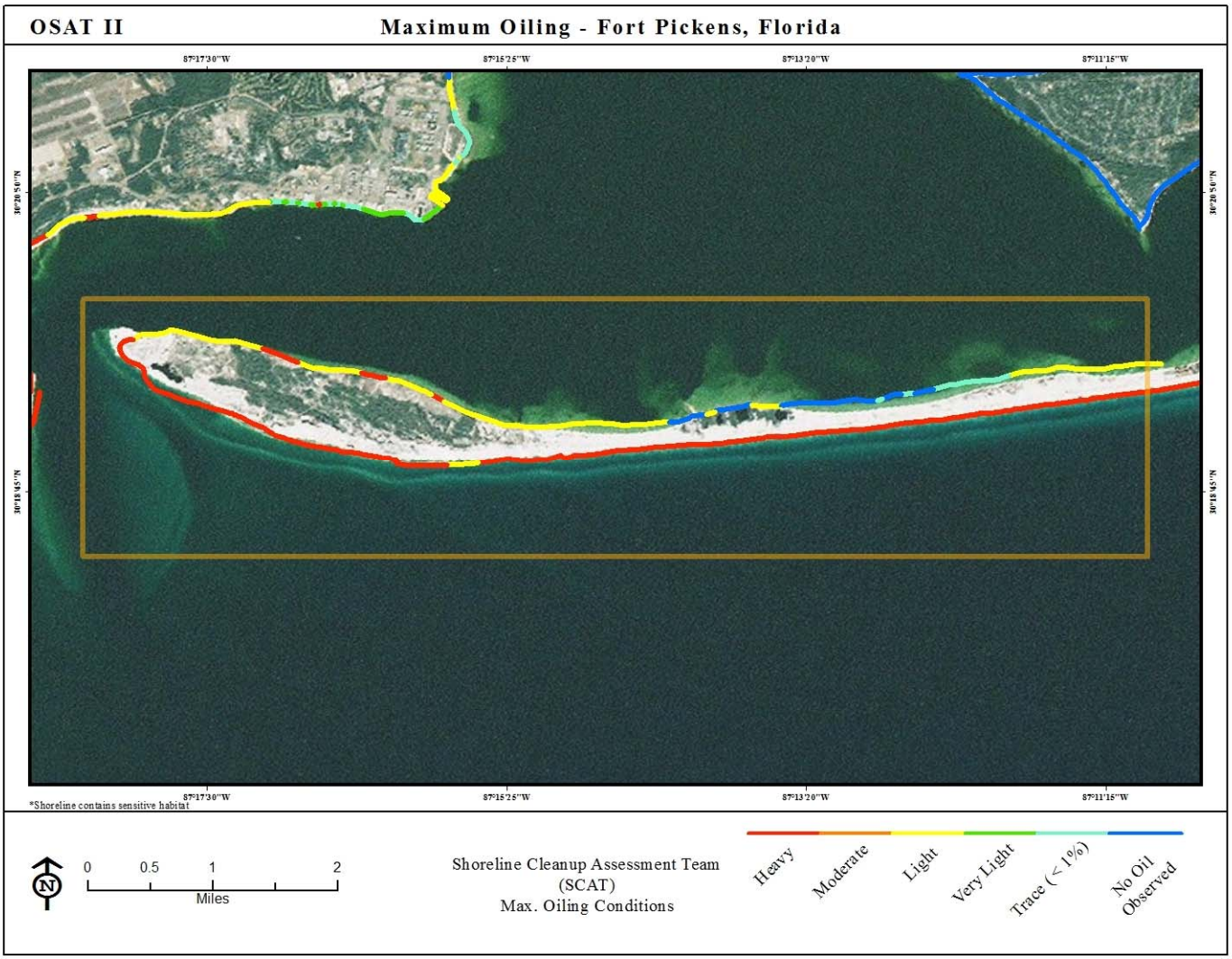


Figure 29. Maximum oiling of Fort Pickens.

