SECTION 6. WILDLIFE IMPACTS

On 8 February, as soon as oil started to be released from the vessel, U.S. Fish and Wildlife Service (USFWS) and Oregon Department of Fish and Wildlife (ODFW), in cooperation with the Responsible Party, set up a Wildlife Response and Rehabilitation Mobile Facility on the east side of North Spit. Personnel from the International Bird Rescue and Research Corp. were mobilized to assist in oiled wildlife rehabilitation. Spill response efforts included trained wildlife survey teams to recover dead birds, report live oiled birds for recovery and rehabilitation, and census bird populations at risk. On 3 March, when the bow section grounded near Waldport, a second wildlife rehabilitation facility was set up there.

Bird Rehabilitation and Morgue Data

During the response, 1,467 birds were turned into the rehab centers and morgues. Of these, 133 oiled birds (mostly sanderlings, cormorants, and scoters) and 11 non-oiled birds were treated and released. Seventeen oiled snowy plovers were treated and released. Table 5 lists the number of birds by species that were turned in dead, died at the centers, or were euthanized. Not all of the dead birds were visibly oiled. However, it is important to note that many of the carcasses had been heavily scavenged, making it difficult to observe oil.

Oiled birds were recovered as far north as Washington. However, birds that were turned into morgues in Washington are not included in this report because it has yet to be determined if they are related to the *M/V New Carissa* spill.

Figure 7 shows the number of dead birds by species in the morgues at each response area. At Coos Bay, grebes, northern fulmars, and rhinocerous auklets accounting for over 40 percent of the total. At Waldport, rhinocerous auklets, scoters, and northern fulmars accounted for over 40 percent of the total. Land birds in the table included a crow, northern flicker, red-tailed hawk (oiled), Stellar's jay (oiled), barred owl, two thrushes, and a sparrow. Most of the bird species affected by the spill are associated with open water or the outer beaches.

Bird recoveries were highly variable depending on the pattern of oil releases, wind, waves, and tides. Most of the birds were recovered from the outer beaches. There were no systematic bird surveys in any of the bays because of the relatively low amount of oil observed in the bays.

It should be noted that the number of dead birds recovered during a spill may represent only a fraction of the total bird mortality, because injured birds are lost to predation or hide, and dead birds sink, drift out to sea, or are quickly scavenged. On the other hand, not all of the dead birds collected during a spill may have been killed as a result of the spill, but instead may have been killed during storms or by other factors unrelated to the spill. Thus, the Trustees and RP representatives are undertaking additional assessments to determine the total bird injury.

Shorebird Surveys

USFWS and ODFW response personnel conducted regular field surveys to determine bird populations at risk and the percent of the population that was oiled, classified by the degree of oiling. On 14 February, USFWS response personnel conducted an instantaneous shorebird

TABLE 5. List of dead birds by species turned into the morgues during the *M/V New Carissa* spill.

Species	Number	Species	Number
Alcid, sp.	22	Kittiwake, Red-legged	1
Auklet, Cassin's	47	Loon, Common	59
Auklet, Parakeet	7	Loon, Pacific	12
Auklet, Rhinoceros	227	Loon, Red-throated	9
Auklet, spp.	1	Loon, spp.	2
Bufflehead	4	Mallard	1
Coot, American	2	Murre, Common	104
Cormorant, Brandt's	86	Murre, spp.	1
Cormorant, Double-crested	1	Murrelet, Ancient	4
Cormorant, Pelagic	2	Murrelet, Marbled	28
Cormorant, spp.	7	Owl, Barred	1
Crow, American	1	Pelican, Brown	1
Duck, Harlequin	1	Plover, Snowy	1
Duck, spp.	3	Puffin, Horned	27
Duck, Wood	1	Puffin, spp.	1
Flicker, Northern	1	Puffin, Tufted	1
Fulmar, Northern	136	Sanderling	2
Grebe, Clark's	2	Scaup, Greater	1
Grebe, Eared	2	Scoter, Black	5
Grebe. Horned	8	.Scoter, spp.	12
Grebe, Red-necked	3	Scoter, Surf	131
Grebe, spp.	6	Scoter, White-winged	43
Grebe, Western	73	Shearwater, Short-tailed	3
Gull, Bonaparte's	1	Shearwater, Sooty	3
Gull, Glaucous-winged	8	Shearwater, Wedge-tailed	1
Gull, GW*WE (hybrid)	9	Shorebird, spp.	1
Gull, Herring	3	Sparrow, Fox	1
Gull, Mew	2	Storm-petrel, Fork-tailed	9
Gull, spp.	22	Storm-petrel, Leach's	9
Gull, Western	39	Surfbird	1
Hawk, Red-tailed	1	Thrush, Varied	2
Jay, Steller's	1	Unknown Bird	40
Kittiwake, Black-legged	77		
		Totals	1323

