3.0 INJURY DETERMINATION AND QUANTIFICATION

3.1 SUMMARY OF PREASSESSMENT ACTIVITIES

Three threshold requirements identified in OPA must be met before restoration planning can proceed: injuries have resulted, or are likely to result, from the incident; response actions have not adequately addressed, or are not expected to address, the injuries resulting from the incident; and feasible primary and/or compensatory restoration actions exist to address the potential injuries.

The Trustees and Tesoro collected information during the preassessment phase for the Incident. This information satisfies the three criteria listed above and confirms the need for restoration planning to address spill impacts.

Resources and services potentially impacted by the discharged oil included:

- intertidal and subtidal habitats and the biota in those habitats,
- endangered and threatened marine species, including Hawaiian monk seals and green sea turtles,
- seabirds, and
- lost human use of subsistence and recreational activities.

Below is a more detailed discussion on specific assessments undertaken for the natural resources at risk.

3.2 ASSESSMENT APPROACH

The goal of injury assessment under OPA is to determine the nature and extent of injuries to natural resources and services which will provide a basis for evaluating the need for, type, and scale of restoration actions. The assessment process occurs in two stages -- injury determination and then injury quantification.

Injury determination begins with the identification and selection of potential injuries to investigate. In accordance with the OPA regulations, the Trustees considered several factors when making this determination, including, but not limited to, the following:

- the natural resources and services of concern;
- the evidence indicating exposure, pathway, and injury;
- the mechanism by which injury occurred;
- the type, degree, and spatial and temporal extent of injury;
- the adverse change or impairment that constitutes injury;
- available assessment procedures and their time and cost requirements;
- the potential natural recovery period; and

- the kinds of restoration actions that are feasible.

The list of potential injuries investigated for the Incident is provided in Table 1. As indicated in this table, the Trustees evaluated four injury categories. The Trustees selected these categories based on observations made and data collected during the preassessment phase and input from state and federal officials, Tesoro representatives and academic and other experts knowledgeable about the affected environment.

For each category of potentially injured resources, the Trustees determined the probability of exposure to oil from the Tesoro spill, the likelihood of injury, and the nature of the potential injury. This process is discussed in more detail below for each category of potentially injured resources. The assessment methodologies used for the Incident are summarized in Table 1.

Table 1. Potentially Injured Resources and Associated Assessment Methods

Potentially Injured Resources	***Assessment Methodologies***
Intertidal and Subtidal Biota	site investigations sampling and chemical analysis consultation with experts relevant scientific literature
Marine Mammal	site investigations ground and aerial surveys consultation with experts relevant scientific literature
Seabirds	site investigations ground and aerial surveys computer modeling consultation with experts relevant scientific literature
Lost Human Use	site investigations interviews relevant economic literature

In selecting appropriate assessment procedures, the Trustees considered:

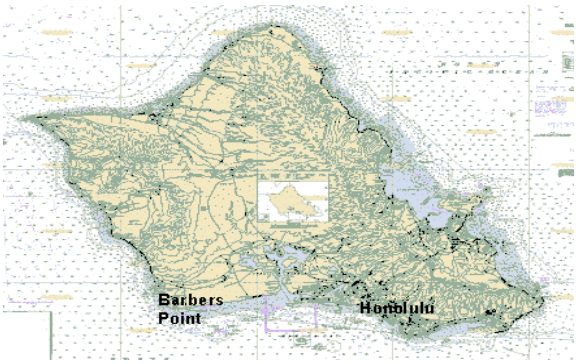
- the range of procedures available under § 990.27(b) of the OPA regulations;
- the time and cost required to implement the procedures;
- the potential nature, degree, and spatial and temporal extent of the injury;
- the potential restoration actions considered for the injury;
- the relevance and adequacy of information generated by the procedures to meet information requirements of restoration planning; and
- the input/suggestions of Tesoro.

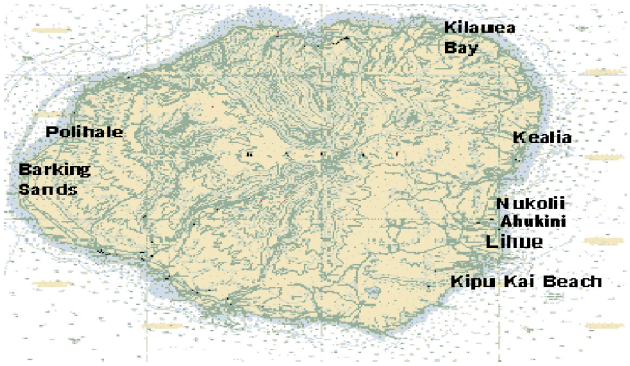
Because the Trustees and Tesoro agreed that their goal was to implement restoration as quickly as possible, the Trustees and Tesoro did not pursue expensive, multi-year injury studies. Instead, they generally used simplified, cost-effective procedures to document exposure and potential injuries to natural resources and services. Accordingly, depending on the injury category, the Trustees and Tesoro relied on site investigations, surveys, sampling and relevant scientific and economic literature. They also consulted with academic and other experts. This approach is consistent with damage assessments under OPA.

