OPERATIONAL SCIENCE ADVISORY TEAM

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

Annex J: Terrestrial Mammals

Introduction

Polycyclic aromatic hydrocarbons (PAHs) associated with the residual oil that remains on beaches may have the potential to affect terrestrial mammals. The effect of individual PAHs has generally been well documented for laboratory and domestic mammals. Studies with experimental species have shown that chronic exposures to PAHs (i.e., 7,12-dimethylbenz(a)anthracene, benzo(a)pyrene, some >4 ring PAHs) can lead to the development of tumors (Eisler, 2000). The metabolization of PAHs via microsomal enzymes (mixed function oxygenase, MFO) produces intermediate metabolites (i.e., diol epoxides) that can react with internal tissues and induce tumors. Other metabolites are more water soluble and are easily excreted from the body. Although experimental studies have shown adverse chronic effects following exposure to PAHs, the exposure conditions and doses are often environmentally unrealistic, and therefore extrapolation to wildlife resources must be made with caution. Laboratory experimental studies with deer mice, designed to be representative of field PAH exposures via ingestion of contaminated food, found reduced food consumption (2-30 percent; Schafer and Bowles, 1985) and suppression of immune response (Dickerson *et al.*, 1994). Field studies, on the other hand, have not been able to link exposure and effects, even in populations inhabiting highly polluted areas (see Douben, 2003).

Because PAHs generally do not accumulate in the food web, direct ingestion of contaminated soil can be a particularly important pathway of exposure for wildlife. Therefore, terrestrial mammals may be potentially exposed to small surface residue balls (SSRBs) via incidental ingestion of tar balls in soil. Only in the event that these mammals construct burrows, may they be directly exposed to supratidal buried oil (SBO).

Receptor species

Early during the Deepwater Horizon (DWH) oil spill response, the U.S. Fish and Wildlife Service (USFWS) raised concerns regarding the potential impact of oil to several endemic subspecies of beach mouse inhabiting coastal dunes and barrier islands of Alabama and Florida:

- Perdido Key beach mouse (*Peromyscus polionotus trissyllepsis*)
- Choctawhatchee beach mouse *(Peromyscus polionotus allophrys*)
- St. Andrew beach mouse (*Peromyscus polionotus peninsularis*)
- Alabama beach mouse (*Peromyscus polionotus ammobates*)

These four endangered subspecies and their critical habitats are federally protected under the Endangered Species Act of 1973. These subspecies have experienced dramatic habitat losses from coastal development, and are threatened by the introduction of predators (domestic cat, *Felis catus* and red fox *Vulpes vulpes*) and by competition with house mice.

Since these subspecies are similar in size and in habitat utilization, this assessment focused on the Alabama beach mouse as the representative member of this group. This selection was also based on the following considerations: (1) this subspecies has the western-most

distribution – and therefore, closest to the oil source– (see Figures 1-4); (2) it has the smallest known habitat area (4.9 km^2) compared to the other three subspecies (Perdido: 5.2 km^2, Choctawhatchee: 9.7 km^2, and St. Andrew: 10 km^2); and (3) its habitat had the largest percentage of observations with degree of oiling other than "No Oil Observed" (40 percent) compared to the habitat of other subspecies for which similar data are available (Perdido: 16 percent and Choctawhatchee: 8 percent).

The Alabama beach mouse is the smallest species of its genus in North America (total length =122-153 mm; weights =10-17 g; Hall and Kelson, 1981). This endangered subspecies is found in a few, isolated populations along the Gulf Coast of Alabama, and is protected in Bon Secour National Wildlife Refuge, Alabama. Critical habitats include coastal sand dune ecosystems, where dune plants and their seeds comprise their primary food source. Studies have reported burrowing depths of up to 1 m (mean depth = 53 cm; Smith, 1966), and a home range varying from 4,086 to 7,000 m^2 (Lynn, 2000). Their burrowing behavior and broad home range indicate that this species would potentially be exposed to oil residues.