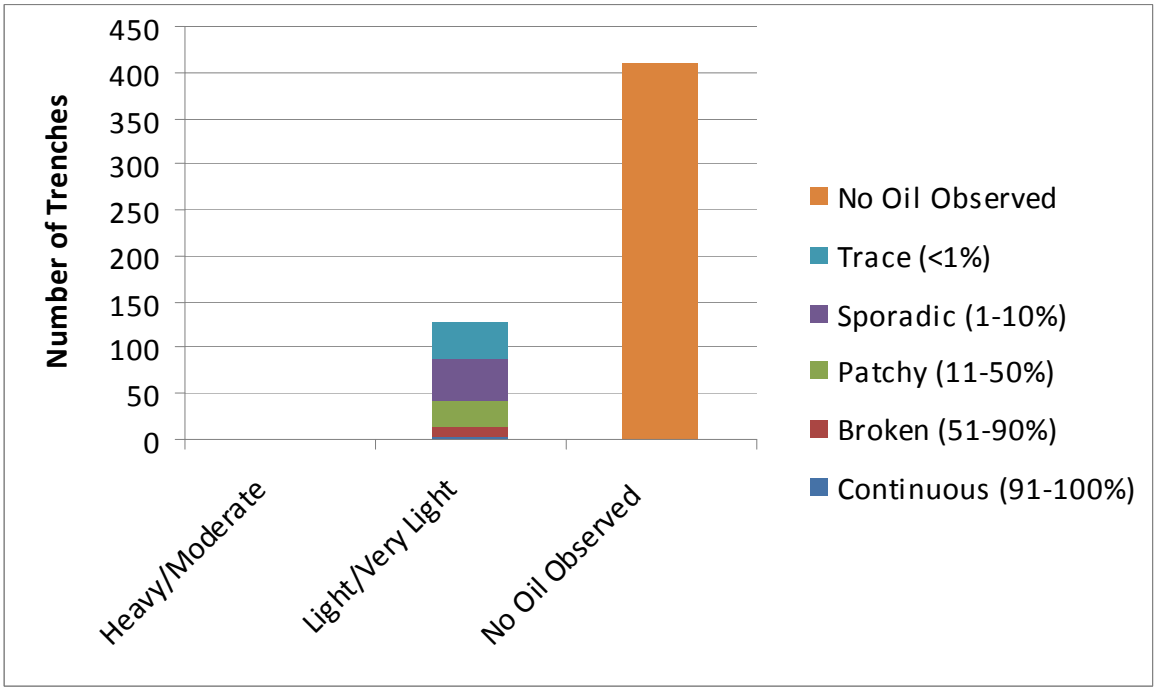


Figure 30. Distribution of oil in trenches from beaches at Fort Pickens.