Using these procedures, the Trustees determined, as described above, that the following resources were exposed to the oil and that injury may have occurred in the following four categories: intertidal and subtidal biota, endangered and threatened marine species, seabirds, and human use services.

3.3 PATHWAY OF OIL

On August 24, 1998, a hose failure at Tesoro's single-point mooring located offshore of Barbers Point, Oahu released up to 117 barrels[1] of intermediate fuel oil (IFO 380). The USCG, DOH, and Tesoro responded to the spill and mobilized cleanup efforts. After recovery of the visible oil in the general vicinity of the offshore single-point mooring, the United Command demobilized the spill response because of the inability to find any more recoverable oil.





Approximately two weeks later, tarballs and oiled birds began to appear on the northeastern shore of Kauai, more than 100 miles from the location of the original spill. The USCG matched the tarballs and oiled birds with the oil from the Tesoro spill on Oahu. The following description of the extent of oiling is taken from Shoreline Cleanup Assessment Team (SCAT)[2] data

[1] This is approximately 4,914 gallons of oil.

[2] SCATs evaluate shoreline oil conditions during a spill and provide data and/or advice to spill response organizations. SCAT data do not necessarily provide a comprehensive overview of all areas impacted or potentially impacted by a spill. Rather, these data are representative of conditions on a specific day and at a certain location(s).

and information releases of the USCG Honolulu Area Unified Command (USCG 1998a, 1998b). These documents can be found in the administrative record.

Small tarballs washed ashore at Barking Sands on the west side of Kauai on a section of beach estimated to be 45 meters long and at Polihale Beach. Tarballs appeared at Kilauea Bay on the northern shore of Kauai and on the Island of Niihau, located to the southwest of Kauai. The remainder of the observed oiling occurred at various locations on the eastern side of Kauai, predominantly in several natural collection areas along a 31-kilometer stretch from Kipu Kai to just north of Kealia.

Within that 31-kilometer shoreline, Kipu Kai and Ahukini were the heaviest oiled areas. At Kipu Kai, SCAT reports indicated a 250-meter long, heavily oiled section of a boulder beach and a more lightly oiled sandy beach just north of the boulder beach. The oiled boulder beach had a thin coating of weathered oil on many rocks with fresher oil underneath some rocks. At Ahukini, the SCAT report described a 160-meter supratidal basalt bench as having a 70% covering of oil. The SCAT report noted some pooling of oil in this area as well. The Trustees have not attempted to determine the pathway by which the oil moved from Barber's Point, Oahu, to these various other locations. Wind and currents, over a two-week period, apparently moved the oil substantial distances and may have dispersed it widely.

3.4 POTENTIALLY AFFECTED NATURAL RESOURCES AND RESOURCE SERVICES

This section discusses four categories of natural resources and resource services potentially injured as the result of the Incident: intertidal and subtidal biota, threatened and endangered marine species, seabirds, and human use services.

3.4.1 Intertidal and Subtidal Biota

The intertidal habitat is defined as the shoreline area which is inundated by sea water during high tide cycles and then exposed to the air during low tide cycles. For a given tidal range, gently sloping sandy beaches have a wider band of intertidal habitat which can be subjected to oiling than areas of vertical, shoreline cliffs. Subtidal habitat is bottom areas which are perpetually submerged by water.

Species of concern in the intertidal and subtidal habitats include opihi, helmet urchin *(Colobocentrotus atrata)*, nerites (snails) *(Nerita picea, et al., n. polita),* species of Drupes (*Thaidid sp.)*, rock crab (*Grapsus tenuicrustatus)*, sand crabs, ghost crabs, other crustaceans, cowrys, algae (limu), polychaetes, anemones, and flatworms. Other species also utilize these habitats such as fish, shore birds, seabirds, marine mammals and sea turtles. Several of these species are discussed below in separate subsections.

The Trustees decided to use opihi as the representative species for evaluating intertidal and shallow subtidal injury. Opihi are indigenous to intertidal and shallow subtidal rocky shores in Hawaii. They feed by scraping food items off rocky surfaces. Opihi are a commercially and culturally valuable resource. Opihi are also gathered by subsistence and recreational fishermen. In Hawaii, opihi are a delicacy in great demand.

