SECTION 9. FISH AND INVERTEBRATE IMPACTS

Impacts to Fish

Fish species spawning in shallow waters were at the greatest risk of impact during the spill. Recent toxicity tests with fish embryos and weathered crude oil have shown malformations, genetic damage, and mortality for salmon and herring at exposures as low as 0.7 ppb total PAH at 5-6°C (Carls et al., 1999; Heintz et al., 1999). Fish that may have been spawning at the time of the spill were: Lingcod, in shallow water on rocky substrates, including the jetties at the entrance to Coos Bay; surf perch, along the outer beaches; and Pacific herring, in the estuaries. Salmon fry were of concern because they were beginning their migration to salt water at the time of the spill, but they had not yet reached the estuaries at the time of the major releases. Also, very little oil reached the estuaries.

No unusual fish mortality events were reported during the spill. Field studies to detect impacts to fish populations are difficult and expensive to conduct. There is insufficient pre-spill information for time-series comparisons of larval abundance, or comparison of abundance, growth, and survival of the young of the year juvenile fish. Therefore, the Trustees decided to evaluate the degree of impacts to fish through an oil fates and effects model. French (1999) described the model inputs and results for six model runs. These model runs used: 1) different spill volumes (70,000 and 140,000 gallons); 2) tidal currents alone and with the addition of a southward drift component near the shore; and 3) three different values for horizontal dispersion. The larger spill volume was a simple doubling of the estimated spill volume since the amount of oil released was acknowledged to be uncertain. The objective was to determine if an increase in the spill volume had any significant influence on the degree of biological impacts calculated by the model.

The PAH in the filtered water samples taken near the vessel on 12 February were taken as representative of the dissolved PAH constituents in the water column. On average, 94 percent of the dissolved total PAH were 2- to 4-ringed PAH that have some water solubility and thus are available to aquatic organisms. French (1999) calculated the percent composition of these PAH in the water samples collected near the vessel, and then calculated a LC50 of the PAH mixture in oil from the *M/V New Carissa* using the quantitative structure-activity relationship (QSAR) model approach. This approach estimates the LC50 of a mixture as a weighted toxicity value based on the LC50 of each individual PAH and its percent composition in the mixture.

The estimated acute LC50s at 25°C for the seven water samples collected near the ship on 12 February range as follows:

- 14-46 ppb for sensitive species (such as amphipods)
- 46-107 ppb for species of average sensitivity

Only a few water samples contained over 10 ppb dissolved PAH (Table 9). Thus, the average LC50 for the dissolved PAH mixture after the spill was likely near the low end of the calculated LC50 range. The average 96-hour LC50 of 51 ppb at 25°C was used in the modeling studies. Toxicity is a function of water temperature, thus the average 96-hour LC50 at the water temperature at the time of the spill (9°C) is calculated to be 317 ppb (French, 1999).

It is interesting to note that the dissolved PAH concentrations for the model run with a spill volume of 140,000 gal were the closest to the measured dissolved PAH concentrations after the spill, as reported in Payne and Driskell (1999). The trajectory output for this run at midnight on 15 February is shown in Figure 23. The trajectory maps only show the pathway of the oil; the dots do not infer any mass or volume. Note that some dissolved oil does enter Coos Bay.

Figure 24 shows the dissolved PAH concentrations calculated by the model, for the same time and date as Figure 23. The model estimates some dissolved PAH in the nearshore zone north and south of the vessel, but the model did not predict concentrations above 0.01 ppb in Coos Bay. Refer to the report by French (1999) for maps for different times and spill scenarios. The highest concentrations of dissolved PAH calculated by the model (for the 140,000 gallon release scenario) are in the range of 10-20 ppb on 14 February.