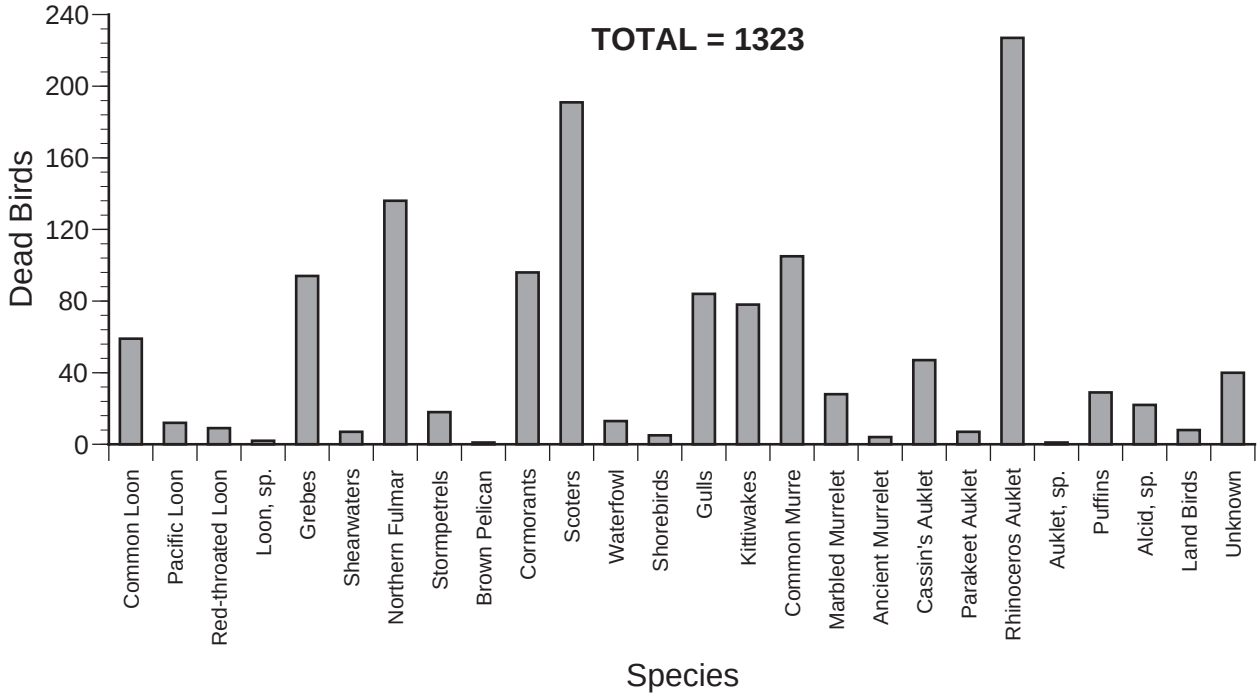

FIGURE 6. Number of dead birds by species in the morgues.

census in the Coos Bay spill area, from Horsfall Beach access to Heceta Head, about 10 km north of the Siuslaw River. On 8 and 10 March, the shorebird survey was repeated, but expanded to extend from Bastendorff Beach (in the south) to Yaquina Head (to the north), which includes the Waldport area (Jaques, 1999). Sanderlings were the most common shorebird on the outer beaches, accounting for 99.9 percent of all shorebirds counted. The number of sanderlings present in the Coos Bay area declined by 16 percent (from 4,947 to 4,588 birds) between the February and March counts.

The percent of sanderlings that were observed as oiled during the March survey was highly variable, from 0-24 percent, and averaged 6 percent in the Coos Bay area and 13 percent in the Waldport area. Oil was observed on 3 percent of the gulls in the Coos Bay area and 5 percent of the gulls in the Waldport area (Jaques, 1999). Oiling of sanderlings was mostly categorized as spottily oiled (total body coverage <1 percent) and mostly on the underbelly and abdomen. A greater number of moderately to heavily oiled birds were reported by survey teams earlier in the spill at both locations, along with overall higher percentages of oiled birds, however, these data are still being compiled.

Based on observations and data compiled to date, there appear to be impacts to shorebirds that warrant further NRD study. The baseline survey data, the morgue data, as well as other field data will be used in a model being developed by USFWS and ODFW to estimate the actual number of shorebirds oiled and injured as a result of the *M/V New Carissa* spill events.

Seabird Surveys
A boat survey for marbled murrelets (Federally-threatened species) and other seabirds was conducted on 14-15 February to serve as baseline population data (Strong, 1999). The survey covered 226 km of coastline from Heceta Head (44° 08.3'N) to Whiskey Run Beach (43° 12.7'N). On 6-7 March, a second survey was conducted along 214 km of coastline from north of Siletz Bay (44° 55.6N) to Heceta Beach (44° 02.2'N). Densities of marbled murrelets and other seabirds in these areas were low relative to their nesting season abundance. Some murrelets were in proximity to the hull and slicks of oil at Coos Bay, and in the Alsea River outflow plume at Waldport. Scoters occurred in large flocks, totaling over 7,000 birds in the area. During the 14-15 February offshore surveys, only one bird was seen with oil on it: a western gull with a light brown tint across its breast and around the vent.

Aerial surveys of offshore seabirds were conducted in the Coos Bay area on 19-20 February, and in the Waldport area on 7 March (Ford, 1999). Lines were flown: 1) parallel to shore about 50-100 m from the edge of the surf zone (an area of highest densities of scoters); and 2) in a sawtooth pattern along the coast 1-5 km offshore (an area of highest densities of seabirds). Also, offshore lines extending as far as 67 km seaward were flown several times on each survey day. Birds in bays and estuaries were counted separately. Scoters were by far the most abundant birds (16,587 out of a total of 19,598 birds counted). The heaviest concentration of scoters was observed 1-2 km offshore along the southern edge of the freshwater plume flowing out from the Umpqua estuary.

Based on the number of dead seabirds turned into the rehabilitation centers, there appear to be impacts to seabirds that warrant further NRD study. The baseline survey data, the morgue data, as well as other field data will be used in a model being developed by USFWS and ODFW to estimate the actual number of seabirds (including waterfowl) oiled and injured as a result of the *M/V New Carissa* spill events.

