

In order to generate data used to derive the compensation formula, the NRDAM/CME was run at a series of latitude-longitude grids where each grid cell has associated environmental characteristics such as depth, habitat type, temperature, currents, etc. The environmental data were similar to "reality," but simplified and modified to describe generic environmental conditions for spills. Each of the habitat types contains specific biological data. The biological database (Volume IV of the NRDAM/CME, Version 2.4, documentation) contains wildlife, fishery species, and fishery young-of-the-year abundances per unit area. Fishery and young-of-the-year abundances differ for open water versus structured (Exhibit 2.1), and for estuarine versus marine habitats. Wildlife abundances are assumed only in habitats where those species exist. The database also contains lower trophic level production rates by trophic habitat type (Exhibit 2.1). All abundances and rates vary seasonally.

The types of habitats differentiated for the estuarine and marine compensation formula are a simplification of that in the NRDAM/CME, which is based on Cowardin et al. (1979). Zones and trophic habitats are clearly defined in the NRDAM/CME documentation (Volume I, Section 6). The following is further clarification.

"Estuarine environment" means deepwater tidal habitats that are usually semi-enclosed by land but have an open, partially obstructed, or sporadic access to the open ocean and in which ocean water is at least occasionally diluted by freshwater runoff from the land. The estuarine environment extends upstream and landward to where ocean-driven salts measure less than 0.5 parts per thousand during the period of average annual low flow; and (1) seaward to an imaginary straight line closing the mouth of a river, bay, or sound; or (2) to the seaward limit of wetland emergents, shrubs, or trees where not included in (1) of this definition. The estuarine environment also includes offshore areas of continuous upwellings of freshwater containing typical estuarine plants and animals.

"Marine environment" means the greater of the open ocean extending landward from the seaward limit of the fishery conservation zone established by the Magnuson Fishery Conservation and Management Act of 1976 or the Exclusive Economic Zone established by Presidential Proclamation 5030 (48 FR 10605, March 10, 1983) to one of the following: (1) the landward limit of the intertidal (see below); or (2) the seaward limit of the estuarine environment. The marine environment does not include offshore areas of continuous upwellings of freshwater containing typical estuarine plants and animals.

"Intertidal" means an estuarine or marine environment with hard shore or sand beach in which the substrate is exposed and flooded by tides. It incorporates: (1) the splash area, which lies above the extreme high water level of spring tide; (2) the upper shore, which lies between the average high tide level and the extreme high water level of spring tides; (3) the midshore, which lies between the average low tide level and the average high tide level; and (4) the lower shore, which lies between the extreme low water level of spring tides to the average spring tide level.

"Subtidal" means an estuarine or marine environment in which the substrate is continuously submerged. All subtidal applications used to generate the compensation formula are included in the estuarine and marine environment scenarios.

The biological data also vary by region for the coastal United States, termed (biological) provinces. A listing of the provinces and their boundaries are in Exhibit 2.1, which is identical to Exhibit 6.1 of the NRDAM/CME, Version 2.4, documentation.

Representative habitat-province combinations were used in model runs to develop the compensation formula. These habitat-province combinations are referred to herein as "cases." A total of 55 cases were used in the model runs, as listed in Exhibits 2.2 to 2.4 and summarized in Exhibit A.1 of Appendix A. Case IDs beginning with the letter "M" refer to scenarios occurring in marine environments; those beginning with "E" refer to estuarine scenarios; and those beginning with "I" refer to intertidal scenarios. In Exhibits 2.2 to 2.4, the "Province # Run" heading lists the province code number, from the list in Exhibit 2.1, in which the model was run for the noted cases. The numbers in parentheses show other provinces from Exhibit 2.1 that are sufficiently similar in characteristics to be adequately represented by the "Province # Run."

For each of the 55 cases, 100 runs of the model were made: 4 seasons x 5 oil types x 5 volumes spilled. Seasonal variation in biological abundances and temperature are important influences on resulting damages. Thus, the compensation formula damages vary by season of the spill. The seasons are defined as follows:

Winter	January 1 - March 31
Spring	April 1 - June 30
Summer	July 1 - September 30
Fall	October 1 - December 31

Spill dates used in model runs were set at the beginning of each season so that resulting damages would reflect the season of the spill (i.e., January 5, April 5, July 5, and October 5), and would be unlikely to extend into a different season. The season is meant to be representative of the time period where most of the injury is expected to have occurred. This is most often that season containing the date of the spill. However, if a spill occurs at a change in seasons, the following season may be more representative.

Due to the simplified nature of the compensation formula, it would be impossible to have every specific type of oil represented. Therefore, it was necessary to select representative oil types of the many crude and petroleum products that might be discharged.