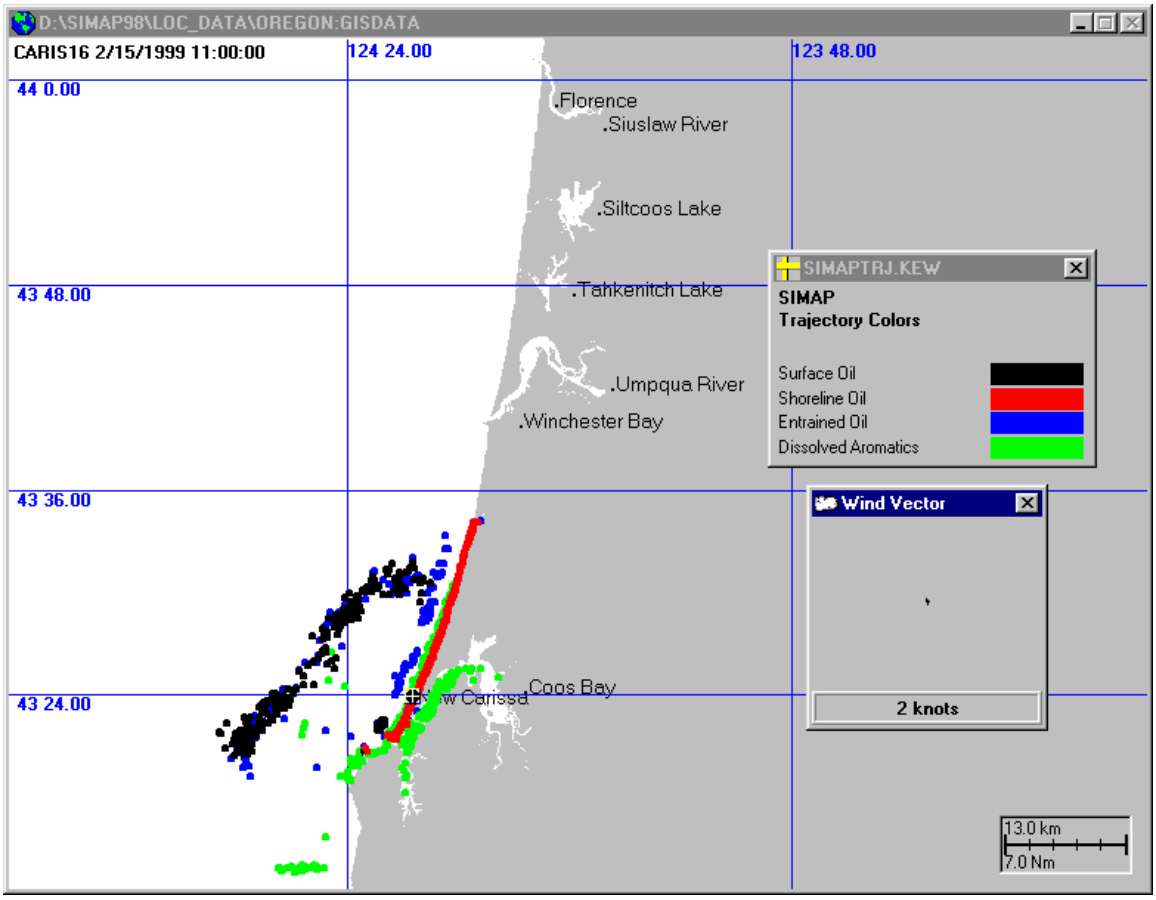

FIGURE 23. Trajectory output from the oil fates and effects model, for midnight on 15 February 1999. The green dots indicate the distribution of dissolved PAHs. Note that the dots do not infer any mass or volume (French, 1999).