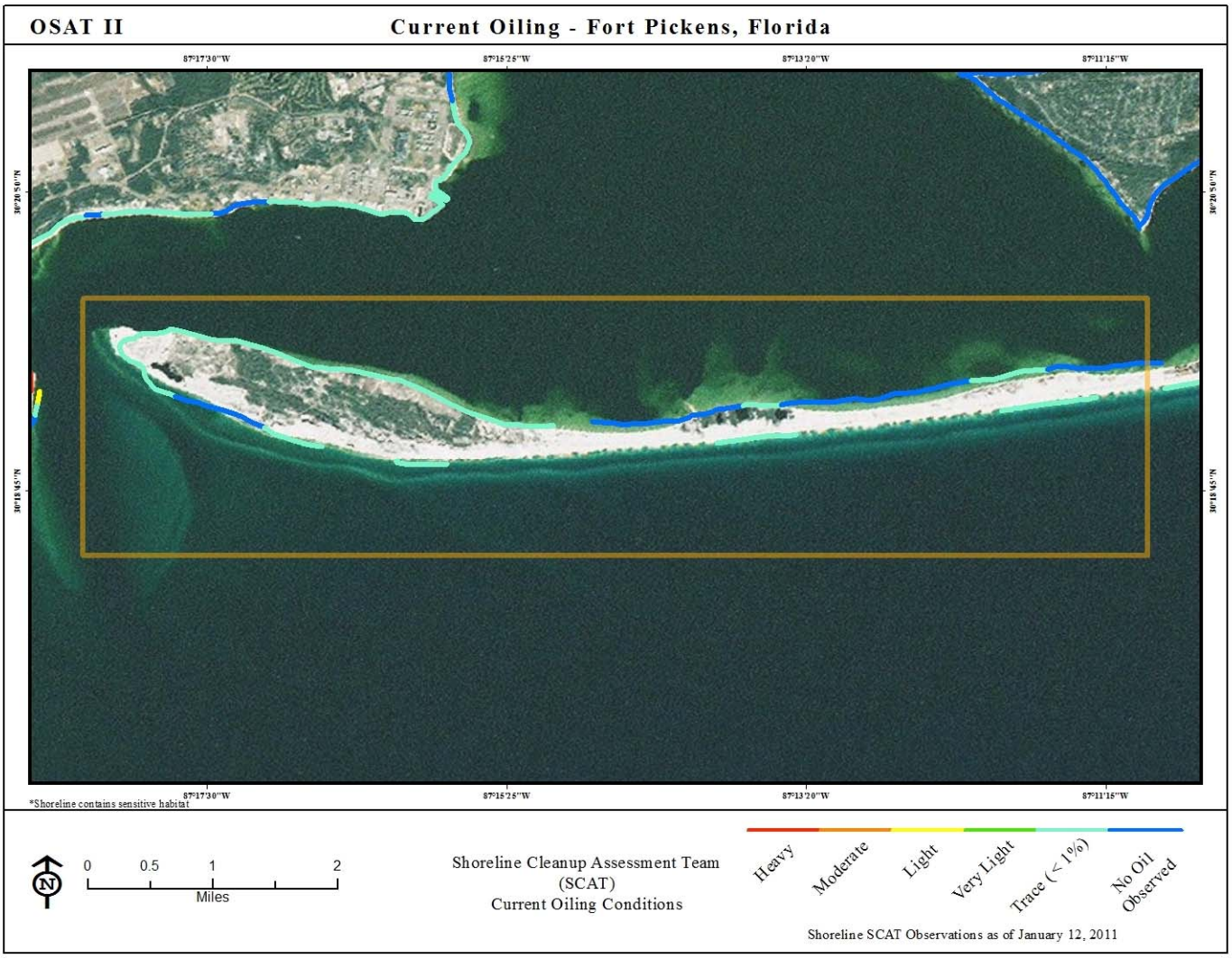


Figure 31. Shoreline SCAT observations at Fort Pickens. January 12, 2011.

