Oil Spills at Sea
Potential Impacts on Hawaii

Rose T. Pfund, Editor

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Preface

No report on a dynamic policy field can fully capture the scope and depth of the complex issues that are intrinsic and extrinsic to it. This study has found that oil spills could be more than sources of environmental pollution—their impact could cut across the social and economic fabric of Hawaii. The economic analysis was based on the U.S. Coast Guard’s worst case, not most probable, catastrophic oil spill of nearly 10 million gallons of crude oil. The statistical projection for the occurrence of an oil spill of that magnitude is once in 135 years. As a comparison, the projection for a similar size oil spill in Alaska, just before the Exxon Valdez disaster, was once in about 235 years.

Because Hawaii has never had a major oil spill, the economic and ecological data were obtained by convening expert panels on marine biology, tourism, and oil spill responders. Panel members are listed under acknowledgments. In addition, researchers interviewed many other experts to obtain a good balance of data. Descriptions of oil spill characteristics and sites are based on the analysis of historical data on international at-sea oil spills >10,000 gallons and a nine-year record of reported oil spills in Hawaii. The state’s existing statutes and regulations were evaluated for their adequacy by comparing them with those of three states and the federal Oil Pollution Act of 1990 (OPA). The research activities were divided into two parts: the economic studies were conducted under the direction of Dr. Jack R. Davidson, principal investigator, and the environmental impact, review of statutes and regulations, and the analyses of vulnerability and prevention were done under the direction of Dr. Rose T. Pfund.

The economic cost projections are based on the U.S. Coast Guard’s worst case scenario for Hawaii in which nearly 10 million gallons of crude oil are spilled in the Kawai Channel in Kona weather. The worst case scenario was used as the basis for economic analysis because historical spills have not had a lasting adverse impact on the state’s economy. In the worst case scenario, essentially all of Oahu’s beaches and coastal areas are oiled. The projected cleanup costs based on this scenario as well as the projected revenue losses of the tourism industry reflect what can be called the ceiling of the range of costs and damages. Response costs for a smaller oil spill would be lower, but there is a basic cost for mobilizing equipment and workers. What this means is that response costs for a 100,000 gallon spill would exceed 50 percent of the response costs for a 200,000 gallon spill.

As the economic studies progressed, it became apparent that Hawaii would not be able to recover readily or completely from a major oil spill. The recession suffered by tourism would negatively affect all sectors of Hawaii’s economy but would increase the demand for governmental services at a time when resources are greatly reduced. Given these impacts, prevention became a significant area of focus.

As in any research, the scoping of the research parameters is based on the judgment of the researchers. While the scope of work outlined by the Department of Health (DOH) has been fulfilled, there is no way in which every possible, or even desirable, aspect of the complex issues related to a major oil spill in Hawaii could have been analyzed and included in this report. Within the limitations of time and funding, we are satisfied that the most salient issues have been addressed. Our analyses, presented in this report, are a snapshot of the state’s vulnerability and its ongoing efforts to develop a response and prevention plan for addressing the risks associated with oil spills. However, the text of this report and the recommendations have been reviewed by the oil industry, various state agencies, and the U.S. Coast Guard. Their comments have been incorporated into the report. We have also included the comments of the state DOH where appropriate in the text and reprinted their comments verbatim under the specific recommendations addressed.

We do not expect total agreement with our conclusions and recommendations. If this report generates discussion and heightened awareness of the potentially devastating impacts of oil spills on Hawaii’s economy and environment, our intent will have been fulfilled.
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# Table of Contents

Executive Summary ........................................................................................................... vii

**Chapter 1**

The Vulnerability of Hawaii to a Major At-Sea Oil Spill

*Rose T. Pfund* ............................................................................................................. 1

- Introduction .................................................................................................................. 3
- Underlying Causes of Hawaii’s Vulnerability to Major Oil Spills ......................... 4
- Problems and Issues .................................................................................................. 11
- Recommendations ..................................................................................................... 13
- References .................................................................................................................. 14

**Chapter 2**

Economic Impacts of a Catastrophic Oil Spill: Clean-up Costs and Damages

*Jack R. Davidson and Christina A. Olive* ................................................................. 15

- Scope of this Chapter ............................................................................................... 17
- Introduction ............................................................................................................... 17
- Costs and Damage Assessments Associated with the Worst Case Catastrophic Oil Spill: Results and Discussion ................................................................. 21
- Cost of the Vessels and Spilled Oil ........................................................................ 32
- Damages to Resources ............................................................................................ 32
- The Natural Resources Damage Assessment Model for Marine and Coastal Environments ........................................................................................................ 32
- Summary of Cleanup Cost Estimates .................................................................... 35
- Cleanup Costs Associated with a 30,000 Barrel Oil Spill in the Kaiwi Channel .... 36
- Response, Cleanup and Disposal Costs Associated with a 100,000 Gallon Black Oil Spill in Honolulu Harbor ................................................................. 37
- Recommendations ................................................................................................. 40
- References ............................................................................................................... 41

**Chapter 3**

The Economic Effect of a Catastrophic Oil Spill on Tourism in Hawaii

*Donna J. Lee, Jack R. Davidson, Christopher La Franchi, and Marissa C. Garcia* .... 43

- Introduction ............................................................................................................... 45
- Economic Effect of an Oil Spill on Hawaii’s Visitor Industry ............................... 47
- Ocean Recreation Industry Effects ........................................................................ 55
- Oahu Effects ............................................................................................................ 55
- Oahu Hotel Industry Effects .................................................................................. 55
- Summary .................................................................................................................. 57
- Recommendations ................................................................................................. 57
- References ............................................................................................................... 57
Chapter 4
The Impacts of an Oil Spill on Hawaii's Natural Environment: A General Overview

Kim Des Rochers .................................................................................................................. 59

Introduction ....................................................................................................................... 61
Corals and Coral Reefs .................................................................................................... 61
Effects of Oil on Coral ....................................................................................................... 62
Impacts of Oil Pollution on Tropical Marine Communities ........................................... 64
Impacts of Oil Pollution on Temperate Marine Organisms ........................................... 68
Seabirds ............................................................................................................................. 69
Marine Mammals ............................................................................................................. 75
Effects of Oil on Marine Mammals ................................................................................... 77
Sea Turtles ....................................................................................................................... 79
Recommendations ........................................................................................................... 81
References ...................................................................................................................... 82

Chapter 5
An Evaluation of State and Federal Statutes on Oil Spill Response and Hawaii's Response Preparedness

Peter Rappa and Phil Moravcik ......................................................................................... 87

Introduction ....................................................................................................................... 89
Legislative Comparison .................................................................................................... 89
Discussion ....................................................................................................................... 90
Hawaii's Preparedness for Major Oil Spills ................................................................... 94
Recommendations ......................................................................................................... 103
References ...................................................................................................................... 105

Chapter 6
Analysis of the Causes and Prevention of Oil Spills

Rose T. Pfund .................................................................................................................... 107

Introduction ....................................................................................................................... 109
Research Methodology ................................................................................................... 109
Causes of Major Oil Spills Worldwide ........................................................................... 110
Causes of Oil Spills in Hawaii ........................................................................................ 112
Inadequacies of Response Technology .......................................................................... 119
Provisions Under OPA that Define State Authority ..................................................... 120
The Human Factor Dimension in Oil Spills: The Prevention and Mitigation of
Social Dysfunction .......................................................................................................... 123
Recommendations ......................................................................................................... 124
References ...................................................................................................................... 129
Chapter 7
Final Words: A Synthesis

Rose T. Pfund .................................................................................................................. 131

Recommendations .............................................................................................................. 136

Appendices
A. Comparison of OPA and State Statutes ...................................................................... 141
B. Description of Response Technologies ....................................................................... 149
C. Oil Spill Equipment Inventory ..................................................................................... 157

Figures
Figure 1.1 Tanker and tanker barge transit routes in Hawaiian waters ......................... 7
Figure 3.1 Annual visitor arrivals to Hawaii .................................................................. 45
Figure 3.2 Trend in annual visitor expenditures in Hawaii ............................................ 45
Figure 3.3 Percent of annual state income from visitor expenditures ......................... 46
Figure 3.4 Seasonality of visitor arrivals to Hawaii ....................................................... 46
Figure 3.5 Visitor industry revenue losses after a catastrophic oil spill ....................... 51
Figure 3.6 Alternative recovery paths ........................................................................... 53
Figure 4.1 Feeding habits of Hawaiian seabirds ............................................................ 71
Figure 4.2 Distribution of humpback whales in Hawaiian waters ............................... 77
Figure 4.3 Important feeding and resting areas in the main Hawaiian Islands for resident green turtles 80
Figure 6.1 Oil spill statistics (1989, 1990) by month ...................................................... 110
Figure 6.2 Detail of southern coast of Oahu ................................................................. 113
Figure 6.3 Histogram of reported oil spills in Hawaii .................................................... 114

Tables
Table 1.1 Inbound Vessels: 1988 ...................................................................................... 5
Table 1.2 Distribution of undocumented state registered vessels ................................. 6
Table 1.3 Consumption of energy: 1960, 1970, 1980, 1989, Trillion/Btu ......................... 8
Table 1.4 Interisland shipment of petroleum and petrol products in 1988 ....................... 10
Table 1.5 Neighbor island residual oil (No. 6 fuel oil) demand: 1990 ............................ 10
Table 2.1 Estimated costs of oil spills ............................................................................ 17
Table 2.2 Summary of at-sea response costs by type of operation ............................... 22
Table 2.3 Summary of shoreline cleanup costs ............................................................. 24
Table 2.4 Estimated costs of cleanup per bird ................................................................. 25
Table 2.5 Projected amount of oil and oily wastes from a catastrophic spill in Hawaii .... 26
Table 2.6 Summary of oil and oily waste disposal costs ............................................... 27
Table 2.7 Federal oil spill response costs, selected spills .............................................. 28
Table 2.8 Summary of federal agency cost on the Exxon Valdez ................................... 29
Table 2.9 Comparison of federal government costs for selected spills ......................... 29
Executive Summary

The enactment of the Oil Pollution Act of 1990 (OPA) by Congress in the wake of the Exxon Valdez oil spill in 1988 has clearly identified the states' role in relation to oil spills — the states are not frontline responders, they are the trustees of their natural resources. OPA has created a $1 billion oil spill liability trust fund to enable the federal government to respond quickly to oil spills. Beginning in 1993, a part of the regulations now being formulated to implement OPA will be in place. However, OPA has already made an impact on Hawaii with the refusal of oil companies to supply black fuel oil to the neighbor island counties because of potential liability.

The scope of this report includes:

- The assessment of Hawaii's vulnerability to a major at-sea oil spill
- The cleanup cost and the economic impact on tourism of a major oil spill described as the U.S. Coast Guard's worst case scenario
- Statutes and regulations on response and prevention of oil spills
- Issues related to the prevention of oil spills
- Recommendations
- Future research

Vulnerability

Two contributing factors were examined to explore the state's vulnerability to an at-sea oil spill. The first was Hawaii's nearly 100 percent reliance on maritime shipping for consumer and industrial goods. The Port of Honolulu alone annually receives nearly 8,000 inbound ships of which 671 are oil or oil product carrying tankers or tanker barges which offload more than 2.5 billion gallons of oil and oil products in Hawaii. The second contributing factor is Hawaii's 90 percent dependence on oil for energy and little immediate prospect of a viable alternative energy source. Short of moving the offshore mooring elsewhere, Oahu's southern coastline between Honolulu Harbor and Barbers Point remains vulnerable to a major oil spill, particularly in the winter months under Kona weather conditions.

Statistically, Hawaii can expect a 10--20,000 gallon oil spill once in 2.25 years and a 40--50,000 gallon oil spill once in 4.5 years. The expectation of a 10--11 million gallon oil spill is once in 135 years.

Cost of Oil Spill Response: U.S.C.G. Worst Case Scenario

The cost of cleaning up a major oil spill of 9,800,000 gallons, based on the U.S. Coast Guard's worst case scenario, was determined by consulting oil spill cleanup and oil industry experts, state officials, and U.S. Coast Guard officers. The estimated cost of cleanup of a major oil spill ranges between $210--$305 million. These figures do not include damage to private property and wildlife. The state faces a potential problem with the disposal of emulsified oil, oily trash, and oil-soaked sorbents and cleanup materials. The lack of a predetermined holding site could cause a slowdown in cleanup response.

Impact of a Major Oil Spill on Tourism: U.S.C.G. Worst Case Scenario

An iterative procedure was used to elicit individual response and agreement from an expert panel representing various sub-sectors of the tourism industry. The panel established recovery trends (time v. revenue loss/
recovery) for the tourism industry under the condition of the U.S. Coast Guard’s worst case scenario. The projected loss to tourism would be $640 million to $6.8 billion in direct revenue and 67,000 workers would be furloughed for two months to two years. The loss to these workers’ household income is projected to be well over $1 billion. The panel also identified economically significant coastal sites, such as Waikiki Beach and other resort areas for first response in the event of an oil spill.

Impact of a Major Oil Spill on Hawaii’s Natural Resources

A panel of biologists agreed that the resilience of Hawaii’s fisheries and wildlife and their wide distribution throughout the islands precluded any danger of extinction from an oil spill. There was concern, however, for coral reefs, particularly if a spill occurs during low tide. The expectation under such conditions is that the reef will be oiled. Under high tide conditions, however, the oil will bypass the reefs and land on the beaches. Habitats of endangered species (monk seals, green sea turtles) and endemic species (Hawaiian stilts) in embayments which are low-salinity habitats were identified as ecologically sensitive areas.

Analysis of Federal and State Statutes and Regulations on Oil Spills

The state’s oil spill response contingency plan, statutes, and administrative regulations were evaluated by interviewing officials and analyzing OPA and the oil spill laws of Washington, Florida, and Louisiana. Hawaii currently lacks a plan for the prevention of oil spills. The existing contingency plan is administered by the Department of Health as the lead agency. The plan addresses all hazardous spills; oil is only one of many hazardous materials. Hawaii’s “superfund,” currently funded with state general funds and fines, could be funded by a point of entry charge of a $0.05/barrel fee. There is one memorandum of understanding (MOU) on use of dispersants. Other MOUs should be developed to address such questions as cleanup sufficiency and all areas of interagency cooperation.

Analysis of the Causes and Prevention of Oil Spills

Historical data were analyzed statistically to understand the causes and location of oil spills worldwide and for Hawaii. Human error was the cause of about two-thirds of oil spills worldwide, but Hawaii’s accident records (9-year period) indicated that only 10 percent of the oil spills were caused by human error. Structural/equipment failure was the cause of about 40 percent of the oil spills. The oil industry and the U.S. Coast Guard have jointly and individually initiated measures to prevent oil spills, including developing a tanker-free zone advisory for the Kaiwi channel for adoption by the International Maritime Organization and more stringent procedures for offloading oil and for ship operations at the offshore mooring.

Recommendations

It is clear from our study that a major at-sea oil spill off Oahu’s southern coast has the potential for triggering a significant downward spiral that will cut deeply into the state’s economy. Over the long term, the mystique of a pristine environment which lures visitors to pay higher transportation costs to stay in upscale beachfront resorts would be shattered, if the news media were to transmit worldwide views of Hawaii’s coastal vistas coated with black oil.

Given these serious consequences, we concluded that as the trustee of its natural resources, the state needs to give the prevention of oil spills its highest priority. Our analysis identified two critical recommendations that would enable the state to address oil spill prevention:
1. A comprehensive oil spill prevention plan to augment the oil spill response plans currently being developed by the U.S. Coast Guard and the Area Committee, as mandated by OPA, and the "Hawaii Energy Strategy Plan," being developed by the state Energy Office.

2. A small staff in the Hazards Evaluation and Emergency Response (HEER) office responsible for responding solely to oil spills so that adequate attention can be given to developing a plan for the prevention of oil spills and to addressing fully the complex institutional issues surrounding the implementation of OPA.

A Comprehensive Oil Spill Prevention Plan

We recommend the development of a comprehensive strategic plan for the prevention of oil spills developed in tandem with efforts currently underway by the state's Energy Division and the U.S. Coast Guard's Area Committee.

The most critical issues that need to be addressed in the oil spill prevention plan are:

1. Articulation and definition of the roles of county and state governments vis-a-vis each other and with the federal government formalized by memoranda of agreement.

   Because OPA precludes the federal government from preempting state's rights, to avoid inaction, formal pre-agreements should be defined where and how each jurisdiction's responsibilities interface with those of the other two.

2. Pre-agreed standards for acceptable levels of "clean" based on wide input from the public and special interest groups.

   Should the standards be based on esthetics or ecological needs? Should the standards be subjective or objectively established? Should they be based on some threshold levels of key compounds in the sand/sediment or on dosage tolerance? Whose values should prevail?

3. Institutional infrastructure to operationalize pre-agreements on appropriate response technolo-gies and to designate and manage holding/disposal sites.

   Response efforts and technology are costly and their effectiveness for recovering oil at sea is time dependent. As such, mobilization procedures, inter-jurisdictional memoranda of understanding for outlining the conditions for use of response technologies of choice, and disposal/holding sites should be established apriori.

4. Identification and mapping of all significant institutional and non-governmental energy-related linkages and the inter-related reciprocal and triggering impact of these linkages.

   Because the ongoing Hawaii Energy Strategy Program will not adequately map the energy policy field, particularly the state's role under OPA, this critical analytical work should be given high priority. Without this information, efforts to mitigate one problem could trigger other problems.

5. Regulations and administrative rulemaking for fulfilling the state's role as trustee under OPA.

   A critical analysis of extant state policies is needed to integrate current efforts of the state Energy Office on energy conservation and alternative energy production with new statutes and regulation on oil spill prevention. Statewide standards should be established for regulations and procedures for evaluating the adequacy of loss prevention and risk management procedures as integral parts of tanker and facility oil spill response plans. Pre-determined procedures for establishing non-market values of coastal resources should also be determined.
Oil Spill Evaluation and Monitoring Staff for Hazard Evaluation and Emergency Response Office (HEER)

*We recommend a uniformly applied fee/barrel to provide HEER with the required staff dedicated to dealing with oil-related problems.*

The fee internalizes the costs of prevention; response costs are already part of the price consumers pay for fuel and energy. The oil industry indicated their support for the imposition of a fee (with fund cap) provided that the fee is used solely for oil-related purposes.

The burgeoning economy and population, following statehood in 1959, sharply increased the demand for energy. The oil industry responded by increasing their capacity to supply the nearly three billion gallons of oil and oil products now required to meet transportation, commercial/industrial, and residential fuel and energy demand. Unlike the ready market response, the state's monitoring and oversight infrastructure and administrative rulemaking have not kept pace with the growth in volume and risks of imported oil. Moreover, this study clearly showed the vulnerability of the state to a major oil spill because of its reliance on maritime shipping and lack of viable alternative energy sources. Coupled with these is the high statistical probability of a large oil spill caused by human error and outdated or malfunctioning equipment or facilities.

Although the state must be prepared to function as the trustee of its natural resources when OPA kicks into gear in 1993, *it is currently not fully prepared to assume this responsibility.* The HEER office lacks staff to monitor and evaluate procedures used by private and public sectors to maintain their coastal facilities and pipelines and to provide the aggressive leadership needed to develop and implement the state's plan for prevention and mitigation of oil spills. Staff is also needed to ensure the smooth integration of state plans and policies with the federally mandated OPA beginning in 1993.
Oil Spills at Sea

Potential Impacts on Hawaii

1992
CHAPTER 1
THE VULNERABILITY OF HAWAII TO A MAJOR AT-SEA OIL SPILL

Rose T. Pfund, Ph.D.
Introduction

The State of Hawaii would lose between $640 million and $6.8 billion, a conservative mid-range loss, in direct tourism revenues, if the U.S. Coast Guard's current worst case scenario of a 9.8 million gallon oil spill (or about one-third of the cargo of a tanker carrying 29.5 million gallons of crude oil) were to be accidentally released into the Kauai Channel. Based on the mid-range revenue loss, more than 67,000 jobs contributing $1.671 billion to the employees' household income would be temporarily lost during the 12-month cleanup period. Experts estimate that it would take up to two years for the state to completely recover from the effects of the oil spill. The social costs stemming from the projected labor force cutback would go beyond loss of income. The psychological impact on the lives of those affected will be seen in such incidences as increased domestic violence, alcoholism, and crime. There would be substantial increases in public welfare and safety costs to state and county governments in the face of potential tourism revenue losses of about 20–25 percent of the $10.1 billion that tourism contributes to the gross state product.

Beyond the mainstream tourism sectors, hotels and transportation, the negative ripple effect of the drop in visitor count on the many small tourism-dependent businesses would be immediate and severe. These businesses form the network that provides ocean and other recreational activities and goods expected by tourists for the complete resort experience that makes Hawaii a prime destination. It is highly probable that many businesses would not be able to continue operating or to re-establish themselves when the tourism sector begins economic recovery after the projected four to 12-month recession.

The Role of the State Under OPA

The state's role, as outlined in the federal government's response to oil pollution, is contained in the Oil Pollution Act (OPA) of 1990, which was enacted by Congress in the wake of the Exxon Valdez oil spill in Prince William Sound, Alaska on March 24, 1989. OPA is the omnibus federal legislation on oil spill prevention, liability, and compensation that cross cuts several existing laws, including the Federal Water Pollution Control Act, Intervention of the High Seas Act, Ports and Waterways Safety Act, etc., particularly in creating the oil spill liability trust fund. OPA explicitly recognizes the authority of all states to levy additional liability or requirements on oil spills or removal activities or to establish (or continue) a fund to pay for costs and damages arising from oil spills or to require any person to contribute to such a fund (Section 1018(a)(1); (b)(1)(2)). In addition, OPA allows the state to impose or determine the amount of any fine and civil or criminal penalties based on discharge or substantial threat of discharge of oil (Section 1018(c)(1)(2)).

OPA explicitly designates the state as the trustee of its natural resources (Section 1006(c)(2)(A)(B)), but not as a responder although the state may respond to an oil spill under the National Contingency Plan and be reimbursed "for the reasonable costs incurred for that removal, from the Oil Spill Liability Trust Fund" (Sec. 4201(d)(H)). The primary governmental responder for an at-sea oil spill is the U.S. Coast Guard (Subtitle B, Section 4201-4202); however, the liability for the cleanup costs rests with the owners of the vessel while the oil is in transit or the oil handling and processing facilities once the oil is delivered. The U.S. Coast Guard is responsible for responding immediately to an oil spill, if the spiller is incapable of responding. It is currently operating on what it describes as the "shoot first and ask questions later" mode in recognition of the narrow window of opportunity available for optimum response. The $1-billion oil spill liability trust fund established under OPA provides the U.S. Coast Guard with the capability for responding rapidly with the latest technology.

1 The size of the spill of the worst case scenario in the Area Contingency Plan being developed under OPA will be the total discharge of a 150,000 DWT tanker (carg: 1,000,000 barrels of Alaskan crude).
The state’s responsibility for responding to an at-sea oil spill, therefore, is primarily not as a frontline responder, but as the trustee of the natural resources and the public’s general welfare and their well-being. The Department of Health, the designated agency that acts as trustee for the state, has no response capability to clean up an oil spill; neither does any other state agency, except for the limited capability of the Harbors Division of the Department of Transportation to respond to very small spills on the order of quarts with the small amount of sorbents that is stocked at the harbors. The state, in addition, has the option to hire contractors to clean up an oil spill. However, it is the U.S. Coast Guard who is responsible for overseeing at-sea oil spill cleanup and the shipowner or the facility, who must pay for all clean up costs under OPA’s “polluter pays” principle. The two oil refineries, Hawaiian Independent Refinery, Inc. (HIRI) and Chevron, USA, and other oil handling companies have formed a consortium, the Clean Islands Council (CIC), to respond to oil spills at-sea or at the offshore mooring or other facilities owned by the refineries and member companies.

While local cooperative efforts like the CIC and private oil spill response firms like Pacific Environmental Corporation (PENCO) will continue to clean up small spills, on the heels of the catastrophic Exxon Valdez accident, the Petroleum Industry Response Organization (PIRO) was formed to respond to oil spills that were beyond the capability of the local co-ops. As other non-oil sectors, like shippers and facility owners, expressed interest in joining PIRO, the name of the organization was changed to Marine Spill Response Corporation (MSRC). Oahu has been designated a staging area in the Southwest Region which has its headquarters in Port Hueneme, California. MSRC is expected to become fully operational by February 1993. In addition to expending $300 million for purchasing ships and equipment, MSRC will be conducting research and development of response technology (MSRC, 1991).

As discussed in Chapter 5, the state has developed an oil spill contingency plan outlining the responsibilities of the various agencies in the event of a spill, under its “Oil and Hazardous Substances Emergency Response Plan.” However, because oil is only one of several hazardous materials considered, the full spectrum of the complex problems and issues related to a major oil spill is not completely addressed. The present study is a first step in looking at oil spills discretely as a potential source of major environmental pollution that would have a disastrous impact on the social and economic well-being of the entire state.

The Scope of this Chapter

The discussion that follows focuses on the analysis of the risks related to the state’s dependence on maritime shipping of dry cargo and oil and how these risks contribute to the state’s vulnerability for suffering an at-sea oil spill. The first assumption made was that the probability of an accident occurring is directly related to the number of vessels in transit at the same time and the frequency of use of routes and sites of cargo discharge. The second assumption was that the state’s increasing dependence on oil, with no aggressive planning for alternative energy options, added to the risk of oil spills.

Underlying Causes of Hawaii’s Vulnerability to Major Oil Spills

Hawaii’s maritime shipping activities are focused on Honolulu Harbor, the port of call for freighters and other large container ships, cruise liners, and tankers. Less than five percent of the incoming freight to the islands is shipped by air, the only other public transportation for shipping cargo to the islands. Honolulu Harbor also bunkers fuel oil. To the west at the Barbers Point offshore mooring, large tankers (70-150,000 DWT) deliver crude oil from Southeast Asia and Alaska to the Chevron, USA and HIRI refineries.

How vulnerable is Hawaii to a major at-sea oil spill? Even if risk is solely based on statistical odds, Hawaii is vulnerable to at-sea oil spills. These spills would probably be larger than those caused by structural and
equipment failures, unless the source of the spill is an undetected underwater or underground pipeline leak. One reason for Hawaii’s vulnerability to an at-sea oil spill is its insular environment and its mid-Pacific location which gives the state no option but maritime shipping for the transport of almost all of the goods necessary to sustain its highly urbanized economy. The second reason is Hawaii’s reliance on oil as its primary source of energy.

**Hawaii’s Reliance on Maritime Shipping**

Coupled with Hawaii’s sole reliance on ocean-going tankers for delivery of oil, its vulnerability to oil spills is made more acute by the number of inbound container ships that off-load cargo at Honolulu Harbor. Hawaii was ranked No. 12 in the nation in the use of watertight transport in 1989. A total of 13,005,644 tons of cargo were received in Hawaiian Ports. This is an increase of more than 2,000,000 tons over the 10,951,237 tons received in 1985 (Office of Market Promotion, 1991).

Hawaii is envied for its natural beauty and climate, but it has severe limitations in land and natural resources for agricultural and industrial development that make it impossible to supply the basic needs of the 1.1 million residents and 6.5 million tourists. This is a condition that is not atypical of insular environments. The demand for physical comfort and conveniences provided by engineered systems, automobiles, and other amenities is far beyond what can be supplied by locally produced goods. Indeed during the decade between 1980 and 1990, imports rose by 28 percent (U.S. Coast Guard briefing: May 24, 1991). This figure is especially significant in that nearly all of the 98 percent of goods that are shipped to Hawaii are discharged at the Port of Honolulu and then transshipped by barge to the neighbor islands. Thus, there is major loading and unloading of dry cargo at Honolulu Harbor in addition to bunkering and off-loading of oil products.

During 1988, there was a total of 7,929 ship arrivals at the Port of Honolulu alone. Of these, 671 vessels — 92 tankers and 579 tanker barges — transported oil products (Table 1.1). In addition, there were 5,616 shipments of merchandise to nine other commercial ports in the state.

<table>
<thead>
<tr>
<th>Harbor</th>
<th>No. of Vessels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hilo</td>
<td>922</td>
</tr>
<tr>
<td>Kawaihae</td>
<td>660</td>
</tr>
<tr>
<td>Kahului</td>
<td>1,451</td>
</tr>
<tr>
<td>Kaumalapau</td>
<td>654</td>
</tr>
<tr>
<td>Kaunakakai</td>
<td>682</td>
</tr>
<tr>
<td>Kalaupapa</td>
<td>6</td>
</tr>
<tr>
<td>Honolulu</td>
<td>7,929</td>
</tr>
<tr>
<td>Barbers Point</td>
<td>458</td>
</tr>
<tr>
<td>Nawiliwili</td>
<td>643</td>
</tr>
<tr>
<td>Port Allen</td>
<td>75</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>13,480</strong></td>
</tr>
</tbody>
</table>

Data Source: Department of Business and Economic Development and Tourism, 1990
When these vessel movements are annualized, on any given day, there are 37 dry and oil cargo carrying vessel movements in the state's channel or offshore waters. This figure does not include the more than 15,000 documented and undocumented recreational and fishing charter boats and other vessels that serve tourists and residents. While figures were not available for the number of documented vessels, Table 1.2 clearly shows that most of the undocumented vessels are on Oahu.

