

## OPERATIONAL SCIENCE ADVISORY TEAM

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

#### Annex G: Ecological Framework

##### Introduction

OSAT2 was charged with answering the question of whether the three types of residual oil pose adverse risks to the sandy beach environment, including the supratidal, intertidal, and subtidal areas, and whether removal of these residual oils would cause more harm than leaving them in place. In order to answer these questions, several tasks, which involve an evaluation of data collected during the response, needed to be completed:

- Define, to the extent possible, the spatial scale and magnitude of the problem
- Based on case histories, relevant literature and ongoing studies, describe the potential biodegradation/persistence of the residual oil, and its potential acute/chronic toxicity, and ecological effects
- Evaluate all pertinent information collected during the response, including toxicity and chemistry characterization of applicable samples.
- Develop a *Net Environmental Benefit Analysis* (NEBA) contrasting the effects of removal actions versus natural attenuation.
- Identify data gaps, and recommend further monitoring and evaluations

To provide input for the NEBA, OSAT-2 developed a conceptual model, which encompasses a set of working hypotheses. This model helps to support and guide the assessment of potential adverse risks to sandy beach resources from residual oil (see Table 1). Although OSAT-2 developed a relatively complete conceptual model (see Appendix 1), time constraints and data limitations precluded the team from addressing all of the components. In order to meet OSAT-2 goals, the assessment focused on the most critical environmental components.

Localized deposits of the three forms of residual oil have been encountered on beach habitats along the shoreline impacted by the spill. Although much of the residual oil stranded in the beach habitat is highly weathered (>86% PAH depletion), concerns exist regarding its potential effects on beach biological resources. Natural attenuation processes that will impact residual oil include: beach erosion, and storm and wave action, which will expose the residual oil to elements that facilitate oil physical and microbial degradation. Although these external driving forces would partially determine the long-term fate of the residual oil it is a slow process and therefore, OSAT-2 focused on evaluating whether the oil constituents currently may be posing unacceptable risks to beach biological resources. The residual oil is composed of several constituents that have the potential to cause toxicological effects.

The following table provides an overview of potential environmental concerns with the three forms of residual oils that are the focus of OSAT-2.

Table 1. Potential environmental concerns of the three forms of residual oil.

Residual oil	Potential environmental concerns
Supratidal buried oil	If not strongly impacted by drivers of natural attenuation, buried oil will be least likely to biodegrade, and will likely remain in its current weathered state for an extended period
Small surface residue balls	<p>When uncovered, the least weathered residues may pose unacceptable risks to specific receptors</p> <p>Represent a nuisance, and decrease the recreational value of amenity beaches</p> <p>May pose unacceptable risks to foraging or nesting beach resources</p>
Submerged oil mats	<p>May pose unacceptable risks to receptors residing in the intertidal sands</p> <p>Physically smother nearshore sediments, preventing fauna settlement and habitat utilization.</p> <p>Continuously feed nearby habitats with tar balls, re-oiling cleaned up areas.</p> <p>Hardened surfaces hinder natural degradation of the oil trapped within the mat</p> <p>May remain in the environment for decades without substantial degradation</p> <p>May pose unacceptable risks to receptors residing in or adjacent to the mats</p>

### Chemicals of concern

The toxicity of fresh crude oil is the result of the combined toxicity contribution of a complex mixture of chemicals. The large majority of the toxicity is commonly attributed to the water-soluble fractions (monocyclic aromatic hydrocarbons—benzene, toluene, ethylbenzene, and xylene, or BTEX) and the polycyclic aromatic hydrocarbons (PAHs). PAHs consist of a base structure of 2-7 fused carbon rings. The behavior of PAHs depends on the number of rings, and the presence of functional groups. BTEX and 1-3 ring PAHs with fewer substituted functional groups, have low molecular weights and high water solubility, and therefore are more acutely toxic. By contrast, high molecular weight PAHs ( $\geq 4$  rings and more substituted functional groups) are less acutely toxic and are more likely to persist in the environment. These compounds are also more likely to induce chronic toxicity. In addition to acute and chronic toxicity of oil constituents, oil residues in a liquid form (i.e., supratidal buried oil or oil residues heated during the warmer months) have the potential to cause physical smothering. OSAT-2 focused its evaluation primarily on PAHs, which are the primary constituents of concern,

because of their recognized toxicity and persistence in the environment. In addition, toxicity benchmarks for PAHs may be available or can be estimated.