Routes of hydrocarbon exposure for opihi include absorption from water, dermal contact, and ingestion through feeding on oil-coated rocks. There appear to be no studies regarding the susceptibility of opihi to oiling. However, studies have reported mortality of molluscs, including limpets, after major oil spills (*e.g.,* Exxon Valdez, Houghton, *et al.* 1993, 1997; Sea Empress, Moore, *et al.* 1997). In smaller spills, the extent of mortality appears to be dependent on the amount, toxicity and persistence of oil at different levels of the intertidal zone (*e.g.,* Bahia las Minas, Cubit and Connor 1993). Oiling may cause sublethal impacts on molluscs such as changes in growth rates (Farrington 1988; Stromgren 1987; Stromgren *et al.* 1986; Stekoll, *et al.* 1980; Gilfillan and Vandermeulen 1978; Thomas 1978), size-specific body weight (Cubit 1984; Thomas 1978), fecundity (Sole, *et al.* 1996; Widdows *et al.* 1990; Leavitt *et al.* 1990; Farrington 1988; Capuzzo 1987) and recruitment (Garrity and Levings 1990; Smith and Hackney 1989; Johnson 1988; Capuzzo 1987; Sindermann 1982). Other potential injuries to opihi from the oil spill include mortality related to cleanup activities (crushing or detaching opihi from rocks) and a decrease in the palatability of the limpet.

Based on these potential injuries, the Trustees considered a number of studies designed to determine population reduction, body burden of spill-derived oil, size-specific body weight, size-specific individual growth rates, reproductive output and recruitment. The Trustees and Tesoro began work on one of the studies -- body burden of spill-derived oil. The Trustees and Tesoro focused on the two areas most heavily oiled.

Samples gathered by the Trustees and Tesoro at the oiled boulder areas of Kipu Kai had total polycyclic aromatic hydrocarbon (PAH) concentrations ranging from 140 to 410 parts per million (ppm). This range of concentrations was higher than background levels. Several tissue samples had no detectable PAH's. A second round of representative sampling from the same location at a later point in time suggested that the impacts were not persistent.[3] The Trustees did not initiate a third round of sampling due to the passage of time from the initial exposure of the opihi to the oil. The Trustees also decided not to pursue additional work related to opihi. The Trustees believed that some of their proposed studies would be difficult to conduct so long after the spill and that others would be time-consuming, expensive,and likely inconclusive. It was also concluded that such studies would not provide a level of information justifying the additional expense and the delay in restoration implementation.

[3] Some samples from the second round of testing at Ahukini proved inconclusive because the samples had been collected from an unoiled, rather than an oiled, section of Ahukini.

The Trustees concluded that injury to opihi, the representative species for intertidal and shallow subtidal biota, may have occurred. This conclusion is based on three factors. First, there was Tesoro oil in certain intertidal and shallow subtidal areas on the eastern shore of Kauai. Second, the initial sampling and subsequent chemical analyses show PAH concentrations in some opihi tissues. Third, information from scientific literature suggests that sublethal impacts to molluscs, including limpets, occur from hydrocarbon exposure.

3.4.2 Threatened and Endangered Marine Species

The threatened Pacific green sea turtle is frequently seen around Kauai and has been known to nest on the island. The Tesoro spill oiled many areas that provide green sea turtle nesting habitat. During the preassessment stage, a USFWS representative sighted a live, green sea turtle which appeared to be oiled (S. Henry, USFWS, pers. comm.). The Trustees could not confirm whether the turtle was oiled by the Tesoro spill as they were not able to capture the turtle. The Trustees did not confirm or observe any other oiled turtles. Because of the lack on data indicating exposure of green sea turtles and the fact that federal and state biologists did not expect any nesting by green sea turtles in the impacted area to occur in 1998, the Trustees did not pursue any further injury investigations for green sea turtles.

The Trustees focused more attention on investigating potential injury to the endangered Hawaiian monk seal. Although the majority of Hawaiian monk seals reside in the Northwest Hawaiian Islands, there is a small population of approximately 16-30 individuals in the Kauai-Niihau Island area. Little is known about the sex ratio, foraging areas, individual behavior or population trends of this population. Six or seven of these monk seals haul up frequently on the beaches of Kipu Kai (Shaw 1999).

Little is known about the effect of oiling on Hawaiian monk seals. There is some knowledge, however, related to pinniped exposure to oil which is informative. Direct contact with oil can cause skin lesions and secondary burns due to the heating of oil on the skin. The major concern is the toxic effect of oil on internal organs, especially those with mucous membranes. Signs of injury to these systems include, but are not limited to, bleeding from mouth, lungs or intestines, signs of respiratory infection and signs of "intoxication" such as severe lethargy and dullness. Pinnipeds with oil-related injuries also may exhibit behavior changes such as hauling out more frequently than usual (Shaw 1999).

Between September 15 and September 22, 1998, SCAT teams observed nine Hawaiian monk seals in the Kipu Kai area. Two appeared to be oiled. However, because of the protected status of the monk seals, the Trustees did not attempt to obtain confirming samples from the animals. Trustees and Tesoro observed another oiled monk seal on September 23, 1998. These observations were made over a number of days. Thus, it is possible that some of the same monk seals may have been observed more than once, and that there were not nine individual monk seals in the area during this time period.

When the Trustees began designing a study to investigate potential injury to the Hawaiian monk seals, they determined that the null hypothesis (*i.e.,* no injury as a result of the spill) was not the appropriate starting point due to the lack of information about the Kauai-Niihau Island population. Instead, the Trustees designed a study to assess the observable effects of the Tesoro spill on the Hawaiian monk seal population at Kipu Kai. Because Hawaiian monk seals are known to move five to twenty-five miles in a single day around Kauai, the Trustees specified that the study would be conducted for the entire Island of Kauai.