<table>
<thead>
<tr>
<th>Island</th>
<th>No. of Vessels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hawaii</td>
<td>1,987</td>
</tr>
<tr>
<td>Kauai</td>
<td>1,091</td>
</tr>
<tr>
<td>Lanai</td>
<td>50</td>
</tr>
<tr>
<td>Maui</td>
<td>1,266</td>
</tr>
<tr>
<td>Molokai</td>
<td>181</td>
</tr>
<tr>
<td>Oahu</td>
<td>8,926</td>
</tr>
<tr>
<td>Total</td>
<td>13,501</td>
</tr>
</tbody>
</table>

Data Source: Department of Business and Economic Development and Tourism, 1990

These vessels would add another 37 vessels/day, if each vessel sailed only once a year. Some of these vessels could be found in channel waters. In addition, according to the Coast Guard's "Oil and Hazardous Substance Contingency Plan," fishing boats and research vessels constitute 55 percent of the vessel traffic in the Honolulu area, a significant number along with other documented vessels that are not part of the 74/day vessel movement. Also not factored into the ship traffic around the state are the movements of the U.S. Navy's submarine and surface vessels.

There is, therefore, a potential for collision or grounding within the channel and nearshore waters of the state where most of the vessel traffic occurs. Figure 1.1 is a composite map showing the major tanker traffic paths from Asia and Southeast Asia, Alaska, the West Coast, and the interisland tanker barge routes. Tankers laden with crude oil, for the most part, approach the southern coast of Oahu to discharge their cargo at Barbers Point from the open ocean or through the Kauai Channel which is about 60 miles wide. Tankers from the West Coast approach Oahu through the Kaiwi Channel. In doing so, they cut across tanker barge routes to Molokai, Lanai, Maui, and Hawaii. The risk exposure of this routing is substantial from the standpoint of the significance of both Oahu and Molokai's coastal areas that could be oiled if an accident were to occur. Moreover, given the prevailing summer currents and the increase in summer boating activities, the probability of a disastrous accident occurring and injuring the coastal areas and wildlife and tourist activities would be greater during the summer months. However, since outdoor recreation is carried out year round in Hawaii, the seasons are significant in that they could enhance or diminish the intensity of risk exposure because of the changes in the prevailing currents.

Figure 1.1 also shows paths of the tanker barges (and dry cargo barges) that deliver oil products to the neighbor islands. The ecologically and economically sensitive areas were plotted on the map to show the potential impact an accident could have on wildlife and tourism. The well-being of both is dependent on a pristine environment. As shown in Figure 1.1, the narrowest channels in the state are found in the County of Maui. The Kaiwi Channel between Oahu and Molokai and the Alenuihaha Channel between Maui and Hawaii are not as narrow, but the latter, well-known for its turbulence, is traversed by tanker barges on their way to Hilo and Kawaihais Harbors.
Figure 1.1. Tanker and tanker barge transit routes in Hawaiian waters
The reliance on ocean transport and the convergence of vessel activity in Honolulu Harbor places it at risk from accidental spills during bunkering and product offloading operations and collisions and grounding caused by guidance error. However, because crude oil is not off-loaded there, the risk of "dirty" oiling of the coastline by a spill emanating from Honolulu Harbor would be minimal. The most likely site for a large "dirty" oil spill is at the Barbers Point offshore mooring which receives all of the crude oil that enters state. Until very recently, interisland tanker barge shipment of No. 6 fuel oil was also a source of risk, but this risk has been reduced considerably with the termination of shipments by Pacific Resources, Inc. and Chevron, USA and the substitution of shipments of diesel fuel oil for the No. 6 fuel oil to Kauai Electric Company. At this writing, Hawaiian Tug and Barge is the only interisland carrier of No. 6 fuel oil to Hawaii and Maui, but it will terminate black oil shipments at the end of 1993.

The potential for the occurrence of an oil spill caused by a vessel remains relatively high despite reduction of tanker-barge traffic. There apparently have been near-collisions between tugs and recreational boats in the narrow channels between the islands that comprise the County of Maui. This issue is discussed in greater detail in Chapter 6.

**Hawaii’s Reliance on Oil**

The other contributor to the state’s vulnerability is its high consumption of imported oil and oil products because it currently has no alternative sources of renewable energy. Table 1.3 graphically illustrates the burgeoning demand for energy. Residential use has more than tripled in three decades. Commercial use increased by tenfold, industrial use more than tripled, and transportation use more than doubled over the same period. It is a simple equation: the greater the demand for oil-generated energy, the greater the number of inbound tankers and the greater the probability of an accident. At present, there are no real options for reducing the state’s dependence on oil, which now supplies 90 percent of its energy requirements. In spite of the state’s sporadic pursuit of alternative renewable energy sources, such as wind, ocean thermal energy conversion (OTEC), biomass, and geothermal, to date, none has been successfully scaled up to serious levels except for biomass. Barring unforeseen problems, Puna Geothermal Ventures is expected to produce 25 megawatts of power by the end of 1992, which is about 20 percent of the power requirements of the County of Hawaii. According to the state’s Energy Division, only about 10 percent of the state’s energy requirement is met by other alternative non-oil energy sources, mostly by biomass (6–7 percent) and coal (~3 percent) (Personal communication: Lynn Y.S. Zane, Research Statistician, Energy Division).

<table>
<thead>
<tr>
<th>Year</th>
<th>Residential</th>
<th>Commercial</th>
<th>Industrial</th>
<th>Transportation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960</td>
<td>7.3</td>
<td>5.2</td>
<td>20.7</td>
<td>61.8</td>
</tr>
<tr>
<td>1970</td>
<td>16.4</td>
<td>11.6</td>
<td>43.6</td>
<td>125.3</td>
</tr>
<tr>
<td>1980</td>
<td>23.2</td>
<td>20.8</td>
<td>62.4</td>
<td>146.7</td>
</tr>
<tr>
<td>1989</td>
<td>25.3</td>
<td>52.8</td>
<td>68.6</td>
<td>152.4</td>
</tr>
</tbody>
</table>


Hawaii’s social and economic well-being relies on the uninterrupted shipment of food, durable goods, building materials, oil, etc. This dependency requires increasing numbers of freighters and tankers to call on the state’s ports and significantly increases Hawaii’s risk for suffering a major, if not catastrophic, oil spill. The vulnerability of Hawaii to a major or catastrophic at-sea oil spill is enhanced by the state’s sole reliance
on tankers as the means of importing oil and Hawaii's ever-increasing demand for and dependence on oil. It now takes more than 2.5 billion gallons annually to satisfy the state's energy needs. Not surprisingly, between 1980 and 1990, the number of incoming tankers rose by 70 percent, according to the U.S. Coast Guard's Marine Safety Office (Honolulu, Hawaii).

The rising number of incoming tankers validates the tripling of energy use by the resident population and the tourism industry. In the foreseeable future, there are no prospects for infusion of locally produced energy that can significantly lower the 90 percent met by imported oil. Given these conditions, the expectation is that oil imports would continue to increase to meet the demand for power and fuel, unless more vigorous efforts are directed in the near term toward energy conservation and use efficiency and over the long term aggressive development of both renewable energy and non-oil fossil fuels.

In domino fashion, as ship traffic increases, the state's vulnerability to oil spills will predictably also increase. And indeed, the probability of more oil spills is borne out in the 557 oil spills reported to the U.S. Coast Guard in 1990 — up 200 percent in a decade (U.S. Coast Guard briefing on oil spills, May 1991). While the reported oil spills are small, 10 to 100 gallons, it took only 120 gallons, less than 10 percent of the total estimated spill of 1,500 gallons at Chevron's Barbers Point offshore mooring to close one beach on Kauai. It took 40 workers 6 days to clean oil-coated beach and coastal areas along a 20-mile stretch at a cost of about $150,000, according to newspaper reports in the Honolulu Star Bulletin and Honolulu Advertiser between May 3–18, 1984. In this instance, the source of the oil was a leaking underwater pipe at the offshore mooring. Under certain meteorological and oceanic conditions, a little oil can go a long way, particularly because it can increase nearly fivefold in bulk.

Along with incoming container ships and miscellaneous cargo and other vessels, the Port of Honolulu is also the port of call of about 28 product tankers per year each carrying between 110,000 to 270,000 barrels of aviation/jet fuel or Bunker C or other fuel oil. About 16 miles to the west, 14 tankers per month, approximately one tanker every 54 hours (or 1 tanker/2.14 days) with a carrying capacity between 8.82–37.8 million gallons of crude oil, off-load their cargo at one of the Barbers Point offshore moorings.

The Coast Guard noted that tanker traffic accounts for only five percent of the Honolulu area vessel traffic. However, as is shown in Table 1.3, the five percent of ship traffic delivers about 1.642 billion gallons of crude oil that is off-loaded at the Chevron, USA refinery and HIRI and an additional 409.7 million gallons of fuel products at Honolulu Harbor. Besides these two major ports, other commercial ports — Kaunakakai, Port Allen, Nawiliwili, Kahului, Kawaihae, and Hilo — receive about 153.5 million gallons of gasoline, jet fuel, and fuel oil (Table 1.4). The No. 6 fuel oil demand of sugar plantations and electric utility companies on three of the five major islands is shown in Table 1.5.
### Table 1.4. Inter-island shipment of petroleum and petrol products in 1988

<table>
<thead>
<tr>
<th>Honolulu Harbor, Oahu</th>
<th>Kahului, Maui</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude</td>
<td>Gasoline</td>
</tr>
<tr>
<td>Gasoline</td>
<td>Jet fuel</td>
</tr>
<tr>
<td>Jet fuel</td>
<td>Distillate fuel oil</td>
</tr>
<tr>
<td>Distillate fuel oil</td>
<td>Lubricating oil and grease</td>
</tr>
<tr>
<td>Residual fuel oil</td>
<td>Asphalt, tar, and pitch</td>
</tr>
<tr>
<td>Petrol and coal products</td>
<td>Liquid gas</td>
</tr>
<tr>
<td></td>
<td>Petrol and coal products</td>
</tr>
<tr>
<td>Barbers Point, Oahu</td>
<td>Kawaihae, Hawaii</td>
</tr>
<tr>
<td>Crude</td>
<td>Gasoline</td>
</tr>
<tr>
<td></td>
<td>Distillate fuel oil</td>
</tr>
<tr>
<td>Kaunakakai, Molokai</td>
<td>Naphtha and petrol solvents</td>
</tr>
<tr>
<td>Asphalt, tar, and pitch</td>
<td>Asphalt, tar, and pitch</td>
</tr>
<tr>
<td>Petrol and coal products</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Port Allen, Kauai</td>
<td>Hilo, Hawaii</td>
</tr>
<tr>
<td>Distillate fuel oil</td>
<td>Gasoline</td>
</tr>
<tr>
<td>Petrol and coal products</td>
<td>Jet fuel</td>
</tr>
<tr>
<td></td>
<td>Distillate fuel oil</td>
</tr>
<tr>
<td>Nawiliwilli, Kauai</td>
<td>Residual fuel oil</td>
</tr>
<tr>
<td>Distillate fuel oil</td>
<td>Lubricating oil and grease</td>
</tr>
<tr>
<td>Petrol and coal products</td>
<td>Asphalt, tar, and pitch</td>
</tr>
<tr>
<td></td>
<td>Liquid gas</td>
</tr>
<tr>
<td>Gasoline</td>
<td>Petrol and coal products</td>
</tr>
<tr>
<td>Asphalt, tar, and pitch</td>
<td></td>
</tr>
<tr>
<td>Liquid gas</td>
<td></td>
</tr>
<tr>
<td>Petrol and coal products</td>
<td></td>
</tr>
<tr>
<td>Jet fuel</td>
<td>2,143,915</td>
</tr>
<tr>
<td>Lubricating oil &amp; grease</td>
<td>467*</td>
</tr>
</tbody>
</table>

Data Source: Energy Division, Department of Business and Economic Development and Tourism
(Data = gallons, * = short tons)

### Table 1.5. Neighbor Island residual oil (No. 6 fuel oil) demand: 1990

<table>
<thead>
<tr>
<th>Island</th>
<th>No. 6 fuel oil user</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Electrical Utility (gals.)</td>
</tr>
<tr>
<td>Hawaii</td>
<td>43,119,972</td>
</tr>
<tr>
<td>Kauai</td>
<td>3,176,838</td>
</tr>
<tr>
<td>Maui</td>
<td>22,771,770</td>
</tr>
<tr>
<td>Lanai</td>
<td>—</td>
</tr>
<tr>
<td>Molokai</td>
<td>—</td>
</tr>
</tbody>
</table>

Data Source: Energy Division, Department of Business and Economic Development and Tourism
No. 6 fuel oil is transported to the neighbor islands by tanker barges with cargo capacity ranging between 1.3 and 2.2 million gallons. The transport of No. 6 fuel oil has become problematic because of the high cost of cleaning up this dense “dirty” product. The most complex recent oil spill accident, according to the U.S. Coast Guard, occurred on January 20, 1987 involving the tank barge Hana carrying Bunker C, which has a specific gravity of 1.07. Two factors worked against response efforts: 1) like crude oil, Bunker C has a higher than seawater density; and 2) once the oil sank below the sea surface, it was impossible to track the spill trajectory from the air. The cost of cleanup and potential environmental damage have curtailed shipments of black fuel oil by Chevron, USA and PRI to the neighbor islands because the risk of potential liability far outweighs the profits. However, if the purchase of the fuel tug and barge from Hawaiian Tug and Barge Corp., the present shippers of fuel oil, by Petromarine Hawaii, Ltd. is successfully closed, the fuel oil problem for the neighbor island counties may be solved. Petromarine is expected to continue shipment of No. 6 fuel oil to the neighbor island counties. The sale is scheduled to close on September 1, 1992. The complex legal issues related to the liability of the oil and the tanker barge companies are discussed in Chapter 6 of this report.

In the interim, at least one county, Kauai, is producing power with the more expensive, but cleaner, diesel fuel at the same cost as the cheaper residual fuel oil because Chevron, USA is subsidizing the diesel oil price. Since the oil company will not continue to subsidize the difference in cost of the No. 6 fuel oil and diesel oil, questions are being raised on the distribution of the higher costs over the long term.

A significant factor, shown in the inventory of products transported inter-island in Table 1.3, is that most of the oil products will dissipate into the water or the air. There is only minimal danger of refined products coating coastal and beach areas. The real danger lies in the volatile nature of these products and the potential for an explosion and/or fire and the impact of their toxicity on living marine resources during their resident time in the water column.

Problems and Issues

As noted earlier, the statistical tendency that predicts the probability of an oil spill occurring is positively related to the volume of vessel traffic, i.e., the chance of an accident occurring increases with the number of ships approaching or leaving the islands as well as the number of inter-island barge or vessel crossings. This tendency is further enhanced by human error. According to an industry source, the boredom of long trips is made more acute by automated pilot systems of tankers and vessels and the small crew required to operate a vessel (Personal communication: Capt. Jerry A. Aspland, President, ARCO Marine, Inc.). While it may be a sound procedure, based on economics, a minimal crew does not provide the redundancy needed for safeguards against the long shifts and fatigue that plague every ocean crossing voyage. This problem is addressed in OPA by mandating a 15-hour per 24-hour period or 36-hour per 72-hour period as lengths of licensed seamen's watches (OPA, Title IV, Section 4114 (b)). However, a 15-hour watch is still a long stretch of time. This subject is discussed in more detail in Chapter 6.

Hawaii Congressman Neil Abercrombie's bill to add two crew members on the bridge and a crew member in the engine room on all tugboats was heard on March 17, 1992 by the House Merchant Marine Subcommittee. Currently, a single crew member could not only be manning the pilothouse but he may also be tending the radio room and the engine compartment. The bill was opposed by the tugboat owners association, but supported by the boatmen's union. No action has been taken by Congress on the measure.

In the interest of safety, local channel and harbor waters are generally designated as pilotage waters that can only be entered with either a tug escort or licensed pilot or both. A bill was introduced in the 1992 session of the State Legislature by the Department of Transportation to expand the pilotage waters near Barbers Point. Following the near disaster of the Exxon Houston grounding in 1989, the U.S. Coast Guard has promulgated a requirement that tankers hooking up to the offshore single-point mooring system at Barbers Point maintain
a live bridge watch, proper bow/single point mooring lookout, and an engineer on immediate standby to handle ship movement. In addition, tankers are required to take on a pilot who has a federal pilot’s license and obtain tug assistance during all mooring and unmooring and standby assistance, as appropriate. There are also prescribed weather conditions that govern all transfer and hose disconnect operations and vessel departure from the mooring. All pier side oil transfers require the predeployment of a containment boom.

Unlike mainland states, which have access to vast networks of pipelines and overland routes via tank trucks and trains, Hawaii has no option but ocean-going tankers to transport the nearly 3 billion gallons of crude oil and oil products it requires annually. This reliance on tankers places the state at risk and between the proverbial "rock and a hard place" in developing regulations to ensure its protection from the potentially catastrophic consequences of a major oil spill. If the regulations are too stringent and impose high operating and liability costs, U.S. regulated tankers may cease to call on Hawaii. Arco Marine, for example, no longer delivers crude to Hawaii because of these reasons. Chevron, USA and PRI have also ceased barge shipment of fuel oil to the neighbor islands. On the other hand, the state needs to be assured that tankers calling at Hawaii ports are properly maintained and operated by crews trained to meet U.S. standards. The tankers must also show evidence of financial responsibility for responding to any accidental discharge of oil. An important requirement, under the federal OPA of 1990 is assurance of financial capability of tankers and/or their agents to respond to a major spill, i.e., the discharge of their entire cargo under storm conditions. A policy issue that needs to be addressed is the level of liability that the state should impose on tankers and other parties that own and/or handle the oil beyond the level imposed under OPA. Prudence dictates that even under the current uncertainties, some ceiling needs to be established under Hawaii’s statutes. Otherwise, the cost of the required insurance would make interisland tanker barge and overseas tanker shipping to Hawaii economically unattractive.

The vulnerability of the state is also enhanced by the impact of an oil spill on the state’s sensitive coastal zone and nearshore areas which are wildlife and fishery habitats and unique ecosystems. These coastal resources are also economically significant to the tourism-related industries. Panels of experts validated sensitive species and habitats of marine wildlife and coastal areas of high economic significance. The single most significant finding was that, based on such information as that obtained from post-oil spill monitoring at Prince William Sound, living resources were found to be resilient. In addition, their wide distribution throughout the Hawaiian Archipelago precludes singling out “critical habitats” for any of the locally popular fish and algae species. There was some concern expressed on the impact of an oil spill on intertidal flora and fauna (especially invertebrates) and their habitats. All of the biologists agreed that special consideration should be given to areas where endangered and threatened mammals and seabirds pup, feed, and nest and to embayments that provide unique low salinity environments that are thought to be significant in the life cycle of many nearshore fisheries.

The implications of the results of the natural resources study diminished somewhat the significance of sites other than known habitats of endangered species and embayments. The two general conclusions given below should be considered in setting priorities for deploying available equipment and human resources in response to an oil spill:

1. Coastal flora and fauna, other than endangered species, may recover more rapidly from the impact of oil spills, if extraordinary cleanup efforts, e.g., use of pressurized hot water, are not used.

2. Sites that have been identified (see Figure 1.1 for gross macro-view) as being significant both to endangered species and to tourism should be defined and serve the basis for establishing response priorities.

Response priorities, however, need to be established by the public.
Conclusions

Hawaii’s reliance on oil and maritime shipping for consumer and industrial goods and the high number of commercial and recreational boats in nearshore waters increase the state’s vulnerability from an at-sea oil spill. When annualized, statewide monthly ship traffic includes 55 oil-laden vessels; 1,073 dry cargo carriers; more than 1,100 undocumented vessels; and 2,000 documented vessels. These ships contribute to a daily vessel movement of more than 100 vessels distributed throughout the islands. However, the concentration of traffic is in Oahu’s coastal waters. Over the past several years, the ratio of vessel traffic to accidents has been <10 percent. Based on reported spills over a nine-year period, the statistical probability of a small spill (<20,000 gallons) is once in 2.25 years; mid-range spill (40–50,000 gallons) is once in 4.5 years; and a catastrophic spill of 10–11,000,000 gallons is once in 135 years (Lee, 1992).

While the historic data identifies Pearl Harbor as the likely site of oil spills (one in two oil spills >5,000 gallons occurred there between 1983 and 1991), the good news is that with advanced preparation, oil spills can be contained within the locks. Oil spills in Honolulu Harbor can also be contained, but the danger might be the toxicity and/or volatility of the refined oil products. About 17 percent of the 81 percent of the oil spills off Oahu during 1983–1991 occurred at Barbers Point. When the data for Barbers Point were annualized, there were about four spills (<1,000 gallons) per month over the nine years. Because of the nature of the off-loading system of crude oil at the two offshore moorings, located 2 and 2.5 miles from shore, oil spills at Barbers Point will always be “at-sea.” Even with the designation of the Kawai Channel as a tanker free zone, Barbers Point can be the site of an oil spill as catastrophic as any in the Kawai Channel. The easterly currents in winter months, enhanced by Kona weather conditions, could carry the crude oil from the offshore mooring site to Waikiki and through the Kawai Channel to the windward coast of Oahu. However, the prevailing currents are only indications of macro trends and are not likely to reflect short-term micro conditions. There is no way as yet known to enable an accurate micro prediction of currents.

Recommendations

Editor’s note: The recommendations that follow are based on the findings of our research. As indicated in italics, the DOH notes that some of the recommendations are already in the process of being implemented by the appropriate agencies.

1. Elevate the priority given to the development of alternative renewable energy, such as solar and geothermal

2. Promote energy conservation programs more vigorously

3. Continue to pursue efforts currently underway to establish tanker-free transit zones

   The U.S. Coast Guard has asked for voluntary compliance in avoiding the Kawai channel. Presently, Chevron does not pass tankers through the Kawai channel and Pacific Resources, Inc. is negotiating to avoid the channel.

4. Study the volume of tug-barge and recreational boat traffic in the Kalohi, Paitolu, and Auau Channels and promoting public education programs on boating safety for recreational boaters; explore possibility for licensing all recreational boaters

   It is suggested that all recreational boats be equipped with a radar detection dish so that commercial boats with radar can identify recreational boats in the near vicinity.

5. Require rigorous loss control procedures as part of the facility contingency plans for all public and private onshore facilities that handle oil and oil products

   33 CFR Part 156 provides regulations to prevent loss during transfer. Facility response plans are required to be submitted by February 18, 1993; this area will be addressed in these plans.
6. Ensure that oil spill risk is a significant consideration in the selection of fossil fuel products under the state's integrated energy planning activities

7. Give equal weight to economic and ecological sensitivities of a coastal site in establishing cleanup response priorities

References


CHAPTER 2

ECONOMIC IMPACTS OF A CATASTROPHIC OIL SPILL: CLEANUP COSTS AND DAMAGES

Jack R. Davidson
Cristina A. Olive
Scope of this Chapter

Hawaii is vulnerable to at-sea oil spills because of its annual import of nearly three billion gallons of oil and oil products and the fact that this oil is transported to and between the islands solely by sea. Current oil spill response capability in-state can effectively handle the cleanup of up to 100,000 gallons under most conditions. This cleanup capacity is provided jointly by The Clean Islands Council, the state’s industry-supported oil spill response cooperative, and the independent oil spill response contractors. The Marine Spill Response Corporation, a national oil industry cooperative, has announced that it will expand Hawaii’s response capability by 250,000 barrels in mid-1993.

Over a nine-year period between 1983 and 1991, 40 percent of the oil spills in Hawaii were <1,000 gallons/spill (see Chapter 6 for a more detailed discussion). About 10 percent of the spills that occurred during this period were large spills, ranging between 5,000 and 120,000 gallons. Based on these data and the fact that there has been no lasting adverse economic impacts from past oil spills, including a 1987 spill of 120,000 gallons, the focus of this chapter is on the cost of responding to the very large or catastrophic oil spills described in the U.S. Coast Guard’s worst case scenario. The same scenario was used in analyzing the effect of oil spills on the state’s tourism industry in Chapter 3.

Introduction

In March of 1989, the catastrophic Exxon Valdez oil spill in Prince William Sound, Alaska demonstrated that oil spills can produce tremendous negative impacts on natural resources and on the economy. It impacted thousands of people and cost billions of dollars. Several other catastrophic oil spills preceded the Exxon Valdez spill. Table 2.1 shows the estimated cost of some of these spills. These costs, however, are difficult to compare directly. As a result of court decisions, what can be claimed as legitimate injury to resources and persons from oil spills has changed dramatically over the two decade span covered by the spill incidents. Methods of analyzing and calculating the damage (cost) resulting from the various types of injury have also changed. Today costs incurred from spills may include some if not all of the following: at-sea response expenses, shoreline and other property cleanup costs, oil and oily waste disposal expenses, value of the loss of vessel(s) and cargoes, economic damages to natural resources, loss of use value of affected resources, reduced tourism income, impacts on the state’s economy, disruption of the lives of people, litigation and damage recovery costs, and research expenses.

<table>
<thead>
<tr>
<th>Vessel</th>
<th>Location</th>
<th>Year</th>
<th>Amount spilled (million gal)</th>
<th>Estimated costs ($million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exxon Valdez</td>
<td>Alaska</td>
<td>1989</td>
<td>10.0</td>
<td>3,000.0</td>
</tr>
<tr>
<td>Amoco Cadiz</td>
<td>France</td>
<td>1978</td>
<td>68.0</td>
<td>195-284.0</td>
</tr>
<tr>
<td>Argo Merchant</td>
<td>Massachusetts</td>
<td>1976</td>
<td>7.5</td>
<td>5.2</td>
</tr>
<tr>
<td>Chesapeake Bay</td>
<td>Virginia</td>
<td>1976</td>
<td>0.3</td>
<td>1.3</td>
</tr>
<tr>
<td>Zoe Colocotroni</td>
<td>Puerto Rico</td>
<td>1973</td>
<td>2.1</td>
<td>14.7</td>
</tr>
<tr>
<td>Santa Barbara Channel</td>
<td>California</td>
<td>1969</td>
<td>3.3</td>
<td>12.5</td>
</tr>
</tbody>
</table>

a/ cleanup costs alone costs $2B; b/ 1978 $; c/ 1976 $; d/ 1973 $; e/ 1969 $  
Data Sources: U.S. GAO (1977); Assaf et al. (1986); Grigalunas, et al. (1986); Temple Barker and Sloane, Inc. (1991).

A study by Moller et al. (1987) estimated the per barrel cost of responding and cleaning up a spill to range between $313 and $768 (in 1985 dollars) per barrel. Costs, estimated by region, were lowest in the Far East
and highest in North America. The study also highlighted the incident-specificity of oil spills costs. Costs vary greatly between oil spill cases depending on the type of oil, spill size, shoreline characteristics, and extent of contamination. As such, total costs cannot be computed by using standardized unit (e.g., per gallon) costs.

The economic study to determine the costs of a catastrophic oil spill in Hawaiian waters was based on the following summary of a catastrophic oil spill scenario developed by the U.S. Coast Guard for their Oil Spill Contingency Plan (U.S. Coast Guard, 1989):

A fully loaded tanker with 29,400,000 gallons (average tanker size) of crude oil, collides with a container ship in the Kauai Channel at 0330 hours, November 30, during a Kona squall. The collision is seven miles southeast of Makapuu Point at the center of the channel. On collision, the tanker loses one-third of its cargo or 9,800,000 gallons. From this point, it could lose from zero to 19,600,000 gallons depending on specific circumstances. The weather is cloudy with rain showers, the seas from the south with 6-7 foot swells. The weather is not expected to change for several days.

Some of the heavy oil will immediately begin to sink, making tracking difficult and booming on only about 30 percent effective. Also, booms will not be available for some time and heavy seas will hinder operations. The currents are expected to flow northwesterly but to be influenced by many variables like tides, wind speed and direction, etc...

The movement of the oil will be towards Oahu with the slick impacting Makapuu Point in eight hours. The current moving the subsurface oil could impact the area in four hours. The vast size of the slick would eventually blanket both windward and leeward shores and could reach the west coast if the oil is trapped in near-shore tidal currents and eddies.

Once the slick passes Oahu, it would impact Kauai in four days and Niihau in five days. Some tarballs could move to the Northwestern Hawaiian Islands (NWHI). It is estimated that response and cleanup could take 10-16 months.

The U.S. Coast Guard has stressed that although this is not the most likely large spill scenario, it is a possible worst case scenario that would maximize the impact on Oahu where 80 percent of the state’s population resides and where tourism activities and facilities are concentrated. In addition, a trajectory analysis on the path of the oil spill was run for the worst case scenario by the NOAA office in Seattle, Washington. Their analysis is summarized as follows:

Winds from the south combined with currents to the southwest would result in heavy beach impacts between Makapuu Point and Koko Head within 12 hours after the initial spill. With southerly winds continuing for the next 48 to 72 hours, we would expect oil to enter Muanalua Bay on the south side of Oahu, and a slick extending north off Makapuu Point, on the north side of Oahu.

Due to the large amount of oil spilled, beach impacts along the shorelines of Oahu may continue for several weeks due to refloating oil and varying wind conditions. The times and locations of the impacts would depend on the wind conditions. Under trade wind conditions, oil would impact the north shore between Makapuu Point and Kahuku Point with the heaviest impacts between Makapuu Point and Makapuu Point (Kaneohe Marine Corp Air Station). Oil along the south shore would move west towards Barber’s Point and eventually toward Kaena Point under trade wind conditions. The trade winds would keep most if not all of the oil off the southern shore of Oahu. However, any south wind episode may result in heavy beach impacts between Koko Head and Kaena Point.

The worst case scenario would have the entire island of Oahu impacted over a span of several weeks as oil refloated and wind conditions changed between trade winds and Kona winds. Kauai would be impacted within one and a half to two weeks of the spill depending on the winds. We would not expect any of the crude oil to sink unless tar mats or tarballs picked up sand along the beach. We would not expect much penetration of oil into the sand. Past spills on sandy beaches have shown that even if the oil is fresh and the sand is coarse, penetration is limited to about 0.50 inch unless waves work the oil deeper. Penetration in cobble or coral rock beaches may be several inches.
The major costs that may be incurred from a large oil spill can be broadly classified as follows:

**Cost of Cleanup**

Cost of at-sea response and containment includes the cost of responding to the oil spill at sea, by booming, skimming, lightering, and with salvage operations, and chemical treatment.