### **Exposure pathways**

The pathways by which resources may be exposed to the toxic components of the three forms of oil include direct and indirect contact. Direct exposure may occur through ingestion of oil residues and small surface residue balls by receptors feeding on sand beaches, incidental ingestion, or through physical (dermal) contact, particularly with the less weathered and less viscous oil residues. Aquatic organisms can be indirectly exposed to toxic constituents via diffusion of dissolved oil fractions through gills and cell membranes, or directly exposed by feeding on suspended oil residues.

### **Receptor Species**

Beaches and their nearshore areas along the Gulf of Mexico harbor a variety of resident and migratory species (See Appendix 2). Although OSAT-2 scientists realize that species across various taxonomic and ecological groups may be at risk of exposure from the three forms of oil, OSAT-2 focused on quantifying risks to a select number of receptor species. Key receptors were selected based on one or more of the following criteria:

- The receptor is a representative member of its taxonomic or ecological group
- The receptor is currently, or in the future, exposed to one or more of the three forms of oil
- The receptor has a high likelihood of exposure to the forms of oil through one or more exposure pathways
- The receptor is a resident or migratory species with important habitat within the area of concern
- The receptor is currently, or in the future, utilizing resources (i.e., food, habitat) available within the area of concern
- The receptor is a species of concern (i.e., endangered, threatened)
- The receptor has known natural history information in the area
- The receptor's risk of adverse effects can be estimated using available toxicity data from surrogate species

Note that: 1) these criteria were specifically selected for the purpose of OSAT-2; and 2) the risk estimates for selected species are not intended to replace other ongoing assessments (i.e., NRDA).

Based on these criteria, OSAT-2 characterized the potential risk to the following receptor species (Table 2):

- Aquatic invertebrates and fish were identified as one of the most sensitive ecological receptors that may be directly or indirectly exposed to submerged oil mats. These receptors are treated as a generic group, which encompasses mollusks (i.e., clams, snails), marine worms (i.e., polychaetes), and crustaceans (i.e., crabs, amphipods), among others.
- Several bird species use sand beaches along the Gulf of Mexico as foraging and nesting grounds. These habitats are also important wintering grounds for a number of migratory species.

- Several species of marine turtles inhabit in the waters of the Gulf of Mexico, and are considered species of concern. Accessible flat beaches along the impacted shoreline likely represent important nesting grounds for these species, where eggs can be deposited below the sand surface (~1-3 feet deep) and above the high tide line.
- Several subspecies of small terrestrial mammals are found in small coastal dunes of Florida and Alabama. All of these small mammals are endangered species with critical habitats restricted to small beaches along the Gulf of Mexico.
- Other receptors: Ghost crabs are one of the most abundant and conspicuous invertebrates inhabiting the intertidal zone of beaches. These crabs build burrows along sandy beaches of the Gulf of Mexico, and are an important food resource to higher trophic level species. Other receptors included in this analysis also were marine mammals and terrestrial plants.

Other sections of this report expand on the known ecological aspects of each group of receptor species, address receptor-specific measures of direct and/or indirect exposure, and provide input information relevant to the NEBA.