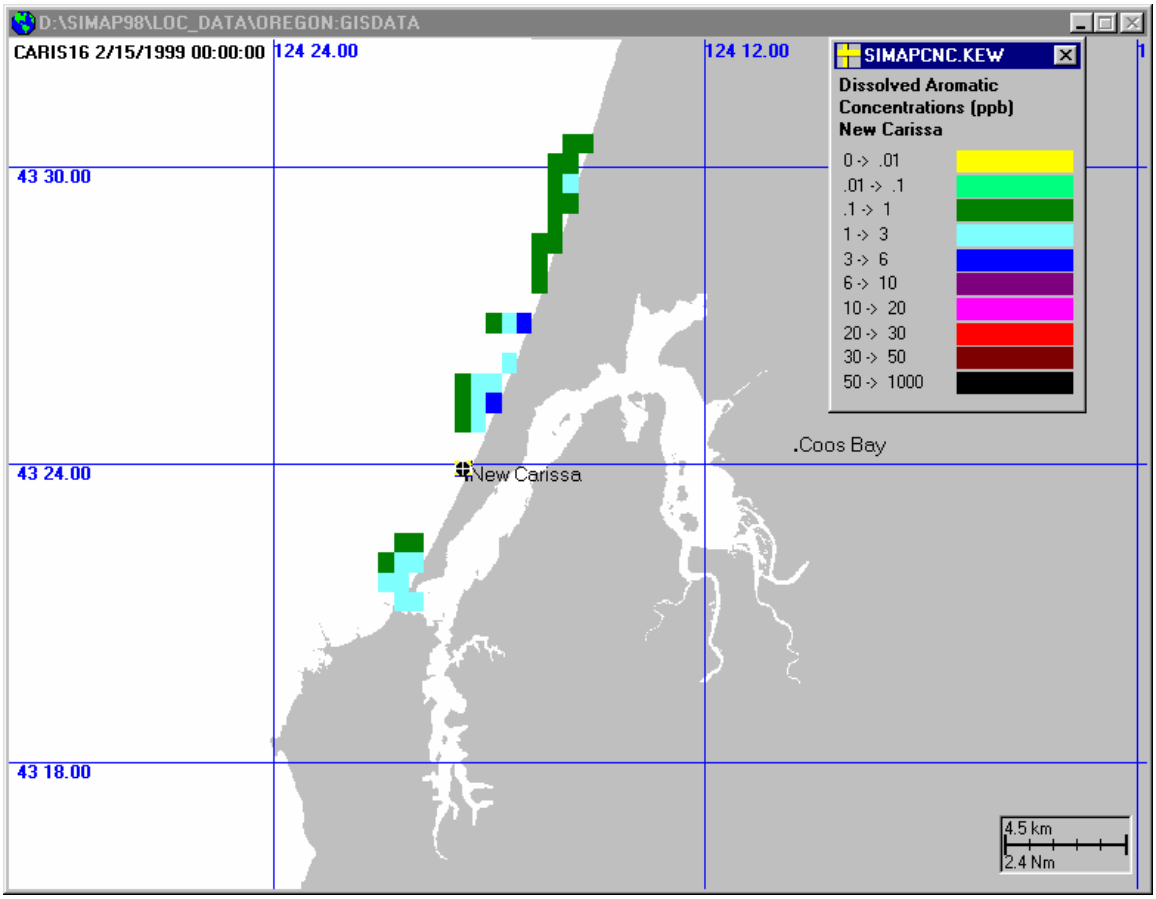

FIGURE 24. Concentration of dissolved PAH predicted by the oil fates and effects model, for a 140,000 gal release, at midnight on 15 February 1999 (French, 1999). Highest concentrations are north of the vessel.

Based on the model outputs for various scenarios, injuries resulting from acute mortality to fish are estimated to be very low in all cases (Table 12). The acute water-column injuries estimated by the model were all for organisms on the outer coast; no acute mortalities were modeled in Coos Bay (French, 1999). The model was also used to estimate interim losses resulting from the direct kills from acute exposure, measured as production foregone. Production foregone is defined as the biomass that would have been produced by animals killed by the spill if they had not been killed and had been subject to the same growth and mortality as animals which had not been killed. It is calculated from numbers in each age class killed, as follows. The number of an age class which would have lived the following year (percent survival times number killed) is multiplied times average weight gain from the killed age class to the next annual age class. Those surviving to the following year are multiplied times that next year's weight gain; and so on, until the end of the species life span. The losses for each killed age class are then summed for all age classes to calculate total production foregone. In addition, discounting of future losses is applied at a three percent annual discount rate. Thus, next year's losses are 97 percent of present-year value, the following year's value is 94 percent of present value, etc. Table 12 includes the estimated losses from production foregone, and an estimate of the total injury as

TABLE 12. Summary of model estimates of injuries (French, 1999). Young-of-the-year (#) is the number of eggs, larvae, and juveniles less than 1 year old that would have survived to age 1 year. Catch loss is the catch which would have been realized from all age classes of fish and shellfish killed.