Cost of shoreline cleanup includes the cost of cleaning up the shoreline, beaches, marshlands, and rocky shores. It also includes the cost of cleaning up boats and other sea vessels, harbors and marinas, and oiled marine animals, such as seabirds and marine mammals.

Cost of oil and oily waste disposal includes the disposal cost of large quantities of oil and oily debris. The oil referred to here is the oil recovered from the skimming operations as well as the more viscous oil-water emulsion (mousse). Oily debris includes disposable sorbents and booms used in the cleanup operations, as well as other materials contaminated by oil like sand, marine debris, or even beach and shoreline structures that could accumulate oil and gradually release it into the environment over time.

Depending on the type of waste and disposal system used, disposal costs can vary. For instance, oil recovered from the skimming operations may be recycled in an oil refinery, but there is a cost associated with doing this. In Hawaii, where there is an H-power plant, some oily wastes may be disposed of by burning. Wastes may also be stored in drums and shipped to the mainland or other appropriate disposal sites. Wastes may also be disposed of in designated landfills, or could be “farmed”, i.e. plowed into the soil until bacteria degrade the oil materials.

Each of these methods not only involves different costs, but also different environmental effects. Disposal decisions necessarily involve trade-offs between environmental considerations, costs, and expediency. To date, Hawaii has no specific state provision or regulation on disposal methods for oil and oily wastes of the magnitude that may be generated by a catastrophic spill.

Cost of government response includes the cost of federal, state, and local agencies response to oil spills including personnel, equipment, and other related costs. In addition, there are non-market costs involved. For instance, when personnel are disrupted from normal duties to respond to an oil spill or when government vehicles and equipment are used, opportunity costs are involved.

**Cost of the Vessel(s) and Spilled Oil**

Costs of an oil spill at-sea include the loss of cargo, cost of repairs, and opportunity costs of lost use of the vessel and crew. If the vessel is incapacitated, it may be necessary to tow it farther offshore to avoid or lessen the impact of the oil spill on the islands, adding more costs. Alternatively, it may sink at or near the location of the spill or after being towed to sea. Depending on the decision made regarding the fate of the vessel, the cost will vary. One of the options that could be considered is to repair the vessel for later use or to salvage it for scrap. In this cost analysis, the assumption made was that the ship will be totally lost by towing it offshore. Therefore, the costs referred to include the value of the vessel and lost cargo.

**Damages to Resources**

Cost of natural resource damages includes the costs of dead animals, decline in fisheries populations, removal and replacement of oil contaminated sand, and loss of mangroves, corals, and other marine and coastal resources.

These costs are generally difficult to estimate because they are resources that are not commonly sold in the market. For instance, endangered animals do not have a market price and thus their costs may be derived as the value that society puts on them. Because replacing these animals is next to impossible, a surrogate price may not be used. There are, however, certain economic techniques that can be used to estimate these values.

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1A surrogate price is the price of a similar or substitute resource that can be used in place of the resource whose price is not known.
but they require extensive surveys and data analysis. An example is the use of a contingent valuation technique wherein the value of the resource is estimated by asking individuals the value they attach to a resource.

For resources like sand, it may be easier to estimate values by using market prices. Sand is a traded good and thus has a market price. However, to the extent that the quality of the replaced sand is not as good as the removed, there exists an incongruity in prices. The quality of sand on some beaches in Hawaii is unique and it is doubtful whether a comparable replacement can be obtained.

Damage to fisheries has a biological basis. Total cost of damages to fisheries in this report is based on population decline due to mortality or loss in recruitment and the market price and does not include losses in income from the inability of fishermen to catch fish. The latter is addressed separately as damages to ocean industries.

Damages to (private) coastal properties may be large if the damage is irreparable. Because oil spills taint coastal areas, they have the potential to reduce the value of beachfront properties. If the property can be recovered, cleaned, or restored, replacement or restoration costs, together with the loss from impaired value of the property, can be used as the total cost associated with the spill. Real estate values may or may not decline over time if the damage is recoverable and/or is temporary.

**Damages to Businesses and Other Commercial Activities**

**Losses in tourism revenues resulting from the decline in tourist arrivals** could be both short-term and long-term. Millions of tourists visit Hawaii annually. Their expenditures account for about one-third of the state's income according to the 1991 State Data book. A catastrophic oil spill would foul beaches and shorelines and result in their closure. Losses would occur as tourists cut vacations short and consider other vacation sites for future travel. The success of cleanup efforts and restoration of natural resources and the transmittal of this information globally would be key to restoring the image of Hawaii as a "quality destination."

**Losses in revenues from tourist-related businesses and ocean Industries (commercial and recreational)** include losses incurred by industries relying on offshore and nearshore resources directly affected by the spill, for instance, recreational and commercial fishermen who forego their utility or income, respectively, derived from fishing activities. We may be able to measure the impact on commercial fisheries as the loss in income of individuals who use these resources, but as a result of the spill, cannot have access to the resource. Thus, a fisherman who is not able to harvest his usual catch because of the spill, is foregoing that income or utility. These losses may be partially offset if fishing boats and crew are hired to participate in the cleanup process. Recreational fishermen, on the other hand, will incur losses in utility by not being able to go fishing. Such utility loss can be translated to economic losses.

Other activities that may be adversely affected are dinner cruises, sailing, and ocean charter businesses. There are also ocean activities that take place year-round in the islands, like triathlons, surfing events, etc., which may be affected by the spill.

**Advertising or marketing costs for tourism sector** would be incurred to counteract wide media coverage on the spill. Because Hawaii is a tourism-led economy, the impact of oil spills reaches far beyond the physical damage to resources. It is anticipated that news coverage of an oil spill in the national and international media will have a large and immediate adverse impact on the number of visitor arrivals. Once cleanup and restoration are accomplished, a parallel media and advertising campaign will be needed to restore the "Hawaii image" as a destination site. This would mean larger than usual advertising and promotional budgets for state agencies, tourist facilities, and transportation companies.

**Losses due to disruption or curtailment of seaport activities** include losses in income to the Harbors Division, to the owners of vessels including cruise ships and recreational boats, to wholesalers and retailers
distributing goods passing through the port, and the losses experienced by the firms and individual users of the goods. In addition, when the delay in the berthing of vessels causes a decline in the stock of food and other commodities, speculative inflationary effects can be generated.

Costs and Damage Assessments Associated with the Worst case Catastrophic Oil Spill: Results and Discussion

Estimated costs associated with at-sea and on-shore cleanup, cost of the vessel and spilled oil, and partial damage to natural resources are shown in this chapter. Estimated losses to the tourism industry and to the ocean recreation industry are provided in Chapter 3. Marine animal cleanup, damage to private coastal properties, port closure impacts, and the socioeconomic impacts on the lives of Hawaii's people are not estimated in this report.

Cost of Cleanup for the Worst case Oil Spill

Methodology. Historical spill data can provide insights into response requirements and cleanup costs if conditions are similar. However, few spills have occurred in areas where conditions approximate those in Hawaii. Nevertheless, the type of response strategy and the requirements for shoreline cleanup and response at sea can be obtained from individuals who are knowledgeable in the area of response, cleanup, and waste disposal. On this basis, a panel of experts was assembled from the U.S. Coast Guard and the oil industry to determine the costs likely to occur when cleaning up an oil spill of the magnitude described in the U.S. Coast Guard's worst case scenario. The approach was to reach a consensus among the experts on response strategy, cleanup techniques, length of cleanup, expected personnel, equipment requirements, and prices. The varied experience and background of panel members required several rounds of "brainstorming" to converge on a single or narrow range of estimates. The cost estimates are specific to the physical impacts and response strategies assumed in this analysis — that of the worst case catastrophic oil spill.

The following costs and cost analysis assumes only 10 million gallons of the 29-million gallon cargo will be released. If more oil escapes, there would be a significant increase in the cost of collecting and disposing of oil and oily waste materials, as well as for cleaning up the shorelines. However, it is not expected that costs would increase proportionately.

Cost of At-Sea Response and Containment

Response Strategy. The expert panel visualized the main body of floating oil would strike the east shore of Oahu as a single wave assault and then proceed to spread around the south, north, and west shores. A significant portion of oil would bypass the island and be carried westward toward Kauai and the NWHI. Because of the location (seven miles offshore) and timing (at night) of the spill, there would be little effective response at sea before the main wave of oil impacted the east shore. However, depending upon availability of personnel and equipment and the rate at which they could be mobilized, there would be a wide range of opportunity and demand for response at sea in the first few days following the spill. It is assumed that the period for effective at-sea response would be limited to the first two weeks after the spill occurs.

Hawaii's contingency plan calls for the use of booms and skimmers to contain and retrieve oil from the sea waters. An inventory of available equipment and supplies is provided in Appendix C. A Memorandum of Understanding exists among the Hawaii State Department of Health, the EPA, and U.S. Coast Guard to allow the use of chemical dispersants to break up oil at sea. Use of dispersants is confined to waters more than 60 feet in depth and where shoreline resources would not be impacted.

If the damaged vessel becomes incapacitated, it may be towed out to sea and abandoned in offshore waters or salvaged for repair or for scrap. In addition, lightering operations will be needed to unload the remaining

21
oil, if conditions allow. For this study, the assumption is that lightering will be done and the vessel is lost at sea. Given this response scenario, the following assumptions were used to estimate at-sea response costs. A summary of these costs are shown in Table 2.2.2

<table>
<thead>
<tr>
<th>Operation</th>
<th>Amount, $000</th>
<th>Distribution, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skimming</td>
<td>3,273</td>
<td>15</td>
</tr>
<tr>
<td>Booming</td>
<td>13,980</td>
<td>65</td>
</tr>
<tr>
<td>Dispersant application</td>
<td>1,408</td>
<td>7</td>
</tr>
<tr>
<td>Lightering</td>
<td>658</td>
<td>3</td>
</tr>
<tr>
<td>Salvage and underwater survey</td>
<td>236</td>
<td>1</td>
</tr>
<tr>
<td>Helicopter overflights</td>
<td>589</td>
<td>3</td>
</tr>
<tr>
<td>Logistics and others</td>
<td>1,497</td>
<td>7</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>21,641</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Cost of at-sea response operations, estimated at $21.6 million includes offshore skimming of oil, booming, dispersant application, lightering, salvage and underwater survey, and helicopter overflights. Offshore skimming costs, which comprise 15 percent of the total at-sea response costs, includes the cost of skimming vessels or skimming systems, workboats, crew, and barges and tankships to hold the skinned oil. Intensive skimming operations are expected to last for a week. Booming, which is 65 percent of total at-sea response cost, will be the major cost component in the response process. This is because the cost of booms alone is 60 percent of the total at-sea response cost. In addition to the cost of booms, booming costs include hiring fishing boats and crew to deploy, tend, and clean the booms. About 50 percent of the offshore booms that are used require cleaning.

Dispersant application, about $1.4 million or 7 percent of the total at-sea response cost, includes the cost of dispersants flown in from various storage sites on the mainland and the cost of specially equipped airplanes to apply the chemicals. It is assumed that use of dispersants is in compliance with state and federal regulations stipulated in the pre-agreement. Because the effectiveness of dispersants decreases rapidly, they should be applied as soon as possible. The efficacy of dispersants is within the first 72 hours. In a best case scenario, it will take at least 19 hours to get a plane capable of applying dispersants to Hawaii. The following time schedule is required to hire a plane from Sacramento to Hawaii:

- 5 hours preparation time for the plane
- 2 hours to fly to Mesa, Arizona to pick up equipment
- 1 hour to load equipment
- 10 hours to fly from Mesa to Honolulu
- 1 hour to load dispersants on board
- 19 hours TOTAL.

There is a further loss of at least eight hours of downtime for the crew before application can begin unless a second set of crew is available.

2Details of these cost estimates can be found in the supplemental report Cost of at-sea response, shoreline clean-up and waste disposal for a catastrophic oil spill in Hawaii: assumptions and cost worksheets by J.R. Davidson, and C.A. Olive. Copies are available from the UH Sea Grant Communications Office, 1000 Pope Road, MSB Room 200, Honolulu, HI 96822.

3Presentation during the “Emerging Oil Spill Response Options Workshop”, Honolulu, HI, November 13, 1991.
Lightering operations, costing up to $660,000, include the rental costs of barges, tugs, and pumps. Lightering is necessary to rid the vessel of oil and to minimize further leakage. In addition to the lightering operations, it may be necessary to salvage and tow the tanker to deeper waters, particularly if there is any danger of sinking. Salvage operations involve the use of tugs and salvage boats. Underwater hull surveys will also be performed in order to determine the extent of damage to the vessel. The partial cost estimate of underwater hull surveys and salvage operations is $240,000.

Other costs include helicopter overflights to determine the size and direction of slick movements and time required for government officials and staff to monitor the extent of the damage and to gather information necessary for decisionmaking. These overflights are estimated to be $590,000 or 3 percent of total at-sea response costs. Logistics costs include the chartering of boats and planes to transport crew, equipment, and supplies from shore to the cleanup site and from the mainland, the rent of command posts and staging areas, and rental of other miscellaneous equipment. These costs can reach $1.5 million.

**Shoreline and Associated Resource Cleanup Costs**

Onshore cleanup is far more costly than the at-sea response in most oil spills (Moller, et al., 1987). Because cleanup costs are highly variable depending on various factors such as location of the spill, amount and type of oil spilled, weather conditions, type of coastlines and other similar factors, it was not deemed appropriate to use per unit cost estimates from other oil spills. It can be expected that the cost of response equipment and manpower would be higher in Hawaii due to additional transportation and freight costs. This section will be divided into 4 subsections: 1) cost of shoreline cleanup, 2) cost of boat cleanup, 3) cost of harbor cleanup, and 4) cost of marine animal cleanup.

**Shoreline Cleanup Costs**

**Cleanup technique.** It is assumed that due to the high value and shoreline diversity of Hawaii's beaches, manual cleanup using rakes, shovels, and sorbents will be employed to minimize the physical, biological, and environmental damage.

Oil-contaminated shores will be cleaned with sorbents and the oil recovered with vacuum trucks. Tar mats and tarballs will be manually collected and packaged in plastic bags for disposal. Any oil-coated shoreline debris would be removed and disposed. Shoreline structures like pilings and seawalls will be cleaned or, when necessary, removed to prevent leaching or recurring contamination of the surrounding areas.

Oil-coated sand will be removed from the beach and replaced with new material. It is assumed that the contamination will be an average of 10 feet wide and two inches deep on the beach areas. Under the worst case scenario, all of the 265,584 feet (50.2 miles) of beaches in Oahu will be contaminated to some degree with oil.

**Length of cleanup.** The estimated length of time for intensive cleanup of shorelines and beaches, in particular, would be two months -- the first month at full scale 12-hour shifts and the second month at half-scale. In addition, a less intensive cleanup effort is expected to continue for up to a year, including responding to occasional beach re-oiling and discovery of small pockets or buried deposits of oil. All major beaches would be open by the end of the second month.

**Extent of contamination.** It is assumed, based on the NOAA trajectory, that all of Oahu’s shorelines will be blanketed with oil. In addition, Kauai will also be impacted and would therefore require simultaneous response with Oahu. The Northwestern Hawaiian Islands are also expected to be impacted by tarballs.
Table 2.3. Summary of shoreline cleanup costs

<table>
<thead>
<tr>
<th>Input</th>
<th>Amount, $</th>
<th>Distribution, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor</td>
<td>45,488,250</td>
<td>87</td>
</tr>
<tr>
<td>Materials and equipment</td>
<td>5,805,585</td>
<td>11</td>
</tr>
<tr>
<td>Transportation</td>
<td>955,350</td>
<td>2</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>52,249,185</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

A major cost component in shoreline cleanup is labor which amounts to $45.5 million or 87 percent of shoreline cleanup costs. Labor costs include wages and allowances paid to laborers and supervisors. About 50 percent of the laborers already trained or experienced in cleanup work would be flown in from the mainland. Workers from the mainland may be hired through a contractor like VECO, which responded during the Exxon Valdez spill in Alaska, or Burlington Environmental of California. The other half of the laborers, hired locally, would require the minimum training. Possible sources of laborers in the islands are hotel workers, construction, and landscape firms. Volunteers are generally not allowed to work on shoreline cleanup because they are not covered by liability insurance and there could be problems regarding contamination of the waste collected.

Most volunteers are expected to be assigned to less hazardous operations like cleanup of birds.

Materials and equipment constitute about 11 percent of the total shoreline cleanup costs. Cost items in this category include sorbents, vacuum truck rentals, communication equipment, hand-held cleanup equipment, and disposable protective clothing. Transportation costs include plane fare for workers coming from the mainland as well as bus and car rentals. Transportation expenses are expected to cost roughly $1,000,000.

**Boat Cleanup Costs**

Boats that are moored or out at sea during the spill will likely be contaminated with oil. Boat cleanup costs range from $50 to $150 per boat based on the estimate by Motter, et al. (1987) corrected for inflation and Hawaii's prices. If it is assumed that the the number of boats contaminated is equal to the 3,079 wet moorings in Oahu and Kauai, boat cleanup costs would range from $225,800 to $677,000.

**Port Cleanup Costs**

Although ports are one of the top priorities for first response, there is no guarantee that they will not be contaminated by oil. If oil enters ports, intensive cleanup operations have to be performed expeditiously to enable ocean-going vessels to load and unload cargoes. In November 1991, when the YUPEX spilled 10,000 to 20,000 gallons of diesel fuel oil in Honolulu Harbor, Pacific Environmental Corporation (PENCO), the cleanup contractor, recovered 5,000 gallons with skimmers and sorbents at a cost of $60,000.

Cleanup costs depend on the size of the spill and the type of oil. The type of oil dictates the cleanup method, e.g., port structures (pillsars, etc.) contaminated with heavier oils could be difficult to clean.

Honolulu Harbor has about 28,0017 linear feet of piers. In addition, there are piers at Barber's Point and several small boat harbors. If all of these are contaminated, they could produce a large cleanup cost.

**Bird and Marine Animal Cleanup Costs**

Birds and marine animals are susceptible to oiling. Once oiled, it may be necessary to clean them to reduce...
risk of mortality. Because Hawaii has a significant number of threatened and endangered seabirds and marine animals, it is probable that intensive efforts to rescue and treat these animals can be expected. Diving seabirds are particularly vulnerable because of their feeding habits (see Chapter 4). Once their plumage is oiled, seabirds are susceptible to hypothermia and loss of buoyancy. Unless they are cleaned, oiled birds will perish. It is suspected that seabird mortality is underreported in wildlife damage reports.

Bird rescue and cleanup vary significantly depending on the method of rescue operations. Although the actual cleanup (washing and drying) could be fairly uniform, special animal handling procedures may cause drastic cost changes. For example, in the Tenyo Maru oil spill off Washington, rescue operations cost $200,000-225,000. About 125 birds were rescued, of which only one out of seven (about 18 total) survived. This rescue operation translates to $12,000 per survivor.

Oiled birds are cleaned and treated in bird facilities or in makeshift bird rescue centers. These cleanup operations entail varying costs. As a minimum estimate, however, labor and some material costs can be computed. This is assuming that no extraordinary rescue operations or special handling procedures are needed.

Table 2.4 shows the cost estimate to clean up a bird, based only on labor, detergent, drying area, and heat lamps. Valuation was limited to those factors for which monetary values could be readily determined. Other inputs, such as electricity, water, medicine, and wash tanks were not considered in the cost estimate. Cost estimates were based on personal interviews with experienced local persons. Experts from the International Bird Rescue Research Center in California and Sea Life Park in Hawaii were also consulted but could provide no applicable cost estimates. Since most oil spills are unanticipated events with high public visibility, especially with respect to wildlife impacts, little attention is paid to keeping accurate records of the breakdown of bird cleanup costs.

<table>
<thead>
<tr>
<th>Input</th>
<th>Quantity</th>
<th>Unit</th>
<th>Cost/unit, $</th>
<th>Total, $</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor a/</td>
<td>1.00</td>
<td>manhour</td>
<td>6.00</td>
<td>6.00</td>
</tr>
<tr>
<td>Detergent b/</td>
<td>0.10</td>
<td>bottle</td>
<td>2.00</td>
<td>0.20</td>
</tr>
<tr>
<td>Drying area rental c/</td>
<td>2.00</td>
<td>sq. ft.</td>
<td>0.70</td>
<td>0.14</td>
</tr>
<tr>
<td>Heat Lamps d/</td>
<td>0.17</td>
<td>pieces</td>
<td>9.00</td>
<td>0.15</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td>6.49</td>
<td></td>
</tr>
</tbody>
</table>

a/ a persons per bird for 0.5 hours; b/ based on 10 birds per bottle; c/ warehouse type drying area at $0.70/sq. ft./month; each bird occupying two sq. ft. for three days; d/ 10 lamps/120 sq. ft., three days per bird.

Given the minimum cleanup cost, assuming that at least 10 percent of the 247,000 breeding pairs (Harrison, 1990) of seabirds in Oahu and Kauai are oiled and rescued, cleanup cost (washing and drying) could amount to $320,000. If it is assumed that 25 percent of these breeding pairs will have to be cleaned, the cost could go up to $800,000. In addition, if the oil reaches the NWHI, where 95 percent of the total population of seabirds in the state nests, the cost could be higher.

Oiled marine animals also pose large cleanup costs. There is no estimate on the cost of cleanup but they are expected to be significant. Endangered and protected species, would require special rescue and handling operations.

Oil and Oily Waste Disposal Costs

The disposal of oil and oily wastes resulting from the U.S. Coast Guard scenario would be a disaster-level problem for the state because there are no pre-designated disposal methods or sites. Because of special
handling procedures and stringent environmental regulations concerning contaminated oil, costs alone will not determine the method and site of waste disposal. Unfortunately, disposal decisions could involve trade-offs among costs, environmental considerations, and expediency.

**Type of debris collected.** There are different types of wastes collected from a catastrophic spill: 1) oil and water emulsion (mousse) from skimming operations and shoreline cleanup, 2) cleanup materials like booms, sorbents, disposable protective clothing, 3) oil contaminated debris like trash, shoreline vegetation, seaweeds, and 4) oil contaminated sand and rocks.

**Amount of debris.** The volume of oil and oily waste collected from a 10-million gallon spill is based on the following assumptions (the volumes of debris collected from the spill are shown in Table 2.5):

1. Oil-water emulsion — 10–15 percent skimming rate; mousse is 29 percent oil and 71 percent water (Expert panel, Hann, 1979).
2. Oil on beaches — 33–40 percent of total spill; mousse is 29 percent oil and 71 percent water (Expert panel, Hann 1979).
3. Booms — 50 percent of the offshore booms are disposed (the remaining 50 percent will be cleaned), and 100 percent of the harbor booms will be damaged and disposed. A foot of boom, without the metal links, weighs 2 pounds (offshore booms) or 1 pound (harbor booms).
4. Oily wastes collected from the shoreline — based on the Exxon Valdez spill. The total volume of debris collected in that spill was 30,687 tons for 25.57 tons per mile of contaminated shoreline (OSIR, August 1, 1991). Oahu’s general coastline is 112 statute miles.
5. Sorbents — it is estimated that about 6,000 pounds of oil were absorbed by a container of sorbents. Twenty containers will be used, each weighing 12,000 pounds.
6. Sand — based on two-inch depth of oil penetration, an average width of 10 feet (Expert Panel), and total beach length of 50.3 miles (265,584 feet).

<table>
<thead>
<tr>
<th>Type of Debris</th>
<th>Amount</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mousse from skimmers</td>
<td>3.4-5.2</td>
<td>gallons (millions)</td>
</tr>
<tr>
<td>Mousse from beaches</td>
<td>11.4-13.8</td>
<td>gallons (millions)</td>
</tr>
<tr>
<td>Booms</td>
<td>130</td>
<td>tons</td>
</tr>
<tr>
<td>Oil-saturated sorbents</td>
<td>160</td>
<td>tons</td>
</tr>
<tr>
<td>Oil-contaminated sand</td>
<td>22.900</td>
<td>tons</td>
</tr>
</tbody>
</table>

**Disposal methods.** The state has not specifically identified the waste disposal methods to be employed in case of a catastrophic oil spill. As such, this study estimates disposal costs based on likely alternatives for disposal.

The mousse derived from the skimming operations may be kept in temporary holding facilities or vessels, and recycled on Oahu. However, there are limitations, e.g., recycling requires separable oil-water mixture, and consisting of at least 30 percent oil. Another limitation is the low volume capacity of the recycling firms on Oahu like UNITEK or Oil Re-refining Co. (ORCO) which imposes larger storage capacities and longer processing time — possibly increasing costs.

If on-island recycling is not possible, another option for disposing the mousse is to ship it to the mainland to be disposed by deep-well injection (Texas may be a possible site), or if the oil content is 85–90 percent, the oil separated from the mousse may be used for cement kilns. To do the latter, the mousse should produce at least 5,000 BTU per pound. Other possible off-island disposal methods include incineration, recycling, landfilling, land cultivation, asphalt batching, and bioremediation.
The disposal options for liquid oil recovered from the shoreline are similar to the options for mousse recovered from the skimming operations. Solidified oil like tarballs and tarmats may be disposed like oily trash.

Oil-contaminated booms, sorbents, and trash may be disposed at the H-power plant or the Waipahu incinerator. There appears to be no technical constraints for disposing the sorbents and the trash in either facility. Booms need to be pre-cut and ropes must be removed for disposal at the H-power plant to avoid mechanical problems.

Another way of disposing debris is to ship it to the mainland either as "dry" or "wet" waste. Dry waste requires physical, chemical, or biological waste treatment procedures, like squeezing out the oil by running the waste in a centrifuge, then solidifying and stabilizing the residue. On the other hand, wet waste means transporting it as is and the receiving facility will treat and dispose of the waste. The transportation cost of wet wastes is higher than dry wastes because of the different handling techniques used, e.g., containers used. Disposal fees also differ.

Sand cannot be disposed at the H-power plant nor can it be landfilled locally. It would have to be shipped to the mainland for disposal. The method of treatment and disposal would be similar to that of oil contaminated waste (explained above). A summary of oil and oily waste disposal costs is shown in Table 2.6.

<table>
<thead>
<tr>
<th>Table 2.6. Summary of oil and oily waste disposal costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Disposal fees</td>
</tr>
<tr>
<td>Oil-water from skimming</td>
</tr>
<tr>
<td>Oil-water from beaches</td>
</tr>
<tr>
<td>Sorbents/trash</td>
</tr>
<tr>
<td>Booms</td>
</tr>
<tr>
<td>Sand</td>
</tr>
<tr>
<td>Other costs</td>
</tr>
<tr>
<td>TOTAL</td>
</tr>
</tbody>
</table>

Oil and oily waste disposal costs can range from $48 million to $123 million depending on the disposal method used. The least costly disposal method of oil-coated debris will be to take it to the H-power plant, if technically and legally feasible. Otherwise, there is no in-state waste disposal facility that can handle this type and volume of debris, except on the mainland. Shipping the wastes to the mainland drastically increases costs. Disposal of mousse from sea and shoreline and sand accounts for almost all of the disposal costs (94-99 percent). Oil-coated debris like booms, sorbents, and trash account for the rest of the disposal costs.

The investigation of cleanup operations for a 10-million gallon oil spill exposed a serious bottleneck for managing large volumes of recovered oil, debris, and other materials. Transportation, storage, and solid waste disposal facilities in the state lack the capacity to handle the volume of oils and oily waste resulting from a major oil spill. Existing contingency plans focus exclusively on at-sea response and shoreline cleanup strategies without planning for the disposal of waste from cleanup operations. A supplemental report, details disposal problems and explores various options that address the proper disposal of oil and oily materials recovered from a catastrophic spill in Hawaii.5

5 Details of disposal problems can be found in the supplemental report Disposal of recovered crude oil and debris from a catastrophic spill in Hawaii: regulations, existing capacity, options and issues by J.R. Davidson, M.C. Garcia, and C.A. Olive. Copies are available from the UH Sea Grant Communications Office, 1900 Pope Road, MSB Room 200, Honolulu, HI 96822.
Cost of Government Response

When federal, state, and local government agencies respond to an oil spill, costs over and above their usual expenditures as well as costs associated with the disruption of normal agency functions are incurred. It is difficult to measure the extent of government agency expenditures in Hawaii, but it is expected to be very high. In order to estimate the magnitude of this cost, the number of employees and equipment that will be detailed for the spill response have to be known, as well as their wages or rental rates.

The U.S. Coast Guard is expected to be the major government responder to the spiller. The following government agencies are also expected to be at the forefront:

Federal Agencies
U.S. Coast Guard
Department of Defense (DOD)
National Marine Fisheries Service (NMFS)
National Oceanic and Atmospheric Administration (NOAA)
Environmental Protection Agency (EPA)

State Agencies
State Department of Health
State Civil Defense
Department of Land and Natural Resources

Information provided by the U.S. Coast Guard National Pollution Fund Center on the cost incurred by the federal government in responding to selected spills is tabulated in Table 2.7.