The Trustees and Tesoro participated in three island-wide surveys to locate and assess the physical condition of the monk seals. The first occurred between October 5 and October 12, 1998; the second between October 19 and October 30, 1998; and the third on February 26, 1999. The Trustees used the same protocols for the first two surveys. For details, *see* Kipu Kai Monk Seal Monitoring Progress Report (Shaw 1999) in the administrative record. Due to the protected status of the monk seals and to avoid disturbing the animals, observations were made using binoculars or a spotting scope. Because the observers were some distance from the monk seals, the assessment of the oiling status of individual animals could not be confirmed.

Trustees observed three Hawaiian monk seals during the first survey. The first monk seal (KK01) appeared relatively normal. The second (KK02), which may have been oiled, had its entire oral mucosa coated with a red, blood-like fluid. This animal also acted agitated.[4] The third monk seal (KW01) appeared less than 10% oiled and acted normally.

The Trustees observed the first (KK01) and third (KW01) monk seals again during the second survey. The first (KK01) again appeared normal. The other (KW01) appeared normal initially, but later during the survey showed signs and behavior consistent with an upper respiratory tract infection. Such infection could be an effect of the oil, but neither the infection nor the presence of oil could be confirmed. Although the Trustees did not resight the other monk seal (KK02) from the first survey, they did observe two additional monk seals during this second survey. One (KK03) appeared possibly 1-5% oiled and relatively normal although it did exhibit some "gagging" behavior.[5] The other monk seal (KW02) appeared possibly oiled, but seemed unaffected. Based on the results of these surveys, the Trustees were most concerned about two monk seals -- KK02 and KW01.

Because of the unusual signs in three of the Hawaiian monk seals and the absence of one seal after the first survey, the Trustees decided and Tesoro agreed to conduct an additional island-wide survey on February 26, 1999. This third survey used a helicopter

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[4] Many etiologies can result in blood coating the oral mucosa. Oiling, while not the most likely explanation, cannot be ruled out. Based on anecdotal reports, this monk seal had exhibited agitated behavior prior to the spill.

[5] Biologists have observed gagging behavior in the field in unoiled areas. However, exposure to oil can cause gastric, esophagael and duodenal ulceration.

to locate the seals and a four-wheel drive vehicle to observe haul out areas. The aerial survey located eight Hawaiian monk seals. The ground team was able to assess five of these animals. All appeared unoiled and healthy. None of these animals had been observed during the first two surveys.

The Trustees concluded that it was impossible to draw any definite conclusions concerning injury based on the data gathered during these three surveys. The Trustees remained concerned that none of the monk seals observed during the first two surveys had been re-sighted during the third survey. Likewise, the health status of the two monk seals of most concern to the Trustees (KK02 and KW01) remained unknown. Based on the potential exposure of some of the monk seals to Tesoro's oil and some signs of abnormal physical conditions of those individuals, the Trustees could not conclude that the Hawaiian monk seals either suffered or did not suffer adverse effects from exposure to the oil.

3.4.3 Seabirds

The Trustees initiated oiled wildlife response and natural resource injury assessment activities for seabirds on September 5, 1998 when an observation of an oiled seabird was reported to staff at the Kilauea Point NWR, Kauai. A Seabird TWG, composed of Trustees and Tesoro representatives, was formed to develop injury assessment studies and to determine impacts to seabirds from the spill. This TWG strived to obtain consensus on injury quantification and assessment activities. A chronology of assessment activities carried out to estimate seabird injury is presented in Table 2. Seabird recovery and rehabilitation activities were concluded on November 19, 1998 when the USCG determined the response phase of the spill was completed.

Seabirds that have been oiled typically arrive on shore in two ways (Helm, USFWS, pers. comm.; this Incident). Those that are severely incapacitated or dead wash in, while others that are still capable of flight usually return to their colonies or land elsewhere along the shore. During this spill, oiled seabirds were recovered over a period of 49 days, from August 28 to October 15, 1998, by private citizens or by personnel from a number of public agencies or private companies. For example, the International Bird Rescue Research Center (IBRRC) was contracted by Tesoro to conduct oiled wildlife response activities from September 8 to October 24, 1998 (Elliott and Sangiacomo 1999).

During the spill response, 54 seabirds were collected as potential evidence of injury. Sample analysis determined that some of the recovered birds were either not oiled by the Incident or results were inconclusive. Birds which were not oiled by the Incident included a brown booby collected on Kauai, a masked booby collected on Laysan Island, a petrel collected on Lanai, and a red-footed booby collected from the Kaneohe Marine Corps Base on Oahu. Thirty-three live birds, assumed to be oiled, were found along the shoreline or captured in the colonies during the oiled wildlife response phase of the spill. These birds were transported to rehabilitation facilities and 19 birds were cleaned, banded, and released (Elliot and Sangiacomo 1999).