Exposure characterization

Exposure of the Alabama beach mouse to PAHs can occur via dermal exposure, and via incidental ingestion of contaminated sediment as a result of foraging or grooming. Currently, there is no information to adequately quantify dermal exposure, and therefore, risks from this exposure pathway remain uncertain. However, ongoing efforts may provide indirect estimates of exposure. Localized supratidal buried oil residues that overlap the documented habitat of the Alabama beach mouse have been categorized by the Shoreline Cleanup Assessment Techniques (SCAT) teams (see Figure 1). As part of the shoreline cleanup assessment a total of 1,501 trenches were dug within the Alabama beach mouse habitat, with 60 percent and 37 percent of the trenches categorized as "No Oil Observed" and "Light-Very Light" oiling, respectively, and 3 percent of the trenches categorized as "Moderate-Heavy" oiling. Chemical analyses from supratidal buried oil have shown a substantial depletion of total PAHs (greater than 86 percent). The relative small contribution of "Moderate-Heavy" oiling to the overall supratidal buried oil, and the high level of oil weathering, may indicate a low probability of exposure to these oil residues. Furthermore, for most contaminants, the dermal exposure is expected to contribute less than 1 to 11 percent of the total risk when compared to oral exposures (USEPA, 2005). In addition, it is likely that the Alabama beach mouse would effectively avoid burrowing in areas with high levels of residual oils.

Quantifying the risk from incidental exposure of small surface residue balls (SSRBs) can be estimated using the growth and reproduction Toxicity Reference Values (TRVs) developed by the USEPA for low (2-3 ring) and high (4-7 ring) molecular weight PAHs (65.6 and 0.615 mg dw/kg-bw/d, respectively; http://www.epa.gov/ecotox/ecossl/). These TRVs are solely intended to represent conservative soil screening levels. Efforts focused on estimating exposure point concentrations and calculated daily intakes for the Alabama beach mouse. The daily PAH dose (DD_{PAH}) for the Alabama beach mouse was calculated using readily available information on the species natural history or information of species within its genus. The generic equation for calculating DD_{PAH} is as follows:

$$TDD_{PAH} = (FIRf \times C_i \times F_i \times AUF)/ BW$$

Where,

TDD_{PAH} = total daily dose of PAH ingested (mg/kg-bw/day)

FIRf = field ingestion rate (kg/day), or the daily food intake;

C_i = PAH concentration in substrate (mg/kg)
F_i = fraction of incidental ingestion of substrate *i* (unitless);
AUF = area use factor (unitless);
BW = receptor's body weight (kg);

Model assumptions included the following:

- This model does not take into account exposure via contaminated food or water, or dermal exposure; the primary pathway for contaminant uptake is assumed to be through incidental ingestion of residual oil;
- Because the likelihood of SSRB adhesion to the feet, tail or fur of the Alabama beach mouse is currently unknown, this model does not take into account incidental ingestion of SSRBs through grooming;
- Field ingestion rate (daily food intake) was assumed to be the same as that of the cactus mouse (*Peromyscus crinitus*; 0.00281 kg dry food/d; Nagy, 2001);
- Incidental ingestion of soil was assumed to be 2 percent of the daily diet based on the white-footed mouse (*Peromyscus leucopus*) diet (Sample, 1994); two scenarios were run: 1) a worst-case scenario assuming 100 percent contribution of SSRBs to the total ingestion of soil; and 2) a scenario assuming 10 percent contribution of SSRBs to the total ingestion of soil (consistent with other assessments within the OSAT-2 report);
- Receptor's body weight was assumed to be 0.01 kg (Hall and Kelson, 1981);
- Area use factor (AUF), a measure of the size of the site relative to the size of the receptor's home range was assumed to be 1. This implies that oil residues exist in the entire foraging area of the Alabama beach mouse. This assumption is justified based on the overlap between this receptor's habitat and reported field observations on the distribution of SSRBs;
- Sample PAH concentrations were adjusted to account for 80 percent sand concentration in SSBRs.