<table>
<thead>
<tr>
<th>Vessel</th>
<th>Date</th>
<th>Location</th>
<th>Response Expenses, $M</th>
</tr>
</thead>
<tbody>
<tr>
<td>M/V Exxon Valdez a/</td>
<td>March 24, 1989</td>
<td>Prince William Sound, AK</td>
<td>118.2</td>
</tr>
<tr>
<td>T/V American Trader</td>
<td>February 9, 1990</td>
<td>Huntington Beach, CA</td>
<td>1.2</td>
</tr>
<tr>
<td>T/V Megaborg</td>
<td>June 6, 1990</td>
<td>Galveston, TX</td>
<td>3.3</td>
</tr>
<tr>
<td>T/B Vista Bella</td>
<td>March 21, 1991</td>
<td>U.S. Virgin Islands</td>
<td>2.4</td>
</tr>
<tr>
<td>M/V Tenyo Maru</td>
<td>July 22, 1991</td>
<td>Puget Sound, WA</td>
<td>5.8</td>
</tr>
</tbody>
</table>

a/ Costs as of November 22, 1991.

Data Source: U.S. Coast Guard National Pollution Fund Center

Experience has shown that oil spills can cost the federal government at least a million dollars. It is not clear, however, whether all costs have been charged and recovered or are recoverable from the liable party. Whether or not the costs are recoverable, these costs only represent the actual direct expenditures incurred by the federal agencies and do not account for the non-market or opportunity costs associated with the disruption of normal agency functions or the costs of diverting government resources into other uses.

Details of Federal Government Expenditures: The Exxon Valdez Case

As of November 22, 1991, the federal government expended $118.3 million for the Exxon Valdez spill. A detailed summary of federal agency costs, shown in Table 2.8, includes the distribution of costs among the agencies. The list is not complete and costs are expected to increase.
Table 2.8. Summary of federal agency cost on the Exxon Valdez

<table>
<thead>
<tr>
<th>Agency</th>
<th>Amount, $Million</th>
<th>Distribution, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S. Coast Guard</td>
<td>43.6</td>
<td>36.9</td>
</tr>
<tr>
<td>National Oceanic and Atmospheric Administration</td>
<td>5.8</td>
<td>4.9</td>
</tr>
<tr>
<td>Federal Aviation Authority</td>
<td>1.0</td>
<td>0.8</td>
</tr>
<tr>
<td>U.S. Fish and Wildlife Service</td>
<td>2.6</td>
<td>2.2</td>
</tr>
<tr>
<td>National Parks Service</td>
<td>3.2</td>
<td>2.7</td>
</tr>
<tr>
<td>Bureau of Land Management</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Environmental Protection Agency</td>
<td>no bill</td>
<td></td>
</tr>
<tr>
<td>Food and Drug Administration</td>
<td>no bill</td>
<td></td>
</tr>
<tr>
<td>U.S. Forestry Service</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Department of Defense</td>
<td>61.9</td>
<td>52.3</td>
</tr>
<tr>
<td>Interest</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>118.3</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

Data Source: U.S. Coast Guard (1991)

The Department of Defense and the U.S. Coast Guard have incurred 90 percent or $105.5 million of the federal government’s costs. The other agencies incurred the remaining 10 percent. If these costs could be recovered from Exxon, the actual cost incurred by federal agencies will be nil except for the opportunity costs (social costs) incurred in diverting government resources from their normal functions.

Comparison of Federal Government Costs

Other detailed examples of government costs include the Argo Merchant (1976) and the Chesapeake Bay (1976) spills. The U.S. GAO (1977) prepared a report showing details of the actual and estimated costs incurred by government and private entities who were involved in various aspects of spill response and cleanup. These cost estimates were compared with the Exxon Valdez case in terms of proportion spent by different government agencies. Table 2.9 shows a comparison of these distributions.

Table 2.9. Comparison of federal government costs for selected spills

<table>
<thead>
<tr>
<th>Agency</th>
<th>Argo Merchant</th>
<th>Chesapeake Bay</th>
<th>Exxon Valdez</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S. Coast Guard</td>
<td>70</td>
<td>96</td>
<td>37</td>
</tr>
<tr>
<td>Department of Defense</td>
<td>5</td>
<td>0</td>
<td>52</td>
</tr>
<tr>
<td>Other Federal Agencies</td>
<td>25</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
<td><strong>100</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Data Sources: U.S. GAO, 1977; U.S. Coast Guard, 1991
While the different spill events have different cost distributions, generally, the U.S. Coast Guard incurs most of the total cost. In the Exxon Valdez case, a large portion of the total cost was incurred by the Department of Defense (DOD) (including the Navy, Army and Air Force) — far more than that incurred by the U.S. Coast Guard. The expert panel attributes this difference, in part, to the extensive use of DOD resources like aircrafts and sea vessels in isolated and hard to reach areas of the spill. In addition, ships were used for berthing cleanup and response crews.

**Federal Government Cost for a Spill in Hawaii**

In spite of the fact that government costs can vary over different spill incidences, we have attempted to estimate the costs that the federal government could incur for a catastrophic spill in Hawaii. This was done by presenting the cost schedule of the Exxon Valdez (Table 2.8) to the expert panel and soliciting their estimates of the federal government’s costs. Estimates are shown in Table 2.10.

<table>
<thead>
<tr>
<th>Agency</th>
<th>Amount, $Million</th>
<th>Distribution, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S. Coast Guard</td>
<td>30.9</td>
<td>61.8</td>
</tr>
<tr>
<td>National Oceanic and Atmospheric Association</td>
<td>4.1</td>
<td>8.2</td>
</tr>
<tr>
<td>Federal Aviation Authority</td>
<td>0.7</td>
<td>1.4</td>
</tr>
<tr>
<td>U.S. Fish and Wildlife Service</td>
<td>1.8</td>
<td>3.7</td>
</tr>
<tr>
<td>National Parks Service</td>
<td>2.3</td>
<td>4.5</td>
</tr>
<tr>
<td>Bureau of Land Management</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Environmental Protection Agency</td>
<td>unknown</td>
<td></td>
</tr>
<tr>
<td>Food and Drug Administration</td>
<td>unknown</td>
<td></td>
</tr>
<tr>
<td>U.S. Forestry Service</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>U.S. Department of Defense</td>
<td>10.0</td>
<td>20.0</td>
</tr>
<tr>
<td>Interest</td>
<td>0.1</td>
<td>0.3</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>50.0</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

The estimated total federal costs in Hawaii is $50 million. There is a significant difference between the DOD costs at $10 million and the Exxon Valdez cost of $62 million because Hawaii does not have problems of accessibility that Alaska has. It is the experts’ judgment that a significant portion of the DOD costs are for vessels used for berthing and messing of cleanup and response workers. Although Hawaii is geographically isolated from the mainland, accessibility and berthing problems are not as complex as in Alaska — most shorelines are accessible from the main roads and lodging and messing facilities abound.

After adjusting the DOD cost to reflect lower expenditure, the costs incurred by all the other agencies were scaled down, using the Exxon Valdez cost distribution as a basis (Table 2.8). Based on these estimates, the U.S. Coast Guard could incur costs of $30.9 million, or 62 percent of the total spill cost, while the DOD’s estimated expenditure is only 20 percent of the total costs ($10 million). All other federal agencies would account for 18 percent ($9 million) of total costs.
Estimated U.S. Coast Guard — Hawaii Costs

In the section above, the expert panel estimated the total cost incurred by the U.S. Coast Guard to be about $31 million. This is for all the U.S. Coast Guard operations, including not only the costs of the Hawaii 14th District, but those of U.S. Coast Guard resources nationwide.

The estimated cost of the U.S. Coast Guard's 14th District resources is for personnel and equipment already in Hawaii. For instance, response equipment like skimmers and drones staged at the Pacific Strike Team in San Francisco are not included although they will be used.

Equipment costs were estimated using the current oil spill equipment inventory list for Hawaii and the U.S. Coast Guard standard rates for reimbursable charges. On the other hand, personnel costs were estimated using the expected number of staff involved in the response and the corresponding hourly wages. Table 2.11 shows the summary of these costs.

<table>
<thead>
<tr>
<th>Resource</th>
<th>Cost, $Million</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personnel</td>
<td>5.20</td>
</tr>
<tr>
<td>Equipment</td>
<td></td>
</tr>
<tr>
<td>Aircrafts</td>
<td>1.92</td>
</tr>
<tr>
<td>Sea Vessels</td>
<td>1.53</td>
</tr>
<tr>
<td>Other equipment a/</td>
<td>0.24</td>
</tr>
<tr>
<td>TOTAL</td>
<td>8.89</td>
</tr>
</tbody>
</table>

a/ Includes OWOCR boom system, sorbents, etc...

Data Source: Estimated from U.S. Coast Guard, MSO-Honolulu data.

State Government Costs

The following state agencies were contacted to determine the amount of personnel and equipment that will be deployed during a catastrophic spill: Division of Forestry and Wildlife, State Parks, Aquatic Resources Division of the Department of Land and Natural Resources, State Civil Defense, and Department of Health. These numbers are reflected in Table 2.12. To estimate the cost, it is assumed that each worker will devote 14 days on the spill and median salaries were used. It is estimated that personnel costs from state agencies will be about $400,000.

<table>
<thead>
<tr>
<th>Agency</th>
<th>Number of workers</th>
<th>Cost a/</th>
</tr>
</thead>
<tbody>
<tr>
<td>Division of Forestry and Wildlife</td>
<td>147</td>
<td>156,621</td>
</tr>
<tr>
<td>State Parks</td>
<td>151</td>
<td>152,950</td>
</tr>
<tr>
<td>Division of Aquatic Resources</td>
<td>14</td>
<td>22,748</td>
</tr>
<tr>
<td>Civil Defense</td>
<td>30</td>
<td>48,706</td>
</tr>
<tr>
<td>Department of Health</td>
<td>11</td>
<td>20,921</td>
</tr>
<tr>
<td>TOTAL</td>
<td>353</td>
<td>401,946</td>
</tr>
</tbody>
</table>

a/ based on the median salaries: state employees are expected to put in 14 days of work for the spill.

Cost of the Vessels and Spilled Oil

Cost of the Vessel

The estimated value of the 90,000 dwt single hull tanker ranges from $25.0 to $43.3 million. A 10-year old vessel has a present value of $25 million; a 1991 built vessel would cost $43.3 million (personal communication, 1991, Gary Reiter. PRI-Hawaii).

Cost of the Spilled Oil

Based on the estimated volume of oil spilled and the average price of crude oil ($20/barrel), the cost of the spilled oil can be between $4.7 to 14 million.

Damages to Resources

Cost of Natural Resource Damages

Damages to natural resources are often difficult to measure because some resources do not have market values. As such, certain valuation methods need to be employed to obtain a reasonable estimate of the damage. There are different tools available to measure these costs, however, most of them involve costly surveys and data analysis which are beyond the scope of this study. In short, although the methods are available, the resources of this project did not allow an intensive analysis of these costs.

The Natural Resources Damage Assessment Model for Coastal and Marine Environments (NRDAM/CME)6

One estimation method currently available is the Natural Resources Damage Assessment Model for Coastal and Marine Environments (NRDAM/CME). It is a computer model designed for the Type A assessment under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA).7 Under this Act, the polluter (of oil and other hazardous substances) may be required to compensate public and private parties for the cost of responding to and cleaning up the discharge or release. In addition, the state and federal governments, in their role as trustees, may also recover damages for injury to, destruction of, or loss of natural resources and for the reasonable cost of conducting a natural resource damage assessment. “Damages” is defined as the difference between the pre-incident and the post-incident in-situ value of the resource. It covers publicly controlled natural resources only. Therefore, it does not cover private losses like those incurred by fish processing plants or coastal hotels.

The NRDAM/CME: Algorithm

NRDAM/CME consists of three major components or sub-models. The physical fates sub-model and the biological fates sub-model identify the pathways of contaminants and quantify injuries to natural resources defined under CERCLA (land, fish, wildlife, biota, air, water, groundwater, drinking water supplies, and other

6The discussion is summarized from U.S. Department of Interior (1987), and Opalach and Grigalunas (1989).
7CERCLA §301(c)(2) specifies two types of assessment procedures — Type A and Type B. Type A assessment applies to incidents that are less extensive or relatively minor, requiring minimal field observations, and for which a refined, site-specific assessment of natural resource damages are judged not to be cost-effective. On the other hand, Type B assessment would apply to incidents involving complex situations or extensive discharges of oil or hazardous substances. It could involve costly surveys and extensive field studies.
such resources). This information is then passed on to the economic sub-model which will assess the economic damages.

The economic damages sub-model is based on the physical and biological injuries determined in the first two sub-models. In analyzing the economic damages, it is assumed that the spill event is too small to cause changes in the market prices of fish, the catchability coefficient, or the cost per unit effort. The sub-model measures the long and short term losses incurred in the following resource uses: 1) commercial and recreational fishing, 2) consumptive and non-consumptive uses, 3) use of public beaches, and 4) reduced food chain productivity in terms of lost in-situ use value from time of spill through the period of resource recovery.

Commercial losses refer to the change in total landings minus the change in harvesting cost, while recreational losses are measured in terms of the change in the gross value of sportsfishing due to reduced catch because of smaller stocks, minus the change in the cost of catching the fish.

Losses in consumptive use are estimated using region-specific estimates of the marginal value of an additional waterfowl harvest, while losses in non-consumptive use (e.g. photography) are estimated using the marginal change in the visitor days associated with a change in bird population for wildlife refuge.

Losses in public beach use are measured based on the reduction in the desirability of beaches thereby shifting the aggregate demand curve downwards which leads to a loss in consumer surplus. Reduction in productivity of the food chain refers to damage to the lower food web which affects bio-mass harvest.

**The NRDAM/CME: An Example**

In order to give some idea of the extent of economic damage to natural resources using the NRDAM/CME Type A model, we will use the Exxon Houston oil spill at Barber’s Point in 1989 as a sample case. The results are summarized in Table 2.13.

<table>
<thead>
<tr>
<th>Date</th>
<th>March 2, 1989</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Barber’s Point, Oahu</td>
</tr>
<tr>
<td>Type and Volume of Oil</td>
<td>Prudhoe Crude: 25,200 gallons</td>
</tr>
<tr>
<td></td>
<td>Bunker C: 8,400-8,800 gallons</td>
</tr>
<tr>
<td>Coastline affected</td>
<td>2-3 miles</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Impacts (Subtidal and Intertidal)</th>
<th>Estimated Damages, $</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. From Prudhoe Bay Crude</td>
<td></td>
</tr>
<tr>
<td>Fishery losses</td>
<td>217</td>
</tr>
<tr>
<td>Bird and Fur Seal Losses</td>
<td>168</td>
</tr>
<tr>
<td>Damages to Public Beaches</td>
<td>74,455</td>
</tr>
<tr>
<td><strong>SUB-TOTAL</strong></td>
<td><strong>74,840</strong></td>
</tr>
<tr>
<td>2. From Bunker C</td>
<td></td>
</tr>
<tr>
<td>Fishery losses</td>
<td>207</td>
</tr>
<tr>
<td>Bird and Fur Seal Losses</td>
<td>132</td>
</tr>
<tr>
<td>Damages to Public Beaches</td>
<td>74,449</td>
</tr>
<tr>
<td><strong>SUB-TOTAL</strong></td>
<td><strong>74,788</strong></td>
</tr>
<tr>
<td>3. <strong>TOTAL</strong></td>
<td><strong>149,628</strong></td>
</tr>
</tbody>
</table>

Data Source: Department of Interior (1991)
The Exxon Houston spilled 25,000 gallons of Prudhoe Bay Crude and 8,400-8,800 gallons of Bunker C. When the model was run for the subtidal and intertidal cases, it yielded a damage assessment of $74,834 and $74,788 for Prudhoe Bay and Bunker C, respectively. Noteworthy in this case is that the damages to fisheries, birds and fur seals were minimal. Damage to public beaches accounts for almost all of the cost.

A sensitivity analysis to determine changes in economic damages with respect to different environments (e.g., marine vs. estuarine conditions) did not show significant differences. It appears that in using this model for Hawaii, fishery, bird and fur seal losses are minimal compared to the losses incurred from the lost use of beaches.

Type A analysis like the one illustrated above is only applicable to small spills and even then the database used for the sensitivity analysis must be called into question. Since the NRDAM/CME model is designed for use in smaller and less complex spills, a large spill such as the one considered in the study is too large for Type A analysis. Extensive collection of information on the physical, biological, and economic characteristics of the resources, beyond the scope of this study, is required to measure the economic damages to natural resources. Therefore, the model was not used in the study.

Sand and Beach Value Losses

Since very few studies exist on the valuation of natural resources in Hawaii, it is difficult to determine the extent of potential damage posed by a catastrophic oil spill in the absence of critical baseline information. An analysis of the economic damages to sand and beaches in Hawaii is provided below.

Sand

Sand in Hawaii is unique and not easily replaced. However, if beach sand is removed and replaced because of oil contamination, it is estimated to cost up to $800,000. Sand may be bought locally in limited amounts or it may be imported from other countries like Australia. It is assumed that approximately 2 inches of sand will be removed from 50.3 miles of Oahu's beaches at an average width of 10 feet. This is equivalent to 16,392 cubic yards of sand at $47.00 per cubic yard.

Beach Values

Hawaii's beaches are among the best in the world. They are a major resource played up when "selling" Hawaii as a resort destination. As such, when beaches are oiled, the expectation is that tourism would decline and result in revenue losses to the tourism industry (see Chapter 3).

On the other end of the spectrum, most Hawaii residents are frequent beach users. When beaches are closed during the cleanup period, residents will incur utility losses because of the inaccessibility of the beaches. This lost utility can be measured by using economic techniques.

Moncur (1972, 1973) measured the value of selected beach parks on Oahu, using the travel cost model to estimate the willingness of Oahu's population to pay for beach park recreation experiences. The parks studied include Alii Moina, Waikiki to Hawaii Kai, Hanauma Bay, Sandy Beach and Makapuu, Waimanalo and Bellows, Kahua, Kaneohe to Laie, Punukea to Mokuleia, Yokohama Bay to Sand Island, and Keaiwa Heiau are beach parks.

An update of this report (Personal communication: Moncur, 1991) notes some of the earlier study's deficiencies with the passage of time, e.g., the change in underlying demand conditions and the emergence of new analytical techniques. Nevertheless, the study is the only economic evaluation of beach parks available. Adjusting the 1972 price to current levels provides some valuable insights.

Table 2.14 shows the estimated recreational value of these beach parks as $194 million per year or more than half-a-million per day to residents of Oahu. Therefore, if these beaches were closed for a certain period of time,
the corresponding loss in beach value would be equal to the number of days they are closed multiplied by the beach value per day.

<table>
<thead>
<tr>
<th>Beach Park</th>
<th>Willingness-to-pay per 2 weeks, 1972$</th>
<th>Total value for Oahu population, 1972$</th>
<th>Value per 2 weeks for Oahu population, 1990s a/</th>
<th>Total value for Oahu population, 1990, million$ a/</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ala Moana</td>
<td>687</td>
<td>86,473</td>
<td>460,548</td>
<td>12.0</td>
</tr>
<tr>
<td>Waikiki to Hawaii Kai</td>
<td>1,688</td>
<td>211,839</td>
<td>1,128,237</td>
<td>29.3</td>
</tr>
<tr>
<td>Hanauma Bay b/</td>
<td>798</td>
<td>100,444</td>
<td>534,955</td>
<td>13.9</td>
</tr>
<tr>
<td>Sandy and Makapuu b/</td>
<td>1,029</td>
<td>129,501</td>
<td>689,710</td>
<td>17.9</td>
</tr>
<tr>
<td>Waimanalo and Bellows</td>
<td>445</td>
<td>56,012</td>
<td>298,315</td>
<td>7.8</td>
</tr>
<tr>
<td>Kailua</td>
<td>1,917</td>
<td>241,671</td>
<td>1,287,119</td>
<td>33.5</td>
</tr>
<tr>
<td>Kanehoe to Laiie</td>
<td>1,218</td>
<td>153,310</td>
<td>816,516</td>
<td>21.2</td>
</tr>
<tr>
<td>Pupukea to Mokuleia</td>
<td>1,126</td>
<td>141,730</td>
<td>754,842</td>
<td>19.6</td>
</tr>
<tr>
<td>Yokohama Bay to Nanakuli</td>
<td>1,057</td>
<td>133,045</td>
<td>708,586</td>
<td>18.4</td>
</tr>
<tr>
<td>Barber’s Point to Sand Island</td>
<td>1,168</td>
<td>147,016</td>
<td>782,995</td>
<td>20.4</td>
</tr>
<tr>
<td>TOTAL</td>
<td>11,133</td>
<td>1,401,041</td>
<td>7,468,823</td>
<td>194.0</td>
</tr>
</tbody>
</table>

a/ column (1) x inflation adjustment (336%) x population adjustment (1990 number of households/1972 number of households) x 26 (annual estimate); b/ In Moncur’s study, the estimates for these beaches were not statistically significant, therefore the authors of this report assumed that these beaches are as popular as Waikiki and the ‘willingness-to-pay’ value found for Waikiki was used to estimate their total value.

Data Source: Moncur (1973)

In the catastrophic oil spill scenario, beach cleanup is expected to last for two months as workers focus on only a few beaches at a time. It is assumed that high use beaches will be prioritized for earliest cleanup and opened to the public as soon as they are clean. Therefore, if each of the beaches considered in Moncur’s study is closed for at least two weeks, the resulting loss to Oahu residents will be at least $7.5 million.

Summary of Cleanup Cost Estimates

The following section provides a summary of the estimated cleanup costs for the “worst case” catastrophic oil spill and for two additional isolated cleanup scenarios. Cleanup costs were estimated for the latter scenarios and examined to answer questions raised while the study was in progress. The first of the additional scenarios projects a 30,000 barrel spill in the same location and under the same conditions as the worst case spill. This is a possible worst case spill resulting from loss of cargo of an interisland barge. The second scenario is a 100,000 gallon black oil spill in Honolulu Harbor. This assumes that this is an isolated event and that the appropriate available cleanup equipment which is available can be focused on this cleanup problem.

Summary Cleanup Costs for a Worst Case Catastrophic Oil Spill

Preliminary and tentative estimates show that a 10 million-gallon catastrophic oil spill in Hawaii can cost between $210 million to $305 million (Table 2.15). This translates to $21–31 per gallon or $882–1,302 per barrel of oil spilled. Included in these estimates are the value of spilled oil and vessel, at-sea response, shoreline cleanup, oil and oily waste disposal, harbor, boat and seabird cleanup, federal and state governments costs, value of the lost use of beaches and cost of sand replacement. This does not include marine animal cleanup, and non-market costs like damage to and lost use of natural resources, impacts on ocean industries, and losses to tourism (see Chapter 3).
Table 2.15. Summary of financial costs of a $10 million-gallon oil spill in Hawaii

<table>
<thead>
<tr>
<th>Cost Item</th>
<th>Amount, $Million</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Cost of spilled oil</td>
<td>4.7</td>
</tr>
<tr>
<td>2. Value of vessel</td>
<td>25-44</td>
</tr>
<tr>
<td>3. At-sea response</td>
<td>21</td>
</tr>
<tr>
<td>4. Shoreline cleanup</td>
<td>52</td>
</tr>
<tr>
<td>5. Boat cleanup</td>
<td>0.2-0.7</td>
</tr>
<tr>
<td>6. Port cleanup a/</td>
<td>included in (2)</td>
</tr>
<tr>
<td>7. Bird cleanup</td>
<td>0.32-0.80</td>
</tr>
<tr>
<td>8. Marine animals cleanup</td>
<td>not estimated</td>
</tr>
<tr>
<td>9. Oil and oily waste disposal</td>
<td>48-123</td>
</tr>
<tr>
<td>10. Cost of federal government operations</td>
<td>50</td>
</tr>
<tr>
<td>11. Cost of state government operations b/</td>
<td>0.4</td>
</tr>
<tr>
<td>12. NRDAM/CME</td>
<td>not applicable</td>
</tr>
<tr>
<td>13. Beach values</td>
<td>7.5</td>
</tr>
<tr>
<td>14. Sand replacement costs</td>
<td>0.7</td>
</tr>
<tr>
<td>15. Damages to private coastal properties</td>
<td>not estimated</td>
</tr>
<tr>
<td><strong>SUB-TOTAL</strong></td>
<td><strong>210-305</strong></td>
</tr>
<tr>
<td><strong>Per Unit Estimates, $</strong></td>
<td></td>
</tr>
<tr>
<td>Cost per gallon</td>
<td>21-31</td>
</tr>
<tr>
<td>Cost per barrel</td>
<td>882-1,302</td>
</tr>
</tbody>
</table>

a/ Cost is about $1 million for port cleanup alone
b/ Personnel only

Cleanup Costs Associated With a 30,000 Barrel Oil Spill in the Kaiwi Channel

In response to a request by the Hawaii State Department of Health, a cost estimate was determined for the cleanup and other costs associated with a worst case spill of approximately 30,000 barrels of black oil in Hawaiian waters.

The analysis assumed the smaller spill would occur in the same vicinity and under the same conditions as the Coast Guard’s “Worst Case” Scenario. Although the quantity of oil spilled is smaller by a magnitude of 10, the smaller spill would probably follow the same distribution pattern as the larger spill impacting most of Oahu and some Kauai shorelines. Alternatively the oil could drift out to sea and result in no damage to terrestrial environments.

Assuming a 30,000 barrel oil spill with approximately the same proportion of oil reaching the shore as assumed in the case of the 10-million gallon spill, distribution of the costs per gallon for cleanup would likely be somewhat different than those shown in Table 2.15. For the smaller spill, the “at-sea costs” would increase on a per gallon basis. The spill would require the same type of mobilization of equipment and manpower as the larger spill. However, the overall efficiency would be less. The cost of shoreline, associated resources and disposal would probably remain about the same on a per gallon basis. On the other hand, government costs would be proportionately higher.
It is difficult to estimate injury to natural resources. In the case of the smaller spill, there should be little or no loss to fisheries and, based on available data, little long-term environment injury should occur from the oil reaching the shoreline, if appropriate cleanup methods are used.

The following estimates are based on the authors' and a member of the expert panel's judgments of how the different areas of cleanup costs would differ in the case of a large vs. a smaller spill. The per barrel cost of the larger spill can be expected to be smaller due to economies of scale, in the ability to spread fixed costs in the case of larger spills. On the other hand, more aspects of a 30,000 barrel spill can be handled with available equipment, supplies and manpower. This would lower the high costs of obtaining these resources on an emergency basis from the mainland.

<table>
<thead>
<tr>
<th>Cost Item</th>
<th>Amount ($Million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Cost of spilled oil</td>
<td>.47</td>
</tr>
<tr>
<td>3. At-sea response</td>
<td>4.00</td>
</tr>
<tr>
<td>4. Shoreline cleanup</td>
<td>5.20</td>
</tr>
<tr>
<td>5. Bird cleanup</td>
<td>0.08</td>
</tr>
<tr>
<td>8. Marine animals cleanup</td>
<td>not estimated</td>
</tr>
<tr>
<td>9. Oil and oily waste disposal</td>
<td>4.80</td>
</tr>
<tr>
<td>10. Cost of federal government operations</td>
<td>12.5</td>
</tr>
<tr>
<td>11. Cost of state government operations</td>
<td>0.4</td>
</tr>
<tr>
<td>13. Miscellaneous</td>
<td>3.00</td>
</tr>
<tr>
<td><strong>TOTAL cost of cleanup</strong></td>
<td><strong>30.45</strong></td>
</tr>
</tbody>
</table>

cost per barrel $1,015
cost per gallon $24.16

Estimates by J. R. Davidson and R. Null.

These costs do not include cost of vessel, marine animal cleanup, and non-market costs like damage to and lost use of natural resources other than beaches, impacts on ocean industries, and losses to tourism.

The above estimates of cleanup costs for a 30,000 barrel spill would be considered conservative for this scenario. Still it is a high cost scenario because of the location and conditions surrounding the spill. Perhaps the only higher cost scenario that might reasonably be presented is a spill that would directly impact the area between Diamond Head and Honolulu Harbor, including the entire length of beach fronting Waikiki. This latter scenario would not necessarily increase cleanup costs per barrel spilled, but it could increase the economic impact on the tourism industry and hence the state. It should be emphasized that this report deals only with cleanup costs, major additional costs that could arise out of litigation are not considered.

Response, Cleanup and Disposal Costs Associated with a 100,000 Gallon Black Oil Spill in the Honolulu Harbor

Scenario

A 30,000 DWT vessel ruptures several fuel tanks as a result of collision or grounding in Honolulu Harbor and loses 100,000 gallons of black fuel oil (bunker C), roughly 10 percent of barge cargo. The same magnitude of spill could have resulted from the products of a catastrophic offshore spill entering the harbor. A few minutes following the event, the Clean Islands Council (CIC), Pacific Environmental Corporation (PENCO)
and Marine Logistics (MarLog) would have been notified and assigned areas of responsibility. Within 30 minutes during normal working hours or 60 minutes after normal working hours, each of the three organizations would begin deploying booms. Containing the spill is the first priority. It would take two to four hours to deploy all the booms in the harbor. PENCO would respond to the Sand Island Bridge end of the harbor. MarLog would close off the Aloha Tower end and CIC would isolate pockets along Pier 30. Booms would have to be constantly adjusted to consolidate the spill. Concurrent with the deployment of booms, vacuum trucks would be dispatched. The first trucks would arrive within two hours and begin recovery operations. After the booms have been deployed, skimming operations will begin. Intense skimming operations would take three to five days, after which operations are scaled down. Initially, an offshore response vessel could be utilized for storage of recovered oil and water, however, a storage area will have to be ultimately secured. In this particular case, a barge would be utilized. When the threat of re-rolling has been mitigated, cleanup could be initiated. This would include use of hot water pressure washers. Oily debris along the shoreline would also be collected and disposed of. Shoreline and pier cleaning is estimated to take four weeks. It is assumed that minimal evaporation would occur during cleanup and that weather conditions would not affect cleanup. Recovered oil and water will be recycled at ORCO and Unitek, sorbents and oily debris sent to the Waipahu Incinerator facility.