Snowy Plover Impacts
The western snowy plover is a Federally-threatened species, which was at significant risk of exposure to the oil because it feeds in the swash zone and nests on the outer beaches in the area most affected by the spill. Therefore, special efforts were made to protect and monitor these shorebirds.

During the spill, 98 western snowy plovers were observed on the southern Oregon coast. Of these, 45 had some degree of oiling on their plumage. Seventeen oiled western snowy plovers were eventually captured and brought to the rehabilitation center to be cleaned and released. Seven birds were released on 26 February and the remaining 10 were released on 7 March. The other oiled snowy plovers were not captured for rehabilitation. One western snowy plover was found dead on 21 April. The bird was oiled and is being necropsied to determine cause of death.

Emergency restoration activities were implemented in April to speed recovery of the western snowy plover population in the impact area, including:

1) Hiring of additional law enforcement personnel to enforce public closures at nesting areas

2) Purchase and installation of barriers at key locations at breeding areas to exclude vehicles and/or human entry
3) Purchase and installation of rope and post at breeding areas to exclude human entry
4) Removal of predator species (i.e., red fox and skunk) of the western snowy plover on BLM-administered lands at New River
5) Purchase of additional signs for delineating no entry zones at plover nesting sites from Sutton south to New River
6) Purchase of additional predator exclosure materials for all plover nesting sites from Sutton south to New River
7) Providing on-site interpretation specialists during the nesting season to increase public education/awareness

Because the potential for significant impacts to the western snowy plover was determined to be high, the Trustees have implemented a population monitoring study to determine the degree of exposure and effects from the *M/V New Carissa* incident. Data are being collected on total number of plovers in Oregon, recruitment, survival, changes in areas of use, and toxic effects on birds/eggs. These data will be compared between oiled and unoiled birds; affected and unaffected areas; and with previous year's data. Comparisons of compliance, nest abandonment due to recreational disturbance, and predation loss will also be made between 1999 nesting season success and previous years to address potential benefits of emergency restoration measures.

Bald Eagles

Two bald eagles were observed in the field near Waldport to be oiled. ODFW has contracted with the Oregon Cooperative Fish and Wildlife Research Unit to conduct surveys of the three eagle nests (out of five total in the area) that failed to produce young in 1999.

Marine Mammals

Harbor seals, Stellar sea lions, northern elephant seals, and California sea lions were present in the area affected by oil from the *M/V New Carissa*. Marine mammal specialists from the National Oceanic and Atmospheric Administration (NOAA) and ODFW on conducted an overflight on 5 March 1999 to identify and assess marine mammal populations along the primary stretch of rocky coastline affected by the Coos Bay and Waldport groundings. The area between Siuslaw River and Cascade Head was surveyed, with the following results: 1,300 harbor seals, 250 Steller sea lions, and 110 California sea lions were counted. These counts were normal numbers for this time of year. All expected haulout areas were in use, and no unexpected or negative observations noted.

A boat survey was conducted in Alsea Bay on 4 March, during which 121 harbor seals were counted.

On 25 February, one dead seal was reported on the beach about 1 km north of Horsfall beach but it was not recovered. One dead, un-oiled harbor seal was collected in the Waldport area on 20 March. There have been no other reports of impacts to marine mammals in the area. Thus, the Trustees have determined that impacts to marine mammals do not warrant further injury assessments.

SECTION 7. SHORELINE IMPACTS

Initial Outer Beach Impacts (8 February-3 March 1999)

Most of the information on the distribution of oil along the outer beaches was collected as part of the Shoreline Cleanup Assessment Team (SCAT) program, which was established under the response and reported to the Unified Command on oil locations and recommended cleanup methods, priorities, and constraints. All of the SCAT data were summarized by Polaris (1999a) in a report entitled "Response to the *M/V New Carissa* Oil Spill: Fate and Persistence of Spilled Oil". Much of the following discussion of the SCAT data was based on information included in the Polaris (1999a) report. Segment maps are included in Appendix F.

Formal SCAT teams, composed of staff representing both the RP and state and federal agencies, conducted surveys from 8 February to 2 March, although most of the SCAT teams were demobilized on 27 February (only 7 segments were surveyed between 27 February and 2 March). During this period, approximately 68.5 km of outer shoreline from the entrance to Coos Bay north were affected by oil released from the *M/V New Carissa* (Polaris, 1999a). The volume of oil stranded on the outer beaches was calculated from the SCAT data, using the length, width, percent cover, and thickness, which is a relatively straightforward procedure. The results for the area covered by segments N1 through N9 and over the period between the initial release of oil and just after the major storm on 15-16 February were summarized by Polaris (1999a) as:

Period	Volume (gal)
9 February	2,004
11 February	27,310
12 February	21,861
13 February	41,353
15 February	26,038
16-18 February*	2,574

*As only a few segments were surveyed on each day during 16-18 February, the data for these dates have been combined to generate the oil volume data for the period.

The Polaris (1999a) report referred to "standard definitions for surface oil cover" cited in Owens and Sergy (1994), for describing oil as heavy, moderate, light, and very light. However, the Trustees have noted that these definitions were derived for the T/*V Exxon Valdez* spill with a volume of nearly 11 million gallons. The NOAA Shoreline Assessment Manual (NOAA, 1998) advises that the SCAT program should "modify this matrix, especially the intervals of width of oiled areas, for specific spill conditions".