Risk was characterized by comparing estimated oil doses to TRV values. Food web-ecological hazard quotients (HQs) were calculated as follows:

$$HQ_{PAH} = TDD_{PAH}/TRV_{PAH}$$

Where,
HQ_{PAH}= ecological hazard quotient for the Alabama beach mouse (unitless)
TDD_{PAH} = Alabama beach mouse PAH total daily dose (mg/kg-bw/day)
TRV_{PAH} = toxicity reference value for terrestrial mammal receptors (mg/kg-bw/ day)

A HQ≤1 indicates that incidental ingestion of oil contaminated substrate does not pose adverse chronic risk; whereas a HQ>1 indicates that incidental ingestion of oil contaminated substrate has the potential of posing adverse growth and reproduction effects. Hazard quotients are presented as HQ-PAH_{LMW} for low molecular weight and HQ-PAH_{HMW} for high molecular weight PAHs.

Risk characterization

A relatively small number of SSRB samples have been collected for chemical analysis in the vicinity of the Alabama beach mouse habitat. Given data limitations, chemistry data from relatively recent tar ball samples (matching the fingerprint of MC252 oil), and not necessarily representative of the area, were used in these calculations. A total of 30 tar ball samples buried in the supratidal zone (collected between September 2010 and January 2011), 2 of which were

collected in the vicinity of the Alabama beach mouse habitat, were used in this analysis. Under the assumptions stated above, estimated daily doses did not exceed the soil TRV for low molecular PAHs, while estimated doses for 5 of the tar ball samples –only under the worst-case scenario– slightly exceed the soil TRV for high molecular PAHs (>1 HQ-PAH_{HMW} range: 1.1-1.3; Figure 5). Dose estimates using the two tar ball samples and one SSRB sample from Bon Secour were below the TRV for high molecular PAHs (either scenario).

Figure 1. Overlay of the Alabama beach mouse with SCAT trench and tar ball oiling data.