Cost Estimates

A summary of estimated costs is presented in Table 217. A 100,000 gallon black oil spill is not a major disaster. Labor and equipment already in place in the state can handle the spill. None will have to be flown in from the mainland. Total cost is estimated at $1.7 million, of which cleanup accounted for more than 50 percent of total costs. In this particular spill scenario, none of the beaches will be affected, thus lowering cleanup costs. Response cost was estimated at $527,625 which comprises 32 percent of total costs. Booming operations contributed more than 65 percent of response costs. Disposal of recovered oil and oily debris is the smallest cost component, accounting for roughly 14 percent of total costs.
<table>
<thead>
<tr>
<th>Type of Operation/Input</th>
<th>Cost($)</th>
<th>% of Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response</td>
<td>527,625</td>
<td>31.6</td>
</tr>
<tr>
<td>Booming</td>
<td>341,150</td>
<td>20.4</td>
</tr>
<tr>
<td>Skimming</td>
<td>101,775</td>
<td>6.1</td>
</tr>
<tr>
<td>Storage</td>
<td>52,500</td>
<td>3.1</td>
</tr>
<tr>
<td>Underwater survey</td>
<td>20,000</td>
<td>1.2</td>
</tr>
<tr>
<td>Salvage</td>
<td>8,000</td>
<td>0.5</td>
</tr>
<tr>
<td>Overflights</td>
<td>4,200</td>
<td>0.3</td>
</tr>
<tr>
<td>Pier, pilings and waterfront cleanup</td>
<td>917,500</td>
<td>54.9</td>
</tr>
<tr>
<td>Wages</td>
<td>671,550</td>
<td>40.2</td>
</tr>
<tr>
<td>Disposable clothing</td>
<td>54,000</td>
<td>3.2</td>
</tr>
<tr>
<td>Lunch boxes</td>
<td>9,450</td>
<td>0.6</td>
</tr>
<tr>
<td>Vacuum trucks</td>
<td>50,000</td>
<td>3.0</td>
</tr>
<tr>
<td>Hot water pressure washers</td>
<td>12,500</td>
<td>0.7</td>
</tr>
<tr>
<td>Sorbents</td>
<td>120,000</td>
<td>7.2</td>
</tr>
<tr>
<td>Disposal</td>
<td>225,800</td>
<td>13.5</td>
</tr>
<tr>
<td>Water and oil</td>
<td>175,000</td>
<td>10.5</td>
</tr>
<tr>
<td>Sorbents</td>
<td>32,000</td>
<td>1.9</td>
</tr>
<tr>
<td>Oily debris</td>
<td>12,800</td>
<td>0.8</td>
</tr>
<tr>
<td>Garbage bags</td>
<td>6,000</td>
<td>0.4</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>1,670,925</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>
Recommendations

Editor's note: The recommendations that follow are based on the findings of our research. As indicated in italics, the DOH notes that some of the recommendations are already in the process of being implemented by the appropriate agencies.

1. Training workshops should be held and incentives for individuals or businesses to maintain a pool of trained workers should be considered. The preparedness analysis has highlighted the limited number of at-sea response equipment currently available on Oahu. However, the greater deficit appears to be trained manpower to operate the equipment. Trained workers imported from the mainland would increase labor costs. Occupational Safety and Health Administration regulations require workers to be trained before fielding.

   Trained workers are required by the Oil Pollution Act of 1990 (OPA 90) and there are existing trained commercial and federal oil spill responders.

2. Inventory and valuation of coastal resources should be undertaken by the state to provide baseline information for determining economic losses associated with an oil spill. A difficulty encountered in assessing resource damages caused by an oil spill is the lack of baseline information on on-shore and offshore resources that can potentially be affected by the spill. The use of these resources and the value of the uses also need to be established. To provide this information, resource inventories should be performed on public coastal natural resources as well as private coastal properties. The NRDAM/CME model, which addresses some of these impacts, may be appropriate for smaller and less complex spills, but it is not designed to handle damage assessments of a complex, catastrophic oil spill.

   The U.S. Coast Guard has already identified sensitive environmental areas in Hawaii; they are in the process of videotaping and photographing all coastal resources; and they have updated the National Oceanic Atmospheric and Administration sensitivity study.

3. The state should look into the different alternatives available for the disposal of oil and oil-coated debris from cleanup operations. There is a severe inadequacy for handling oil spill wastes in the islands. Knowledge of disposal options, as well as coordination with state and local agencies would minimize problems in handling large volumes of oily wastes before and not when it happens. In addition, the environmental and cost trade-offs involved need to be carefully considered.

   As part of the Area Contingency Plan, a subcommittee headed by the Department of Health (DOH) is addressing this issue.

4. Ensure that waste disposal plans are properly incorporated in every vessel's contingency plans. Problems of waste disposal could be reduced if vessels properly incorporate disposal options in their contingency plans.

   This is addressed in Navigation and Vessel Inspection Circular, Section 9.3, Appendix A to Enclosure 1.

5. Inter-agency coordination should be strengthened particularly in identifying government sources of equipment and personnel. Inter-agency coordination is important in emergencies like a catastrophic oil spill. As such, each agency's role should be clearly defined and resources that could be devoted to the response operations should be identified ahead of time. An integrated inventory list/database should be created to identify sources of equipment, personnel, state of availability, and readiness.

   This is the purpose of the Area Committee.

6. Agency-specific contingency plans should be developed by state agencies involved in the spill response. There is a need to develop contingency plans within state agencies that are involved in the spill response. Such a plan should include identification of key personnel, the number of personnel and equipment to be dedicated by each agency to spill response efforts, and the procedures to follow during a spill.
The State has its Oil and Hazardous Substances Emergency Response Plan. This plan clearly states the hierarchy of the county, state, and the federal government response action in an emergency. The Area Planning Committee is set up to facilitate specific contingency planning between state and county agencies. In addition, the Regional Response Team (RRT) functions in a similar capacity to coordinate federal and state agencies.

7. Pre-contract and outfit fishing boats for oil spill response. Outfitting and pre-contracting local fishing/charter boats to deploy booms or perform related tasks would not only hasten the response process but also alleviate income losses associated with lost use of marine resources by these users.

The Clean Islands Council (CIC) has outfitted boats to handle spills for an emergency (i.e. containment of a spill). In the event of a serious emergency, time will permit the contracting of additional boats to do other work. It is believed that outfitting fishing boats with oil spill response equipment would interfere with their commercial fishing operation and the boats, in many cases, are not the type needed for responding to an oil spill.

By the end of 1993, the CIC will have six boats outfitted for oil spill response. In addition, the Department of Defense resources exist which could be used in the event of an oil spill.

8. Public Education. Develop a public education program to inform the public of the magnitude of the potential cost of a major oil spill, and to lower expectations on the capacity and capability of responders to act on the incident.

There is established a public affairs subcommittee which will attempt to present the plan through the media and other sources; however, education programs are always helpful.

9. Develop a socioeconomic contingency plan. The social and economic impacts from a spill on Hawaii residents could be overwhelming. Examples are increase in crime, psychological and emotional stress due to loss of employment, and other indirect impacts of the spill. These impacts, although not covered in this report, are expected to be high and therefore plans to ameliorate them should be considered. Contingency plans should also be designed to counter the negative impacts on the tourist industry.

10. Some questions to be addressed/implications. Cost-incidence is important in the area of prevention and preparedness. The question of “who bears the cost” ultimately determines the willingness of the federal and state governments and industry, to implement prevention and preparedness schemes. The way regulations (e.g. OPA) are written will affect this cost. Although OPA requires that the tanker and/or cargo owner(s) pays for the cost of cleanup and removal and other related costs, the problem arises when there is no clear responsible party for the spill, or when the polluter does not have the resources to pay for the spill. Ultimately, the cost may be borne by the federal or state governments, or the individual resource user.

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CHAPTER 3

THE ECONOMIC EFFECT OF A CATASTROPHIC OIL SPILL ON TOURISM IN HAWAII

Donna J. Lee
Jack R. Davidson
Christopher LaFranchi
Marissa C. Garcia
Introduction

Tourism is a vital part of Hawaii's economy. Each year millions of visitors travel to Hawaii to enjoy the clean, scenic beaches for sight-seeing, sunning, and water sports. A catastrophic oil spill fouling major beaches and resort areas would totally disrupt the tourist economy. This study assesses the effects of a catastrophic oil spill on Hawaii's visitor industry.

Number of Visitors

As a tourist destination, Hawaii has grown in popularity over the years. In 1990, approximately 6.9 million first time and returning visitors came to the islands. The 20-year trend of increasing visitor arrivals is illustrated in Figure 3.1.

![Figure 3.1. Annual visitor arrivals to Hawaii](image)

Visitor Spending

The increase in average spending by visitors parallels the rising number of visitors. In recent years, total annual visitor expenditures have escalated rapidly (Figure 3.2). In 1990, visitors and crew spent $10.1 billion dollars.

![Figure 3.2. Trend in annual visitor expenditures in Hawaii](image)
State Economy

In 1990, visitor industry revenues accounted for 50 percent of the state's total income, employed 210,000 people, and generated about $5990 million in tax revenues. As illustrated in Figure 3.3, Hawaii's economy has become increasingly dependent on visitor expenditures as a source of revenue.

Figure 3.3. Percent of annual state income from visitor expenditures

Seasonality

Although it is not subjected to extreme "boom and bust cycles," visitor arrivals to Hawaii vary seasonally. Figure 3.4 shows both monthly visitor arrivals between December 1989 and November 1990 and the threear year monthly average of visitor arrivals between 1986 and 1988. The number of visitors travelling to Hawaii is highest in the months of August and July, and lowest during the months of September and May. A disastrous event that occurs during a peak month is likely to depress visitor industry revenues more than one that takes place during a low season month.

Figure 3.4. Figure seasonality of visitor arrivals to Hawaii
External Influences

Major events such as the energy crisis in the late 1970's, Hurricane Iwa in 1982, airlines strikes, and the Persian Gulf war in 1991, severely depressed visitor arrival rates and placed the visitor industry in a temporary recession. A large offshore oil spill is also expected to depress visitor arrival rates.

Sector Effects

Numerous sectors of Hawaii's economy (e.g. hotel, restaurant, recreation) benefit from the arrival of visitors. Therefore, a sector's vulnerability to an oil spill is strongly related to its dependence on visitor expenditures as a source of income. Since the hotel, restaurant, and recreation sectors of the state's economy derive most of their income from visitors, they are likely to suffer the most hardship from a catastrophic oil spill.

Economic Effect of an Oil Spill on Hawaii's Visitor Industry

Previous Events

The economic effects of recent spills have been documented in a few studies. One study estimated the effects of the Exxon Valdez spill on private sector businesses in Alaska. Another study assessed tourist industry losses from the Amoco Cadiz spill in Northern France. Since no major oil spills have occurred in Hawaii, the effect of Hurricane Iwa on the visitor industry was examined in this report.

Exxon Valdez Spill

The 1989 Exxon Valdez spill in Prince William Sound was highly publicized due to the size of the spill and the environmental damages that ensued. The economic losses from the spill were detailed in the Oiled Mayors' final report. The report stated that 1 year after the spill, business income fell 5 percent. The small decline in income was partly attributed to the fact that some business generated additional income through contracts with the federal government for oil spill cleanup. Reported business losses were thus smaller than they otherwise might have been. Seafood processors lost 10 percent of gross income as a result of the spill. Results showed that after the spill prices fell, sales declined, and costs increased. Employment fell in all sectors, with the exception of those sectors participating in the cleanup. Businesses reported some difficulty adjusting to post-spill conditions. Economic uncertainty and unavailable labor contributed to a reduction in business investment of 95 percent during the year following the spill. As a result of the spill, industry sectors were more unstable and more sensitive to economic hardships.

Amoco Cadiz Spill

In another study, the National Oceanic and Atmospheric Administration (NOAA) estimated the economic costs of the Amoco Cadiz spill that occurred in March 1978 off the Brittany coast of Northern France. The Brittany coast is the most popular summer vacation area in France. Marine-related tourism, oyster culturing, lobster harvesting, and fishing are second only to agriculture in economic importance to the region. Reduced tourist revenues and lost wages were estimated with pooled time-trend and econometric models. The 220,000-ton spill caused tourist arrivals to decline by 11 percent. Total economic losses to the tourist industry were estimated to be between $28 million and $60 million. The lost recreational values were estimated to be between $1.4 million and $8.3 million. Economic losses included: marine resource damages, cleanup costs, research expenses, and legal fees.
Hurricane Iwa

On November 24, 1982, Hurricane Iwa blew through Hawaii causing a great deal of physical and environmental damage. As a result of national media attention to the hurricane, trips were canceled, plans were changed, and for a time, the flow of visitors to Hawaii was severely stanchied. Hurricane Iwa provides a natural case study for gauging the resilience of the visitor industry to disastrous events. Industry revenue losses from Hurricane Iwa were estimated in the following manner. First, data was obtained on actual visitor arrivals during the 12 months following the hurricane. Then, a model was developed to project the number of visitors that might have arrived had the hurricane not occurred. Actual arrivals were compared to projected arrivals to estimate the economic losses from the hurricane.

A model of visitor arrivals to Hawaii was developed to project revenues for the time period following the hurricane. Monthly visitor arrival data from 1971 to 1982 (Hawaii Visitor's Bureau, 1991) were evaluated with time series methods (Box and Jenkins, 1970) and used to estimate models of westbound and eastbound arrivals. From the estimated models, visitor arrivals were back forecasted for the 12 months following the hurricane. Forecasted visitor numbers were compared to actual visitor numbers. The decline in visitor numbers indicate roughly the magnitude of the lost visitor revenues due to the hurricane.

Interest rates, exchange rates, and national employment rates also affect visitor numbers. In this study, these macroeconomic factors are modeled collectively. Their collective effect on visitor numbers is assumed to be small and random with an expected value of zero and a variance that is constant through time.

Estimates suggest that the visitor industry lost 12 percent of expected revenues in the first month, 10 percent of expected revenues during the next 5 months, and 8 percent of expected revenues in the remaining 6 months of the year after the hurricane. In all, the visitor industry lost a total of 9 percent of expected annual revenues due to the hurricane. The visitor models used to estimate the effects of the hurricane are detailed below.

Model of Westbound Visitor Arrivals to Hawaii

In the model below, $z_i$ is the number of westbound passengers that arrived in Hawaii in month $i$, $y_i$ is the square root of $z_i$, $x_i$ is the difference between $y_i$ and $y_{i-1}$, $\phi_1$, $\phi_2$, and $\theta$ are the model parameters, $u_i$ and $u_{i-12}$ are random variables with zero mean and constant variance, and $\delta$ is a drift term. Westbound visitor arrivals to Hawaii were found to be an ARIMA(2, 0, 0)(0, 1, 1)12. Other models considered were: ARIMA(1, 0, 0)(0, 1, 0)12, ARIMA(2, 0, 0)(1, 1, 0)12, and ARIMA(2, 0, 0)(0, 1, 2)12.

Estimated model:

$z_i = \text{number of passengers arriving in Hawaii in month } i$

$y_i = \sqrt{z_i}$

$x_i = y_i - y_{i-1}$

$\delta = \phi_1 x_{i-1} + \phi_2 x_{i-2} + u_i - \theta u_{i-12} + \delta$

Estimated correlation coefficients:

$\rho_1 = .57$

$\rho_2 = .48$

$\rho_3 = .30$

Estimated model parameters:

$\phi_1 = .59$

$\phi_2 = .29$

$\theta = .85$

$\delta = .19 \times 10^{-3}$

Number of observations = 142

$R^2 = .586$
Model of Eastbound Visitor Arrivals

In the model below, \( z_t \) is the number of eastbound passengers that arrived in Hawaii in month \( t \), \( y_t \) is the square root of \( z_t \), \( x_t \) is difference between \( y_t \) and \( y_{t-12} \), \( \phi_1 \), \( \phi_2 \), \( \phi_3 \), and \( \theta \) are the model parameters, \( u_t \) and \( u_{t-12} \) are random variables with zero mean and constant variance, and \( \delta \) is a drift term. Eastbound visitor arrivals to Hawaii were found to be an ARIMA \((2, 0, 0)(1, 1, 1)_{12} \). Other models considered were: ARIMA\((1, 0, 0)(0, 1, 0)_{12} \), ARIMA\((2, 0, 0)(0, 1, 1)_{12} \), and ARIMA\((2, 0, 0)(0, 1, 2)_{12} \).

Estimated model:

\[
\begin{align*}
    z_t &= \text{number of passengers arriving in Hawaii in month } t, \\
    y_t &= \sqrt{z_t}, \\
    x_t &= y_t - y_{t-12}, \\
    x_t &= \phi_1 x_{t-1} + \phi_2 x_{t-2} + \phi_3 x_{t-12} + u_t - \theta u_{t-12} + \delta
\end{align*}
\]

Estimated correlation coefficients:

\[
\begin{align*}
    \rho_1 &= .49, \\
    \rho_2 &= .49, \\
    \rho_3 &= .46
\end{align*}
\]

\[
\begin{align*}
    \theta &= .85
\end{align*}
\]

Estimated model parameters:

\[
\begin{align*}
    \phi_1 &= .30, \\
    \phi_2 &= .33, \\
    \phi_3 &= .50
\end{align*}
\]

\[
\begin{align*}
    \delta &= .17 \times 10^{-2}
\end{align*}
\]

Number of observations = 142

\[
\begin{align*}
    R^2 &= .404
\end{align*}
\]

A Catastrophic Oil Spill

The effects of an oil spill will vary greatly with the size, time, and location of the spill. This study was designed around a single catastrophic spill. The spill scenario follows.

Summary of the Catastrophic Oil Spill Scenario

On November 30, an oil tanker collides with a container ship in the Kaiwi Channel. As a result of the collision, 9,800,000 gallons of crude oil are spilled. Within 8 hours of the spill, oil washes up on Oahu beaches. Soon after, all of the beaches on Oahu are blanketed with oil. The oil reaches Kauai and Nihoa in 4 days. The contaminated beaches are closed to the public. An intensive cleanup effort begins immediately. Within 2 months, all beaches officially reopen to the public. For the next 10 months, special cleanup teams are dispatched in response to sightings of residual oil sheens. One year after the spill, the cleanup effort is complete.

Extended Scenario

As the oil washes up on shore, nearly all of the beaches on Oahu, and some of the beaches on Kauai and Molokai, would be closed to the public. Some of the visitors in Hawaii at the time of the spill would likely cut their trip short and leave early. Other visitors, postponing or cancelling, would severely staunch the flow of visitors to Hawaii. Although all of the beaches will reopen within 2 months of the spill, the disruption to businesses is expected to last much longer.
Empirical Procedures

This section describes the data and the methods used to predict the economic losses to Hawaii’s visitor industry as a result of a catastrophic oil spill.

Data Collection

Data required to predict the effect of a catastrophic oil spill on the visitor industry was obtained by convening an expert panel of representatives from the hotel, travel, retail, and ocean recreation sectors. The panelists were presented with the catastrophic spill scenario and asked to complete a questionnaire. The intent of the questionnaire was two-fold: 1) to solicit their opinions about the effect of the oil spill on the visitor industry and, 2) to focus the discussion that was to follow. The questionnaire asked the panelists to estimate the decline in visitor numbers, the duration of the decline, the rate of recovery, and the time required for complete recovery. The questionnaires were collected, reviewed, and summarized. For the second round, a summary of the responses was presented to the panel. A lively discussion followed. At the conclusion of the discussion, the panelists were asked to complete a second copy of the questionnaire which was used in the first round. The second-round questionnaires were collected and reviewed.

Data Assessment

Due to the extent of the information queried, the size and diversity of the panel, and the limited time for discussion, a unanimous consensus was not reached by the conclusion of the workshop. However, there was some convergence in the responses after the discussion. Prior to the discussion, panelists responded that industry recovery time from the oil spill would be on average 14 months. The standard deviation was 8.5 months. After the discussion, total recovery time from the spill was expected to be 13 months, and the standard deviation of the responses was five months.

Estimation Procedures

This study used the panelists responses to the second questionnaire to predict the economic effects of the catastrophic oil spill. The median response was fitted to a smooth, quadratic recovery curve. In the equation below, \( \rho_r \) is the percentage below normal visitor numbers, \( t \) is time in months after the spill, \( \alpha_0 \) is the greatest percentage drop in visitor numbers as a result of the spill, and \( \beta_n \) is the quadratic recovery parameter.

\[
\rho_r = \alpha_0 - \beta_n (t - \delta)^2
\]

Letting \( T \) indicate the total length of time for complete recovery and \( \delta \) represent the duration of the recession, the recovery parameter can be computed:

\[
\beta_n = \frac{\alpha_0}{(T - \delta + 1)^2}
\]

Thus, the time path that models the decline in visitor numbers at the time of the spill to the time of complete recovery is expressed:

\[
\rho_t = \begin{cases} 
\rho_r & \text{if } \delta < t \leq T \\
0 & \text{if } t > T 
\end{cases}
\]
The proportionate monthly loss in visitor revenues was estimated from these equations. Estimated losses were based on 1990 industry revenues.

**Model Results**

Visitor numbers in Hawaii are expected to decline by 40 percent for four months following the catastrophic spill. Thereafter, visitor numbers will increase slowly and return to normal in 12 months. As a result, the visitor industry will lose $3.06 billion in revenues, the state will lose $317 million in income from taxes, and 67,000 employees in the visitor industry will be suspended. Figure 3.5 demonstrates graphically the loss in industry revenues immediately following the spill, and the slow recovery to normal levels after 12 months.

Since visitor industry revenues have been rising over time, an oil spill that occurs in the future would likely disrupt a larger revenue stream than was collected in 1990. The spill scenario was not explicit about the year of occurrence, so this study pegged losses to the most recent available data on industry revenues. Alternative future scenarios could be forecasted using the methods described in this work.

![Graph showing lost revenues](image)

**Figure 3.5. Visitor industry revenue losses after a catastrophic oil spill**

**Range of the Data Results**

The range of the data set reflects the divergence of opinion about how soon after the spill visitors will return to Hawaii. If, after cleanup is complete, Hawaii is still perceived to be polluted with oil, then the road to recovery for the visitor industry will be slow indeed. Alternatively, an effective, well orchestrated media blitz could alter public perception and persuade visitors to travel to Hawaii. The visitor industry panelists indicated that an effective campaign would require a high level of cooperation between the state, the visitors bureau, and the visitor industry. A comprehensive campaign would require at least five years of advanced preparation and planning. Such a plan does not currently exist.

To ascertain the actual range of the data set, this study computed the visitor industry losses implied by each panelist's response. The panelists' opinions diverged widely on the issue of the number of months required for complete recovery. Responses ranged from six to 20 months. On the duration of the recession, panelists' responses ranged from 1.5 to eight months. Projections of total revenue losses also varied widely. One panelist indicated that visitor numbers would likely fall only 20 percent after the oil spill and fully recover within six months. Based on this forecast, first year industry revenues would be down 7.1 percent causing a loss of $670
million. Another panelist expected that visitor numbers would drop 50 percent for 8 months and recover only after 20 months had elapsed, implying a 51 percent decline in first year revenues and a 26 percent reduction in second year revenues, or $7.2 billion in revenue losses due to the spill.

To provide some perspective on the precision of the estimates, the range of the data and the frequency of the responses were analyzed to couch the estimates in probability terms. For example, first year losses, as stated previously, are $3.06 billion. Given the range of the data set, we can be 40 percent certain that losses will be at least $3.06 billion in the year following the spill. In other words, there is a 60 percent chance that losses will be less than $3.06 billion. With 50 percent certainty, we can say that losses will be at least $2.8 billion and with 50 percent certainty that losses will be less than $2.8 billion. With full 90 percent certainty we can state that first year losses will be at least $550 million, that is, there is only a 10 percent chance that losses will be less than $550 million.

These probability ranges are provided to give the reader a feel for the variation in the data and the certainty of the empirical results. The following section assesses the sensitivity of the results to the model and the model parameters.

**Sensitivity Tests**

Model specification and the model parameters imply strong assumptions about how potential visitors will perceive the oil spill. In fact, there is a great deal of uncertainty about how potential visitors will react to the catastrophic spill, and more importantly, how their reaction will affect visitor industry revenues. This study varied the initial model parameters and evaluated alternative model specifications to test the sensitivity of the empirical results to initial assumptions.

Five alternative models are shown in Table 3.1. It should be noted that the results from the alternative models do not indicate the range of possible outcomes, rather, they represent the range of likely outcomes for this particular spill scenario, under present economic conditions, given Hawaii's current state of preparedness.

<table>
<thead>
<tr>
<th>Path</th>
<th>Industry recovery scenario</th>
<th>Revenues lost*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Maximum decline (percent)</td>
<td>Year 1 $ billion</td>
</tr>
<tr>
<td>1</td>
<td>30 steady 2 months</td>
<td>-1.3</td>
</tr>
<tr>
<td>2</td>
<td>40 steady 3 months</td>
<td>-2.6</td>
</tr>
<tr>
<td>3 (base)</td>
<td>40 gradual-steady 4 months</td>
<td>-3.1</td>
</tr>
<tr>
<td>4</td>
<td>45 gradual 6 months</td>
<td>-4.1</td>
</tr>
<tr>
<td>5</td>
<td>50 slow 8 months</td>
<td>-4.7</td>
</tr>
</tbody>
</table>

* Based on 1990 visitor industry revenues of $9.4 billion.

Figure 3.6 shows 5 alternate recovery paths including the path used to estimate losses. In path 3, the base case, visitor numbers fall to 40 percent of normal for 5 months after the spill, then gradually return to normal levels in 12 months. The values of the bolded parameters were varied slightly to test the sensitivity of the results. Alternative paths included a range in the decline of visitor numbers from 30 to 50 percent, low times from 2 to 8 months, and recovery times from 9 to 20 months. Recovery rates examined were from steady to gradual.
Recovery Paths

Five different recovery paths were generated based on: expected reduction in visitor numbers immediately following the spill, the amount of time that visitor numbers are expected to remain at that level, the rate of recovery, and the length of time to full recovery. The 5 paths were generated from the 4 models shown in Table 3.2. In the models, \( t \) is time measured in number of months after the spill, \( \rho \) represents the percentage below normal visitor numbers at time \( t \), \( \alpha_0 \) is the percentage below normal numbers immediately following the spill (the lowest that visitor numbers are expected to fall), and \( \delta \) is the number of months that visitor numbers will remain at \( \alpha_0 \). The variable \( \beta \) represents the recovery model parameter and \( T \) is the total number months after the spill required for visitor numbers to return to normal. Where \( \beta \) is defined to be the percentage below normal visitor numbers.

<table>
<thead>
<tr>
<th>Recovery rate</th>
<th>Model type</th>
<th>Model</th>
<th>Recovery parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>steady</td>
<td>linear</td>
<td>( \rho_t = \alpha_0 - \beta_t(t - \delta) )</td>
<td>( \beta_t = \frac{\alpha_0}{T - \delta + 1} )</td>
</tr>
<tr>
<td>steady-gradual</td>
<td>exponential</td>
<td>( \rho_t = \alpha_0 e^{-\beta t (t - \delta)} )</td>
<td>( \beta_t = \frac{\ln 2}{T - \delta + 1} )</td>
</tr>
<tr>
<td>gradual-steady</td>
<td>quadratic</td>
<td>( \rho_t = \alpha_0 - \beta_n(t - \delta)^2 )</td>
<td>( \beta_n = \frac{\alpha_0}{(T - \delta + 1)^2} )</td>
</tr>
<tr>
<td>gradual</td>
<td>cubic</td>
<td>( \rho_t = \alpha_0 - \beta_m(t - \delta)^3 )</td>
<td>( \beta_m = \frac{\alpha_0}{(T - \delta + 1)^3} )</td>
</tr>
</tbody>
</table>

\( \rho_t = \begin{cases} 
\alpha_0 & \text{if } t \leq \delta \\
\rho_t & \text{if } \delta < t \leq T \\
0 & \text{if } t > T 
\end{cases} \)

Results from the sensitivity tests ranged from $1.3 billion to $6.8 billion in losses for the 2 years following the catastrophic oil spill. First and second year losses for the 5 alternate scenarios appear in Table 3.1.
Statewide Sector Effects

Of the estimated $3.06 billion lost in visitor and visitor-related expenditures, $783 million will be lost to the hotel and real estate sector and $483 million will be lost to eating and drinking establishments. Together the losses to the hotels and eating and drinking establishments will account for about 38 percent of the total revenue lost to the visitor industry. In the hotel and real estate sectors, 18,900 employees will be laid off. The eating and drinking sector will release 15,800 employees. The loss of jobs between these two sectors account for about 52 percent of the 67,000 jobs lost due to the oil spill. The economic effect of an oil spill on the primary visitor industry sectors is shown in Tables 3.3 and 3.4. The repercussive effects to the rest of the economy are estimated to be an additional loss in total sales of $1.45 billion. This figure is based on expected 1990 total sales of $14.095 billion.