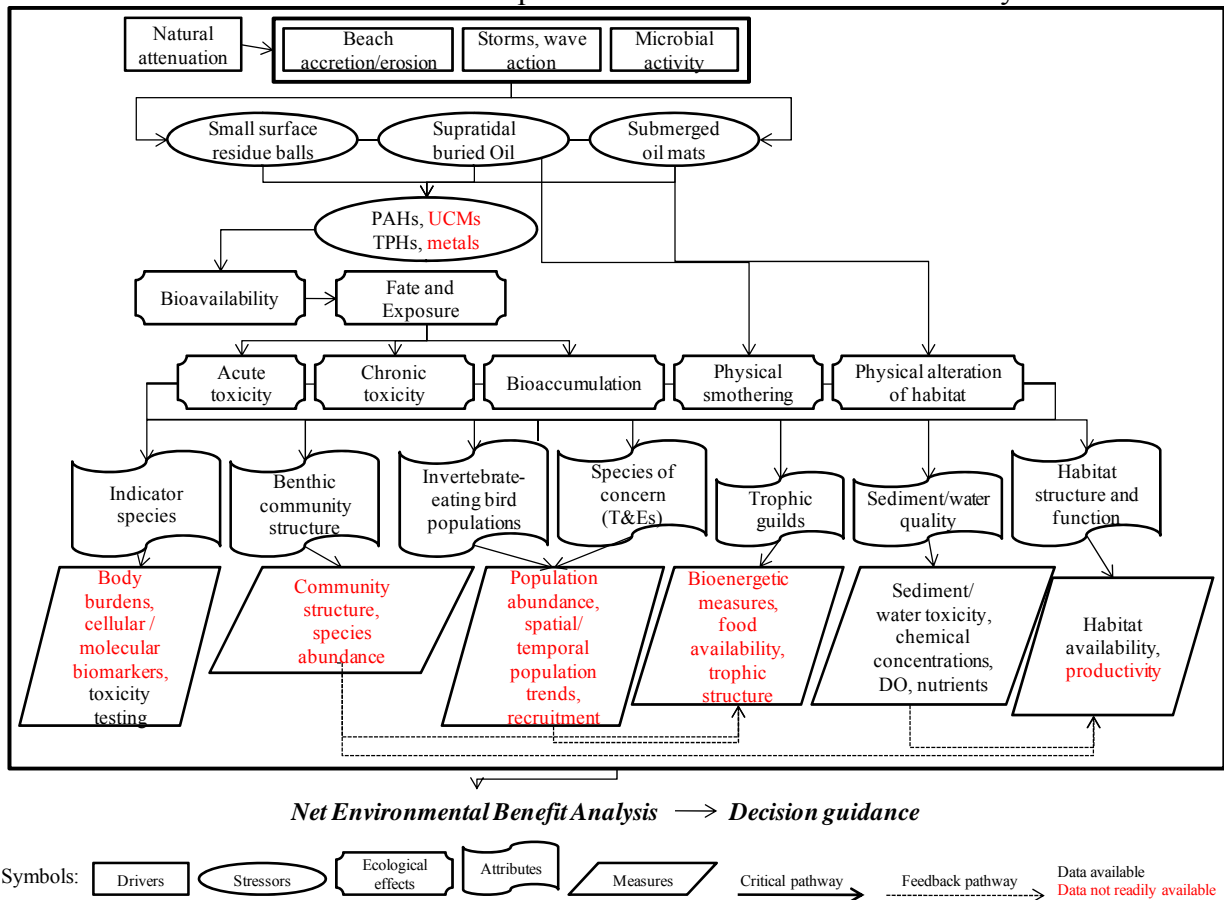
*Note that this assessment is not intended to estimate risks to all the possible receptor species under all possible exposure routes. Instead, a selected number of ecological receptors were selected based on one or more contexts, including species that are sensitive to the adverse effects of contaminants, representatives of a larger group of species, or functional groups and reasonable exposure pathways.*

Table 2. Selected OSAT-2 receptor species. *Note:* individual sections within the report may refer to species other than those included in this table. Submerged oil mats= SOM; small surface residue balls= SSRB; supratidal buried oil= SBO

Receptor	Exposure pathway	Habitat Distribution	Occurrence	Species of concern	Age classes of concern	Most likely exposure oil form
Aquatic invertebrates	Direct/ Indirect contact	Intertidal and subtidal zones	FL, AL, MS, LA	-	All age classes	SOM, SSRB
Fish	Direct/ Indirect contact	Subtidal zones	FL, AL, MS, LA	-	All age classes	SOM
Piping plover ( <i>Charadrius melodus</i> )	Direct contact (ingestion)	Wintering grounds; Critical habitats in the Gulf of Mexico	FL, AL, MS, LA	Threatened	All age classes	SSRB
Western sandpiper ( <i>Calidris mauri</i> )	Direct contact (ingestion)	Intertidal zone	FL, AL, MS, LA	-	All age classes	SSRB
Least tern ( <i>Sterna antillarum</i> )	Direct contact	Nesting grounds	MS, LA	Endangered	All age classes	SSRB, SBO
Southeastern Snowy plover ( <i>Charadrius alexandrinus tenuirostris</i> )	Direct contact	Nesting grounds	FL, AL, MS, LA	Under Review in the Candidate or Petition Process	All age classes	SSRB, SBO
Loggerhead turtle ( <i>Caretta caretta</i> )	Direct contact	Nesting grounds	FL, AL, MS, LA	Threatened	Adult females, eggs, hatchlings	SBO
Green turtle ( <i>Chelonia mydas</i> )	Direct contact	Nesting grounds	FL, AL, MS, LA	Endangered Threatened	Adult females, eggs, hatchlings	SBO
Leatherback turtle ( <i>Dermochelys coriacea</i> )	Direct contact	Nesting grounds	FL, AL, MS, LA	Endangered	Adult females, eggs, hatchlings	SBO
Alabama beach mouse ( <i>Peromyscus polionotus ammobates</i> )	Direct contact	Critical habitats in Alabama	AL	Endangered	All age classes	SSRB, SBO
<b>Other Receptors</b>						
Ghost crabs ( <i>Ocypode quadrata</i> ) and other supratidal invertebrates	Direct/ Indirect contact (ingestion)	Intertidal and supratidal zones	FL, AL, MS, LA	-	Juveniles, adults	SSRB
Plants	Direct contact	Supratidal zone	FL, AL, MS, LA	-	All age classes	SBO, SSRB
Marine mammals	Direct contact (ingestion)	Subtidal; primarily offshore	FL, AL, MS, LA	Endangered Threatened	All age classes	SOM