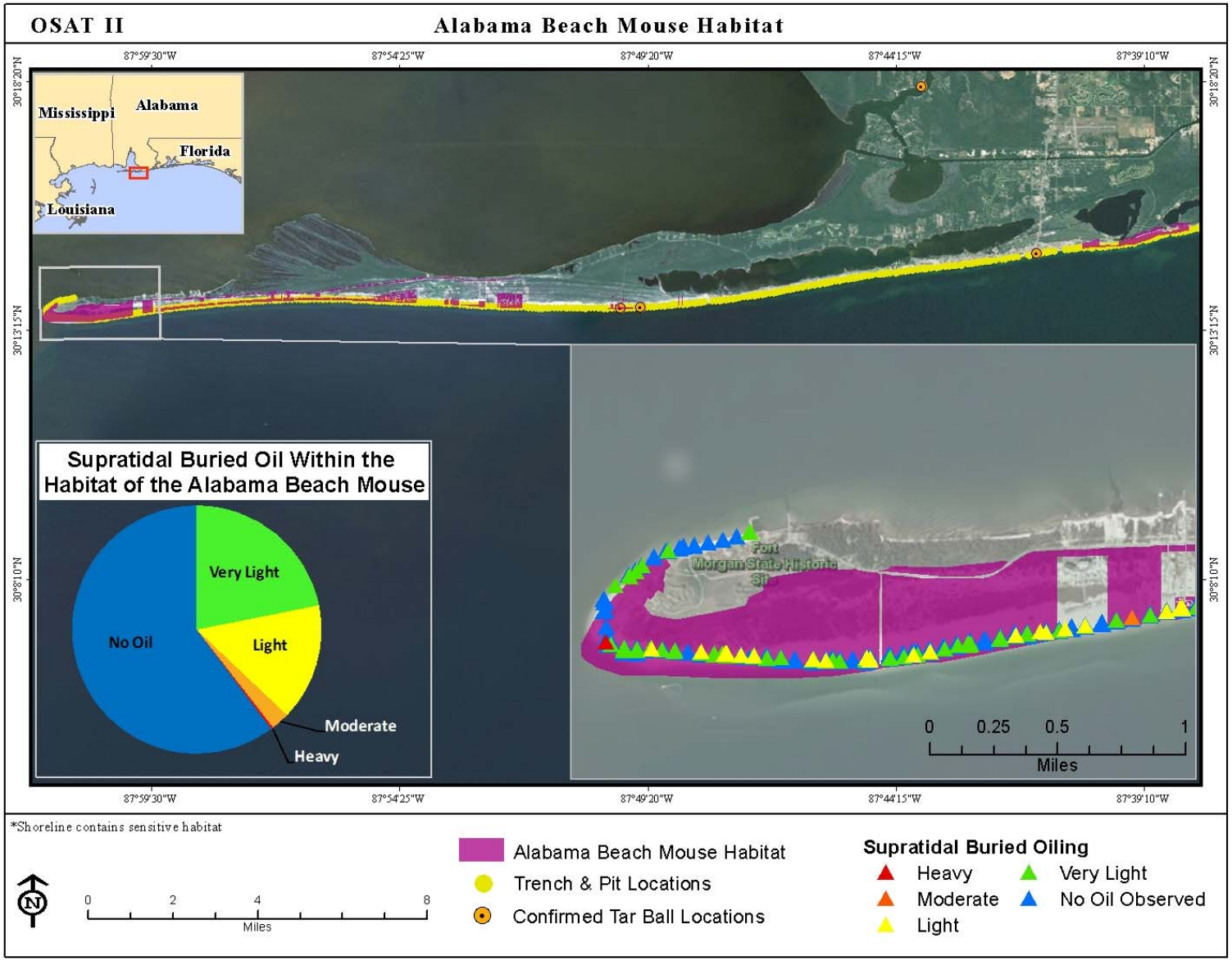


Figure 2. Overlay of the Perdido beach mouse with SCAT trench and tar ball oiling data.