Table 3.3. Economic effects of the spill on sector revenues, employment, and household income

<table>
<thead>
<tr>
<th>Industry</th>
<th>Revenues* from visitor expenditures ($ Million)</th>
<th>Revenues ($ Million)</th>
<th>Jobs (1,000)</th>
<th>Household income ($ Million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>46.0</td>
<td>14.7</td>
<td>.19</td>
<td>14.4</td>
</tr>
<tr>
<td>Textile and apparel</td>
<td>78.9</td>
<td>25.2</td>
<td>1.02</td>
<td>15.4</td>
</tr>
<tr>
<td>Other manufacturing</td>
<td>234.0</td>
<td>74.9</td>
<td>2.02</td>
<td>38.9</td>
</tr>
<tr>
<td>Air transportation</td>
<td>629.6</td>
<td>201.5</td>
<td>4.58</td>
<td>114.9</td>
</tr>
<tr>
<td>Other transportation</td>
<td>243.6</td>
<td>78.0</td>
<td>1.27</td>
<td>64.6</td>
</tr>
<tr>
<td>Wholesale trade</td>
<td>203.8</td>
<td>65.2</td>
<td>2.40</td>
<td>59.4</td>
</tr>
<tr>
<td>Eating and drinking establishments</td>
<td>1,508.6</td>
<td>482.8</td>
<td>15.82</td>
<td>274.8</td>
</tr>
<tr>
<td>Other retail trade</td>
<td>805.9</td>
<td>257.9</td>
<td>12.56</td>
<td>257.9</td>
</tr>
<tr>
<td>Hotel and real estate</td>
<td>2,446.9</td>
<td>783.0</td>
<td>18.91</td>
<td>665.6</td>
</tr>
<tr>
<td>Other services</td>
<td>594.5</td>
<td>190.3</td>
<td>8.31</td>
<td>157.9</td>
</tr>
<tr>
<td>Remaining sectors</td>
<td>3,345.3</td>
<td>886.5</td>
<td>0.01</td>
<td>7.0</td>
</tr>
<tr>
<td>Total</td>
<td>10,137</td>
<td>3,060</td>
<td>67.09</td>
<td>1,671</td>
</tr>
</tbody>
</table>

*Source: Department of Business and Economic Development, 1990.

Table 3.4. Proportionate economic losses by sector

<table>
<thead>
<tr>
<th>Industry</th>
<th>Revenues from visitor expenditures ($ M)</th>
<th>Revenues (percent)</th>
<th>Household income (percent)</th>
<th>Jobs (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>46.0</td>
<td>0.5</td>
<td>0.9</td>
<td>0.3</td>
</tr>
<tr>
<td>Textile and apparel</td>
<td>78.9</td>
<td>0.8</td>
<td>0.9</td>
<td>1.5</td>
</tr>
<tr>
<td>Other manufacturing</td>
<td>233.98</td>
<td>2.3</td>
<td>2.3</td>
<td>3.0</td>
</tr>
<tr>
<td>Air transportation</td>
<td>629.6</td>
<td>6.2</td>
<td>6.9</td>
<td>6.8</td>
</tr>
<tr>
<td>Other transportation</td>
<td>243.6</td>
<td>2.4</td>
<td>3.7</td>
<td>1.9</td>
</tr>
<tr>
<td>Wholesale trade</td>
<td>203.8</td>
<td>2.0</td>
<td>3.6</td>
<td>3.6</td>
</tr>
<tr>
<td>Eating and drinking establishments</td>
<td>1,508.6</td>
<td>14.9</td>
<td>17.0</td>
<td>23.6</td>
</tr>
<tr>
<td>Other retail</td>
<td>805.9</td>
<td>7.9</td>
<td>15.4</td>
<td>18.7</td>
</tr>
<tr>
<td>Hotel and real estate</td>
<td>2,446.9</td>
<td>24.1</td>
<td>39.8</td>
<td>28.2</td>
</tr>
<tr>
<td>Other services</td>
<td>594.5</td>
<td>5.9</td>
<td>9.5</td>
<td>12.4</td>
</tr>
<tr>
<td>Remainder</td>
<td>3,345.3</td>
<td>33.0</td>
<td>&lt;&lt;1</td>
<td>&lt;&lt;1</td>
</tr>
<tr>
<td>Total</td>
<td>10,137.12</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

*Data Source: Department of Business and Economic Development, 1990.
Ocean Recreation Industry Effects

MacDonald and Deese (1987 and 1989) conducted studies to categorize ocean industries in Hawaii. Their findings showed that the ocean industry comprises the aquaculture, commercial fishing, ocean research, seafood marketing, maritime, and ocean recreation industries. The ocean recreation industry includes businesses involved with: recreational fishing, ocean cruise ships, charter boat fishing, diving, surfing, ocean tours, yachting, swimming races, and canoeing. Ocean recreation supports 34 percent of the people employed in the ocean industry. Ocean recreation industry revenues for 1990 were $481 million, predominantly from visitors. The studies showed that the ocean recreation industry exhibited high growth rates and had a large potential for further growth.

Estimation Procedures and Results

An expert panel comprised of 6 representatives from the ocean recreation industry were surveyed to elicit their opinion on how a catastrophic oil spill would affect their industry. Their mean response revealed that industry revenues would fall to 40 percent below normal for the first 5 months following the spill, then would gradually return to normal 14 months after the spill. The quadratic model was used to simulate the recovery path.

An analysis of the results suggested that annual industry revenues would fall 36 percent during the first 12 months following the spill, and two percent during the second 12 months following the spill. Thus, total industry losses are expected to be $171 million in the first year and $9.6 million in the second year. A spill of this magnitude could be expected to severely dampen the strong growth potential exhibited by this industry.

Oahu Effects

The economic damages from the oil spill will be most severe on Oahu. Expert opinion suggested that for the first 5-1/2 months after the spill, visitor numbers on Oahu will be 55 percent below normal. Afterward, visitor numbers will grow slowly and fully recover in 15 months. As a result, Oahu business revenues will be down 51 percent during the first year after the spill, and 5 percent during the second year. Thus, of the $3.06 billion in losses to the state, $2.9 billion will be lost to businesses on Oahu. The decline in Oahu visitor numbers in the second year after the spill will be nullified statewide by an equivalent increase in the number of visitors travelling to the other islands.

Oahu Hotel Industry Effects

In 1989, visitors to Hawaii spent about $4.2 billion on hotel lodging. Japanese visitors spent about $159 per day and mainland United States and Canadian visitors spent about $50 per day on lodging (Hawaii Visitors Bureau, 1990.)

Research Methods and Results

To estimate the economic effect of a catastrophic oil spill on the hotel industry, hotel managers were asked to record their expectations about the decline in hotel occupancy following the spill, to choose an expected rate of recovery, and to detail their management policy under such hardship conditions.

Surveys were mailed to the general managers of all 80 hotel properties on Oahu. Managers that failed to respond to the survey after 6 days were contacted by phone and encouraged to respond. By the conclusion of

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1Based on the calculations made by MacDonald and Deese (1980) using a constant growth scenario of 16% for 1986-1990.
the study, 14 usable responses from small, medium, and large establishments were returned. The responses represented 17 percent of Oahu's 30,142 hotel rooms.

Managers were asked to indicate the monthly decline in occupancy for their hotel for each of the 15 months following the catastrophic oil spill. Their responses were weighted by the number of hotel rooms they managed. Results showed that hotel general managers, on average, expect occupancy rates to drop more than 50 percent below normal during the first four months after the spill. Subsequently, occupancy rates are expected to rise steadily. Fifteen months after the oil spill, occupancy rates are expected to be seven percent below normal. The mean response appears in Table 3.5.

<table>
<thead>
<tr>
<th>Year 1</th>
<th>Percent Decline</th>
<th>Year 2</th>
<th>Percent Decline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Month</td>
<td></td>
<td>Month</td>
<td></td>
</tr>
<tr>
<td>November</td>
<td>0</td>
<td>November</td>
<td>9.66</td>
</tr>
<tr>
<td>December</td>
<td>50.20</td>
<td>December</td>
<td>8.03</td>
</tr>
<tr>
<td>January</td>
<td>55.51</td>
<td>January</td>
<td>7.80</td>
</tr>
<tr>
<td>February</td>
<td>54.51</td>
<td>February</td>
<td>7.06</td>
</tr>
<tr>
<td>March</td>
<td>54.16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>April</td>
<td>49.41</td>
<td></td>
<td></td>
</tr>
<tr>
<td>May</td>
<td>38.97</td>
<td></td>
<td></td>
</tr>
<tr>
<td>June</td>
<td>32.70</td>
<td></td>
<td></td>
</tr>
<tr>
<td>July</td>
<td>24.60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>August</td>
<td>23.83</td>
<td></td>
<td></td>
</tr>
<tr>
<td>September</td>
<td>19.46</td>
<td></td>
<td></td>
</tr>
<tr>
<td>October</td>
<td>16.70</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

To estimate the effect of occupancy decline on hotel revenues, mean room rates of $150 per day were used. Lost hotel revenues for the 15 months after the spill were estimated to be $441 million.

Hotel managers were also asked to estimate the recovery rate to normal occupancy levels after the spill. The expected rate of recovery by the respondents was mixed. Six hotel managers expected rapid recovery, 2 expected a steady rate of recovery, and 6 expected a gradual rate of recovery. Respondents indicated occupancy rates would return to normal in about 12 months.

Hotel managers indicated that they would reduce labor costs by 33 percent and overhead costs by 27 percent. In the event of a catastrophic oil spill, 89 percent of respondents said they would also use discounts, advertisements, and public relations promotions to boost occupancy rates. In 1991, the legislature spent over $6 million to promote the hotel industry after the Persian Gulf war (Towill, 1992).

The hotel sector is an important part of the visitor industry. This study offered insight into the risk of a catastrophic oil spill to the hotel sector by using the experience of hotel general managers to forecast short-term hotel vacancies following a spill. A more detailed study would be needed to assess long-term losses, hotel failures, promotion costs, job losses, and the losses to other businesses linked to the hotel industry.
Summary

Hawaii’s visitor industry is a growing and vital component of the state’s economy. Oil spills in other locations, and previous natural disasters in Hawaii suggest that an oil spill off the island of Oahu would result in a severe decline in the number of visitors to Hawaii and a correspondingly large reduction in visitor revenues. Economic estimates indicate that visitor industry revenues would decline by 32 percent in the first year after the spill and cause a loss of $3.06 billion dollars in revenues to the visitor industry. Revenue losses to the ocean recreation industry were estimated to be $180 million and losses to Oahu hotels were estimated to be $441 million. The repercussive effects of this shock will likely be felt through the entire economy. The secondary losses in sales were estimated to be $1.45 billion. An oil spill of this magnitude would deal a devastating blow to the entire state economy. The results reported in this study were confined to a single-spill scenario. The economic effects of alternative spill scenarios could readily be evaluated with the methods described here.

Recommendations

Editor’s note: The recommendations that follow are based on the findings of our research. As indicated in italics, the DOH notes that some of the recommendations are already in the process of being implemented by the appropriate agencies.

The Department of Business, Economic Development and Tourism and the Office of State Planning should develop an economic recovery contingency plan that would include the ability to:

1. Deploy the large numbers of workers in tourism-related businesses to other jobs.

2. Provide social services, including speeding up workmen’s compensation and medical and healthcare assistance.

3. Arrange for early departure of tourists who wish to leave the islands because of oiled beaches.

In addition, procedures for recovering lost wages for employees of affected businesses should be discussed with federal government representatives.

References


Hawaii Visitors Bureau, Market Research Department. 1990 Visitor Plant Inventory Report.

Hawaii Visitors Bureau, Market Research Department. 1989 Westbound Visitors to Hawaii.


Towill, M.E. 1992. Statement before the Committee on Tourism and Recreation House Committee on Tourism, State Department of Business, Economic Development and Tourism.
CHAPTER 4

THE IMPACT OF AN OIL SPILL ON HAWAII'S NATURAL ENVIRONMENT:

A GENERAL OVERVIEW

Kim Des Rochers
Introduction

The potential impacts of an oil spill on Hawai‘i’s natural environment range from inconsequential to disastrous. The factors which determine the intensity of a spill include: the amount and type of oil spilled, the location of the accident, physiography of the coastline, the time of day, and the height of the tide. For example, an oil spill that is carried shoreward to a reef flat when neap tide coincides with low tide would cause maximum damage to exposed reef flats and tide pools which would come into direct contact with oil. Numerous marine organisms including corals, algae, crustaceans, and other invertebrates would be killed. Undoubtedly, the worst possible situation would be an oil spill off French Frigate Shoals in the Northwestern Hawaiian Islands (NWHI) either during the breeding and nesting season for seabirds, or the pupping and hatching period for endangered monk seals and threatened sea turtles.

It is sometimes difficult to determine which biological effects can be directly attributed to oil as many marine species exhibit seasonal variations in abundance and sensitivity to stress. In addition, different organisms react to oil pollution in different ways. It is generally believed that coastal and estuarine environments, especially the intertidal region, are far more sensitive to oil pollution than the open ocean. These areas are habitats for a greater number and diversity of nearshore marine organisms as well as of many oceanic species during their juvenile stage. Local biologists and zoologists are not in complete agreement as to which organisms will be most affected by an oil spill and to what degree they will be impacted. This is due, in part, to lack of experience. To date, Hawai‘i has been fortunate in that it has not experienced a spill of the magnitude of the Exxon Valdez. We must therefore look to the experiences and research elsewhere. Much of the oil spill literature deals with temperate or polar regions. Only recently have there been data on the impacts of oil in tropical areas, particularly on coral reefs and mangroves, but no field studies have addressed the impacts of oil in Hawai‘i waters. In addition, baseline studies may be either lacking or inadequate to make pre-spill and post-spill statistical analyses. Thus, this section references studies from other locations and applies them, as appropriate, to Hawai‘i in order to develop an understanding of what is likely to occur here in the event of a major oil spill.

This report treats various parts of the environment discretely for ease of discussion and analysis. However, it should be understood that numerous species of fish, crustaceans, invertebrates, as well as turtles and mammals are mutually interactive within Hawai‘i’s marine environment.

Corals and Coral Reefs

Coral reefs are one of the most diverse and biologically productive ecosystems on earth (Goreau et al. 1979). Their high productivity is the result of efficient biological recycling and a high retention of nutrients in an otherwise nutrient-poor environment. Coral reefs are tropical, shallow-water ecosystems restricted to latitudes 25° to 30° North and South and year-round surface water temperatures of 25° to 30°C (Randall and Myers, 1983). Hermatypic corals (i.e. reef-building or stony corals) are multicellular animals which collectively secrete the hard external skeleton of calcium carbonate that form reef structures. These reefs provide habitats for a wide variety of marine organisms such as fish, sea turtles, marine mammals, crustaceans, and invertebrates. A critical aspect of reef-building corals is their symbiotic relationship with the unicellular algae, zooxanthellae. The algae live, conduct photosynthesis, and process the coral’s waste products all within the cells of their host. The entire biological productivity of the coral reef ecosystem rests on this symbiotic relationship (Goreau et al. 1979).

Corals have very specific requirements for light, temperature, water clarity, salinity, and oxygen. Coral growth is relatively slow, especially in areas where sediments are regularly disturbed because silted substrates prevent larval settlement. If light penetration is decreased, there is a reduction in photosynthesis by the zooxanthellae algae. Most corals, therefore, are restricted to depths of less than 30 meters. Their lack of mobility makes them vulnerable to environmental disturbances such as oil spills through smothering and oxygen depletion.
Coral reefs in Hawaii are fairly well developed but display low species diversity because of Hawaii’s extreme isolation and more northerly latitude (International Union for Conservation of Nature and Natural Resources, 1988). The best developed reefs in Hawaii are found on leeward (south and southwestern) coasts or in bays which are sheltered from wave action. Examples include the Kona Coast of Hawaii; the south coast of west Maui; north coast of Lanai and Kauai; Kaneohe Bay, Hanauma Bay, and Barber’s Point, Oahu; and the lagoons of the NWHI.

**Effects of Oil on Coral**

The impact of oil on coral reefs has been the subject of much research in the last two decades (Reimer, 1975; Loya and Rinkevich, 1980; Bak, 1987; Knap, 1987; Loya and Rinkevich, 1987; Burns and Knap, 1989). Of particular concern are oil terminals, tanker traffic, refineries, and offshore oil reserves adjacent to coral reefs. The long-term effects of oil and petroleum hydrocarbons on corals are poorly understood but short-term effects have been discussed (Reimer, 1975; Loya and Rinkevich, 1979; Knap, 1987; Burns and Knap, 1989).

Loya and Rinkevich (1987) remark that although major spills make the headlines of newspapers, “the smaller day-to-day spills in coastal waters produce chronic pollution that is much larger in total volume and probably more severe in biological consequences.” In contrast, another researcher (Ray, 1981) has written that, “The single largest threat to coral reef areas is the one-time large oil spill.” In 1975, Johannes wrote, “To date there appears to be no conclusive evidence that floating oil above reef corals damages them.” There is increasing evidence, however, which indicates that petroleum hydrocarbons have serious detrimental effects on the production, growth rate, cell structure, colonization, feeding and behavioral responses of corals and on the photosynthesis of its symbiotic zooxanthellae algae (Reimer, 1975; Birkeland et al. 1976; Rinkevich and Loya, 1977; Cook and Knap, 1983). A study which tested the effects of crude oil and oil dispersant on four species of Caribbean corals indicated that both types of pollutants have harmful effects on corals at concentrations of 100 to 500 parts per million (Lewis 1971). It has been suggested that although oil may not always cause immediate mortality or other visible damage, it undoubtedly has long-term physiological effects which shorten the survival and normal behavior of corals and further, that:

"...corals are among the most important organisms in tropical reef communities, both by providing habitat for other organisms and by entering in the overall metabolism of the reef community. Any changes in their physiology, however subtle will probably cause a very dramatic change in the overall ecology of the reef." (Reimer, 1975):

The vulnerability of coral reefs to oil spill damage varies with reef type, zonation patterns, and tidal actions (Fucik et al. 1984). As an example, the seaward-facing side of a fringing reef (e.g. West Maui) is exposed to high wave action. In this situation, oil will probably have a short residence time before it is dispersed through natural means. In contrast, wave action on reef flats (e.g. Black Point, Oahu) is quite low. Oil here would be expected to have a relatively longer residence time with a correspondingly higher risk of damage, particularly in tidepools (Fucik et al. 1984). Oil impacts corals and organisms associated with coral reefs by smothering and by the uptake of water-soluble fractions within the water column. If there is significant damage to corals, the entire reef community may collapse. Table 4.1 lists stress responses of corals exposed to oil and oil fractions.

The premature release of coral larvae has been described by Loya and Rinkevich (1979). Under normal environmental conditions, the coral, *Stylophora pistillata*, releases its larvae at night. However, in the presence of low concentrations of crude oil, *S. pistillata* releases its larvae immediately, with no connection to time, day or night. The larvae are therefore expelled into an oil polluted environment containing water-soluble fractions of crude oil which decrease the larva’s chances of survival and colonization.
Table 4.1. Stress responses shown by corals exposed to oil and oil fractions

<table>
<thead>
<tr>
<th>Responses</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Larval death</td>
<td>Rinkevich and Loya, 1977</td>
</tr>
<tr>
<td>Impaired feeding response</td>
<td>Reimer, 1975; Lewis, 1971</td>
</tr>
<tr>
<td>Gonad damage</td>
<td>Rinkevich and Loya, 1979; Peters et al. 1981</td>
</tr>
<tr>
<td>Premature expulsion of larvae</td>
<td>Loya and Rinkevich, 1979; Cohen et al. 1977</td>
</tr>
<tr>
<td>Impaired larval settlement</td>
<td>Rinkevich and Loya, 1977</td>
</tr>
<tr>
<td>Change in calcification rate</td>
<td>Birkeland et al. 1976; Neff and Anderson, 1981</td>
</tr>
<tr>
<td>Decreased zooxanthellae production</td>
<td>Neff and Anderson, 1981</td>
</tr>
<tr>
<td>Impaired sediment clearance ability</td>
<td>Bak and Elgershuizen, 1976</td>
</tr>
<tr>
<td>Increased mucus production</td>
<td>Mitchell and Chet, 1975</td>
</tr>
</tbody>
</table>

Data Source: after Fucik et al. 1984.

Table 4.2. Percentage of live tissue left on the coral, Pocillopora damicornis after one minute of exposure to oil

<table>
<thead>
<tr>
<th>Colony no.</th>
<th>Type oil*</th>
<th>7 days</th>
<th>13 days</th>
<th>16 days</th>
<th>20 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>MD</td>
<td>86</td>
<td>1</td>
<td>0</td>
<td>—</td>
</tr>
<tr>
<td>2</td>
<td>MD</td>
<td>91</td>
<td>16</td>
<td>0.8</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>BC</td>
<td>92</td>
<td>53</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>BC</td>
<td>92</td>
<td>30</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>BC</td>
<td>92</td>
<td>16</td>
<td>0</td>
<td>—</td>
</tr>
<tr>
<td>6</td>
<td>control</td>
<td>97</td>
<td>96</td>
<td>96</td>
<td>95</td>
</tr>
<tr>
<td>7</td>
<td>control</td>
<td>99</td>
<td>99</td>
<td>99</td>
<td>97</td>
</tr>
</tbody>
</table>

* MD = marine diesel  BC = bunker C

Data Source: Reimer, 1975

Recovery Rates of Oiled Reefs

Data on coral reef recovery time from oil pollution are scarce although several studies have described recovery rates of coral after severe storms, hurricanes, and predation by crown-of-thorns starfish. These examples,
however, report extensive damage whereas the damage resulting from an oil spill would most likely be restricted to the upper surfaces of the reef. Loya (1975, 1980) reports that the chronically oiled reef flats in the Red Sea show little or no potential for recolonization, even 10 years after initial damage.

### Impacts of Oil Pollution on Tropical Marine Communities

Much of the world’s oil production and tanker traffic occurs in the tropics and subtropics (Vandermeulen and Gilfillan, 1984). At least 100 loaded tankers travel in Caribbean waters at any one time (Vandermeulen and Gilfillan, 1984) and over half the world’s oil passes through the Arabian Gulf. Estimates of the quantity of oil released into the Gulf since the recent war range from one to 11 million barrels (Sheppard and Price, 1991). Approximately three billion gallons of oil are shipped to Hawaii annually from the mainland United States and Asia. Table 4.3 outlines oil spills that have occurred near coral reefs throughout the world.

**Table 4.3. Reported oil spills near coral reefs**

<table>
<thead>
<tr>
<th>Year</th>
<th>Location</th>
<th>Amount and type of oil spill</th>
<th>Reported effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>WW II, name unknown, Dry Tortugas</td>
<td>??</td>
<td>Young mangroves killed</td>
<td></td>
</tr>
<tr>
<td>1957, Tampico Maru, Baja California, Mexico</td>
<td>7,153 tons, type ??</td>
<td>Many invertebrates and fish killed; abundance of certain species changed 12 years after the wreck</td>
<td></td>
</tr>
<tr>
<td>1962, Areca Prima, Puerto Rico</td>
<td>10,000 tons, crude oil</td>
<td>Death of adult and juvenile lobsters, crabs, anemones, sea urchins, sea cucumbers, gastropods, octopuses, and fish. Thalassia beds degenerated, rocky areas demoded of algae, extensive damage to mangrove habitat</td>
<td></td>
</tr>
<tr>
<td>1967, R.C. Stoner, Wake Island</td>
<td>22,000 tons gasoline, jet and turbine fuel, Bunker C</td>
<td>About 2,500 kg of nearshore reef fish killed and stranded on shore; snails and sea urchins found dead in large numbers; gasoline or black oil thought to be lethal to fish</td>
<td></td>
</tr>
<tr>
<td>1968, Ocean Eagle, San Juan, Puerto Rico</td>
<td>??</td>
<td>Many intertidal organisms killed or damaged by oil and emulsifier, including fish, molluscs, and algae</td>
<td></td>
</tr>
<tr>
<td>1968, General-Coconut oil installation, Eleuthera, Bahamas</td>
<td>4,500 tons crude oil</td>
<td>Few details on biological damage</td>
<td></td>
</tr>
<tr>
<td>1968, Winwin, Galera Island, Panama Canal</td>
<td>20,000 barrels diesel oil &amp; Bunker C</td>
<td>Harmful effects to meiofauna; mangroves reduction of fiddler crab population; elimination of algae and sedentary animals on mangrove silt pools</td>
<td></td>
</tr>
<tr>
<td>1970, pipeline break, Tarut Bay, Saudi Arabia</td>
<td>100,000 barrels, Arabian light crude</td>
<td>Mortality suffered by crabs, bivalves, gastropods, and numerous fish; no detrimental effects on corals and associated fauna</td>
<td></td>
</tr>
<tr>
<td>1970, Oceania Grandeur, Torres Strait, Australia</td>
<td>1,100 tons, crude oil</td>
<td>Heavy mortalities of pearl oysters near Thursday Island</td>
<td></td>
</tr>
<tr>
<td>1970, unknown tanker, Ponce de Leon, coral reef on Florida Keys, USA</td>
<td>200,000 barrels, asphaltic</td>
<td>No oil came ashore; no apparent effect on wildlife</td>
<td></td>
</tr>
<tr>
<td>1971, MV Solar Trader, West Fuyu, Caroline Is., Micronesia</td>
<td>520 tons, fuel and lubricating oil</td>
<td>Numerous dead lobsters and crabs; survey made eight months after spill indicated large algal growth on corals</td>
<td></td>
</tr>
<tr>
<td>1973, Zoe Colocotronis, Puerto Rico</td>
<td>1.5 million gallons of Venezuelan</td>
<td>Within 48 hours of spill, dead urchins.</td>
<td></td>
</tr>
<tr>
<td>Year, tanker, location</td>
<td>Amount and type of oil spill</td>
<td>Reported effects</td>
<td></td>
</tr>
<tr>
<td>-----------------------</td>
<td>-----------------------------</td>
<td>------------------</td>
<td></td>
</tr>
<tr>
<td>1974, <em>Sygna</em>, Stockton Bight, East Coast Australia</td>
<td>400 tons, heavy fuel</td>
<td>Cucumbers, conchs, and prawns wash upon shore; red and black mangroves defoliated, and three years afterward, oil persists in soil</td>
<td></td>
</tr>
<tr>
<td>1975, <em>MV Lindenbank</em>, Fanning Atoll, Pacific Ocean</td>
<td>10,000 tons, copra, palm oil, coconut oil, cocoa beans</td>
<td>13 km of beaches affected; no reported damage to marine life</td>
<td></td>
</tr>
<tr>
<td>1975, name ??, Florida Keys, USA</td>
<td>up to 3,000 barrels, crude</td>
<td>Fish, crustaceans, and molluscs killed; complete recovery of original coralline algal community after 11 months</td>
<td></td>
</tr>
<tr>
<td>1978, Numerous accidents and oil discharges, Caribbean</td>
<td>76 million barrels per year</td>
<td>Mass mortality of pearl oysters and mangrove seedlings; decline in crabs and <em>Nerita</em> sp</td>
<td></td>
</tr>
<tr>
<td>1969-1980, two oil terminals, Lack Ilit, Red Sea, Israel</td>
<td>Many small scale spills Iranian crude</td>
<td>No damage to marine life reported</td>
<td></td>
</tr>
<tr>
<td>1978-1980, well drilling, Palawan Islands, Philippines</td>
<td>unknown, drilling mud</td>
<td>Decrease in coral and fish diversity of colonization by stony corals in reefs chronically polluted by oil; damage to coral reproductive systems</td>
<td></td>
</tr>
<tr>
<td>1982, <em>Kyoten Maru</em>, Lihou Reef, Great Barrier Reef, Australia</td>
<td>450 tons, fuel oil</td>
<td>70-90% reduction in corals in an area that extended up to 115 meters out from wheelheads; coelobitic community was greatly disturbed within 40 meters of well site</td>
<td></td>
</tr>
<tr>
<td>1982, 2 incidents, Red Sea, Egypt</td>
<td>250,000 tons type ??</td>
<td>No damage to marine life reported</td>
<td></td>
</tr>
<tr>
<td>1986, ruptured storage tank, Bahia las Minas, Panama</td>
<td>45,000 barrels crude oil</td>
<td>Severe pollution on beaches</td>
<td></td>
</tr>
<tr>
<td>1987, interstand barge, Molokai Channel, Hawaii</td>
<td>42,000 gallons crude</td>
<td>Intertidal mangroves, seagrasses, algae, associated invertebrates were covered in oil and died soon after; extensive mortality of subtidal reef corals and infauna of seagrass beds</td>
<td></td>
</tr>
<tr>
<td>1987, ruptured pipeline, Middle Loch, Pearl Harbor, Oahu, Hawaii</td>
<td>120,000 gallons</td>
<td>Ophi, limu, and sand crabs dead in tidepools; one green sea turtle found dead</td>
<td></td>
</tr>
<tr>
<td>1989, <em>Exxon Houston</em>, Barber’s Point, Oahu, Hawaii</td>
<td>34,000 gallons</td>
<td>Wildlife refuge hit; several endangered birds killed</td>
<td></td>
</tr>
<tr>
<td>1990-1991, Gulf War, Persian Gulf</td>
<td>~1-11 million barrels</td>
<td>No reports of oiled fish, birds, or marine mammals</td>
<td></td>
</tr>
</tbody>
</table>


**Coral Reef Ecosystems**

In 1986, over two million gallons of crude oil were spilled near the east entrance of the Panama Canal (Jackson et al. 1989). This region is comprised of mangroves, seagrasses, and coral reefs. The type and magnitude of effects varied greatly with coastal topography and location and among habitats and taxa. Entire beds of the intertidal seagrass, *Thalassia*, were killed on the heavily oiled reef flats. In contrast, subtidal *Thalassia* survived everywhere after the spill. Seagrass beds provide important habitat and food for numerous species of fish and invertebrates. On the intertidal reef flat, the most extensive damage occurred at the seaward border, where the oil accumulated at low tide. Previously, zoanthids, hydrocorals, and stony corals were the most common sessile organisms in this region. Within several days of oiling, populations of the sea urchin, *Echinometra lucunter*, were reduced by 80 percent and the reef flat was strewn with urchin skeletons. On
subtidal reefs, the abundance of common species of stony corals in depths equal to and less than three meters decreased by 50 to 96 percent and total coral cover decreased by 76 percent. Even at depths of 9 to 12 meters the drop in abundance was 45 percent (Jackson et al. 1989). In summary, the spill affected organisms in all trophic levels (i.e., from producers up through the carnivores) and in both intertidal and subtidal environments. This was the first time that extensive mortality of subtidal corals and seagrasses associated had been demonstrated. The results of the study challenged long-held beliefs that corals and associated organisms are not affected by oil spills. The authors point out the importance of detailed long-term ecological studies and the dangers inherent in extrapolating laboratory data to natural populations.