The "Tarball Period" (3 March-30 September 1999)

The storm on 15-16 February, which lowered the beach face by about 1 meter and eroded the dune line by several meters, also removed most of the oil from the shoreline. Thereafter, the amount of oil stranded on the shoreline was reduced and the character was primarily as tarballs rather than continuous bands of oil. This period of oiling, from 3 March until at least 30 September 1999, is referred to as the "tarball period".

The SCAT methodology was revised on 3 March because the standard SCAT procedure was not applicable to widely scattered tarballs. According to Polaris (1999a):

> BARF (Beach Assessment Reporting Form) surveys were conducted daily from 3 March to 30 September and generally were timed to coincide with low tides. Personnel involved in the surveys were mostly cleanup crews and, occasionally, ODFW staff. As time went on, surveys were almost exclusively performed by cleanup crews, who would report oiling conditions and pick-up tarballs. *In most cases, the observations were noted by the cleanup teams and reported using field notes or verbally to the cleanup crew supervisors, who completed the BARF form* (emphasis added).

In using the BARF data, it is important to consider the inherent limitations in this dataset for quantitative analysis. Cleanup workers often verbally reported their observations at the end of the day to a supervisor who recorded the data. On any day, segments could be divided into sub-segments with and without tarballs (e.g., segment N1 on August 7 was reported as 5200 m with no tarballs, but on August 8 N1 was reported as sub-segments of 2600 m with a tarball density of 0.0019/m^2 and 2600 m with no tarballs). Thus, trends of tarball densities plotted from the data can be highly variable. Polaris (1999a, p. 83) noted "Tar ball observations, therefore, must be treated as individual records of the oiling condition on a section of shore at that time. Extra-polation alongshore and through time is not recommended.....and the data derived from the field surveys should be regarded as primarily descriptive information, or semi-quantitative at best."

Polaris (1999a) calculated the daily volumes of oil on each segment, which are summarized in Table 6 for the Coos Bay area (N1-N13). Sudden increases in the amount of oil removed from the shoreline occurred on 4-11 May and 18-28 July. These two events may not have been attributable to the M/V New Carissa spill. In fact, the USCG took over cleanup of the July "mystery spill".

When the bow section grounded near Waldport on 3 March, an estimated 2,000 gal of oil were released. Polaris (1999a) calculated the daily volumes of oil on each segment, which are summarized in Table 6.

Until the reports on fingerprint analysis of the tarballs are completed, it is not possible to accurately determine the extent of shoreline exposed to tarballs from the *M/V New Carissa,* or the duration of exposure. Based on the limited information on chemical analysis of tarballs provided in Polaris (1999a), only three of the nine sampled collected in February and early March from the Waldport matched with the *M/V New Carissa* source oils; none of the nine tarballs collected in May and analyzed were a match. In contrast, 17 out of 18 tarballs collected from N2 (as late as 31 August) matched with the *M/V New Carissa* source oils.

The Trustees have attempted to use the available data on tarball densities to best describe the behavior of tarballs released from the *M/V New Carissa*. Appendix F shows the tarball density, in g/m^2, for each of the stations for the period from 3 March to 30 September. The data are plotted on a log scale, and zero values (0.0000) were given a "1" on the end so they could be plotted (thus all zero values are shown as 0.00001 g/m^2). Figures 7 and 8 show plots for segments N13 and B1. Temporal patterns in reported tarball distributions are highly variable,

TABLE 6. Semi-monthly volumes of stranded tarballs (in gallons) on the outer beaches.

Coos Bay Area	
March 3-15	360 (including 320 gal from N2 on 3 March)
Match15-31	28
April 1-15	69
April 16-30	1
May 1-15	164
May 16-30	1
June 1-15	1
June 16-30	2
July 1-15	1
July 16-31	25
August 1-15	1
August 16-31	3
September 1-15	2
September 16-30	8
Total	**666 gallons in the Coos Bay area**
Waldport Area	
March 3-15	390
March 16-31	42
April 1-15	0
April 16-30	0
May 1-15	<1
May 16-26	<1
Total	**432 gallons in the Waldport area**

and it is difficult to track spatial trends. However, the temporal trends for the segments do provide some insight into the question of what is the background rate of tarball deposition.

The temporal pattern for N13, located about 88 km north of the first grounding site, is shown in Figure 7. No tarballs were reported on segment N13 for 35 out of 77 days. At this site, it appears that, starting in mid-May, there were tarball deposition "events" where the tarball density increased to about 0.001 g/m^2, then decreased to zero after a period of a week or two. Tarballs were collected for fingerprint analysis on three dates: One sample on 6 March showed a match with *M/V New Carissa* oil, but the others collected on 25 May (3 samples) and 7 July (1 sample) were not matches. Thus, it is likely that the tarball "events" at this site were not all related to the *M/V New Carissa* spill.

The data for each segment shows a unique pattern. For example, Figure 8 shows the tarball density over time for segment B1, located about 122 km north of the first grounding. It shows a pattern of relatively high tarball densities in early March, then a drop-off to zero on 17 March, after which very low tarball densities were reported only on four dates. In comparison, N1, which is located at the stern section, had only one day with no tarballs observed on any part of the segment, out of approximately 170 survey days; 17 of 23 tarball samples collected from N1 matched with oil from the *M/V New Carissa*.