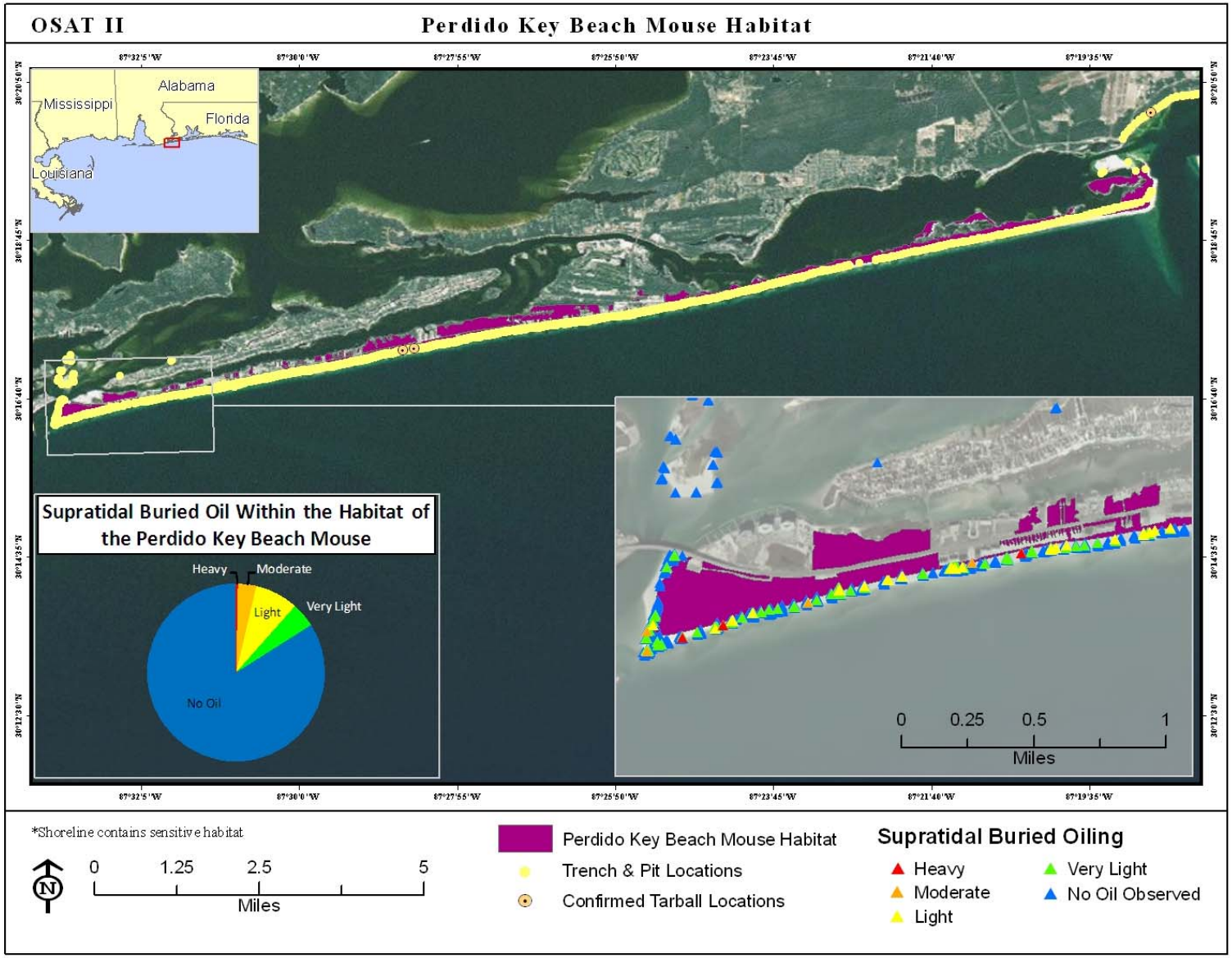


Figure 3. Overlay of the Choctawhatchee beach mouse with SCAT trench and tar ball oiling data.