Table 2. Chronology of assessment activities for seabird injuries in the Incident.

Date	*Activity*
08/24/98	Oil spill reported to USCG and State of Hawaii; initiation of oil spill response activities.
08/28/98	Sea Life Park colony, Oahu, personnel report oiled bird to the USCG and State of Hawaii
08/28 - 09/08/98	Five additional oiled seabirds observed at Sea Life Park colony, Oahu
09/05/98	Oiled seabirds discovered on Kauai beaches; Trustees notified of spill; initiation of spill response activities on Kauai, oiled wildlife response, and NRDA activities.
09/18/98	SCAT teams begin surveying Kauai beaches
09/21/98	Survey for oiled wedge-tailed shearwaters at Kilauea Point NWR
09/25/98	Survey for oiled seabird survey at Lehua Rock colony
09/29-30/98	Survey for oiled red-footed boobies at Kilauea Point NWR
10/06/98	Survey for oiled red-footed boobies at Mokapu Point, Kaneohe, Oahu
10/06-08/98	Aerial seabird surveys in the Kauai Channel
10/07/98	Survey for oiled wedge-tailed shearwaters at Kaena Point, Oahu
10/09/98	Survey for oiled seabirds at Moku Manu Island, Oahu
10/12/98	Shoreline surveys for oiled seabirds on Manana, Kaohikaipu, Mokuluas, and Popoia Islands, Oahu
10/15/98	Final two oiled red-footed boobies collected at Kilauea Point NWR
11/16-17/98	Survey for oiled seabirds at Ka'ula Rock colony
11/19/98	Response phase of spill concluded by USCG

Because some oiled seabirds likely were capable of returning to their breeding colonies, the Working Group undertook surveys of as many colonies as possible on Oahu, Kauai, Lehua, and Ka'ula Islands (Table 3). Surface and shrub nesting species, such as boobies, were visually checked for signs of oiling. Burrow nesting species, such as shearwaters, were sampled by reaching into burrows, removing birds and examining them for oil. Records were kept of the number of birds counted and whether or not they were visibly oiled. Due to logistical and coordination problems, many of these surveys occurred well after the oil was spilled which greatly reduced the likelihood that oiled birds would be detected or recovered. Oiled birds were first reported four days after the spill on Oahu. On September 5, 1998, 13 days after the Incident occurred, oiled birds began appearing on Kauai. Following notification, the Trustees initiated injury assessment studies to determine impacts on seabird colonies. Of the eight colonies surveyed, two colonies

Table 3. Results of seabird colony surveys following the Incident.

Colony	*Days Post-Spill*	*Species*	*No. Birds Checked*	*No. Birds Oiled*	*Percent Oiled (%)*
Sea Life Park, Oahu	4-15	Red-footed booby	23	6	26
Kilauea Point, Kauai	28	Wedge-tailed shearwater	399	0	0
Lehua Rock	32	Red-footed booby Red-tailed tropicbird Great frigatebird	200 4 2	0 0 0	0
Kilauea Point, Kauai	37-38	Red-footed booby	1150	58	5
Mokapu Point, Oahu*	44	Red-footed booby	1326	9	0.7
Kaena Point, Oahu	45	Wedge-tailed shearwater	40	0	0
Moku Manu, Oahu	47	Red-footed booby Masked booby Brown booby Wedge-tailed shearwater (chicks)	60 10 6 200	0 0 0 0	0
Ka'ula Rock	85	Brown booby Masked booby Red-footed booby Great frigatebird Red-tailed tropicbird White-tailed tropicbird Wedge-tailed shearwater	47 113 871 538 6 1 126	0 0 0 0 0 0 0	0

* Trustee and Tesoro representatives observed nine oiled birds during the colony survey (Duffield 1998). It is unclear if these birds were oiled by the Incident since a separate analysis of birds samples collected from Mokapu Point indicated the oil from these samples did not match the Incident.

contained documented oiled birds. Within these two colonies, the number and percentage of oiled birds was as follows: six oiled out of 23 (26%) 4 to 15 days post-spill and 58 oiled out of 1,150 (5%) 37 to 38 days post-spill. No oiled birds were observed in colonies beyond 38 days post-spill.

Oil was only observed on the conspicuous red-footed boobies during the colony surveys. The proportion of oiled seabirds found in any particular colony survey declined as more time elapsed from the spill. Red-footed boobies were observed oiled in the colonies from 4 to 38 days post spill. In the interim, some of the oiled birds had undoubtedly died and been scavenged, died and sank at sea, or washed up on unsurveyed beaches. These types of losses have been noted in numerous studies (Bibby and Lloyd 1977; Burger 1991; Ford *et al.* 1996; Piatt *et al.* 1990). Lightly oiled birds also likely preened the oil from their plumage. It is noteworthy that a very small colony of red-footed boobies at Sea Life Park,

Oahu, observed within the first two weeks of the spill, exhibited 26% oiling. Given the delay in surveying seabird colonies, these percentages reflect an accurate assessment of the birds observed over an extended time frame and they may, or may not, reflect the percentage of oiled birds in the total population.