## Appendix 1

Conceptual model of the rationale for assessing potential adverse effects of residual oil on sand beach resources. *Note:* Not all of the components shown here were addressed by OSAT-2.



### Symbol descriptions:

**Drivers:** External driving forces that would determine the fate of the three forms of oil.

**Stressors:** Oil constituents in the three forms of residual oil that have the potential of causing adverse effects to sand beach resources. Oil constituents include polycyclic aromatic hydrocarbons (PAHs), total petroleum hydrocarbons (TPH), unresolved complex mixtures (UCMs), and metals. This minimum set of oil constituents that can be expanded depending on data availability.

**Ecological effects:** Potential responses elicited by the three forms of oil.

**Attributes:** Indicators, communities, critical resources, or habitat attributes representative of sand beach habitats. Only hypothesized attributes potentially affected by the three forms of oil are shown.

**Measures:** Metric associated with each attribute of potential use for quantifying adverse effects by the three forms of oil. This minimum set of variables that can be expanded depending on data availability.

**Pathways:** Critical and feedback: Hypothesized key linkages among components of the conceptual model.

**Data availability:** Data collected during different phases of the response.

## Appendix 2

Species with reported occurrence on beaches and beach-nearshore habitats along the Gulf of Mexico. Note that: (1) Only a *selected* number of species is shown; (2) OSAT-2 did not address impacts to all these individual species, but rather to either representative species, or to group of species. Data from NOAA-ESI (<http://gomex.erma.noaa.gov/erma.html>).

Common name	Scientific name	Status <sup>1</sup>	Occurrence	Nesting
<b>Birds</b>				
Northern pintail	<i>Anas acuta</i>		Seasonal	-
American wigeon	<i>Anas americana</i>		Seasonal	-
Northern shoveler	<i>Anas clypeata</i>		Seasonal	-
Green-winged teal	<i>Anas crecca</i>		Seasonal	-
Blue-winged teal	<i>Anas discors</i>		Year round	-
Mottled duck	<i>Anas fulrigula</i>		Year round	-
Mallard	<i>Anas platyrhynchos</i>		Seasonal	-
Gadwall	<i>Anas strepera</i>		Seasonal	-
Great blue heron	<i>Ardea herodias</i>		Year round	-
Lesser scaup	<i>Aythya affinis</i>		Seasonal	-
Redhead	<i>Aythya americana</i>		Seasonal	-
Ring-necked duck	<i>Aythya collaris</i>		Seasonal	-
Greater scaup	<i>Aythya marila</i>		Seasonal	-
Canvasback	<i>Aythya valisineria</i>		Seasonal	-
American bittern	<i>Botaurus lentiginosus</i>		Seasonal	-
Cattle egret	<i>Bubulcus ibis</i>		Year round	-
Bufflehead	<i>Bucephala albeola</i>		Seasonal	-
Common goldeneye	<i>Bucephala clangula</i>		Seasonal	-
Green-backed heron	<i>Butorides striatus</i>		Year round	-
Sanderling	<i>Calidris alba</i>		Year round	-
Great egret	<i>Casmerodius albus</i>		Year round	-
Willet	<i>Catoptrophorus semipalmatus</i>		Year round	X
Snowy plover	<i>Charadrius alexandrinus</i>	E	Year round	X
Piping plover	<i>Charadrius melodus</i>	T	Year round/ Seasonal	-
Semipalmated plover	<i>Charadrius semipalmatus</i>		Year round	-
Killdeer	<i>Charadrius vociferus</i>		Year round	-
Wilson's plover	<i>Charadrius wilsonia</i>		Year round/ Seasonal	-
Snow goose	<i>Chen caerulescens</i>		Seasonal	-
Black tern	<i>Chlidonias niger</i>		Seasonal	-
Northern harrier	<i>Circus cyaneus</i>		Seasonal	-
Oldsquaw	<i>Clangula hyemalis</i>		Seasonal	-
Yellow rail	<i>Coturnicops noveboracensis</i>		Year round	-
Little blue heron	<i>Egretta caerulea</i>		Year round	-
Reddish egret	<i>Egretta rufescens</i>		Seasonal	-
Snowy egret	<i>Egretta thula</i>		Year round	-
Tricolored heron	<i>Egretta tricolor</i>		Year round	-
White ibis	<i>Eudocimus albus</i>		Seasonal	-
Peregrine falcon	<i>Falco peregrinus</i>	E	Seasonal	-