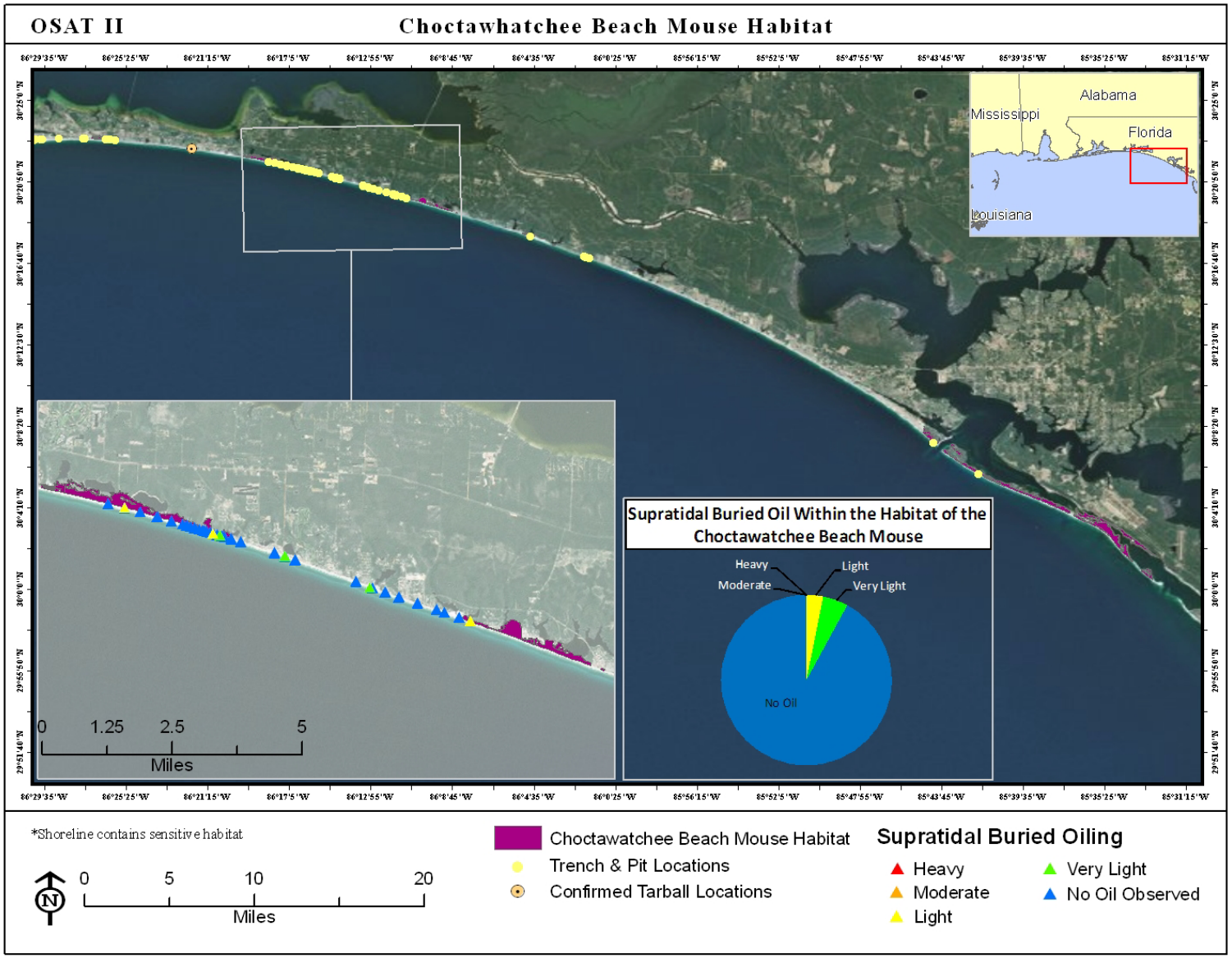


Figure 4. Spatial distribution of the St. Andrew beach mouse. This area was not affected by the DWH oil spill.