This highly variable pattern, both spatially and temporally, makes it very difficult to determine what is background. The very short record of observations, immediately after a spill event, and the on-going releases from the stern as late as September 1999, makes it even more difficult. The dynamic nature of the outer beaches obviously plays an important role in the rates of tarball deposition and erosion. The beaches are regularly cleared of tarballs by wave and sediment action, followed by stranding events. The frequency and degree of tarball stranding is also a function of proximity to where the oil is being introduced into the environment, as well as seasonal variations in current and wind patterns. Thus, background rates will be highly variable even from Coos Bay to Waldport. Classifications for tarball stranding rates empirically derived from other locales are not applicable because of differences in the relative stranding rates, physical setting, and environmental and human-use sensitivity. Most tarball surveys have been conducted in areas of heavy tanker traffic where chronic tarball deposition is a problem. The central Oregon coast differs from these areas is that most tanker traffic remains far offshore. Furthermore, classifications such as Corbin et al. (1993) were developed with recreational use as the resource of concern. Sites with other resources, such as nesting areas for threatened species, would have a different classification, and a much lower tolerance to the presence of tarballs.

Sediment Sampling Results

Table 7 lists all of the sediment samples collected during the spill. Figures 9 through 11 show the PAH concentrations for the samples which were analyzed. The PAH data for the sediment samples have not been evaluated to determine if they match the oils from the *M/V New Carissa*. This evaluation can be conducted if the Trustees decide it is necessary. Much of the tar ball PAH data have been evaluated, and the results will be prepared into a brief report which will summarize which samples match the oils released from the *M/V New Carissa*.

Figures 9 and 10 show the total PAH concentrations in sediment samples collected in Coos Bay pre- and post-oiling. Different teams sampled different locations, so it is not possible to do a time-series analysis of the results. There appears to be an increase in the PAH concentration in sediment samples from Coos Bay pre- and post-oiling, but that could be a function of different sampling sites between the two periods. Nevertheless, all of the post-oiling sediment samples have low total PAH concentrations, with the highest value of 350 parts per billion (ppb) PAH in Coos Bay (Fig. 10). As an initial screening for potential impacts, the post-oiling PAH concentrations can be compared to the "effects range-low" or ERL and the "effects range-medium" or ERM for total PAH as reported by Long et al. (1995). Concentrations below the ERL represent minimal-effects range, where effects are rarely expected to be observed in sediments. Concentrations between the ERL and ERM represent a possible-effects range, where effects would occasionally occur. Above the ERM, effects would frequently occur. These levels are used as guidelines for evaluating sediment quality. The ERL for total PAH is 4 parts per million (ppm); for the lower molecular weight PAH (2- and 3-ringed PAH) that one would expect to be associated with an oil spill, the ERL is 0.552 ppm (Long et al., 1995). All the sediment samples are below both of these ERLs.

Videotape Records

BLM staff took videos with a Sony DSR 200A Digital DV Camera of the spill activities in the Coos Bay area fron 5 February to 26 March. The footage and a detailed log are stored on 15 tapes on file at the BLM Coos Bay District Office (Jim Brende, contact). .

TABLE 7. Sediment samples collected during the *M/V New Carissa* oil spills.

Agency	Objective	Locations	Date	No./Status
Coos Bay Area				
ODFW/ SSNEER	Pre-oiling background	South Slough	9-10 Feb	34 samples; 10 analyzed
ODFW/ SSNEER	Pre-oiling background	Lower, Mid, Upper Coos Bay	9 Feb	28 samples; 7 analyzed
NOAA/ NMFS	Pre-oiling background at monitoring stations for outmigrant juvenile salmon	3 stations each in Coos Bay, South Slough, Ten Mile Ck, and Umpqua, Siuslaw, Yaquina, and Salmon rivers	11-12 Feb	66 samples (triplicates at each station); Not analyzed
NOAA/ DAC	Outer beach samples to characterize and track the oil	Outer beaches from 1 mi. S to 5 mi. N of vsl	11 Feb	9 samples; 5 analyzed
SSNEER	Post-oiling exposure assessment	South Slough	13 Feb	4 samples; Not analyzed
USFS	Pre-oiling background	Tahkenitch lagoon, Siltcoos River, Berry Ck	14-15 Feb	9 samples (3 per estuary; Not analyzed
ODEQ	Post-oiling exposure assessment	From Coos Bay to Yaquina River	17-19 Feb	61 samples; 17 analyzed
USFS	Post-oiling exposure assessment	Outer beaches from 1 mi. S of vsl to Ten Mile Creek	21 Feb	7 samples; All analyzed
ODEQ	Post-oiling exposure assessment	Lower to Upper Coos Bay, South Slough	21-23 Feb	46 samples; 9 analyzed
Waldport Area				
ODEQ	Determine extent of oil exposure	Waldport to Yaquina	4-6 Mar	29 samples; 7 analyzed
ODEQ	Determine extent of oil exposure	Alsea Bay	6 Mar	4 samples; Not analyzed
Polaris	Determine extent of oil exposure	Alsea Bay	23 Mar	2 samples; Not analyzed

FIGURE 9. PAH results for pre-oiling sediment samples collected by ODFW/SSNEER on 9-10 February 1999 in Coos Bay.

FIGURE 10. PAH results for post-oiling sediment samples collected by ODEQ in Coos Bay between 21-24 February 1999.

FIGURE 11. PAH results for sediment samples taken in the Waldport area to Yaquina area on 4 and 6 March 1999.