In addition to colony surveys, aerial surveys were flown on October 6-8, 1998 to record distribution and density of seabirds in the waters surrounding Ka'ula, Niihau, Kauai, and western Oahu (Ford 1998). Figure 1 shows survey tracks flown in the potential oil exposure area. The aerial surveys of bird distribution at sea showed varying seabird density in the potential oil exposure area. Ambiguity and conflicting information about the actual trajectory of the oil made it difficult to apply these data to models designed to estimate the number of seabirds potentially exposed to the oil.

Assessing injury to seabirds from an oil spill in the Hawaiian Islands is complicated by a number of factors. First, the probability that an oiled seabird will be deposited on shore is low due to limited shoreline area relative to open ocean. This problem is further complicated by the complex current and wind patterns in the vicinity of the Islands. Second, a portion of the existing coastline is inaccessible to search effort due to land ownership patterns and geology. General recovery rates for oiled birds on shorelines range between 20 to 25% or less (Burger 1991; RPI International, Inc. 1988). And third, the breeding and foraging behaviors of tropical seabirds increases the possibility that these birds could encounter oil and that oiled birds may not be observed or recovered.

Hawaiian seabirds exhibit a broad range of roosting and breeding behaviors which make it difficult to assess injury. For example, some species nest or roost conspicuously in aggregated groups on shrubs or low lying trees in readily accessible areas while other species nest in widely dispersed burrows in high altitude rainforests at inaccessible or very poorly known sites. Logistical concerns also affected injury quantification since a sizeable proportion of the conspicuous species nest on offshore islands that were difficult or impossible to reach during the month following the spill.

In contrast to their roosting and breeding behavior, the foraging behavior of Hawaiian seabirds is very uniform and can be characterized as pelagic foraging most commonly in association with subsurface predators such as yellowfin and skipjack tuna (*Thunnus albacares* and *Katsuwonus pelamis*) (Ashmole and Ashmole 1967; Au and Pitman 1986). Like the tuna they associate with, these birds are highly mobile and they exhibit prodigious abilities to fly long distances to forage (*e.g.*, up to 522 km for sooty terns) (Ballance *et al.* 1997; Flint 1991). Regardless of prey-capture technique (surface seizing, plunging, pursuit plunging, dipping, or pattering) the birds all come in contact with water and, therefore, with any oil floating on or suspended near the water surface.

Seabird prey, and therefore seabirds, are particularly attracted to eddies, fronts, and drift lines. These areas tend to concentrate debris and floating oil thereby increasing the

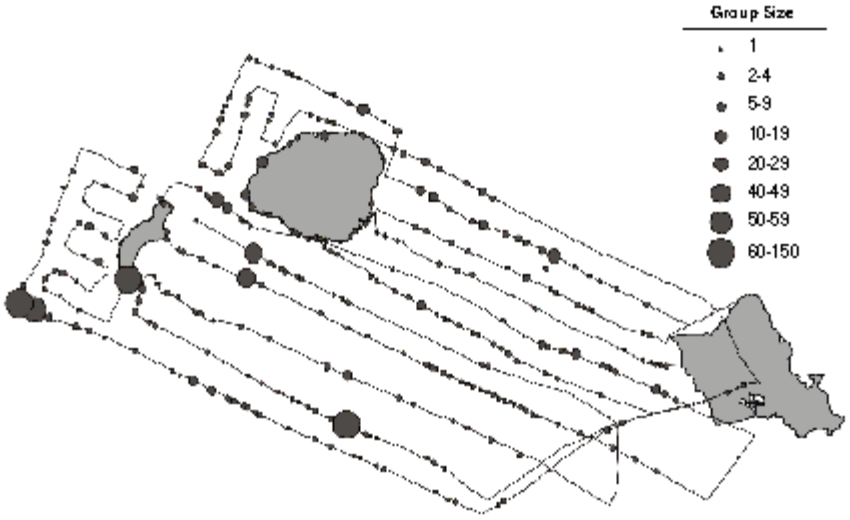

Figure 1.
Aerial surveys of the abundance and distribution of seabirds on October 6, 7, and 8, 1998 within the potential oil exposure area for the incident