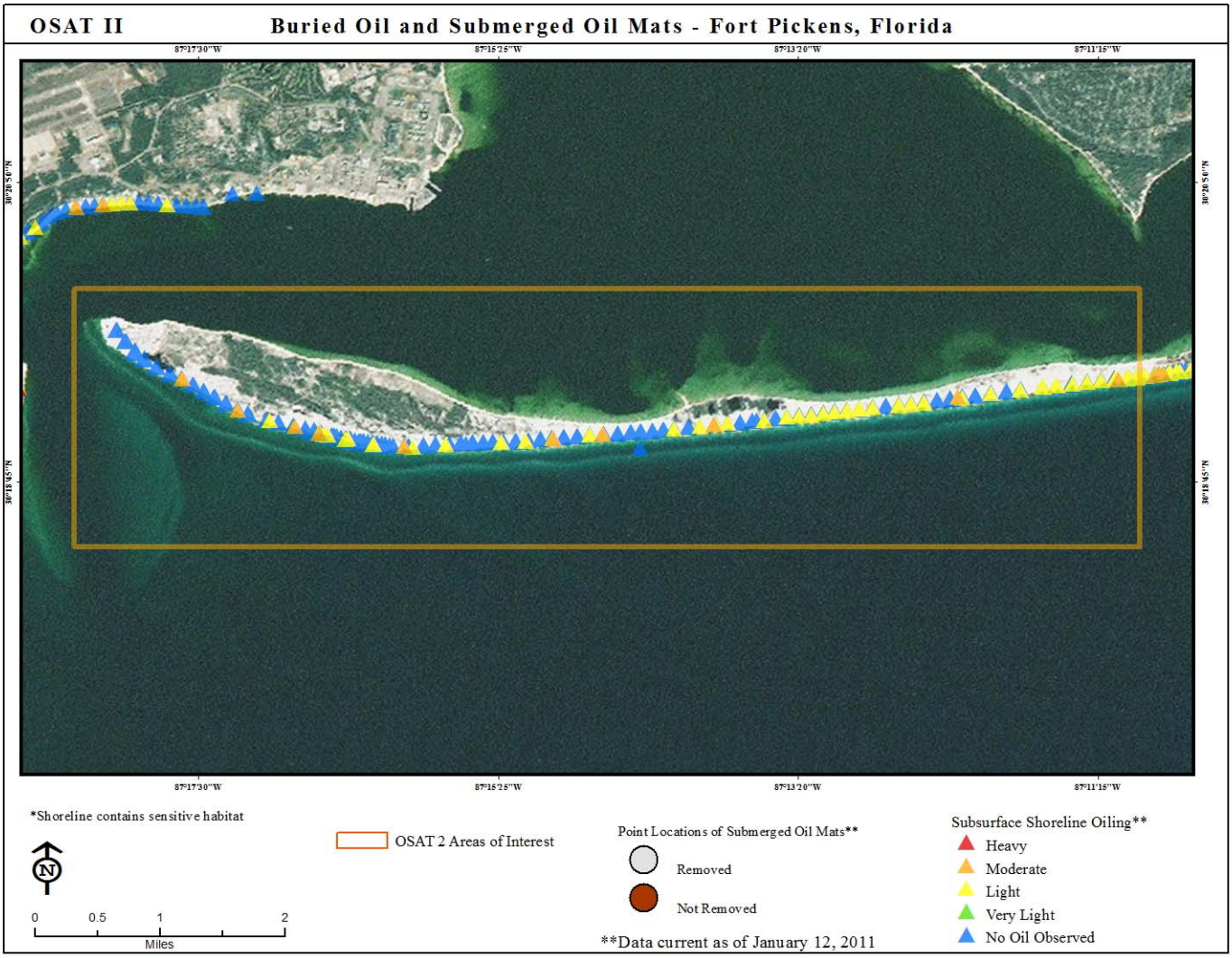


Figure 32. Buried oil locations at Fort Pickens. January 12, 2011.