SECTION 8. WATER IMPACTS

Water Sampling Results

Water samples were collected to determine pre-oiling background levels and post-oiling exposure. Table 8 lists all of the water-sampling efforts by the different agencies. Of these, 98 water samples and 21 filters were analyzed for PAH and n-alkanes. Grab water samples can be used to determine the degree and extent of oil exposure in the water column. However, oil toxicity to aquatic organisms is mostly a function of the dissolved fraction. For spill conditions such as the *M/V New Carissa*, where the oil was physically mixed into the water column during its release in the surf zone, grab samples likely contain both dissolved and particulate oil. The NOAA water sampling program utilized a portable, large-volume (4-L) water sampling system that allowed on-site collection of both filtered water and the particulates on the filter, so that both dissolved and particulate oil concentrations could be measured.

TABLE 8. Summary of water samples collected.

Agency	Objective	Locations	Date	No. and Status
Coos Bay Area				
ODFW/ SSNEER	Pre-oiling background	South Slough	9-10 Feb	25, 1-L samples Not analyzed
ODFW/ SSNEER	Pre-oiling background	Lower, Mid, Upper Coos Bay	9 Feb	16, 1-L samples Not analyzed
NOAA/ NMFS	Pre-oiling background at monitoring stations for outmigrant juvenile salmon	3 stations at the mouths of Coos Bay, South Slough, Ten Mile Ck, and Umpqua, Siuslaw, Yaquina, and Salmon rivers	11-12 Feb	22, 1-L samples Extracted and preserved
NOAA/ DAC	Filtered water samples to measure dissolved and dispersed water concentrations	Outer beaches from 1 mi. S to 5 mi. N of vsl; 4 sites in Coos Bay; offshore 1-3 mi W/NW of vsl	11-16 Feb	21 4-L filtered water, 21 filters, 20 1-L grab water All analyzed
ODEQ	Post-oiling exposure assessment	Umpqua and Siuslaw Rivers	17-18 Feb	40, 1-L samples; All analyzed
ODEQ	Determine extent of oil exposure	Coquille River	19 Feb	20, 1-L samples; All analyzed
Waldport Area				
SSNEER	Pre-oiling background in estuaries	Alsea Bay and Ona River	3 Mar	5, 1-L samples; Not analyzed
ODEQ	Determine extent of oil exposure	Waldport Area and north of Yaquina Bay	4-8 Mar	25, 1-L samples; 11 analyzed
ODEQ	Determine extent of oil exposure	Alsea Bay	6 Mar	5, 1-L samples; Not analyzed

Water sampling at oil spills is also limited because grab samples represent conditions only for a single point and time, for a pollutant that is only slightly soluble. Another approach to document the presence of oil in a waterbody is to measure oil in shellfish, which concentrate oil in their tissues by up to 10,000 times the concentration in the water. Thus, the Trustees have relied upon the extensive bivalve monitoring data to determine the extent of oil contamination in the water column during the spill. Sample location maps, sample logs, and all analytical data for both water and bivalve samples have been distributed both electronically and in hardcopy by Polaris (1999b). Therefore, copies of the data are not included here. The intent of this section is to summarize the data and determine the extent of water-column exposure from the *M/V New Carissa* spill. The results of this analysis were used to support a water-quality fates and effect modeling effort to calculate the acute toxicity to aquatic organisms resulting from the spill.

The chemical results for water samples are reported in units of weight per volume, such as nanograms per liter (ng/L) and micrograms per liter (ug/L). These units can be converted to ratio scales, as defined below:

ng/L = parts per trillion (pptr)
ug/L = parts per billion (ppb)
mg/L = parts per million (ppm)

Payne and Driskell (1999) analyzed the PAH and n-alkane patterns in 119 environmental samples of filtered water, filters, and unfiltered water, collected during the period between 11 February and 8 March 1999. Because of the complexity of the data set, three analytical approaches were used to assist in discriminating between the *M/V New Carissa* oils and background sources: 1) histogram plots of PAH and n-alkanes and PAH double-ratio scatter plots; 2) multivariate principal component analyses (PCA) using both the PAH and n-alkane data, combined with hierarchical, agglomerative cluster analyses; and 3) integration of all the statistical results and plots onto one data sheet to visually determine if the sample contained oil from the *M/V New Carissa*.

Figures 12 and 13 are examples of the data sheet Payne and Driskell (1999) developed. Figure 12 shows the data for a 4-L filtered water sample from mid-Coos Bay on a falling tide, collected on 13 February (sample NC-41-NOAA located on Fig. 14). The upper left box is a plot of the total PAH in all water samples (that were analyzed) versus distance from the original grounding site. The sample is highlighted on the plot (though often difficult to see on the summary data sheets).

On the upper right of Figure 12 is the cluster plot for the PCA, with the sample highlighted. The samples that plot in the upper left have very low concentrations of PAH and n-alkanes and show no evidence of contamination by *M/V New Carissa* oils. The samples that plot in the lower center include all the 4-L filtered water samples taken close to the vessel and in Coos Bay, the Coos Bay water filters, and some offshore grab samples near the vessel. Finally, the samples that plot in the upper right are the filters for the surf-zone samples collected within 1.6 km south and 8 km north of the vessel, and the grab samples with high PAH. These three clusters of samples plot very independently, and the plots were key tools in determining if a water sample was contaminated with *M/V New Carissa* oil.

The next box on the left in Figures 12 and 13, titled “Double Ratios,” is the double-ratio scatter plot of C_3-dibenzothiophene/C_3-phenanthrene versus C_2-dibenzothiophene/C_2-phenanthrene for all water samples and the four source oils. A trend line is drawn between the two bunker oils, MFO 280 and BFO 280. Most of the water samples that contained these PAHs above the detection limits fall in between the two end-points and cluster around the BFO 280 source oil. As discussed in the oil characterization section, the BFO source oil had ten times the total PAH than the MFO source oil, so its PAHs overwhelmed those in the MFO.