On March 18, 1973, the tanker Zoe Colocotronis spilled over 1.5 million gallons of Venezuelan crude oil near Cabo Rojo, southern Puerto Rico. Approximately one million gallons washed ashore and contaminated beaches, sea grass beds, and rocky shore communities. Within two days, dead or near-dead invertebrates such as urchins, sea cucumbers, prawns, and conchs began washing up on shore. Red and black mangroves in one area defoliated and died during the three years following the spill. In addition, soil analyses taken three years after the spill indicated the persistence of significant levels of petroleum hydrocarbon residues in mangrove soil (Nadeau and Bergquist, 1977).

It has been argued that petroleum hydrocarbons are rapidly degraded in tropical marine environments in comparison to oil in temperate regions. However, 11 years later, in a follow-up study of the Zoe Colocotronis spill, petroleum contaminants are still evident in intertidal sediments (Corredor et al. 1990). The authors discovered a thick layer of weathered tar in mangrove soils at a depth of seven centimeters. This oily layer was not seen in soil samples taken from adjacent areas.

In the past five years, Hawaii has experienced three substantial oil spills. On January 20, 1987, 42,000 gallons of Bunker C fuel were spilled from an interisland barge during a transit of the Molokai Channel (U.S. Coast Guard Report, 1987a). Heavy fuel oil covered coastal windward Oahu from Hanauma Bay to Swanzy Beach. Makapuu Beach was considered to be the hardest hit. The porous lava rocks were extremely difficult to clean and tidepools suffered the most damage in terms of marine life. Limpets (opihu), seaweed (limu), and black sand crabs were found dead. Small reef fish were also found dead along the tide line (U.S. Coast Guard Report, 1987a). A young green sea turtle, found dead on Bellow's Beach, was also believed to be the victim of the oil spill. Four birds died as a result of the oiling and another 11 were treated at Sea Life Park, Waikamano, Oahu.

Four months later, on May 13, 1987, 120,000 gallons of jet fuel were released into the Middle Loch of Pearl Harbor. The cause of the spill was a ruptured pipeline carrying petroleum products from a Barber's Point refinery to a Honolulu distribution facility. The spill, which was adjacent to the Pearl Harbor National Wildlife Refuge, occurred during the nesting season for Hawaiian stilts, an endangered water bird. Of the 40 Hawaiian stilts that live at the refuge, one was found dead next to its nest of four eggs. Other casualties were two Hawaiian ducks (also an endangered species) — one found dead, the other seriously injured (U.S. Coast Guard Report, 1987b). Cleanup crews exacerbated the already existing problem by disturbing the birds and their nests during cleanup efforts. While the cleanup was underway, birds no longer sat on their nests and therefore exposed their eggs to the high daytime and the cool night-time temperatures.

A third spill occurred on March 2, 1989. In this particular case, the Exxon Houston was in the process of off-loading over 20 million gallons of Alaska crude oil when it broke away from its single-point mooring off of Barber's Point. Nearly 34,000 gallons of crude were spilled in the process. The U.S. Coast Guard (1989) reported "...wildlife impact was negligible. There were no reports of oiled fish, birds or marine mammals. There may have been damage sustained in the intertidal zone and this is the subject of damage assessments being conducted by appropriate resource trustees."
Extremely little has been written regarding the effect of oil on seaweeds. However, they are primary producers and as such, play an important role in the overall functioning of the food chain. In Hawaii, many herbivorous species of reef fish, crabs, urchins and other invertebrates depend on marine algae for a significant portion of their diet. Marine algae is the primary food source for green sea turtles feeding in Hawaiian waters (see section on sea turtles in this report). In addition to being a main food source for marine organisms, seaweeds have important cultural and nutritional value. Ewa Beach Park is considered to be one of the best seaweed foraging areas on Oahu. The most highly prized algae is limu manaua, or ogo. In Hawaii, seaweeds are found mainly on reef flats, protected tide pools, and wave-swept ledges and cliffs. The beginning of March to the middle of June is believed to be the period of maximum growth for most seaweeds. Algae are considered to be highly sensitive to oil pollution (Personal communication: John Naughton, National Marine Fisheries Service (NMFS), Honolulu, 1991). An oil spill occurring during the period of maximum growth would have adverse impacts not only on the algal population but on many reef organisms (e.g., sea turtles and herbivorous species of reef fish). On Oahu, the following areas have particularly rich species diversity: Maili Beach Park (Waianae), Oneula Beach Park to Barber’s Point, Chun’s Reef (Haleiwa) to Pupukea Beach Park, Malaekahana (Lael), Sandy Beach tide pools (Makapuu Point), and Black Point reef flats (Personal communication: Dr. Karla McDermid, Department of Zoology, University of Hawaii, 1991).

Mangroves and Mangrove Ecosystems

Mangroves are important in shoreline stabilization and as habitats and nurseries for many species of fish, crabs, shrimp, and other invertebrates. Complex adaptations of mangroves to their existence in salt water and anaerobic conditions, and their association with soft muddy or silty sediments render them highly vulnerable to oil pollution (Evans, 1985). In Hawaii, the mangroves, Bruguiera gymnorrhiza and Rhizophora mangle, are relatively recent introductions (1920s) and are found in limited stands on Oahu, Molokai, Lanai, and in small areas of Maui, Kauai, and Hawaii (Wester, 1981).

Effects of Oil on Mangroves

The prop roots of mangroves have numerous small pores through which oxygen enters. When oil comes into contact with the pores, they become clogged, thereby blocking the air passages which comprise the mangrove’s respiratory system. In addition, the highly organic, detritus-derived sediments that are held within the root system make mangroves especially susceptible to oil entrapment. Much of what is known about the effects of oil on mangroves have resulted from observations of accidental spills which demonstrated that mangroves are highly sensitive to oil (Chan, 1977; Vandermeulen and Gillilan, 1984; Evans, 1985). Death of trees is not always immediate and may occur years after a spill. Red and black mangroves continued to die three years after the Zoe Colocroni spill in Puerto Rico in 1977. In 1988, 11 years after the spill, weathered tar was still present in mangrove soils (Corredor et al. 1990).

Recovery Rates of Oiled Mangroves

The recovery rate of mangroves varies depending on the extent of oiling, the type of oil, and a wide variety of biological, ecological, physiological, and geomorphological factors. Recovery is not simply a matter of recolonization and growth of the mangrove trees themselves, but also of the fish, shrimp, crabs, crustaceans, and other associated organisms. There are no data available which predict the recovery time under a worst-case situation. However, Lewis (1971) suggests somewhere between 10 and 50 years for complete recovery from a devastating spill. Mangrove ecosystem recovery rates following severe storms and hurricanes suggest that totally devastated areas may take approximately 20 years.
The January 1987 oil spill in the Middle Loch of Pearl Harbor on Oahu could have spelled disaster for the mangroves and associated fauna. A scientist from NMFS described the nearby Pearl Harbor estuary as a "sensitive ecologic environment" where "mangroves are a component of the habitat which supports a bait fishery for the live-bait tuna fishery."

**Impacts of Oil Pollution on Temperate Marine Organisms**

It is beyond the scope of this report to discuss and review the impacts of oil and hydrocarbons on all marine organisms in Hawaii. There have been numerous in-depth and detailed studies regarding the long-term toxicological effects of oil on biological processes such as development, growth, photosynthesis, recruitment, feeding, and community stability. Although most of these studies have concentrated on temperate or cold water regions, the overall response of the organisms do give an indication of what can be expected to occur here in the event of a major oil spill. Table 4.4 illustrates the sublethal effects of oil on various species of shellfish.

Most benthic organisms spend their lives at the sea bottom, whether on the shore or below low tide levels. Organisms inhabiting the intertidal zone are at the greatest risk from an oil spill, particularly those found in tidepools and on exposed rocky shores (Personal communication: Dr. Alison Kay, Department of Zoology, University of Hawaii, 1991). Some, like limpets and cowries, attach themselves to rocks and move very slowly, travelling only short distances. Such organisms would be unable to move out of the path of an approaching oil spill. Tubeworms and bivalves are filter feeders and may take up oil while feeding. Gastropods, such as limpets and nerites which browse on algae, are vulnerable to oils which can penetrate the delicate tissues underneath their shells. Echinoderms (urchins and sea stars) are notoriously sensitive to any reduction in water quality and are therefore highly sensitive to oil pollution (Nelson-Smith, 1973). Shore crabs are scavengers and thus are quite likely to become adversely affected after feeding on oil-contaminated animals. The 7-11 crab (Hawaiian aama crab), feeds on marine algae which is highly susceptible to oil pollution (Personal communication: Dr. Karla McDermaid, Department of General Science, University of Hawaii, 1991).

In 1969, the harse *Florida* ran aground on a rocky shoal off West Falmouth, Massachusetts. Between 170,000 and 185,000 gallons of Number 2 fuel oil were spilled (Sanders et al. 1980). Strong winds churned the oil into an oil-water emulsion covering several miles of coastline. Mass mortality of macrofauna occurred in the intertidal and subtidal zones. Within eight to 10 days, carcasses of most soft-bodied animals completely decomposed. Mass mortality of the larger benthic organisms occurred immediately in the intertidal and subtidal zones. Physiological and behavioral disorders caused by the oil resulted in impairment of growth and reproduction. More than five years after the spill, the benthic fauna in the vicinity of the spill had still not recovered. Furthermore, Sanders et al. (1980) found that long after the visible traces of oil disappeared, various oil fractions were present in sizeable quantities in bottom sediments down to 13 meters in depth.
Table 4.4: Sublethal effects of oils on shellfish

<table>
<thead>
<tr>
<th>Oil Type</th>
<th>Species</th>
<th>Concentration (ppm*</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bunker C</td>
<td>Softshell clam</td>
<td>89</td>
<td>decreased growth and respiration</td>
</tr>
<tr>
<td>Alaskan crude</td>
<td>Pacific oyster</td>
<td>1,000</td>
<td>abnormal development</td>
</tr>
<tr>
<td>Iranian crude</td>
<td>Blue mussel</td>
<td>0.13</td>
<td>decreased byssal thread attachment</td>
</tr>
<tr>
<td>Auk crude</td>
<td>Blue mussel</td>
<td>1</td>
<td>decreased gill activity</td>
</tr>
<tr>
<td>Nigerian light crude</td>
<td>Softshell clam</td>
<td>0.31</td>
<td>decreased respiration</td>
</tr>
<tr>
<td>East Texas crude</td>
<td>Blue mussel</td>
<td>0.27</td>
<td>abnormal feeding</td>
</tr>
<tr>
<td>Cook Inlet crude</td>
<td>King crab</td>
<td>0.15</td>
<td>decreased molting success</td>
</tr>
<tr>
<td>No. 2 fuel oil</td>
<td>American lobster</td>
<td>0.08</td>
<td>decreased feeding</td>
</tr>
<tr>
<td></td>
<td>Grass shrimp</td>
<td>0.8</td>
<td>decreased growth</td>
</tr>
<tr>
<td></td>
<td>Blue mussel</td>
<td>0.15</td>
<td>increase of tumors</td>
</tr>
<tr>
<td>Venezuelan crude</td>
<td>American lobster</td>
<td>6</td>
<td>abnormal molting and development</td>
</tr>
<tr>
<td>South Louisiana crude</td>
<td>American lobster</td>
<td>0.25</td>
<td>decreased respiration</td>
</tr>
<tr>
<td></td>
<td>Softshell clam</td>
<td>50</td>
<td>increased mucus secretion</td>
</tr>
</tbody>
</table>

* parts per million


Seabirds

Population

The Hawaiian Islands are one of the most important seabird colonies in the world (Fefer et al. 1983). Between 5 and 6 million seabirds breed here; the total population, including non-breeding birds1, is over 15 million (U.S. Department of the Interior, 1986; Harrison, 1990). Approximately 95 percent of Hawaii’s seabirds are found in the NWHI (Table 4.5) (U.S. Department of the Interior, 1986). The total seabird population varies from season to season and many species are present in the colony only during certain months. As an example, black-footed albatrosses are abundant in the month of December but only a few are seen during September. In addition, seabird populations vary annually due to disease and changes in oceanographic conditions (Harrison, 1990). Twenty-two species of seabirds breed in the Hawaiian archipelago. Sooty terns account for over one-third the number of breeding pairs in Hawaii. Laysan albatrosses, Bonin petrels, and wedge-tailed shearwaters are the next numerous species. Harcourt’s storm petrels and dark-rumped petrels are the rarest. Laysan and Lisianski Islands support the largest seabird populations in the entire Hawaiian archipelago (Fefer et al. 1983).

Prior to human colonization, seabird numbers were much higher throughout the main islands and the northwestern islands. Newell’s shearwater, Hawaiian dark-rumped petrel, and Harcourt’s storm petrel are restricted to the main islands and are considered to be in danger of extinction (Fefer et al. 1983). Most seabirds which nest in the main islands are found on the offshore islets such as Manana (Rabbit) Island and Moku Manu.

In Hawaii, the breeding season for most seabirds is spring and summer. However, Laysan and black-footed albatrosses, Bonin’s and sooty storm petrels, and black noddis breed in the winter months (Harrison, 1990) in contrast to other tropical locations where seabirds breed year-round. The reason for this is that Hawaii is

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1 Non-breeding birds include young birds that have never bred before and adults that may have bred in previous years but not that year.
relatively far from the equator. A number of seabirds found in the NWHI are at the northern extent of their breeding range. In higher latitudes, seabird breeding is keyed to coincide with the greatest abundance of food. Hawaii’s subtropical location has characteristics that are somewhere between temperate and tropical waters. Goatfish, mackerel scad, and squid, the primary prey for seabirds, are most abundant during the spring and summer months (Harrison, 1990). Changes in the ecosystem structure and natural climatic and oceanographic fluctuations affect the amount and availability of food for seabirds which consume 8.82 billion pounds of fish, squid, crustaceans, and other marine organisms annually (Fefer et al. 1983).

Table 4.5. Estimated number of nesting seabirds, Hawaiian Archipelago

<table>
<thead>
<tr>
<th>Seabird</th>
<th>Population Main Hawaiian Islands</th>
<th>Population Northwestern Hawaiian Islands</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black-footed albatross (Diomedea nigripes)</td>
<td>20 – 70</td>
<td>36,240 – 49,410</td>
</tr>
<tr>
<td>Laysan albatross (Diomedea immutabilis)</td>
<td>205 – 300</td>
<td>291,361 – 379,570</td>
</tr>
<tr>
<td>Bonin petrel (Pterodroma hypoleuca)</td>
<td>0</td>
<td>203,330 – 331,250</td>
</tr>
<tr>
<td>Bulwer’s petrel (Bulweria bulwerii)</td>
<td>345 – 770</td>
<td>76,520 – 103,125</td>
</tr>
<tr>
<td>Wedge-tailed shearwater (Puffinus pacificus)</td>
<td>40,217 – 70,885</td>
<td>174,425 – 261,400</td>
</tr>
<tr>
<td>Christmas shearwater (Puffinus nativitatis)</td>
<td>115 – 185</td>
<td>2,170 – 2,960</td>
</tr>
<tr>
<td>Sooty storm petrel (Oceanodroma tristriata)</td>
<td>0</td>
<td>3,500 – 7,500</td>
</tr>
<tr>
<td>Red-tailed tropicbird (Phaethon rubricauda rothschildi)</td>
<td>487 – 820</td>
<td>8,360 – 11,235</td>
</tr>
<tr>
<td>Masked booby (Sula dactylatra personata)</td>
<td>208 – 414</td>
<td>2,035 – 2,370</td>
</tr>
<tr>
<td>Brown booby (Sula leucogaster plautus)</td>
<td>0</td>
<td>364 – 474</td>
</tr>
<tr>
<td>Red-footed booby (Sula sula rubripes)</td>
<td>1,450 – 2,300</td>
<td>4,190 – 5,110</td>
</tr>
<tr>
<td>Great frigatebird (Fregata minor palmerstoni)</td>
<td>255 – 361</td>
<td>7,860 – 9,850</td>
</tr>
<tr>
<td>Gray-backed tern (Sternula antillarum)</td>
<td>525 – 650</td>
<td>35,530 – 51,000</td>
</tr>
<tr>
<td>Sooty tern (Sterna fuscata eufaeumis)</td>
<td>105,500 – 160,000</td>
<td>930,750 – 1,330,500</td>
</tr>
<tr>
<td>Blue-gray noddy (Procelsterna cerulea saxatilis)</td>
<td>0</td>
<td>3,000 – 4,000</td>
</tr>
<tr>
<td>Brown noddy (Anous stolidus pileatus)</td>
<td>31,305 – 48,510</td>
<td>61,400 – 92,800</td>
</tr>
<tr>
<td>Black noddy (Anous minutus melancholica)</td>
<td>635 – 1,645</td>
<td>6,345 – 16,305</td>
</tr>
<tr>
<td>White tern (Gygis alba rothschildi)</td>
<td>80 – 140</td>
<td>7,415 – 14,930</td>
</tr>
</tbody>
</table>

Data Source: Harrison, 1990

Feeding Behavior

Some seabirds, such as the masked and red-footed booby, regularly forage as much as 80 miles from land returning late in the afternoon to nest. Laysan albatrosses are capable of flying over 240 miles per day in search of food. There are other species, however, that stay close to land. Unlike temperate zone species which feed on a limited number of fish and crustaceans, Hawaiian seabirds feed on a variety of prey including flying fish, flying fish eggs, squid, lanternfish, hatchetfish, goatfish, mackerel scad, dolphinfish, halibuteaks, saury, herring, lizardfish, sunfish, and cowfish (Fefer et al. 1983; Harrison, 1990). Seabirds are particularly vulnerable to food shortages during the breeding season which normally occurs during the summer months when fish larvae are coincidentally abundant in surface waters. Because breeding seabirds stay close to the nest and forage along banks and shoals they are vulnerable to oil spill. Figure 4.1 illustrates the various feeding methods of Hawaiian seabirds.
**Threats to Seabirds**

Historically, seabirds have nested throughout the entire Hawaiian Archipelago. Today, having withstood near decimation from disease, feather hunting, predation, competition from exotic species, and habitat alteration in the past, seabirds are now exposed to modern pollutants such as petrochemicals resulting from oil spills. While impacts on seabirds could range from nil to catastrophic, oil spills have the potential for killing hundreds of thousands of seabirds in a short period of time particularly if the spill coincides with the breeding season. Such was the case with the Exxon Valdez oil spill which is estimated to have killed between 260,000 to 800,000 seabirds (U.S. Justice Department, 1991).

While the risk of a large oil spill in the NWHI may not be as great as for Oahu, there are potential risks from fishing vessels running aground on the shallow shoals and banks of the NWHI. Some of these fishing vessels carry more than 10,000 gallons of fuel. According to Fefer et al. 1984, "The history of shipwrecks that mark the beaches and reefs of the NWHI, including a Japanese fishing boat aground on Laysan Island in 1969, and the recent groundings of fishing boats and a merchant vessel at French Frigate Shoals in 1980 and 1981, indicates that the threat of an accidental spill is genuine."

The International Maritime Organization, an agency of the United Nations, has circumscribed a 50-mile radius around the islands and atolls of the NWHI, and "advises" all vessels greater than 1,000 gross tons carrying oil and hazardous materials to avoid the area. Despite this 50-mile buffer zone scientists from the U.S. Fish and Wildlife Service and NMFS have reported sightings of oiled birds. Furthermore, the routing measure, however, is only an advisory and therefore carries no sanctions. At a recent Oil Spill Response Workshop in Honolulu, staff from the U.S. Fish and Wildlife Service and NMFS remarked that both agencies would like to see a 100-mile radius placed around the NWHI.

**Effects of Oil on Seabirds**

The effects of oil on seabirds have been the subject of much research in the last 15 years (King and Sanger, 1979; International Bird Rescue and Research Center, 1985; Fry and Addiego, 1989; National Oceanic and

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**Figure 4.1. Feeding habits of Hawaiian seabirds. Data Source: Fefer et al. 1983**
Atmospheric Administration (NOAA), 1988; Harrison, 1990). The primary effect is the oiling of feathers. Oil causes disruption of the small strands that form the feathers and results in a loss of water repellency. The plumage of oiled birds becomes matted allowing water to penetrate to the body which results in hypothermia and a loss of buoyancy. Hemolytic anemia (lack of oxygen in the blood) is the most acute physiological effect of oil. Anemic birds are unable to dive or forage for food and will starve on beaches. To counteract these effects, birds will attempt to rid themselves of oil by preening. This, however, results in the ingestion of oil which can cause damage to liver, kidneys, and gastrointestinal tracts. Ingested oil also causes anemia, pneumonia, altered blood chemistry, decreased growth, and decreased production and viability of eggs (Matthews, 1989; NOAA, 1988; International Bird Rescue Research Center, 1985). Additional ways in which birds can ingest oil include drinking water mixed with oil and eating oil coated food. The inhalation of hydrocarbon vapors can also be deadly.

Adult birds that are exposed to oil and then ingest it may produce fewer eggs (NOAA, 1988). Adults can potentially transfer oil from their feathers or feet to incubating eggs. Small amounts of oil can kill chick embryos and oiling of gull eggs has been found to cause deformities. In addition, the loss of one breeding pair member may mean the complete loss of their reproductive potential for that year. Seabirds have been known to abandon areas after a spill because of reduced prey populations and poor habitat quality (Harrison, 1990). Seabirds have a relatively low productivity rate and recovery from a spill.

Birds vary considerably in their vulnerability to oil (Table 4.6). Diving birds and those feeding on the surface of the water (Figure 4.1) are at greatest risk. Storm petrels, shearwaters, albatrosses, boobies, and some terns are at great risk due to their high reliance on open water marine environments. Boobies are considered to be one of the most sensitive seabirds to oil pollution in Hawaii. The amount of oil which results in the death of a bird is not well understood. Wading birds and gulls which are able to physically remove themselves from the water, thereby reducing their chances of suffering from hypothermia, are more likely to survive a spill than pelagic species (NOAA, 1988).

**Waterbirds**

Five species of endemic waterbirds are found in Hawaii. The Hawaiian duck (*Anas wyvilliana*), the Hawaiian coot (*Fulica americana alau*), the Hawaiian gallinule (*Gallinula chloropus*), the Hawaiian stilt (*Himantopus mexicanus knudsen*) and the Laysan duck (*Anas laysanensis*). The Laysan duck is the only waterbird found exclusively in the NWHI. All five species are listed as endangered by the U.S. Fish and Wildlife Service. Waterbirds were once found on all the main islands except Lanai and Kaho‘olawe which apparently never had suitable habitat. The remaining waterbird habitat on the main islands represents only a small fraction of what once existed. Over the years, the natural habitat of waterbirds — marshes, ponds, and mudflats — have been drained, paved, filled, and polluted. Waterbird habitat today consists primarily of marshes, reservoirs, irrigation ditches, taro patches, and ponds.

The primary breeding seasons for Hawaiian waterbirds is March through September for coots and gallinules, May through June for stints and December through May for the Hawaiian duck. The food of waterbirds includes invertebrates, small fish, crabs, aquatic insects, molluscs, and water plants.

The present population of Hawaiian waterbirds is low. Most waterbirds are highly vulnerable to human disturbance and predation by exotic species of animals. Hawaiian ducks are restricted primarily to Kauai and Oahu. A 1983 census recorded only 53 Hawaiian ducks on Oahu. Coots and stilts are found on all the main islands (except Kaho‘olawe and Lanai); their numbers are 1390 and 1800, respectively. The Hawaiian gallinule is very secretive and difficult to census; however, there is estimated to be approximately 750 birds on Oahu and Kauai.

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2All Hawaiian seabirds, with the exception of sooty terns, have waterproof plumage which is maintained through regular preening.
<table>
<thead>
<tr>
<th>Birds</th>
<th>Vulnerability</th>
<th>low</th>
<th>medium</th>
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<tbody>
<tr>
<td><strong>Albatrosses</strong></td>
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<tr>
<td>Black-footed albatross (Diomedea nigripes)</td>
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<td>Laysan albatross (Diomedea immutabilis)</td>
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<tr>
<td><strong>Shearwaters</strong></td>
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<td>Wedge-tailed shearwater (Puffinus pacificus)</td>
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<tr>
<td>Christmas shearwater (Puffinus nativitatis)</td>
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<tr>
<td>Dark-rumped petrel (Pterodroma phaeopygia sandwichensis)</td>
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<td>X</td>
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<tr>
<td>Bulwer’s petrel (Balweria bulwerii)</td>
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<td>Bonin petrel (Pterodroma hypoleuca)</td>
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<tr>
<td>Newell’s shearwater</td>
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<td><strong>Storm Petrels</strong></td>
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<td>Black noddie (Anous minutus melanogenys)</td>
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<td><strong>Frigates</strong></td>
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<td>Hawaiian coot (Fulica americana alat)</td>
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<td>Hawaiian gallinule (Gallinula chloropus sandwichensis)</td>
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<td>Laysan duck (Anas laysanensis)</td>
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<td>X</td>
<td></td>
</tr>
<tr>
<td><strong>Shorebirds</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pacific Golden plover (Pluvialis fulva)</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Bristle-thighed curlew (Numenius tahitensis)</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Ruddy turnstone (Arenaria interpres)</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Wandering tattler (Heteroscelus incanus)</td>
<td></td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

Waterbirds build their nests directly on the ground adjacent to areas of fresh, brackish, and in rare situations, salt water. They are therefore vulnerable to disturbances such as predation, water pollution, and habitat destruction. Major waterbird habitats include:

**Niihau** habitats consist of intermittent shallow lakes and small coastal ponds. Primary areas include Halali, Halulu and Nonopapa lakes and Apana reservoir.

**Kauai** major habitats include Hanalei National Wildlife Refuge, Lumahai River, Puu ka Eke reservoir, Huleia National Wildlife Refuge, Wilcox ponds (north island), Waimea reservoir (south island), Mana ponds and ditches (west island).

**Oahu** major habitats include Ukoa, Haleiwa lotus fields, James Campbell National Wildlife Refuge, the various ponds at the Kaneohe Marine Corps Air Station, Kawainui.

**Molokai** major habitats include Kukahaia National Wildlife Refuge, Halawa Valley, Ooioa and Kaluaapuhi ponds, Pailoa marsh, and the south coast.

**Maui** primary waterbird habitats include Kanaha Pond State Wildlife Sanctuary, and Kealia Pond.

**Hawaii** habitats include Kiholo Bay, Waiea and Lokoaka ponds near Hilo.

**Treating Oiled Birds**

Local experts and scientists are not in complete agreement as to the number of birds that would likely be affected by a severe oil spill. What is known, however, is that Hawaii is presently unprepared to deal with the impacts of a spill of any magnitude on its wildlife. The few oiled birds that turn up each year are turned over to Sea Life Park at Makapuu Point for cleaning and care. The facilities and staff there are incapable of handling no more than 10 oiled birds at a time. Sea Life Park staff have suggested designating a school gymnasium, warehouse, or firehouse as a site for housing and cleaning oiled birds (Personal communication: Marli Breeze and Diane Pugh). Oceania Regional Response Team has recently established a wildlife cleanup committee which has identified a site for oiled wildlife cleanup.

The International Bird Rescue Research Center (IBRRC) in Berkeley, California has developed an excellent field guide for rehabilitating oiled seabirds. Founded in the early 1970s, the IBRRC has been called upon to manage oiled bird rehabilitation efforts in over 25 major oil spills in 10 states including the Exxon Valdez spill in Alaska. The IBRRC provides training and consultation to the petroleum industry, local, state, and federal Fish and Wildlife agencies, wildlife rehabilitators, and researchers. The IBRRC guide covers the handling, collection, initial treatment, cleaning, drying, and release of oiled seabirds and notes that “the earliest phases of rehabilitation may be the most crucial in lessening the effects of oil on birds.”
Marine Mammals

Eighteen species of marine mammals are found in Hawaiian waters (Table 4.7). With the exception of the monk seal and humpback whale, very little data exists on the natural history of these animals. This report, therefore, focuses predominantly on the Hawaiian monk seal and the humpback whale, both of which are listed as federally endangered species.