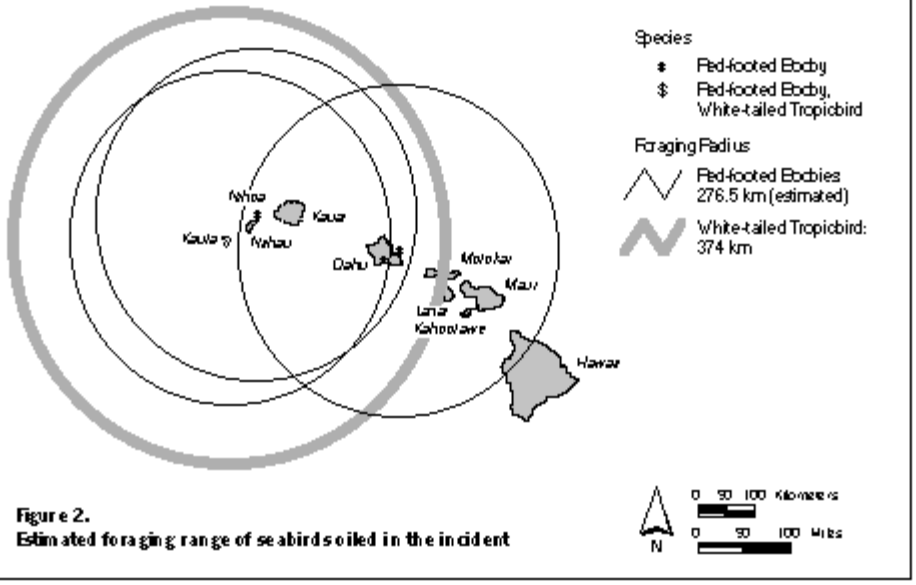

Figure 2.
Estimated foraging range of seabirds oiled in the incident

likelihood that seabirds will encounter oil and that oiled birds may not be observed or recovered. After analyzing the foraging radii of Hawaiian seabirds, the Trustees determined that the potential oil exposure area for this Incident potentially affected seabird colonies on Oahu and all surrounding islets, Kauai and all surrounding islets, Niihau, Lehua, and Ka'ula Rock. Figure 2 presents the estimated foraging radii for a representative sample of species known to have been oiled and establishes an area in which these birds were potentially exposed to the oil (hereafter referred to as the potential oil exposure area). Species expected to have been affected by the spill include those observed oiled and those species observed in the potential oil exposure area during ground or aerial surveys.

The number and species of birds estimated to have been present in late August/early September 1998 in the potential oil exposure area is shown in Table 4. Population estimates of breeding and non-breeding individuals of each species in the potential oil exposure area were derived from counts and estimates completed as closely as possible to the spill date. Population estimates for seabirds can be highly variable because not all species or colonies are surveyed in a given year, breeding areas are not always known or accessible, and burrow nesting species, which return to their colonies at night, are difficult to accurately count.

The Trustees believe it is most likely that seabirds were exposed to oil under the following circumstances. Since most tropical seabirds spend far less time sitting on the surface of the water than do arctic and temperate seabirds, they are less likely to come in contact with the oil during typical resting periods. However, several of the seabirds (petrels and shearwaters) on the Hawaiian Islands typically congregate on the water just offshore of their roosting and nesting colonies each evening before returning to the colony (Ainley *et al.* 1997; Ainley, pers. comm.; Flint, pers. comm.). In addition, there is anecdotal evidence that some of these species may even be attracted to floating oil due to its potential as a fish aggregating agent or due to its appearance on the water (Fefer 1984). Thus, although these seabirds may not have encountered oil over the entirety of their foraging area, they had the capability to reach oiled areas from all the colonies in the potential oil exposure area and some species likely were also vulnerable to exposure when they returned to the ocean area in the vicinity of their breeding colonies each evening. The Trustees believe that due to these complicating factors, coupled with the other biological aspects of each species, only a portion of the seabirds known to have been in the area at the time of the spill, and which may have been exposed to oil, were actually observed or recovered oiled.

In addition to direct surface contact with oil, seabirds may also have been exposed to oil through ingestion and absorption. Exposure to oil can cause a variety of physiological effects. Direct contact with oil can foul feathers, irritate mucous membranes, and smother animals. As feathers become clogged with oil, heat insulation and water-repellancy are compromised (Holmes and Cronshaw 1977), and the bird may become hypothermic or drown. Oil droplets on the feathers of adults can be transmitted to chicks or eggs.

Table 4. Estimated population size and number of seabirds potentially exposed to oil during the Incident.

Species	*Status*[1]	*Estimated Population within the Potential Oil Exposure Area*
Newell's shearwater (*Puffinus auricularis newelli*)	T - S & F	26,000
Christmas shearwater (*P. nativitatis*)		52
Wedge-tailed shearwater (*P. pacificus*)		154,000
Hawaiian dark-rumped petrel (*Pterodroma phaeopygia sandwichensis)*	E - S & F	1,680
Band-rumped storm petrel (*Oceanodroma castro*)	E - S; C - F	Unknown
Bulwer's petrel (*Bulweria bulwerii*)		1,430
Red-tailed tropicbird (*Phaethon rubricauda*)		1,744
White-tailed tropicbird (*P. lepturus*)		560
Masked booby (*Sula dactylatra personata*)		1,244
Brown booby (*S. leucogaster plotus*)		932
Red-footed booby (*S. sula rubripes*)		27,350
Great frigatebird (*Fregata minor*)		2,060
Black noddy (*Anous minutus melanogenys*)		612
Brown noddy (*A. stolidus pileatus*)		85,400
Blue-gray noddy *(Procelsterna cerulea saxatilis*)		4
Gray-backed tern (*Sterna lunata*)		2,360
Sooty tern (*S. fuscata*)		188,850
White tern (*Gygis alba*)	T - S	420

[1] Status: C=Candidate, E=Endangered, F=Federal, S=State, T=Threatened.