The histograms titled “Water Aliphatics” (n-alkanes) and “Water PAHs” are the analytical results for the filtered water and represent the dissolved petroleum fraction, whereas the histograms titled “Particulate Aliphatics” (n-alkanes) and “Particulate PAHs” are for the filter for the same sample and represent dispersed oil droplets in the water. The row of boxes on the bottom of Figure 13 titled “Source Oil Aliphatics” and “Source Oil PAHs” show the aliphatic and PAH histogram for a surf-zone grab water sample (NC008-NOAA) collected adjacent to the bow. This sample provides a "water fingerprint" of *M/V New Carissa* oil contamination in an unfiltered water sample.

In Figure 12, note that the dissolved PAH pattern is similar to the source oil PAH pattern, and the particulate aliphatics look very similar to the source oil aliphatics. The different behavior of PAH versus aliphatics is because the PAH are much more water-soluble that the aliphatics. The sample plots in the lower center part of the PCA cluster plot and in the cluster near BFO in the double-ratio plot. Therefore, the Coos Bay water sample is contaminated with oil from the *M/V New Carissa*.

In contrast, Figure 13 shows the data for a 1-L unfiltered grab sample from the Umpqua River collected 6 km upstream from the mouth on 17 February. It plots with the upper left cluster on the PCA plot and on the x-axis on the PAH double-ratio plot. The PAH histogram does not match the source oil in that the parent PAH is higher than the homologs (i.e., for naphthalene, N is bigger than N1 and N2) whereas in the source oil, the parent compound is always smaller.

Payne and Driskell (1999) made such interpretations for all 119 water samples that were analyzed, and the results are listed in Table 9. Figure 14 shows the location and PAH concentrations (dissolved and particulate) in the four filtered water samples taken in Coos Bay on 13 February. Figures 15-17 show the location and PAH concentrations (dissolved, particulate, and grab) in the water samples collected by NOAA from the surf zone on 11, 12, and 14 February, respectively. Figure 18 shows the location and PAH concentrations for the offshore water samples collected by NOAA on 15 February. The NOAA water samples collected in the surf zone 1.6 km south and 8 km north of the vessel on 11-13 February, from the surface and bottom 1.6-4.8 km offshore west and northwest of the vessel on 15 February, and in Coos Bay on 13 February have elevated levels of PAH that have been verified as matching the oils from the *M/V New Carissa*. Total dissolved PAH showed a general trend of decrease with distance from the vessel for samples collected on 12 and 14 February, with concentrations of 21-45 ppb within 0.4 km north of the vessel, 0.9-8.6 ppb within 3.3 km north of the vessel, and 0.6-1 ppb within 8.2 km north of the vessel. Samples collected on 12 February within 0.3 and 1.6 km south of the vessel contained 12 and 9.4 ppb total dissolved PAH, respectively.

Total dissolved PAH concentrations in the four samples from Coos Bay on 13 February were relatively consistent: 4.9 ppb at the entrance to South Slough, 5.7 ppb at the entrance to North Slough, 7.7 ppb at Jerry's Channel, and 7.0 ppb over some oyster beds due west of North Bend. They all showed evidence of *M/V New Carissa* oil.

As can be seen in Table 9, total PAH concentrations in grab samples usually exceeded the dissolved PAH concentrations. There is good agreement at many of the stations between the sum of the total PAH levels in the dissolved and particulate phases and the PAH levels in the grab samples.

It was not possible to verify that any other water samples contained oil from the *M/V New Carissa*. The closest water sample to this area was a 1-L grab sample collected from the surf zone just south of the entrance to the Umpqua River on 17 February where tar balls first appeared on 13 February. The 20 water grab samples collected from the Umpqua River on 17 February (Fig. 19) contained 14-120 ng/L (0.01-0.12 ppb) total PAH, but they did not show evidence of contamination by oils from the *M/V New Carissa*. The eight samples collected from the Siuslaw River on 18 February (Fig. 20) contained 15-370 ng/L (0.01-0.4 ppb) total PAH, but no evidence of *M/V New Carissa* oil. Water samples from the surf zone from Waldport to Yaquina Head (Fig. 21) collected from 3-8 March contained 23-83 ng/L (0.02-0.08 ppb) total PAH. Again, they did not show evidence of contamination by oils from the *M/V New Carissa*. The inability to match the PAH and n-alkane patterns in the 1-L grab samples with the oil fingerprints from the *M/V New Carissa* is strongly tied to the detection limits achievable with a sample volume of 1 L.

PAH in Tissue Samples

Shellfish can be used to indicate the extent and degree of water-column exposures because they are known to concentrate oil in their tissues up to 10,000 times the concentration in water. They also tend to average out concentrations over space and time. As of early August, Payne (pers. comm., 9 August 1999) had evaluated the PAH data for the bulk of the tissue samples that have been analyzed, using the same procedures described above (e.g., PCA clustering, double-ratio plots, PAH histograms). However, only PAH were analyzed. The results of his analysis available to-date are shown in Table 10. Station locations are on Figure 22.

The mussel tissue collected on 14 February from the North Jetty contained the highest total PAH concentrations of all samples, 41 ppm, dry weight (or 7120 ppb, wet weight), and it matched *M/V New Carissa* oil. Inside Coos Bay, in South Slough, there was a trend in the fingerprint in bivalves with distance from the entrance to South Slough. That is, those bivalves collected near the entrance (e.g., BAR-1) contained *M/V New Carissa* oil; those collected a little further to the south (e.g., JN-1 at the entrance to Joe Ney Slough and from Brown Cove) contained some *M/V New Carissa* oil but mostly background; and those collected even further south (e.g., LI-1 at Long Island Point, VAL-1 at Valino Island, and GH-1 at Graveyard Hole) all had the same background pattern. Thus, it appears that only the upper part of South Slough was exposed to *M/V New Carissa* oil.