Case	12	13	14	15	16	17
Fish and Shellfish:						
Harvestable stock (kg)	123	0	7	0.2	193	37
Young-of-the-year (#)	554	0	29	8	15270	1110
Catch loss (kg)	179	0	9	0.3	474	62
Total kill (kg)	144	0	8	0	414	59
Production foregone (kg)	166	0	9	0	845	86
Total injury (kg)	310	0	17	1	1258	145

kg of biomass. For model run 16, which most closely matches the field data for dissolved PAH concentrations, the total fish and invertebrate injury from acute effects is a biomass loss of 1,300 kg.

Sublethal or chronic (long-term exposure) effects on fish or shellfish are not considered in the model. However, the physical fates model output of PAH concentrations may be evaluated to determine the potential for chronic effects, at the Trustee's discretion. One estimate of the threshold for chronic effects used in risk assessments is an aqueous concentration equivalent to 1% of the LC50, which would be about 3 ppb for the *M/V New Carissa*.

In recent experiments, aqueous PAH concentrations as low as 0.4 ppb PAH at 5-6°C were shown to have effects on fish eggs and larvae (Marty et al., 1999; Bue et al, 1998; Carls et al., 1999; Heintz et al. 1999; White et al., 1999). However, this effects level resulted from higher-molecular weight PAHs in highly weathered oil. For less weathered oil, the effects levels were on the order of 9 ppb PAH at 5-6°C (Carls et al., 1999). For the water temperature during the *M/V New Carissa* spill, fresh oil PAH concentrations of about 10 ppb for several days of exposure would cause chronic impacts to fish larvae.

Based on the water sampling and model runs, it is likely that the oil spill had some chronic impacts to fish larvae present within an offshore area 4-5 km to the north and as far south as the entrance to Coos Bay. There could have been some chronic impacts to fish larvae in Coos Bay, where dissolved PAH concentrations of 5.7-7.7 ppb were measured in samples, however, not all of these dissolved PAH can be attributed to the spill.

Impacts to Invertebrates

The Coos Bay and Waldport areas have a rich and varied population of crabs, native oysters, clams, shrimp, and mussels. Dungeness crab are intensively harvested in both the bays and offshore waters. There are commercial oyster growers in the larger estuaries, from Coquille to Yaquina. Floating oil was observed to have entered Coos Bay and South Slough. There was concern that some of the bunker oils released from the vessel had mixed with sand and sunk or was submerged below the water surface. Thus, benthic resources would be at risk of oiling.

Several surveys were to determine the potential for impacts to invertebrates. Impacts would be from both acute exposures during the major releases in February and chronic exposure to oil releases through October.

1. Offshore Dungeness crab sampling. On 13 February, NOAA inspected offshore crab pots at ten locations ranging from 2.5 km north and south of the vessel, and about 0.8 km offshore. No evidence of oil was observed on any of the pots, ropes, buoys, or crabs. All the crabs behaved normally. Four crabs were taken from the northern- and southern-most sites and two sites within 1 km of the vessel. These samples were analyzed for PAHs in tissue and hepatopancreas. Total PAH in tissue were very low, ranging from 22-90 ppb, dry weight. In the hepatopancreas (where PAHs are known to concentrate), total PAH ranged from 96-825 ppb, dry weight. An evaluation of the PAH results, similar to that described in Payne and Driskell (1999), was conducted for the tissue and hepatopancreas PAH data and the results are included in Table 10. The PAH patterns for two of the four offshore crabs showed possible evidence of contamination with the oils spilled from the *M/V New Carissa* (Payne, pers. comm. 9 August 1999). The PAH in tissue for offshore crab No. 3 (collected 1.1 km due west of the vessel) showed a possible match with *M/V New Carissa* oil. The PAH in the hepatopancreas for offshore crab No. 10 (collected 2.5 km south of the vessel) was a match with *M/V New Carissa* oil. Thus, it is possible that the dispersed oil spread several kilometers offshore of the grounded vessel. These results are consistent with the offshore water samples collected on 15 February and the model runs.