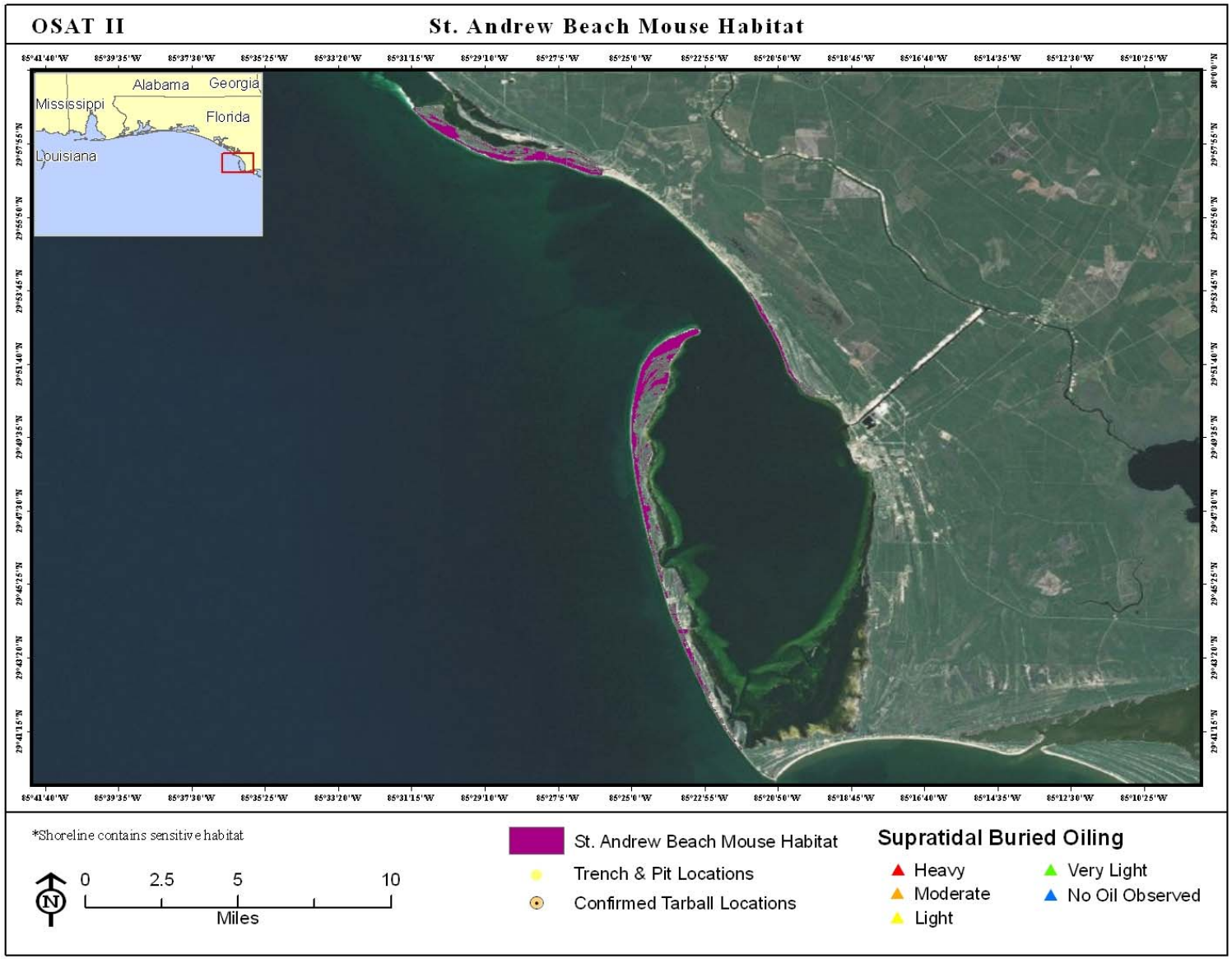
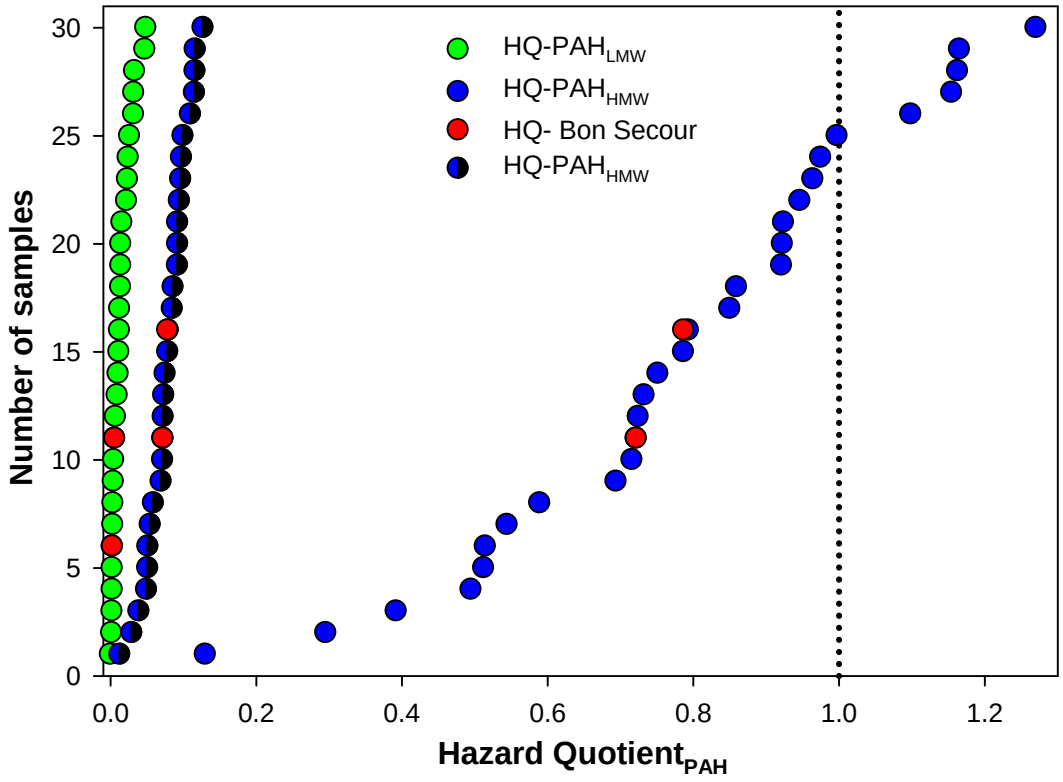