The Oregon Department of Agriculture had closed areas to commercial shellfish harvesting because of the threat of contamination from the spill. They conducted time-series sampling of

FIGURE 19.

FIGURE 20.

FIGURE 21.

FIGURE 22.

TABLE 10. Results to-date of evaluation of PAH patterns in post-oiling shellfish samples to determine if they match the oils from the *M/V New Carissa* (Payne, pers. comm., 9 August 1999).

Sample Name	*New Carissa* Match?	Sample Name	*New Carissa* Match?
*Bay Dungeness Crabs**		*Coos Bay Clams (2/17)*	
219	Y	CB NS	Y
319	?	CB NBAP	Y + bkgd
419	Y	CB EBR	Y + bkgd
519	Y	BAR-1	Y + bkgd
619	Y	VAL-1	N
719	Y		
819	Y	*Coos Bay Oysters*	
919	Y	JN1	?
1019	Y	BC1	?
		LI1	N
Offshore Dungeness Crab	N	GH1	N
#1 Tissue	N	SP-1	?
#1 Hepatopancreas	N		
# 3 Tissue	Y?	*Umpqua Rr. Oysters (2/20)*	
#3 Hepatopancreas	N	Jerden Cove (2/20)	N
#4 Tissue	N	South	N?
#4 Hepatopancreas	N	North	N?
#10 Tissue	?		
#10 Hepatopancreas	Y	*Outer Coast Mussels*	
		Mussel Tissue	Y
Umpqua River Clams		BB1	Y? + bkgd
217	Y + bkgd	LBM-1	N
Macey Cove 1(2/17)	N	SCM-1	N
		BB 323 (3/23)	N

*For both tissue and hepatopancreas

the Coos Bay and Umpqua River beds, as shown in Table 11 below, noting that nearly all sampling stations increased over the period of 14 and 20 February. Although the closures were lifted on 4 March based on a risk assessment (see Section 10), they required continued sampling until the total PAH showed a decreasing trend, which occurred at most sites by 5-6 March, and continued through the end of April. The pattern of an increase in total PAH in oysters after the oil from the *M/V New Carissa* spilled, then a steady decrease, occurred at all sites sampled over time in Coos Bay and near the mouth the Umpqua River, strongly suggesting a correlation.

According to Payne (pers. comm., 9 August 1999), the oyster samples from Coos Bay contained some evidence of weathered *M/V New Carissa* oil plus a background pattern. Furthermore, the bay dungeness crabs that were collected in crab pots deployed from 19-21 February all had PAH patterns that reflected the presence of *M/V New Carissa* oil (Payne, pers. comm., 9 August 1999), though the concentrations were very low. Thus, it is likely that small amounts of *M/V New Carissa* oil entered mid-Coos Bay.

TABLE 11. Total PAH, µg/Kg dry weight, for oyster samples collected in the Coos Bay area over time. See Figure 22 for sampling locations.

	10 Feb	14 Feb	17/20 Feb	5-6 Mar	23 Mar	14/21 Apr
South Slough						
Joe Ney Lower	1700	9400	8300			
Joe Ney Upper			2500 (2/27)			
Browns Cove		2800	3600, 3700	2400		
Graveyard Hole		2400, 2400	3500	2300		
Long Island Pt.		2800	2600			
Coos Bay						
SP 1/3 (North Slough)	1800	2700, 2600	3700, 3500	3330		1670 (4/14) 1080 (4/21)
SP 4/5/6		2700	2800			
SP 7/8/9	1200, 1200, 1500	2400, 2100, 2200	2700, 2400, 2700	2710		1230, 1710
Umpqua River						
Triangle Area	420, 950	4400 (S) 6300 (N)	9200 (S) 11000 (N)	8100	2400	
Jorden			2500		1500, 1600	
Macey Cove			2800 (2/17) 3100 (2/20)			

According to Payne (pers. comm., 9 August 1999), the oyster samples from the Umpqua River beds at Jerden and Macey Cove did not contain evidence of contamination with *M/V New Carissa* oil. The oyster samples from the Umpqua Triangle area at the mouth of the river may have contained some *M/V New Carissa* oil. One sample of clams collected on 17 February (sample 217) from the mouth of the Umpqua River did have a PAH pattern similar to that of *M/V New Carissa* oil, but the total PAH level was low, at 88 ppb, weight wet. Thus, it is possible that some oil entered the Umpqua River as longshore and tidal currents moved oil/sediment mixtures to the north and in/out of the Umpqua River estuary.

Snare Trawls in South Slough

There was concern that oil suspended in the water column was entering Coos Bay and the South Slough National Estuarine Research Reserve (SSNERR). Oil snares were attached to weighted ropes and trawled through the water column at several sites at the entrance to South Slough. No oil was observed on the snares.

Summary

Based on the water and tissue sample results, oil from the *M/V New Carissa* spill impacted water-column resources in an area as far north as the entrance to the Umpqua River, several km in the offshore direction, as far south as Cape Arago, and in Coos Bay to the upper part of South Slough and up the main channel to about Pierce Point. This area of impact is similar to that determined by the oil fates model, as discussed in the next section.