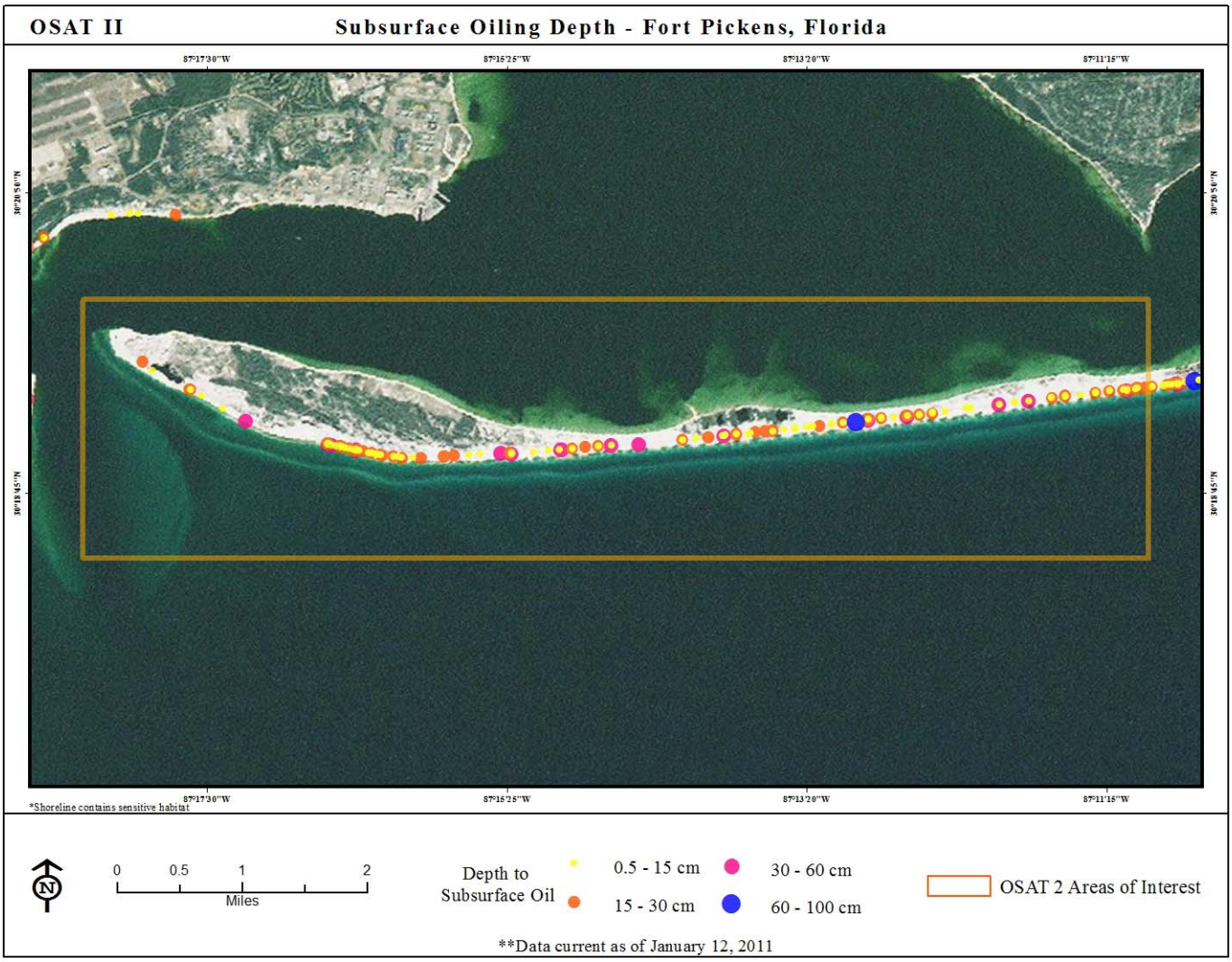


Figure 33. Buried oil depth at Fort Pickens. January 12, 2011.