The types of oils and total volumes spilled into U.S. waters from 1973-1990, as available in the U.S. Coast Guard Pollution Reporting System (PIRS) database, are in Appendix C, Exhibit C.1. Most spills are of crude oil, followed by gasolines, fuel oils, and diesel. Collectively, miscellaneous oils amount to a considerable number and volume of spills.

In addition, the recently published Port Needs Study, Maio et al. (1991), provide estimates of cargo tons transported into or out of 23 U.S. ports (Appendix C, Exhibits C.2 and C.3). The major commodities are crude oil, gasoline, distillate fuels, and residual fuels. The percentage of cargo (Exhibit C.3) by oil type varies considerably by port. However, there is no clear pattern by region of the country. Therefore, the same oil types were used for model spill runs in all regions of the U.S.

Five oil types were selected to be representative of the many oils that might be spilled (and for which the formula may be used):

Heavy crude
Light crude
No. 2 Fuel oil
Diesel
Gasoline

When the compensation formula is used for an actual spill case, an oil in the above table must be selected which most closely represents the spilled oil. Exhibit A.6 (Appendix A) gives suggested choices for the types of oils contained in the U.S. Coast Guard oil spill data set (CHRIS). The most similar oil was based on the viscosity and percentage components of the oil. The properties of the oil types are given in Volume III of the NRDAM/CME documentation.

Timothy Goodspeed (NOAA, Strategic Environmental Assessment Division, pers. comm., Nov. 1991) has analyzed the numbers and volumes of spills of oil of all types into U.S. waters using data obtained from the U.S. Coast Guard PIRS database. (Appendix C, Exhibit C.4) His analysis shows that 99.8% of spills are less than 50,000 gallons and 99% of spills are less than 10,000 gallons. Thus, for model runs used to develop the compensation formula, the spill volumes used were:

100 gal
1,000 gal
5,000 gal
10,000 gal
50,000 gal

The spills are all assumed to be instantaneous and spilled on the water surface.

Exhibit 2.1 Provinces and their boundaries (National Estuarine Atlas, NOAA, 1985).

Prov. Code	Province	Water Bodies and Boundaries
1	Northern Maine Coast	Passamaquoddy Bay (Maine-Canadian border) to line from Port Clyde to Monhegan Is., ME; incl. northern Gulf of Maine (<200m depth)
2	So. Maine and New Hampshire Coast	Port Clyde to NH-Mass. border; incl. NW Gulf of Maine (<200m) (southwest of line from Port Clyde to Monhegan Is. and north of 42° 52'N at NH-Mass border)
3	Gulf of Maine	central Gulf of Maine (>200m depth, east of Cape Cod at 69° 50'W, north of 42° 20'N)
4	Mass. Bay	Mass and Cape Cod Bays (NH border to Provincetown: west of 69° 50'W, outside Boston Harbor, south of 42° 52'N)
5	Boston Harbor	Boston Harbor (inside line from Hull to Nahant = Boston Bay of National Estuarine Atlas)
6	Georges Bank	Georges Bank (ICNAF 5Ze) (40° N - 42° 20'N, 65° 30'W - 69° 50'W)
7	Offshore Mid-Atlantic	South of Georges Bank, Atlantic Mid-Atlantic offshore (35° N - 40° N, >200m, plus >200m depth north of 40° N and west of 69° 50'W)
8	So. New England Shelf	So. New England Shelf (ICNAF 5Zw, west of 69° 50'W, east of Montauk Pt. at 71° 52'W, <200m, not incl. Buzzards and Narragansett Bays)
9	Buzzards Bay	Buzzards Bay (inside line from Cuttyhunk Is. to Gooseberry Neck)
10	Narragansett Bay	Narragansett Bay (north of line from Sakonnet Pt. to Narragansett Pier - as in National Estuarine Atlas)
11	Long Island Sound	Long Island Sound (west of Montauk Pt. at 71° 52'W = LIS and Gardiners Bay in National Estuarine Atlas)
12	New York Harbor	Hudson R. and NY harbor (inside line from Rockaway Pt. to Sandy Hook -- Hudson River/Raritan Bay in National Estuarine Atlas)
13	NY-NJ Shelf	NY-NJ Shelf (ICNAF 6A) (west of 71° 52'W, north of Cape May at 39° N, <200m)

Exhibit 2.1 (continued)