American coot	<i>Fulica americana</i>		Year round	X
Common moorhen	<i>Gallinula chloropus</i>		Seasonal	-
Common loon	<i>Gavia immer</i>		Seasonal	-
Mississippi sandhill crane	<i>Grus canadensis pulla</i>	E/E	Year round	-
American oystercatcher	<i>Haematopus palliatus</i>		Seasonal	-
Bald eagle	<i>Haliaeetus leucocephalus</i>	T/E	Seasonal	X
Least bittern	<i>Ixobrychus exilis</i>		Seasonal	X
Herring gull	<i>Larus argentatus</i>		Year round	-
Laughing gull	<i>Larus atricilla</i>		Year round	-
Ring-billed gull	<i>Larus delawarensis</i>		Year round	-
Bonapartes gull	<i>Larus philadelphia</i>		Seasonal	-
Black rail	<i>Laterallus jamaicensis</i>		Year round	-
Hooded merganser	<i>Lophodytes cucullatus</i>		Seasonal	-
Red-breasted merganser	<i>Mergus serrator</i>		Seasonal	-
Northern gannet	<i>Morus bassanus</i>		Seasonal	-
Yellow-crowned night heron	<i>Nyctanassa violacea</i>		Year round	-
Black-crowned night heron	<i>Nycticorax nycticorax</i>		Year round	-
Osprey	<i>Pandion haliaetus</i>		Year round	X
American white pelican	<i>Pelecanus erythrorhynchos</i>		Seasonal	-
Brown pelican	<i>Pelecanus occidentalis</i>	E/E	Year round	-
Double-crested cormorant	<i>Phalacrocorax auritus</i>		Seasonal	-
Black-bellied plover	<i>Pluvialis squatarola</i>		Year round	-
Horned grebe	<i>Podiceps auritus</i>		Seasonal	-
Pied-billed grebe	<i>Podilymbus podiceps</i>		Year round	-
Purple gallinule	<i>Porphyryla martinica</i>		Seasonal	-
King rail	<i>Rallus elegans</i>		Year round	X
Clapper rail	<i>Rallus longirostris</i>		Year round	X
Black skimmer	<i>Rynchops niger</i>		Year round	-
Least tern	<i>Sterna antillarum</i>		Seasonal	-
Sooty tern	<i>Sterna fuscata</i>		Seasonal	-
Royal tern	<i>Sterna maxima</i>		Year round	-
Sandwich tern	<i>Sterna sandvicensis</i>		Year round	-

### Fish<sup>2</sup>

Atlantic sturgeon	<i>Acipenser oxyrinchus</i>		Seasonal	-
Gulf sturgeon	<i>Acipenser oxyrinchus desotoi</i>	T	-	-
Skipjack herring	<i>Alosa chrysochloris</i>		Seasonal	-
Bowfin	<i>Amia calva</i>		Year round	-
Striped anchovy	<i>Anchoa hepsetus</i>		Seasonal	X
Bay anchovy	<i>Anchoa mitchilli</i>		-	-
Freshwater drum	<i>Aplodinotus grunnius</i>		Year round	-
Sheepshead	<i>Archosargus probatocephalus</i>		-	-
Hardhead catfish	<i>Arius felis</i>		Seasonal	X
Gafftopsail catfish	<i>Bagre marinus</i>		Seasonal	X
Silver perch	<i>Bairdiella chrysoura</i>		-	-
Gulf menhaden	<i>Brevoortia patronus</i>		-	-
Blue runner	<i>Caranx crysos</i>		Year round	-
Crevalle jack	<i>Caranx hippos</i>		-	-
Spinner shark	<i>Carcharhinus brevipinna</i>		Year round	-