On 9 March, there were two reports of oiled pots from a crabber fishing in the immediate vicinity of the stern section and another fishing off Tahkenitch Creek, about 40 km north of the grounding site. ODFW sampled the oil from the pot near the stern section, but it has not been analyzed. There were no reports of oiled crabs.

2. Coos Bay Dungeness crab pot oiling survey. The commercial Dungeness crab fishery in Coos Bay was closed at the time of the spill. To determine if submerged oil had entered Coos Bay, 10 crab pots were deployed on 19 February in Lower Coos Bay from the entrance to near the North Bend Airport, a distance of about 13 km. Snares (polpropylene sorbent material, to detect the presence of oil) were placed in the pots and they were baited. The pots were pulled on 21 February. No oil was observed. Crabs were sampled from nine of the pots and both the tissue and hepatopancreas analyzed for PAH. Tissue concentrations of total PAH ranged from 23-170 ppb and averaged 72 ppb, dry weight; the hepatopancreas concentrations ranged from 200-860 ppb and averaged 380 ppb, dry weight. The PAH patterns for all of the crab tissue and hepatopancreas samples showed evidence of *M/V New Carissa* oil (Table 10, Payne, pers. comm., 9 August 1999).

3. Coos Bay bivalve sampling. Between the period 11 February and 6 March, 38 samples of oysters and clams were collected from Coos Bay. The oyster sampling was conducted as part of the process for re-opening the area to shellfish harvest, but the results provide information on the risk of benthic communities to oil from the *M/V New Carissa*. PAH fingerprint analysis has been completed for only a few bivalves from Coos Bay, as shown in Table 10 and discussed in Section 8.

4. Outer coast mussel sampling. Two samples of mussels from rocky intertidal sites at Cape Arago and Lighthouse Beach and one sample from the North Jetty were collected on 17-19 February. Mussels at Bastendorff Beach were sampled on 17 February and 23 March. The mussel tissue from North Jetty had the highest PAH levels (7 ppm, wet weight; 41 ppm, dry weight) of any biological sample collected during the spill, and the PAH pattern clearly indicated a *M/V New Carissa* source. The mussels south of the entrance to Coos Bay contained very low PAH levels, with 0.016-0.125 ppm, wet weight. However, the 17 February sample from Bastendorff Beach had 2-4 times the total PAH as the other sites and the PAH pattern indicated possible contamination with *M/V New Carissa* oil (Table 10). The model also shows that some dissolved oil reached these areas to the south, but at very low concentrations (Figs. 23 and 24).

5. Mole crab (*Emerita*) and razor clam surveys. Mole crabs live in the surf zone on the outer beaches and are key prey items for fish and birds. They feed by capturing small food particles at the sediment surface, making them at high risk of exposure to oil and good indicators of the bioavailability of oil in the surf zone environment. No mole crabs were found on 12 February, searching from Horsfall Beach access to 2 km north. They have very patchy distributions and may have been in deeper water because of the high-wave conditions. In late February another sampling effort was made in an unaffected area south of the jetties, but the mole crabs were too deep to be collected using chest waders. No further sampling was attempted.

NOAA and ODFW attempted to collect razor clams that also live on exposed sand beaches during the 14 February low tide in an area just 150 m north of the North Jetty. The wind kept the waves high and the effort was unsuccessful.

6. Baseline intertidal surveys and sampling of estuaries. For the estuaries of Coos Bay, South Slough, Umpqua River, Siuslaw River, Alsea Bay, and the Ona River, SSNERR and ODFW agency personnel collected pre-oiling samples of water and sediment and conducted rapid biological assessments as baseline data in the event of oil contamination. Post-spill sediment sampling was repeated at selected sites in Coos Bay and South Slough. Because very little oil entered any of the estuaries, no further biological assessments were conducted. Shellfish were collected to determine the extent and degree of exposure, and the need for further assessments.

In summary, it is likely that there were acute impacts to invertebrates present along the outer beaches and adjacent subtidal habitats resulting from the February release of at least 70,000 gallons at the Coos Bay grounding site. There is also a potential for impacts from the chronic exposures to oil released intermittently through September.