14	Delaware Bay	Delaware River and Delaware Bay (inside line from Cape May to Cape Henlopen)
15	Delmarva Shelf	Delmarva Shelf (ICNAF 6B) (Cape Henlopen to Cape Henry, 37° N - 39° N, <200m)
16	Upper Chesapeake	Upper Chesapeake Bay (north of 38° 30'N)
17	Lower Chesapeake	Lower Chesapeake Bay (south of 38° 30'N and inside (north of) line from Cape Charles to Cape Henry)
18	James River	James River and Hampton Roads (inside Hampton Roads Bridge-Tunnel)
19	Pamlico Sound	Pamlico Sound, Albemarle Sound complex (inside barrier islands running from Virginia Beach to Cape Lookout)
20	Hatteras Shelf	Virginia and North Carolina Shelf (ICNAF 6C) (35° N - 37° N, <200m, Cape Henry to Cape Lookout)
21	Carolina Shelf	No. and So. Carolina coast and shelf (Cape Lookout to So. Carolina-Georgia border at Hilton Head and Calibogue Sound, 32° 05'N - 35° N, <200m)
22	Georgia Bight	Georgia coast, Georgia Bight and Northern Florida coast (Savannah, Ga. to Cape Canaveral = Cape Kennedy, 28° 30'N - 32° 05'N, <200m)
23	Offshore Carolinian	Carolinian offshore (>200m, Cape Hatteras to Cape Canaveral, 28° 30'N - 35° N)
24	SE Florida Shelf	Southeast Florida coast and shelf (Cape Canaveral to Key Largo, 25° 10'N - 28° 30'N, <200m, not incl. Biscayne Bay)
25	Biscayne Bay	Biscayne Bay (inside line from Cape Florida to Ragged Keys)
26	Straits of Florida	Straits of Florida (Cape Canaveral to Key West, 23° 30'N - 28° 30'N, east of 82° W, >200m)
27	Caribbean Is.	Puerto Rico, U.S. Virgin Islands; Caribbean Sea islands
28	Florida Bay	Florida Bay and Everglades (east of line from Cape Romano to Key West, incl. shelf of Fla. Keys <200m)
29	SW Florida Shelf	Southwest Florida coast and shelf (Key West to Cedar Key, <200m, not incl. Fla. Bay, 24° 20'N - 29° 07'N)
30	Tampa Bay	Tampa Bay (inside line from Anna Maria I. to Egmont Key to Mullet Key)

Exhibit 2.1 (continued)

31	Offshore Gulf of Mexico	Gulf of Mexico >200m deep (west of 82° W)
32	South Texas Shelf	So. Texas coast and shelf (Port Aransas, TX to Mexican border, <200m, 26° N - 27° 50'N)
33	Florida-Miss. Shelf	Fla. panhandle, Ala., Miss. coast and shelf: (Cedar Key, Florida to Mississippi R. Delta, <200m)
34	Mobile Bay	Mobile Bay
35	Mississippi Sound	Miss. Sound, Lake Borgne Sound inside barrier islands (seaward); Lake Pontchartrain, Lake Maurepas (landward)
36	Mississippi River	Miss. River and Delta
37	Louisiana-No. Texas Shelf	La.-No. Texas coast and shelf (Miss. R. Delta to Port Aransas, TX)
38	Port Arthur	Sabine Lake, Port Arthur
39	Galveston Bay	Galveston Bay, Houston
40	So. Calif. Coast	So. Calif. coast and shelf incl. San Diego Bay (Mexican border to Huntington Beach, 32° 35'N - 33° 40'N, <200m)
41	Los Angeles Coast	Los Angeles coastal region (Huntington Beach to Point Dume, 33° 40'N - 34° N, <200m)
42	So. California Offshore	Offshore southern California (Mexican border to San Miguel Island, 32° 35'N - 34° N, >200m)
43	Santa Barbara Channel	Santa Barbara Channel (north of 34° N running along line from Pt. Dume to Anacapa Is. and through Channel Islands, east of line from Richardson Rock to Pt. Conception)
44	Central Calif. Coast	Central Calif. coast and shelf (Point Conception to Cape Mendocino, 34° 27'N - 40° 30'N, <200m)
45	Central Calif. Offshore	Offshore central California (San Miguel Is. to Cape Mendocino, 34° N - 40° 30'N, >200m)
46	San Francisco Bay	Sacramento River Delta to San Francisco Bay (inside Golden Gate Bridge)
47	No. Calif-Oregon Coast	No. Calif. and Oregon coast and shelf (Cape Mendocino to OR-Wash. border, 40° 30'N - 46° 15'N, <200m)
48	Columbia River	Columbia River

Exhibit 2.1 (continued)