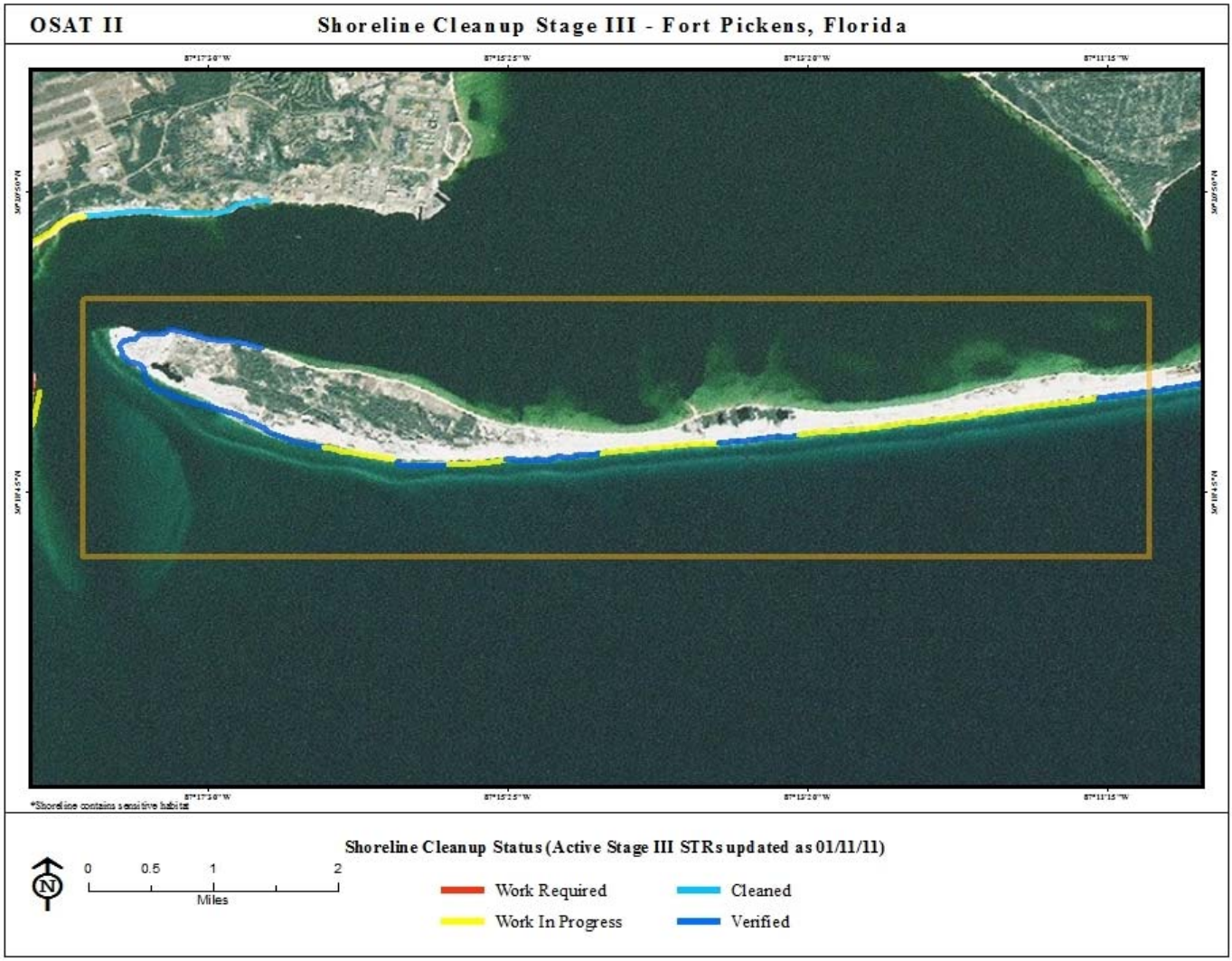


Figure 34. Current Stage III cleanup of Fort Pickens. January 11, 2011.

| Location | Oil Type | | | | | |
|---|---|---|---|---|---|---|
| | Submerged Oil Mats | | SSRBs | | Supratidal Buried Oil | |
| | % Sand | % Oil | % Sand | % Oil | % Sand | % Oil |
| Grand Isle | 83.2 | 16.8 | 87.2 | 12.8 | 92.3 | 7.7 |
| Petit Bois Island | 90.6 | 9.4 | 91.4 | 8.6 | 91.1 | 8.9 |
| Bon Secour | 89.3 | 10.7 | 92.6 | 7.4 | 93.5 | 6.5 |
| Fort Pickens | 90.0 | 10.0 | 95.8 | 4.2 | 96.8 | 3.2 |

Table 1. Mass percentage of sand and oil in three oil types.

| Location | SSRB Size | |
|---|---|---|
| | Smallest Sieve Sizes Used | |
| | mm | inch |
| Grand Isle | 19 | 3/4 |
| Grand Isle State Park | 3 | 1/8 |
| Petit Bois Island | 17 | 2/3 |
| Bon Secour - USFWS | 17 | 2/3 |
| Bon Secour - Amenity | 6 | 1/4 |
| Fort Pickens - NPS | 6 | 1/4 |
| Fort Pickens - Amenity | 6 | 1/4 |