Embryos in the early state of incubation are especially vulnerable to contact with oil and small quantities ranging from 1 to 20 microliters may be sufficient to cause death (Albers 1991). Experiments with exposure of wedge-tailed shearwaters to weathered crude oil resulted in reduced laying, lowered hatching success, and reduced breeding success (Fry *et al.* 1986).

The probability of detecting an oiled seabird varies between species because their nesting and roosting behaviors and colony locations are much less uniform than their foraging

behavior. The number of oiled seabirds recovered or observed during the spill event are listed in Table 5. The majority of these birds were recovered or observed on Kauai.

Table 5. Number of oiled birds recovered or observed during the Incident.

Species	*Oiled Birds Recovered or Observed*
Brown booby	21
Red-footed booby	77
Unidentified booby	1
Great frigatebird	1
Wedge-tailed shearwater	1
White-tailed tropicbird	3
Unidentified species	1

Figure 3 shows the locations of all oiled birds recovered on Kauai. Recoveries were scattered around the island. Oiled birds recovered on Oahu all came from the Sea Life Park colony. The species composition of oiled birds recovered or observed likely does not reflect that of all the birds that were oiled due to differences in size, color, and behavior of each species. The largest number of oiled birds recovered were for the relatively large-sized brown and red-footed boobies (65 cm - 74 cm long). Brown boobies forage close to shore and are thus more likely to wash up or return to shore if oiled. Red-footed boobies roost and nest above ground in accessible colonies. Their white plumage and conspicuous nesting and roosting behavior make it relatively easy to observe whether they have been oiled.

Due to the relative inaccessibility of most seabird colonies potentially affected by this spill, it was impossible to measure direct impacts to populations. Therefore, red-footed boobies were used as an indicator species for the impacts of the oil on all seabirds within the potential oil exposure area. Red-footed boobies were chosen for several reasons: (1) their

[see separate Adobe .pdf file for figure]

colonies were accessible for survey, (2) oil easily could be detected on their white plumage, and (3) they forage in the same general area as other seabirds present in the potential spill exposure area.

In order to estimate the number of birds potentially impacted by the spill, the Trustees employed two methods. The first method used the rate of oiling observed in red-footed boobies at the Kilauea Point colony on Kauai as a representative sample of an injured population and extrapolated this rate to other seabird populations. The second method involved the development of a correction or adjustment factor based on the estimated population impacted divided by the number of oiled birds found. This value was then compared to those for birds oiled in spills in California, Oregon, and Washington, as summarized by Carter *et al.* (1997). The Trustees used practical and conservative

estimates and their best professional judgment in the development of these methods. However, due to the delay in initiating injury assessment studies, numerous assumptions were required to develop these methods and seabird injury could not be determined with any requisite degree of certainty. Therefore, the Trustees and Tesoro commenced restoration planning with the intention of identifying restoration projects that would address a conservative estimate of injury.

3.4.4 Human Use Services

The eastern coast of Kauai provides numerous recreational opportunities to residents and tourists such as general beach recreation, surfing, kayaking, boating, fishing, opihi gathering and limu harvesting. The Tesoro oil spill affected several recreational sites on this coast including Fujii Beach (Waipouli Beach) and Nukoli'i Beach. Fujii Beach is a favorite location for many families on Kauai because an offshore reef creates a shallow pool where children can swim safely. Nukoli'i Beach is located behind two hotels and is used primarily by guests at those hotels.

As a result of the Tesoro oil spill, officials closed Fujii Beach and Nukoli'i Beach on September 13, 1998 (USCG 1998c). Both beaches had experienced oiling for several days prior to the official closing. During the closure, officials posted warning signs and used exclusionary tape to prevent the public from using the beaches. Fujii Beach reopened on September 16, 1998, though beach attendance did not return to normal until the beginning of the next week. Officials partially reopened Nukoli'i Beach on September 17, 1998. This beach fully reopened on September 20, 1998. Trustees believe that attendance levels at Nukoli'i Beach returned to normal quickly.

Substantial oiling and cleanup activities occurred at Kealia Beach and in the Ahukini area, although these areas were not officially closed to the public. Oiling also occurred at Kipu Kai. Fishermen and opihi harvesters would have been precluded from some of these areas. The Trustees estimated that the spill affected approximately 460 trips to Fugii Beach; 1,110 trips to Nukoli'i Beach during the full closure; and 870 trips to Nukoli'i Beach

during the partial closure. The Trustees also estimated that the spill affected approximately 50 fishing trips. Using literature values for general beach recreation and for fishing site closures, the Trustees estimated that the value of the recreational losses resulting from the oil spill was approximately $10,000.00. Although the Trustees gathered additional information concerning recreational impacts resulting from the Tesoro spill, the Trustees determined that quantifying those recreational losses would not be cost-effective.