49	Washington Outer Coast	Washington outer coast and shelf (Or-Wash. border to Cape Flattery, 46° 15'N - 48° 30'N, <200m)
50	Oregon-Wash. Offshore	No. Calif., Oregon, Wash. offshore (Cape Mendocino to Cape Flattery, >200m, 40° 30'N - 48° 30'N)
51	Puget Sound	Puget Sound (landward); Strait of Juan De Fuca, Strait of Georgia (seaward)
52	SE Alaska	SE Alaska coast and shelf (Dixon Entrance to Cape Spencer, <200m)
53	Yakutat	Coast of Alaska, Cape Spencer to Cape Suckling, <200m)
54	Copper River Shelf	Copper River Delta and shelf offshore of Prince William Sound (Cape Suckling to Cape Puget, <200m)
55	Prince Wm. Sound	Prince William Sound
56	Kenai Shelf	Kenai shelf (Cape Puget to Cape Elizabeth, <200m)
57	Upper Cook Inlet	Upper Cook Inlet (north of Anchor Point)
58	Lower Cook Inlet	Lower Cook Inlet (south of Anchor Point and line from Cape Douglas to Shuyak Is. to Cape Elizabeth, incl. Barren Is. area)
59	Shelikof Strait	Shelikof Strait (Cape Douglas to Kilokak Rocks)
60	Kodiak Shelf	Kodiak shelf - seaward side of Kodiak Island complex (Shuyak Is. to Trinity Is., <200m)
61	Chignik Shelf	south side of Alaska Peninsula (Kilokak Rocks to Kupreanof Pt., <200m)
62	So. AK Peninsula	south side of Alaska Peninsula (Kupreanof Pt. to Unimak Pass, <200m)
63	Aleutian	Aleutian Islands west of Unimak Pass (shelf north and south of islands, <200m)
64	Gulf of Alaska	Gulf of Alaska and North Pacific (>200m deep)
65	So. Bering Sea Shelf	Southern Bering Sea shelf (east of Unimak Pass and shelf break, to south of 60° N, north of Alaska Peninsula, <200m)
66	Bristol Bay	Bristol Bay (inside line from Cape Menshikof to Cape Newenham)
67	Kuskokwin Bay	Kuskokwin Bay (inside line from Cape Newenham to Cape Mendenhall on Nunivak Is.; south of 60° N latitude in Etolin Strait)

Exhibit 2.1 (continued)

68	No. Bering Sea	Northern Bering Sea Shelf (north of 60° N, south of line from East Cape = Mys Dezhneva to Cape Prince of Whales in Bering Strait, <200m)
69	Yukon Delta	Yukon Delta and River
70	Bering Sea Offshore	Offshore Bering Sea (>200m)
71	Norton Sound	Norton Sound (east of line from Point Romanof to Cape Nome)
72	Kotzebue Sound	Kotzebue Sound (inside line from Cape Espenberg to Cape Krusenstern)
73	Chukchi Sea	Chukchi Sea (north of Bering Strait to Point Barrow)
74	Beaufort Sea	Beaufort Sea (east of Point Barrow to Canadian border)
75	Hawaii	Hawaiian Islands (<200m)
76	Polynesia	Guam, other Pacific islands (<200m)
77	Central Pacific	Central Pacific (>200m)

Exhibit 2.2 Marine subtidal (rock, cobble, sand, mud) cases.

Case ID	Province # Run (Represent)	Province Name	Region Represented
M01	6 (3,6)	Georges Bank	Gulf of Maine - Georges Bank
M02	13 (7-8, 13, 15, 20)	NY-NJ Shelf	Mid-Atlantic Offshore
M03	21 (21-23)	Carolina Shelf	Carolinas to No. Fla. Shelf-Offshore
M04	29 (24, 26, 27, 29, 31-32)	SW Florida Shelf	So. Fla., So. Texas, Caribbean Shelf-Offshore
M05	37 (33, 35, 37)	La.-No. Texas Shelf	No. Gulf of Mexico Shelf
M06	43 (40-43)	Santa Barbara Channel	So. California Shelf-Offshore
M07	44 (44-45)	Central Calif. Coast (Gulf of Farallones)	Central Calif. Shelf-Offshore
M08	47 (47, 49-50)	Oregon Coast	Oregon-Wash. Shelf-Offshore
M09	56 (52-54, 56, 58-64)	Kenai Shelf	Gulf of Alaska
M10	65 (65-67, 70)	So. Bering Sea Shelf	So. Bering Sea
M11	71 (68, 71-73)	Norton Sound	No. Bering Sea to Chukchi Sea
M12	74 (74)	Beaufort Sea	Beaufort Sea
M13	75 (75-77)	Hawaii	Pacific Islands Shelf-Offshore

Exhibit 2.3 Estuarine and nearshore subtidal and intertidal cases. See Exhibit 2.6 for regions represented by each case.