Impacts to Shellfish Based on PAH Body Burdens

French (1999) summarized data on tissue concentrations of PAHs that have been shown to have effects, as follows. Donkin et al. (1989, 1991) estimated 50 percent effects levels in mussels for non-alkylated PAH tissue concentrations of about 14-31 ppm, wet weight. The highest 50 percent effects levels were for the lowest octanol:water partition coefficient compounds, such as naphthalene. The lowest effects levels, which were not reported, would be lower than these values. Gobas (1989) estimated that, in general for organics, the chronic threshold tissue concentration for effects is 0.1-1 mmole/kg. For PAHs with molecular weight of about 200, this equals 20-200 ppm, wet weight.

The highest PAH concentration in tissues measured during the spill was 7 ppm, wet weight, for the mussel tissue collected on the North Jetty at Coos Bay. The highest oyster sample was 1.3 ppm wet weight, whereas most post-spill oyster samples were in the range of 0.3-0.6 ppm, wet weight.

SECTION 10. RECREATIONAL AND CULTURAL RESOURCES IMPACTS

Impacts to Recreation

As a result of the two groundings and spills, and the extended period required for salvage of the stern, several recreation sites were closed to the public, and there were shellfishing closures and advisories. The Trustees conducted a study of the impacts to recreational resources (NOAA DAC, 2000). They compiled information on the periods that each recreational area was closed, the weather and tides during the closure periods, and historical use rates. The results are summarized in Table 13, listing each affected recreational area, the closure/open dates, a description of how the closure was enforced, the types of activities affected, and the estimated usage levels. The estimated usage levels at the recreation areas are based on historic vehicle count data and preliminary estimates of the number of individuals per vehicle.

Data on the number of individuals engaged in recreational shellfishing is limited geographically and available only for the peak periods in spring and summer. The numbers from these counts only represent a fraction of those shellfishing at these times. During the advisories against shellfish harvesting in Lincoln County, which followed the second grounding, the beaches were already closed for shellfish harvesting due to the toxic domoic acid.

Shellfish Harvest Closure/Re-open Process

Though closure of commercial shellfish harvest is not a natural resource injury, information on closures is provided here to document the process of re-opening of both recreational and commercial shellfish harvesting. The Oregon Department of Agriculture closed commercial shellfish harvesting on 12 February (Fig. 25) because of concern for potential contamination and risks to consumers. The Oregon Health Division derived risk-based criteria for re-opening the shellfish harvest (Gilroy, 1999), which are summarized below. In Figure 25, note that some of the areas closed due to the spill threat were also closed due to rainfall events which trigger closures based on daily rainfall thresholds, river levels, or tidal levels.

A two-tiered approach was used, based on estimates of average consumption of one meal/month (7.5 g/day) and upper-end consumption of one meal/week (32.5 g/day). “Safe” and “unsafe” levels were derived for PAH, the primary contaminants of concern, expressed as total benzo[a]pyrene (BaP) equivalents. It was determined that shellfish would be considered safe for consumption if all samples had less than 10µg/Kg BaP equivalents. Any samples containing more than 45 µg/Kg would be considered unsafe, and monitoring would be continued until safe levels were attained. For samples with BaP equivalents in between these values, the need for further monitoring would have to be assessed.

Composite shellfish samples were collected on 10 February, 14 February, 20 February, and 5-6 March, for a total of 52 samples, including 39 oysters, 10 clams, and 3 mussels. Sampling was continued over this period because there was an increasing trend for all sites sampled in February. The 5-6 March samples showed some decreases. Only two samples from lower Joeney Slough in South Slough were above the 10 µg/Kg level, containing 33.9 and 34.5 µg/Kg BaP, most of which appeared to be from non- *M/V New Carissa* sources. Because of the