Bull shark	<i>Carcharhinus leucas</i>	Year round	-
Blacktip shark	<i>Carcharhinus limbatus</i>	Year round	-
River carpsucker	<i>Carpionodes carpio</i>	Year round	-
Rock sea bass	<i>Centropomus philadelphicus</i>	Seasonal	-
Atlantic spadefish	<i>Chaetodipterus faber</i>	Seasonal	-
Grass carp	<i>Ctenopharyngodon idella</i>	Year round	-
Sand seatrout	<i>Cynoscion arenarius</i>	-	-
Spotted seatrout	<i>Cynoscion nebulosus</i>	-	-
Silver seatrout	<i>Cynoscion nothus</i>	Seasonal	-
Seatrout	<i>Cynoscion sp.</i>	Year round	-
Sheepshead minnow	<i>Cyprinodon variegatus</i>	Year round	-
Common carp	<i>Cyprinus carpio</i>	Year round	-
Gizzard shad	<i>Dorosoma cepedianum</i>	-	X
Threadfin shad	<i>Dorosoma petenense</i>	Year round	-
Ladyfish	<i>Elops saurus</i>	Seasonal	-
Chubsucker	<i>Erimyzon sp.</i>	Year round	-
Spotfin mojarra	<i>Eucinostomus argenteus</i>	Seasonal	-
Little tunny	<i>Euthynnus alletteratus</i>	Year round	-
Marsh killifish	<i>Fundulus confluentus</i>	Year round	-
Gulf killifish	<i>Fundulus grandis</i>	Year round	-
Longnose killifish	<i>Fundulus similis</i>	Year round	-
Scaled sardine	<i>Harengula jaguana</i>	Seasonal	-
Whitespotted greenling	<i>Hexagrammos stelleri</i>	Year round	-
Silver carp	<i>Hypophthalmichthys molitrix</i>	Year round	-
Bighead carp	<i>Hypophthalmichthys nobilis</i>	Year round	-
Halfbeak	<i>Hyporhamphus unifasciatus</i>	Seasonal	-
Blue catfish	<i>Ictalurus furcatus</i>	Seasonal	-
Channel catfish	<i>Ictalurus punctatus</i>	Seasonal	X
Smallmouth buffalo	<i>Ictiobus bubalus</i>	Year round	-
Bigmouth buffalo	<i>Ictiobus cyprinellus</i>	Year round	-
Black buffalo	<i>Ictiobus niger</i>	Year round	-
Pinfish	<i>Lagodon rhomboides</i>	Year round	-
Spot	<i>Leiostomus xanthurus</i>	-	-
Spotted gar	<i>Lepisosteus oculatus</i>	Year round	-
Shortnose gar	<i>Lepisosteus platostomus</i>	Year round	-
Alligator gar	<i>Lepisosteus spatula</i>	Year round	-
Orangespotted sunfish	<i>Lepomis humilis</i>	Year round	-
Bluegill	<i>Lepomis macrochirus</i>	Year round	-
Longear sunfish	<i>Lepomis megalotis</i>	Seasonal	X
Redear sunfish	<i>Lepomis microlophus</i>	Year round	-
Spotted sunfish	<i>Lepomis punctatus</i>	Year round	-
Hybrid sunfish	<i>Lepomis spp.</i>	Year round	-
Bantam sunfish	<i>Lepomis symmetricus</i>	Year round	-
Rainwater killifish	<i>Lucania parva</i>	Seasonal	-
Red snapper	<i>Lutjanus campechanus</i>	Seasonal	-
Gray snapper	<i>Lutjanus griseus</i>	-	-
Lane snapper	<i>Lutjanus synagris</i>	Seasonal	-
Tarpon	<i>Megalops atlanticus</i>	-	-
Rough silverside	<i>Membras martinica</i>	Year round	X
Inland silverside	<i>Menidia beryllina</i>	Year round	X