Case ID	Province # Run (Represent)	Province Name	Location	Habitat Type (Exhibit 2.1)
E01	2 (1,2,4)	So. Maine and N.H. Coast	Casco Bay at Portland, ME	Rock-mud, open water
E02	4 (1-15)	Mass. Bay	Just north of Cape Ann	Saltmarsh, mud flats
E03	5 (5)	Boston Harbor	Boston Harbor entrance	Rock-mud, open water
E04	9 (8-9)	Buzzards Bay	In channel, near entrance	Rock-mud, open water
E05	10 (10)	Narragansett Bay	Near Newport in East Passage	Rock-mud, open water
E06	11 (11)	Long Island Sound	Western LIS	Rock-mud, open water
E07	12 (12)	NY Harbor	Arthur Kill	Rock-mud, open water
E08	14 (13-15)	Delaware Bay	Near mouth	Rock-mud, open water
E09	16 (16)	Upper Chesapeake	Baltimore (or Annapolis)	Rock-mud, open water
E10	17 (17-22)	Lower Chesapeake	Just inside Ches. Bay Bridge Tunnel	Rock-mud, open water
E11	19 (1-23)	Pamlico Sound	SW nearshore area	Seagrass beds (eelgrass)
E12	21 (16-24)	Carolina Shelf	Savannah River	Saltmarshes and flats
E13	25 (24-28)	Biscayne Bay	Miami	Rock-mud, open water
E14	26 (25-29)	Straits of Florida	Coral reefs along Florida Keys	Coral reef
E15	28 (24-32, 75-77)	Florida Bay	Near Key West	Seagrass beds

Exhibit 2.3 (continued)

E16	28 (24-32, 75-77)	Florida Bay	Everglades near mangroves	Mangrove swamp, mud flats
E17	30 (29-30, 32)	Tampa Bay	Near entrance	Rock-mud, open water
E18	34 (33-37)	Mobile Bay	Near entrance	Rock-mud, open water
E19	37 (33-39)	La.-No. Texas Shelf	Near wetlands in Barataria Bay	Saltmarsh, mud flat, seagrass beds
E20	39 (38, 39)	Galveston Bay	Near entrance	Rock-mud, open water
E21	40 (40-43)	So. California Coast	San Diego Bay area, Tijuana Estuary	Mud open water, saltmarsh
E22	44 (40-51)	Central California Coast	Monterey Bay near kelp beds	Kelp beds
E23	46 (44,46)	San Francisco Bay	San Francisco Bay just inside Golden Gate	Rock-mud, open water
E24	46 (44,46)	San Francisco Bay	At Sacramento R. Delta	Saltmarshes, mudflats
E25	48 (48)	Columbia River	Columbia River	Rock-mud, open water
E26	49 (47-50)	Washington Outer Coast	Grays Harbor open bay	Rock-mud, open water
E27	49 (47-51)	Washington Outer Coast	Grays Harbor near marshes	Saltmarsh, mudflats
E28	51 (51)	Puget Sound	Strait of Juan de Fuca near seaward entrance	Rock-mud, open water
E29	51 (51)	Puget Sound	Near Seattle	Rock-mud, open water
E30	55 (52-74)	Prince William Sound	PWS near entrance to Valdez arm	Rock-mud, open water, gravel shores, fjords
E31	57 (52-74)	Upper Cook Inlet	Near Anchorage	Mud flats
E32	65 (52-74)	So. Bering Sea Shelf	Port Moller near eelgrass	Seagrass beds
E33	75 (75-77)	Hawaii	Kaneohe Bay	Sand, open water
E34	75 (75-77)	Polynesia	Coral reef or atoll	Coral reef

Exhibit 2.4 Intertidal cases for beach damages.

CASE ID	Province # Run (Represent)	Province Name	Intertidal Habitat	Region Represented
I01	2 (1-39)	So. Marine and N.H. Coastal	Hard shore	East and Gulf of Mexico Coasts
I02	47 (40-51)	No. Calif-Oregon Coast	Hard shore	West Coast
I03	56 (52-74)	Kenai Shelf	Hard shore	Alaska
I04	75 (75-77)	Hawaii	Hard shore	Pacific Island
I05	20 (1-26)	Hatteras Shelf	Sand beach	East Coast
I06	37 (27-39)	La.-No. Texas Shelf	Sand beach	Gulf of Mexico
I07	44 (40-74)	Central California Coast	Sand beach	West Coast and Alaska
I08	75 (75-77)	Hawaii	Sand beach	Pacific Islands