Figure 5. Estimated distribution of Hazard Quotient (HQ) for the Alabama beach mouse. The dotted line represents HQ=1. Two scenarios are included: 1) a worst-case scenario assuming 100 percent contribution of SSRBs to the overall ingestion of soil (single color filled circles); 2) a scenario assuming 10 percent contribution of SSRBs to the overall ingestion of soil (partially black filled circles; only shown for PAH_{HMW}).



Uncertainty Analysis

This section addresses the uncertainties and sources of variability influencing risk estimates. Table 1 summarizes the main uncertainties in the model.

Although several sources of uncertainty were addressed, the large majority of assumptions used in risk calculations were biased towards overprotection of the Alabama beach mouse. For instance, the model does not account for the fact that the Alabama beach mouse may effectively avoid areas with high density of SSRBs on its preferred foraging habitat (currently unknown). Given all the assumptions above, this analysis indicates that growth and reproduction chronic risk from ingestion of SSRBs is likely to be low for the Alabama beach mouse. This same conclusion applies to the other beach mouse subspecies foraging in areas where SSRBs occur.

Table 1. Major uncertainties and sources of variability associated with risk estimates for the Alabama beach mouse.

Uncertainties/Sources	Underestimate	Overestimate	Unknown	Comments
Field ingestion rate assumed to be the same as that of the cactus mouse			X	The field ingestion rate of the Alabama beach mouse is currently unknown. The reported mass for the cactus mouse falls within the range of reported values for the Alabama beach mouse and therefore it is reasonable to assume that these two species have similar field ingestion rates.
Assumption of 2 percent soil ingestion white-footed mouse		X		The ingestion of soil by the Alabama beach mouse has not been reported. However, the risk calculation assumed that 2 percent of soil ingestion was entirely composed of SSRBs (worst-case scenario).
Use of tar ball chemistry			X	Only two samples included in this analysis were collected in Bon Secour, which had HQs<1 for both high and low molecular weight PAHs. All 30 samples were assumed to be representative of the area, and therefore their use addresses environmental variability.
Body weight assumed to be 10 g		X		Although the reported weight for this species ranges between 10 and 17 g, the use of the lowest available value would translate into an estimated daily dose.
Assumption of AUF= 1		X		The assumption that the entire foraging area occurs within the contaminated area does not account for the fact that this species could forage in areas with very low concentration of SSRBs.
Use of soil TRVs for low and high molecular weights		X		TRVs were developed using relevant ecological endpoints, and are conservative enough to be protective of a wide range of mammals, including mice species.

During its emergency consultation, and in compliance with the Endangered Species Act section 7, the USFWS raised concerns regarding potential impacts of response actions to listed species and to their designated critical habitats. One of the terrestrial mammals included in this consultation was the Alabama beach mouse. The habitat of this receptor already has been

reduced by coastal development, and additional alteration or damages to its habitat from cleanup activities, may result in increased threat to this species. Measures to reduce potential impacts from cleanup are addressed in Bon Secour's shoreline treatment recommendations, which clearly state that cleanup crews are to avoid accessing dune habitats and the vegetation line. Contrasting the potential effects between ingestion of SSRBs and cleanup activities to the Alabama beach mouse are addressed in the NEBA.

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