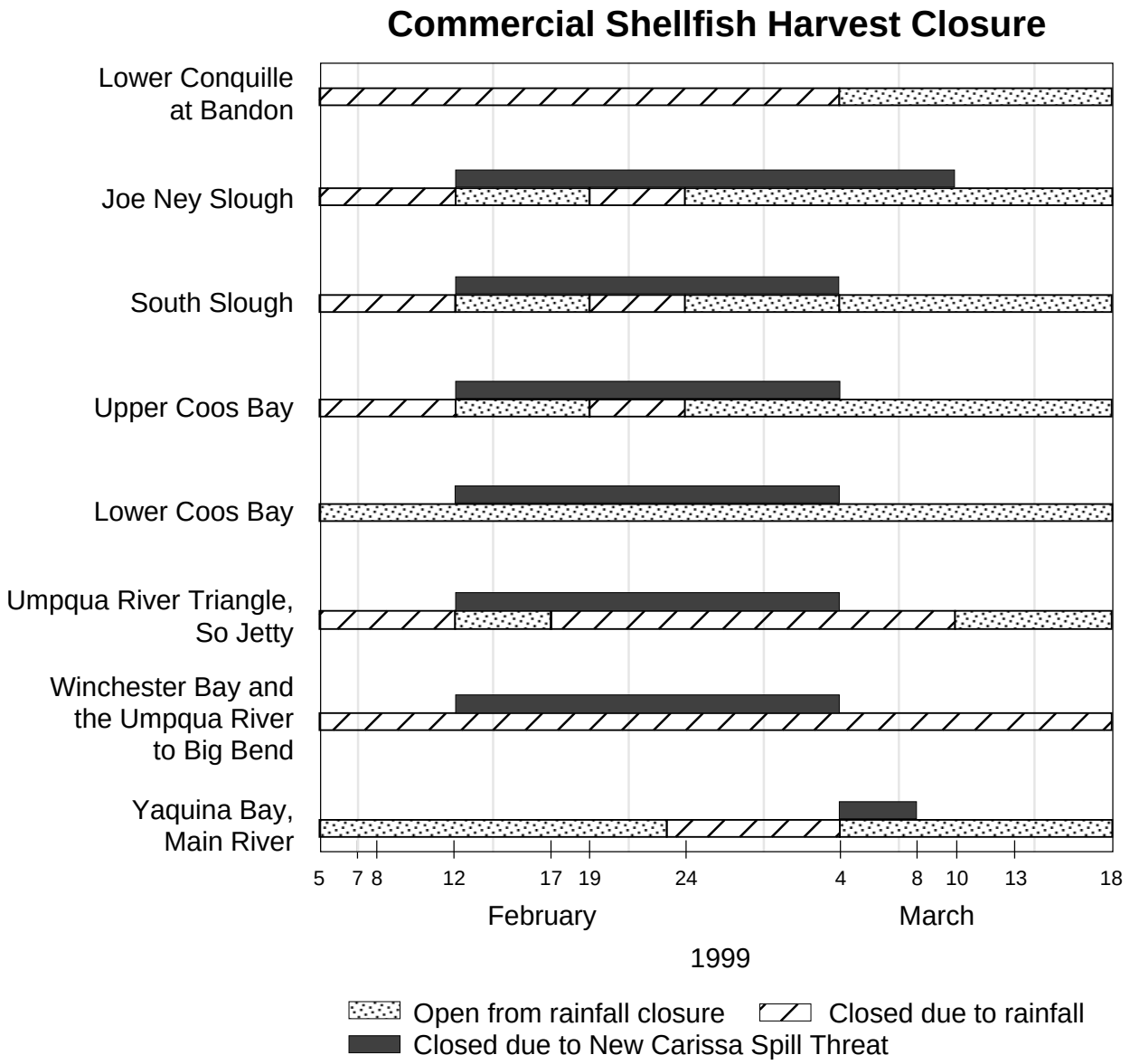

FIGURE 25. Dates for opening and closing of commercial shellfish harvesting by Oregon Department of Agriculture in the estuaries potentially affected by the *M/V New Carissa* oil spill.

elevated background levels of PAH in oysters from this area, oyster harvesting from this area has been discontinued. Because shellfish sample BaP equivalents attributable to the *M/V New Carissa* spill did not exceed 10 µg/Kg, shellfish harvesting was re-opened on 4 March for all but Joeney Slough, which was opened on 10 March.

Impacts to Cultural Resources

The Confederated Tribes of Coos, Lower Umpqua, and Siuslaw Indians have areas of significant cultural value near the grounding site at Coos Bay and Waldport. Efforts were made to reduce potential impacts from response and salvage operations on these sites by coordinating with the

Tribe. Once all response and salvage operations are completed, the Confederated Tribes will make a determination if there have been any impacts to these sites.