Southern kingfish (whiting)	<i>Menticirrhus americanus</i>	Seasonal	-
Gulf kingfish	<i>Menticirrhus littoralis</i>	Seasonal	-
Northern kingfish	<i>Menticirrhus saxatilis</i>	Seasonal	-
Atlantic croaker	<i>Micropogonias undulatus</i>	-	-
Largemouth bass	<i>Micropterus salmoides</i>	Year round	-
White bass	<i>Morone chrysops</i>	Year round	-
Yellow bass	<i>Morone mississippiensis</i>	Year round	-
Striped bass	<i>Morone saxatilis</i>	Seasonal	X
Striped mullet	<i>Mugil cephalus</i>	-	-
White mullet	<i>Mugil curema</i>	Year round	-
Gag grouper	<i>Mycteroperca microlepis</i>	Seasonal	-
Shiners	<i>Notropis spp.</i>	Year round	-
Atlantic thread herring	<i>Opisthonema oglinum</i>	Seasonal	-
Pigfish	<i>Orthopristis chrysoptera</i>	Seasonal	-
Gulf flounder	<i>Paralichthys albigutta</i>	Year round	-
Southern flounder	<i>Paralichthys lethostigma</i>	-	-
Harvestfish	<i>Peprilus alepidotus</i>	Seasonal	-
Gulf butterfish	<i>Peprilus burti</i>	Year round	-
Logperch	<i>Percina caprodes</i>	Year round	-
Sailfin molly	<i>Poecilia latipinna</i>	Seasonal	-
Black drum	<i>Pogonias cromis</i>	-	-
Paddlefish	<i>Polyodon spathula</i>	Year round	-
Bluefish	<i>Pomatomus saltatrix</i>	Year round	-
White crappie	<i>Pomoxis annularis</i>	Year round	-
Black crappie	<i>Pomoxis nigromaculatus</i>	Year round	-
Cobia	<i>Rachycentron canadum</i>	Seasonal	-
Atlantic sharpnose shark	<i>Rhizoprionodon</i>	Seasonal	-
	<i>terraenovae</i>		
Shovelnose sturgeon	<i>Scaphirhynchus</i>	Year round	-
	<i>platorynchus</i>		
Red drum	<i>Sciaenops ocellatus</i>	-	-
King mackerel	<i>Scomberomorus cavalla</i>	Seasonal	-
Spanish mackerel	<i>Scomberomorus maculatus</i>	-	-
Star drum	<i>Stellifer lanceolatus</i>	Seasonal	-
Florida pompano	<i>Trachinotus carolinus</i>	-	X
Rough scad	<i>Trachurus lathami</i>	Seasonal	-
Southern hake	<i>Urophycis floridanus</i>	Seasonal	-
Spotted hake	<i>Urophycis regius</i>	Seasonal	-

### Invertebrates<sup>2</sup>

Atlantic bay scallop	<i>Argopecten irradians</i>	Year round	X
Blue crab	<i>Callinectes sapidus</i>	-	-
American oyster (eastern)	<i>Crassostrea virginica</i>	Year round	X
Bay squid	<i>Lolliguncula brevis</i>	-	-
River shrimp	<i>Macrobrachium sp.</i>	Year round	-
Gulf stone crab	<i>Menippe adina</i>	-	-
Florida stone crab	<i>Menippe mercenaria</i>	-	-
Stone crab	<i>Menippe spp.</i>	Year round	X
Southern quahog (hard clam)	<i>Mercenaria campechiensis</i>	Year round	X
Brown shrimp	<i>Penaeus aztecus</i>	-	-
Pink shrimp	<i>Penaeus duorarum</i>	-	-

White shrimp	<i>Penaeus setiferus</i>		-	-
White river crawfish	<i>Procambarus acutus</i>		Year round	-
Brackishwater clam	<i>Rangia cuneata</i>		Year round	X
<b>Reptiles</b>				
American alligator	<i>Alligator mississippiensis</i>		Year round	-
Loggerhead sea turtle	<i>Caretta caretta</i>	E/T	Seasonal	X
Threatened sea turtles		T	Seasonal	X
Mississippi diamondback terrapin	<i>Malaclemys terrapin pileata</i>		Year round	X
Gulf salt marsh snake	<i>Nerodia clarkii</i>		Year round	-

<sup>1</sup>. Endangered= E; Threatened= T.

<sup>2</sup>. Primarily early life stages (eggs, larvae, juveniles).