Table 2. Smallest screen size used on case study beaches.

| Oil Concentration | Grand Isle | | | |
|---|---|---|---|---|
| | Oiling Depth | | Oiling Thickness | |
| | Deepest Oiling (cm) | Avg. Oiling Depth (cm) | Thickest Oiling (cm) | Avg. Oiling Thickness (cm) |
| Heavy | 100 | 60 | 49 | 29 |
| Moderate | 100 | 50 | 31 | 18 |
| Light | 105 | 30 | 25 | 7 |
| Very Light | 75 | 28 | 20 | 4 |

Table 3. Oiling depth and thickness on Grand Isle.

| Oil Concentration | Petit Bois Island | | | |
|---|---|---|---|---|
| | Oiling Depth | | Oiling Thickness | |
| | Deepest Oiling (cm) | Avg. Oiling Depth (cm) | Thickest Oiling (cm) | Avg. Oiling Thickness (cm) |
| Heavy | 15 | 15 | 13 | 13 |
| Moderate | 10 | 10 | 8 | 6.5 |
| Light | 30 | 13.5 | 12 | 1.4 |
| Very Light | 85.2 | 17 | 6 | 1.5 |

Table 4. Oiling depth and thickness on Petit Bois Island.

| Oil Concentration | Bon Secour | | | |
|---|---|---|---|---|
| | Oiling Depth | | Oiling Thickness | |
| | Deepest Oiling (cm) | Avg. Oiling Depth (cm) | Thickest Oiling (cm) | Avg. Oiling Thickness (cm) |
| Heavy | 80 | 46 | 65 | 39 |
| Moderate | 105 | 32 | 47 | 16 |
| Light | 86 | 24 | 32 | 6 |
| Very Light | 82 | 20 | 21 | 4 |

Table 5. Oiling depth and thickness at Bon Secour.

| Oil Concentration | Fort Pickens | | | |
|---|---|---|---|---|
| | Oiling Depth | | Oiling Thickness | |
| | Deepest Oiling (cm) | Avg. Oiling Depth (cm) | Thickest Oiling (cm) | Avg. Oiling Thickness (cm) |
| Heavy | 20 | 20 | 15 | 15 |
| Moderate | 45 | 16 | 25 | 2.8 |
| Light | 72 | 26 | 25 | 6 |
| Very Light | 48 | 19 | 20 | 5 |

Table 6. Oiling depth and thickness at Fort Pickens.

**ATTACHMENT 1**

**Methodology for generating the percentage of oil still present in the supratidal zone**

The following is the methodology used to calculate the percentage of residual oil present in the supratidal zone for Bon Secour and Petit Bois Island.

All work was completed inside of ArcGIS 10 using data collected during the MC252 response. Specific data sets include:

- 2010 Orthophotography
- SCAT Trenches and Pits

The first step was to define a physical boundary of the supratidal zone. This was accomplished by using the SCAT trench and pits data and drafting a supratidal zone between the maximum extents of the no oil observed pits for Bon Secour. For Petit Bois the supratidal zone was established by drafting from the no oil observed SCAT trenches and pits at the low water line and inland side of the supratidal zone was created by drafting a line along the sand dunes present in the aerial photography. Polygons were established to define the supratidal zones for both areas. The polygons were only drafted within the project areas for OSAT 2.

The second step was to define areas where residual oil was present. This was accomplished by manually drawing polygons around SCAT trench and pits where oil was found. For Bon Secour we excluded the top six inches of material and for Petit Bois we excluded the top three inches of material. This was the depth of material to be cleaned in these areas. We also excluded any areas defined as Very Light Oiling.

The third step was to calculate area of the supratidal zone and the area of the oiled polygons. These were divided together to establish the oil remaining in the supratidal zone.