In the Waldport area, Siletz Tribal members consider the Oregon coastal ecosystem to be an integral part of their history and home. Siletz Tribal members use the Oregon Coast for spiritual and ceremonial purposes, as well as subsistence harvesting and gathering. Tribal members plan to collect cultural site and subsistence use data from Tribal members known to use potentially affected areas. Tribal staff will interview Tribal members first and then conduct on-site inspection of cultural sites for physical injury due to release of oil and emergency response efforts. These data will be used to determine potential visits of diminished cultural and spiritual value by Tribal members. The Tribe will then issue a cultural damage assessment report.

SECTION 11. SUMMARY OF ACTIVITIES OF EACH AGENCY

Trustee activities as of 15 August 1999 are summarized below.

BLM

Activity	Contact	Status
Snowy Plover Population Exposure Assessment (multi-agency)	Larry Mangan	Study on-going
Snowy Plover Habitat Enhancement	Kevin Kritz	Project on-going
Snowy Plover Emergency Restoration	Larry Mangan	Project on-going
Lost Recreational Use and Cultural Injury Assessment (multi-agency)	Larry Mangan	Draft report submitted in August

USFS

Activity	Contact	Status
Snowy Plover Population Exposure Assessment (multi-agency)	Ann Carlson	Study on-going
Baseline Sampling of Estuaries within USFS Lands	Dan Segotta	Sampling completed in February; no further activities planned
Snowy Plover Emergency Restoration	Bob Fujimoto	Project on-going

USFWS

Activity	Contact	Status
Snowy Plover Population Exposure Assessment (multi-agency)	Carrie Phillips	Study on-going
Seabird Injury Modeling	Stephen Zylstra	Study begun in August, report due December 1999
Shorebird Injury Assessment	Stephen Zylstra	Study begun in August, report due December 1999
Snowy Plover Emergency Restoration	Carrie Phillips	Project on-going

NOAA

Activity	Contact	Status
Lost Recreational Use and Cultural Injury Assessment (multi-agency)	Curtis Carlson	Draft report completed August
Offshore, Surf Zone, and Bay Water and Sediment Sampling	Greg Baker	Field work completed February
Baseline and Impact Assessment of Coos Estuary and South Slough	Stephen Rumrill	Assessment completed in February; no further activities planned
Baseline Sampling of Juvenile Salmon Outmigration Stations	Tracy Collier	Sampling completed in February; no further work planned

NOAA (continued)

Activity	Contact	Status
Baseline Sampling of Alsea Bay and Ona River mouth	Stephen Rumrill	Sampling completed in March; no further work planned
Determination of Potential for Oil Exposure to Intertidal Organisms	Nick Iadanza	Study canceled
Determination of Potential for Oil Exposure to Marine Mammals	Tom Loughlin	Assessment completed in February
Source Oil Characterization and Evaluation of Water Samples for Exposure Assessment	Greg Baker	Draft report completed July
Modeling of Impacts to Water-Column Resources	Greg Baker	Draft report completed August
Prepare of Preassessment Data Report	Greg Baker	Draft report completed August

ODEQ

Activity	Contact	Status
Baseline and Post-Oiling Sampling of Water, Sediment, and Tissue in Estuaries	Pam Blake	All field work completed in February/March

ODFW

Activity	Contact	Status
Snowy Plover Population Exposure Assessment (multi-agency)		Study on-going
Baseline and Impact Assessment of Marine and Estuarine Habitats	John Johnson; John Schaefer	All field work completed in February/March
Assessment of Estuarine Hard-Bottom Communities	John Johnson	All field work completed in February
Post-Oiling Sampling of Invertebrates	Greg Robart	All field work completed in February
Determination of Potential for Oil Exposure to Marine Mammals	Brown	Assessment completed in February
Assessment of Potential Impacts on Crabs	Bruce Schmidt	Crab pot surveys in February and June; no further work planned

Confederated Tribes of Siletz Indians

Activity	Contact	Status
Lost Recreational Use and Cultural Injury Assessment (multi-agency)	Terry Lane	Draft report completed in August

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