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hawaiian Monk Seal</td>
<td>Monachus schauinslandi</td>
</tr>
<tr>
<td>Humpback Whale</td>
<td>Megaptera novaeangliae</td>
</tr>
<tr>
<td>Minke Whale</td>
<td>Balaenoptera acutorostrata</td>
</tr>
<tr>
<td>False Killer Whale</td>
<td>Pseudorca crassidens</td>
</tr>
<tr>
<td>Pilot Whale</td>
<td>Globicephala macrorhynchus</td>
</tr>
<tr>
<td>Sperm Whale</td>
<td>Physeter macrocephalus</td>
</tr>
<tr>
<td>Melon-Headed Whale</td>
<td>Peponocephala electra</td>
</tr>
<tr>
<td>Killer Whale</td>
<td>Orcinus Orca</td>
</tr>
<tr>
<td>Pygmy Killer Whale</td>
<td>Feresa attenuata</td>
</tr>
<tr>
<td>Blaineville’s Beaked Whale</td>
<td>Mesoplodon densirostris</td>
</tr>
<tr>
<td>Cuvier’s Beaked Whale</td>
<td>Ziphius cavirostris</td>
</tr>
<tr>
<td>Fin Whale</td>
<td>Balaenoptera edeni</td>
</tr>
<tr>
<td>Rough-Toothed Dolphin</td>
<td>Steno bredanensis</td>
</tr>
<tr>
<td>Bottlenose Dolphin</td>
<td>Tursiops gilli</td>
</tr>
<tr>
<td>Striped Dolphin</td>
<td>Stenella coeruleaenabalba</td>
</tr>
<tr>
<td>Risso’s Dolphin</td>
<td>Grampus griseus</td>
</tr>
<tr>
<td>Spotted Dolphin</td>
<td>Stenella attenuata</td>
</tr>
<tr>
<td>Spinner Dolphin</td>
<td>Stenella longirostris</td>
</tr>
</tbody>
</table>

Data Source: Shallenberger, 1981

Monk Seal

The Hawaiian monk seal, *Monachus schauinslandi*, is the only endemic marine mammal in Hawaii. It is found from Niihau to Kure Island in the NWHI and is occasionally seen in the vicinity of the main Hawaiian Islands. Two other related species of monk seal belong to the genus *Monachus* — the Caribbean monk seal (*M. tropicalis*) and the Mediterranean monk seal (*M. monachus*). The Caribbean seal is believed to be extinct (Gilmartin, 1983). Monk seals are reportedly more susceptible to disturbances to their habitat than many other marine mammals (Gilmartin, 1983). Monk seal habitats are rapidly deteriorating due to industrial and urban development and abusive commercial fishing practices. In Hawaii, disturbances to hauling-out grounds have forced mother seals to the open waters where shark predation further reduces the number of monk seals. The Hawaiian monk seal is listed as endangered by the Federal Endangered Species Act, the Hawaii Endangered Species Act, and the Monk Seal Act (the latter act states that it is unlawful to “molest, kill, capture, or possess” any monk seal). French Frigate Shoals has the largest population of Hawaiian monk seals (Gilmartin, 1983).
Hawaiian monk seals were nearly decimated in the 1800s by commercial sealing expeditions. Once abundant throughout the NWHI, their numbers were reduced to 1,200 in the late 1950s and to less than half that number by the mid-1970s. The current population is somewhere between 1200 and 1500 animals (Personal communication: William Gil Martin, NMFS, Honolulu, 1991). The main food for monk seals includes spiny lobster, octopi, eels, various reef fish, and marine macro-invertebrates. According to the National Marine Fisheries' 1983 Recovery Plan for the Hawaiian monk seal, "critical habitat should include beach areas, lava benches, submerged lands, lagoon waters, and all waters out to 20 fathoms from the low water mark or barrier reef at Kure atoll, Midway Islands (except Sand Island), Pearl and Hermes Reef, Lisianski Island, Laysan Island, French Frigate Shoals, Necker Island, Gardner Pinnacles, Niiha, and Muro Reef."

Hawaiian monk seal haul-out areas for pupping, nursing, and resting are predominantly sandy beaches although rocky ledges and benches are sometimes used. When available, the vegetation behind beaches is used as a shelter from wind and rain. The inner reef waters are critical to weaned pups learning to feed.

Humpback Whales

Humpback whales are found worldwide. Their extensive summer migration towards polar and temperate latitudes for feeding, and towards tropical regions in the winter for breeding has been noted (Nitta and Naughton, 1989). The waters around the Hawaiian Islands are among the most important for breeding and calving activities for humpback whales in the north Pacific. Humpback whales prefer nearshore habitats for feeding and breeding. Humpback distribution in Hawaii is limited to within the 100 fathom isobath (Figure 4.2) (Nitta and Naughton, 1989).

Humpback whales begin arriving in Hawaii from their feeding grounds near Alaska in late November (Balcomb, 1987). By February, a thousand or more are swimming around the islands and offshore banks. Calves are born in January and early February. The breeding population of Hawaiian humpbacks is as much as 2,100 individuals (Nitta and Naughton, 1989). Prior to the commercial whaling period in the 1800s, the population of North Pacific humpbacks was estimated to be 15,000 animals.

Humpbacks range in size from 35-45 feet and weigh approximately one ton per foot (Balcomb, 1987). They have a life expectancy of 30 or more years.
Effects of Oil on Marine Mammals

Monk Seal

Most populations of marine mammals are large and well dispersed so that a major oil spill will not jeopardize their population. The Hawaiian monk seal is an exception, however, in that both its numbers and habitat are extremely limited. An oil spill would add yet one more disturbance to their habitat and would jeopardize a species that is on the verge of extinction. The greatest impact to seals would come from the ingestion of tar balls or the inhalation of volatile hydrocarbons (Geraci and St. Aubin, 1990). Geographically, the most critical area for monk seals is French Frigate Shoals. Seals are most vulnerable during the peak pupping or nursing months, March through June. During this period, the potential for adverse impacts on pups is great as this is when they spend much of their time on beaches. Furthermore, nursing pups would be attempting to feed on the oiled nipples of their mothers. The threat of an oil spill outside the pupping season, is not as great. Adult monk seals feed in deeper water areas away from coastlines and beaches. Seals elsewhere have typically avoided oiled waters by swimming to other areas (Geraci and St. Aubin, 1990). John Naughton, Environmental Coordinator at NMFS in Honolulu, recently stated that unless monk seals are found totally covered in oil, they are left alone. Additional stress due to handling is avoided unless absolutely necessary. An oil spill occurring off the main Hawaiian Islands is likely to have minimal impact on monk seals providing the slick is not carried towards the NWRI. However, monk seals sightings are becoming more frequent in the vicinity of Niihau Island (Personal communication: William Gilmartin, NMFS, 1991).
Other Marine Mammals

The skin of cetaceans (i.e., whales and dolphins) and many seals appears to be relatively impermeable to oil. Oil appears to have little or no effect on adult pinnipeds (true seals) and cetaceans as the blubber layer provides sufficient insulation (NOAA, 1989a). A coating of oil may have other effects, however. It is possible that fouling could interfere with the overall movement of marine mammals, especially in young animals. Oil may also impair the movements of eyelids and vibrissae (stiff nostril hairs) and may foul the feeding apparatus of baleen whales (e.g., humpbacks). Perhaps a greater threat is the ingestion of oil and the inhalation of volatile hydrocarbons. Depending on the amount and type of ingested oil, the effects can range from acute death to sublethally progressive organ damage. Studies appear to indicate however that pinnipeds are able to tolerate small quantities of ingested oil. After the 1969 Santa Barbara oil spill, in which 30 million gallons of oil were released into the surrounding waters, no evidence of ingested oil was found in the stomachs of heavily oiled seal pups nor were hydrocarbon residues found in the blood and tissues of seals and sea lions. However, chronic ingestion of sublethal quantities of petroleum may have subtle effects which would only become apparent through long-term monitoring. The inhalation of hydrocarbons may cause inflammation of mucous membranes, lung congestion, and even pneumonia. Hydrocarbons are rapidly transferred to the bloodstream and lungs and may even accumulate in tissues such as the brain and liver, causing neurological disorders and liver damage. Thus far, spilled oil has claimed the lives of few, if any, cetaceans. Table 4.8 outlines reported accounts of cetaceans associated with spilled oil. The alteration or degradation of cetacean habitat from an oil spill is possible but highly unlikely (Geraci and St. Aubin, 1990). Most cetaceans inhabit the open ocean and therefore would not be subjected to habitat changes.

<table>
<thead>
<tr>
<th>Date</th>
<th>Location and source</th>
<th>Oil type and quantity</th>
<th>Species</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>February, 1969</td>
<td>Santa Barbara, California; Union Oil well</td>
<td>Crude oil, &gt;30 million gallons</td>
<td>Gray, pilot, and sperm whales; common and white-sided dolphins</td>
<td>16 stranded whales and dolphins, no causal relationship</td>
</tr>
<tr>
<td>April, 1970</td>
<td>Alaska Peninsula, Japan</td>
<td>Diesel fuel, quantity? Bunker C, 11.3 million gallons</td>
<td>Killer whale</td>
<td>1 sick, 1 dead observed, 1 dead purpose found</td>
</tr>
<tr>
<td>October, 1976</td>
<td>Texas, pipeline leak</td>
<td>Crude oil, 15,580 gallons</td>
<td>Bottlenose dolphin</td>
<td>Dolphins swim through oil without apparent effect, 43 sightings of animals in and around oil; no obvious reaction</td>
</tr>
<tr>
<td>December, 1976</td>
<td>Nantucket Shoals, Argo Merchant</td>
<td>Bunker C, 7.9 million gallons</td>
<td>Fin whale, pilot whale, others</td>
<td>Six stranded animals with no firm evidence of oil; 20 dolphins swimming through oil without effect</td>
</tr>
<tr>
<td>March, 1978</td>
<td>France; Amoco Cadiz</td>
<td>Crude oil, 60 million gallons; fuel oil, 3,000 gallons</td>
<td>White-sided and common dolphins, pilot whale</td>
<td>Animals sighted in oil-coated debris; apparently unaffected animals feeding, surfacing, and swimming through heavy concentration of oil; Unconfirmed report of a dead porpoise</td>
</tr>
<tr>
<td>September, 1978</td>
<td>Matagorda Bay, Texas; boat</td>
<td>Crude oil, 70 million gallons</td>
<td>Bottlenose and spotted dolphins</td>
<td>Unconfirmed report of a dead porpoise</td>
</tr>
<tr>
<td>June, 1979</td>
<td>Gulf of Mexico, Lido-1</td>
<td>Bunker C, 80,000 gallons, fuel oil, 6,300 gallons</td>
<td>Humback, fin, minke, right whales; white-sided dolphins</td>
<td>Unconfirmed report of a dead porpoise</td>
</tr>
<tr>
<td>June, 1979</td>
<td>Cape Cod, Massachusetts; Regal Sword</td>
<td>Type 97, 3,000 gallons</td>
<td>Pilot whale</td>
<td>Stranded whale with a small patch of tar on skin</td>
</tr>
<tr>
<td>May, 1981</td>
<td>Outer Banks, N Carolina: Helene Carrier</td>
<td>Tar</td>
<td></td>
<td>1 dolphin swimming in oil patches</td>
</tr>
<tr>
<td>March, 1982</td>
<td>Rodanthe, N Carolina: Source??</td>
<td>Crude oil, &gt;1 million gallons</td>
<td>Bottlenose dolphin</td>
<td>Stranded carcasses; possible unrelated natural mortality</td>
</tr>
<tr>
<td>July, 1984</td>
<td>Gulf of Mexico, Alaskan</td>
<td>Crude oil, 11 million gallons</td>
<td>25 gray, 1 fin, 2 minke, and unidentified whales; 7 harbor porpoises</td>
<td></td>
</tr>
</tbody>
</table>

Data Source: Geraci and St. Aubin, 1990.
Sea Turtles

Five species of marine turtles are known to inhabit Hawaiian waters: green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), leatherback (*Dermochelys coriacea*), loggerhead (*Caretta caretta*), and the olive ridley (*Lepidochelys olivacea*). Overall, there may not be more than 15 hawksbill females nesting annually, throughout all beaches in the Hawaiian Islands (Personal communication: George Balazs, NMFS, Honolulu, 1992). Hawksbills are considered to be endangered throughout the world (IUCN *Redbook*, 1988). The leatherback turtle is also listed as endangered. They are occasionally seen in offshore waters but are not known to nest there. The loggerhead and olive ridley are also found in Hawaiian waters but only as rare visitors. Only the green turtle is widely distributed throughout the Hawaiian Islands (Balazs, 1980). Historically, green sea turtles nested on beaches throughout the archipelago. However, during the 1800s and early 1900s, numerous commercial expeditions to the NWHI exploited large numbers of sea turtles along with sea birds and monk seals (Balazs, 1980; Fefer et al. 1983; Harrison, 1990). Turtles were taken primarily for meat and oil but they have since been placed on the federal endangered and threatened species list.

Approximately 85 to 90 percent of all green sea turtle breeding and nesting occurs at French Frigate Shoals in the NWHI (Personal communication: John Naughton, NMFS, Honolulu). The turtle mating season occurs between mid-April and early June with nesting commencing mid-May and reaching its peak during late June. Turtle hatchlings emerge from their nests and enter the water between mid July and early October. As egg-laying reptiles, marine turtles require both the land and the sea in their life-cycle. Undisturbed nesting beaches are critical for egg laying, resting, and basking. Adult and juvenile turtles feed primarily in nearshore waters while hatchlings forage in the open waters.

Feeding and Resting Areas

Green turtles feed primarily on benthic marine algae which is generally restricted to shallow depths where sunlight, substrate, and nutrients are conducive to growth. Green turtles have been reported to feed on 56 species of algae and nine species of invertebrates. Turtles rest on the undersides of ledges, coral recesses, and sandy bottom areas that are free from strong currents. In the main Hawaiian Islands these resting areas usually occur at depths greater than 20 meters and generally not exceeding 50 meters. The major resident areas for green turtles in the main Hawaiian Islands are: Kau and North Kohala Districts (Big Island); Hana District and Paia (Maui); north and northeastern coastal areas bordering the Kauhola and Auau Channels (Lana’i); south coastal area between Kamalo and Hana (Molokai); Kauai and Kane’ohe Bays, northwest coast from Mokuleia to Waialua Beach (Oahu); Princeville, Na Pali Coast, and south coast from Kukuiula to Makahaua Point (Kauai), (see Figure 4.3). In the NWHI, aggregations are known to occur at Necker Island, French Frigate Shoals, Lisianski Island, Pearl and Hermes Reef, and to a lesser extent Midway, Kure and Laysan Islands. To date, data are lacking for Nihoa Island and Gardner Pinnacles.

Effects of Oil on Turtles

Despite the endangered and threatened status of sea turtles, very little is known about the effects of oil on juvenile and adult sea turtles. Hatchlings, however, are considered to be extremely vulnerable to the effects of oil. Tar is particularly harmful and has been found to seal the mouths and nostrils of hatchlings (Chan and Liew, 1988). Tar balls, which can float in sea water for as long as one year, are sometimes mistaken for food. One researcher has suggested bioaccumulation of foreign chemicals and disorientation as possible effects on adult turtles. Because turtles surface frequently to breathe, their chances of coming into contact with oil are great. In 1983, a number of yearling Kemp’s Ridley turtles were released from offshore islands in Texas. Within a week, many of them were found dead or stressed. An examination of the dead turtles revealed that
all of them had ingested floating oil or tar balls which were no doubt mistaken for food items (Chan and Liew, 1988).

The effects of oil on adult turtles have not been well studied. In July 1989, a green sea turtle covered with five pounds of tar was found off the Kona Coast. The animal, which was amazingly still alive, was completely immobilized by tar the consistency of chewing gum. The tar was identified as bunker oil or refined fuel oil and had probably been in the ocean for at least a month or more according to an official at NMFS in Honolulu. The six pound turtle was a size rarely seen in the ocean because juveniles disappear for what is known as a “lost year.” Turtles of this age may be more susceptible to oil contamination because they appear attracted to objects floating in the water. The tar is believed to have originated from the Lanai-Molokai oil spill two months earlier but was too weathered to be positively identified. According to the Draft Hawaiian Sea Turtle Recovery Plan,

“Major spills or other pollution events need immediate response to determine what cleanup measures are required. Attention should be given to the cleanup measures to ensure that their impacts on nesting habitat are not greater than the spill itself...Volatile and water contaminants on the beach during the incubation period should be investigated as these contaminants can be absorbed into the egg and embryo. Sources of pollution and the polluters should be identified...Baseline studies should be made annually on the extent of pollution (plastic nets, fishline, tar balls, etc.) washed up on the nesting and basking beaches...” (NOAA,1989)
Recommendations

Editor's note: The recommendations that follow are based on the findings of our research. As indicated in italics, the DOH notes that some of the recommendations are already in the process of being implemented by the appropriate agencies.

1. All tankers, fishing vessels, and other vessels carrying potentially hazardous materials should remain outside a 100-mile wide radius of the NWHI. The area is a critical habitat for the endangered Hawaiian monk seals and green sea turtles. It is also an important breeding and nesting area for millions of seabirds.

Existing regulations already provide for this recommendation.

2. Officials from NMFS, U.S. Fish and Wildlife Service, Department of Land and Natural Resources (DLNR), local scientists, and non-governmental organizations should establish a priority list of areas which need immediate attention in the event of a spill. It will be impossible to impart equal response measures to all sensitive areas. The above mentioned agencies will need to decide what areas can be saved and the best way to save them. These sites should then be validated by the public. The Nature Conservancy Heritage Program has a wildlife database that might be useful in determining sensitive areas for resources. The DLNR ought to be the lead agency in this decision, with input from others.

This is addressed in the general comment. In addition, the Sensitive Area Subcommittee is addressing this issue.

The following areas should be considered as priority sites for cleanup:

a. the NWHI, from Nihoa to Kure;

b. all turtle haul-out and nesting beaches and rocks as listed in this report;

c. all major turtle feeding and resting areas as listed in this report;

d. all monk seal haul-out rocks and beaches as listed in this report;

e. all monk seal feeding grounds as listed in this report;

f. all reef flats, tide pools, and rocky ledges which are exposed during periods of low tide;

g. all embayments and estuaries; and

h. all Marine Life Conservation Districts.

General comment for items a–h: The Area Contingency Plan has a process for evaluating priorities. Establishing priorities will be conducted within the scope of the entire oil spill. It is possible that cleaning an area may be more harmful to the natural environment than not cleaning the area. Human intervention into these areas may not be desired even to clean up oil contamination. Therefore, it is imperative that cleanup priorities of natural areas consider the option of using the “natural processes”.

3. There should be a designated facility such as a school gymnasium, warehouse, or firehouse where oiled animals can be brought for cleanup. In addition, there should be a number of veterinarians, wildlife biologists, and other appropriate personnel trained in the rehabilitation of oiled animals. Presently, the only available facility and staff capable of dealing with oiled animals are located at Sea Life Park. As discussed earlier in this report, Sea Life Park has extremely limited resources and personnel and therefore, should not be expected to handle all wildlife that become directly impacted from a spill. It is not practical to transport oiled animals from the NWHI to the main islands for care. It may be possible, however, to set-up a facility on Tern Island at French Frigate Shoals as there is a U.S. Coast Guard Station and landing strip there.

A subcommittee of the [Oceania] RRT and the Area Planning Committee (Oiled Wildlife Subcommittee) has been established to look at this issue. The subcommittee has secured a facility at Barbers Point and is in the process of obtaining the proper environmental permits and equipment. In addition, facilities have
been secured on each main island to deal with oiled animals. The only outstanding issue is the availability of specific equipment.

4. There is a real need for ecological baseline studies. These studies should ascertain the following: ability of a particular resource to recover from a spill, rate of recovery, reproduction and spawning cycles, etc., secondary effects of a spill such as cleanup disturbances (e.g., increased numbers of boats and people), oceanographic circulation data, etc...

The Sensitive (sic) Subcommittee is doing this work.

References


CHAPTER 5

AN EVALUATION OF STATE AND FEDERAL STATUTES ON OIL SPILL RESPONSE AND HAWAII'S RESPONSE PREPAREDNESS

Peter Rappa
Phil Moravcik
Introduction

The state’s policy on oil spill prevention and cleanup was examined to assess its adequacy in addressing the need to protect Hawaii’s environment and its resources from the threat of oil spills. Hawaii’s Environmental Response Act, Chapter 128 D, Hawaii Revised Statutes, was compared with the Oil Pollution Act of 1990 (OPA) to determine how they complement each other and to identify gaps in the federal and state laws. Hawaii’s oil spill response law was also compared with appropriate laws of Louisiana, Florida, and Washington to determine how other states have addressed perceived shortfalls in OPA as well as their own priorities and perceptions of risks and methods for mitigating the impacts of oil spills.

Legislative Comparison

Oil Pollution Act of 1990

OPA “addresses wide-ranging problems associated with preventing, responding to, and paying for oil spills through one comprehensive regime,” according to President Bush (Anonymous, 1990). The act, passed in the wake of the 1989 Exxon Valdez oil spill, ended 15 years of unsuccessful attempts by Congress to address the issue of oil spill cleanup. OPA has four basic provisions: 1) limits liability for tanker and other type vessels and offshore and on-shore facilities, 2) expands federal role in responding to oil spills, 3) establishes a $1 billion oil spill trust fund, and 4) places emphasis on preventative measures to reduce the risk of oil spills, including a requirement for double hulls on all U.S. oil tankers after the year 2015 (Grumbles, 1990).

OPA also allows the states to set standards that are more stringent than those set by the federal government and gives the states the option to retain their pre-Exxon Valdez legislation, if none is in place.

Louisiana’s Oil Spill Prevention and Response Act

Louisiana’s comprehensive oil spill legislation, the Oil Spill Prevention and Response Act, was passed in April 1991. The act creates a new chapter in Louisiana’s Revised Statutes, Chapter 19, Title 30 and establishes the Oil Spill Coordinator’s office. Its focus on jurisdictional boundaries among state and county agencies for the response to oil spill led the Southern Legislative Conference to consider it to be the model legislation for oil spill prevention and control (OSLR, 1991).

Washington’s Oil Spill Prevention and Response Act

Washington’s comprehensive oil spill prevention and control legislation was passed by the state legislature in May 1991. The Oil Spill Prevention and Response Act (OSPRA) is codified in Washington’s public laws as Chapter 82 and Sections 88.16, 88.40, and 88.44. OSPRA establishes a new state policy which emphasizes oil spill prevention rather than response and cleanup. The legislation requires the submission of oil spill prevention plans by both vessel and facility operators in addition to the spill cleanup contingency plans required under federal legislation. The act sets up Regional Marine Safety Committees for Puget Sound and the Pacific Coast. It also recommends that one be set up jointly with Oregon for the Columbia River to identify hazards to navigation, and to set up vessel traffic control systems and operational standards that would prevent spills from occurring.

Florida’s Pollution Spill Prevention and Control Act

Florida’s Pollution Spill Prevention and Control Act was passed in June 1990. It has been codified as Chapter 90-54 of the Laws of Florida. The act emphasizes protection of natural resources. Because Florida, like Hawaii,
relied on its natural environment to attract tourists, its oil spill legislation reflects a natural resource protection bias. One section of the law, Section 376.121, is devoted to outlining the liability of damages to natural resources. The section calls for all natural resources to be mitigated to their pre-spill state where feasible and to recover the cost of all damages in cases where restoration is impossible. The amount of compensation paid can be as high as $1,000 per square foot of impacted habitat.

Hawaii’s Environmental Response Law

Hawaii’s Environmental Emergency Response Act was enacted in June 1988 designating the State Department of Health as the lead agency for cleaning up spills of any toxic or hazardous waste. It was amended in 1990 by the Environmental Response Act which created the Hawaii “Superfund” for emergency response to spills of hazardous or toxic substances and waste disposal dumps. An amendment in 1991 added oil to the list of substances covered by the Act. The Environmental Response Act was codified as Chapter 128D, Hawaii Revised Statutes (HRS).

Hawaii’s oil spill response planning is carried out in the Office of Hazard Evaluation and Emergency Response of the Department of Health. They are responsible for writing and enforcing the state’s oil spill contingency plan, as well as for promulgating administrative rules for HRS Chapter 128D.

Hawaii statute on oil spills was compared to OPA and the statutes of Washington, Louisiana, and Florida, using categories given in Table 5.1 (See Appendix B for a summary of these statutes).

<table>
<thead>
<tr>
<th>Table 5.1. Categories used in comparison of federal and selected state oil response laws</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Entities Subject to Provisions of the Act</td>
</tr>
<tr>
<td>2. Coordination of State and Federal Responsibilities</td>
</tr>
<tr>
<td>3. Prevention (including plans)</td>
</tr>
<tr>
<td>4. Government Contingency Plans</td>
</tr>
<tr>
<td>5. Vessel and Facility Contingency Plans</td>
</tr>
<tr>
<td>6. Response Planning Organizations</td>
</tr>
<tr>
<td>7. Liability</td>
</tr>
<tr>
<td>8. Financial Responsibility</td>
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<tr>
<td>9. Funding</td>
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<tr>
<td>10. Natural Resource Damages</td>
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<tr>
<td>11. On-Board Response Equipment</td>
</tr>
<tr>
<td>12. Drug and Alcohol Abuse (Programs)</td>
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<tr>
<td>13. Enforcement - Penalties</td>
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Note: These were developed by the Washington State Department of Ecology, 1991.

Discussion

Hawaii’s legislation on oil spill prevention and control is far less comprehensive than those of the other states and OPA. OPA and Louisiana, Washington, and Florida’s statutes primarily address oil spills, while Hawaii’s statute primarily addresses releases of hazardous substances on land. However, the comparison is useful in determining where Hawaii’s oil spill response policy differs significantly from those of the other three states, especially in addressing areas not adequately covered by the OPA.
Entities Subject to Provisions of OPA and State Laws

OPA applies to all bulk oil carriers, on-shore and offshore oil processing and terminal facilities, and all large vessels such as cargo and passenger vessels, which carry substantial quantities of oil as fuel. Washington, Louisiana, and Florida extend coverage of their oil spill legislation to all vessels carrying large quantities of oil as well as on-shore and offshore facilities. The Washington statute includes all vessels over 300 gross tons and Florida’s law applies to vessels carrying over 10,000 gallons of oil as fuel or cargo. Hawaii’s Chapter 128D applies to any vessel or any artificial means of transportation on the water without limitation on cargo capacity or gross tonnage. The provisions of Hawaii’s law can apply to any vessel regardless of size or purpose because the definition of “vessel” lacks the specificity found in OPA and the other three states’ statutes.

Coordination of State and Federal Responsibilities

Hawaii’s Chapter 128D requires that the state oil spill contingency plan complement the National Contingency Plan (NCP). NCP is a plan required under section 301(c) of the Clean Water Act as revised by section 105 of CERCLA, as amended by OPA, that sets out the duties and responsibilities of federal, state, local, and private sector responders to an oil spill. In addition to NCP, each Coast Guard District with jurisdiction in the coastal zone (as defined in 40 CFR 300.5) will form an Area Committee consisting of federal, state, and local government agencies. The Area Committee’s chief responsibility will be the preparations of an Area Contingency Plan for its geographic area (U.S. Federal Register, 1992).

Prevention (Including Plans)

OPA focuses on regulating vessel structure and shipping procedures such as the use of autopilot and requirements for tugboat escorts. It also provides substantial requirements for port and oil handling facilities contingency plan. Washington, Florida, and Louisiana require vessels and facilities to have state-approved prevention plans. Louisiana requires operators of facilities to obtain a discharge prevention and response certificate. Florida requires that vessels have one person who is designated as an oil spill response officer if the vessel uses its ports. Washington mandates Regional Marine Safety Committees to examine ways to create regional safety plans and a Marine Oversight Board to make recommendations on safety measures and other actions.

Hawaii’s Environmental Response Law does not adequately address the subject of prevention. Because oil spill prevention is likely to be less costly than cleanup, it requires careful consideration in the state’s policy. Issues related to prevention are addressed in Chapter 6.

Contingency Plans

In addition to the requirement under the federal clean water legislation (CERCLA) that requires the development of a national contingency plan for responding to oil spills, OPA added requirements for area spill response plans and encourages states to develop local contingency plans that complement the federal plan. Hawaii is developing an oil spill contingency plan (the State Oil and Hazardous Substances Emergency Response Plan) that delineates the duties of the state and federal governments. An early version of this draft plan was used for this comparison. The U.S. Coast Guard has primary responsibility for responding to all spills in the marine environment and the state for responding to all land-based spills. The federal contingency plan includes an agreement on the use of chemical dispersants.

Both the federal and the draft Hawaii state plans require additional clarity on several issues. One is the determining when a spill cleanup is complete. Under OPA, the U.S. Coast Guard is given the responsibility for directing the cleanup effort, but consultation is required with the state’s on-scene coordinator in determining when the cleanup is completed. However, there is no process in the federal plan on the consultation procedure.
Another issue is protection of sensitive areas. The state needs to identify areas that require maximum protection in the event of a spill. The location and description of the areas need to be clearly delineated on a map so that the federal on-scene coordinator can take appropriate steps to protect those areas. The Area Committee, established under OPA, is currently developing sensitivity maps which identify sites that are economically and ecologically important. High use recreational sites are also being identified.

Vessel and Facility Contingency Plans

OPA requires tankers and facilities to have response plans for addressing a worst case oil spill. Louisiana, Washington, and Florida each has specific requirements for vessel and facilities to develop oil spill response contingency plans. When possible, plans required by OPA can be substituted for plans required by the states. However, states can require more detailed plans than OPA. States may extend the requirement for contingency plans to vessels that are not covered under OPA. For example, Florida requires vessels carrying 10,000 gallons or more of oil as cargo or fuel, to prepare an oil spill response contingency plan. Hawaii has no specific requirements for vessel or facility oil spill response contingency plans.

Response Planning Organizations

OPA has established a national response unit in North Carolina and regional response units around the country. The federal law also requires the formation of regional response teams made up of federal, state, and local governments and others, including oil company officials, private cleanup experts, special interest groups and researchers to develop area contingency plans. Louisiana, Florida, Washington and Hawaii each require statewide advisory groups. Louisiana has also created an Oil Spill Coordinator in the Governor’s office to coordinate state and local planning for oil spill prevention and response. Washington has created the Washington State Maritime Commission to provide assistance to vessels and to formulate a state approved response plan.

Hawaii is part of the Oceania Regional Response Team (RRT). The team has 36 members including representatives of federal, Hawaii, Guam, American Samoa, and the Commonwealth of Northern Mariana Islands governments. The state’s oil spill response planning is carried out in the Office of Hazard Evaluation and Emergency Response of the Department of Health. The office is responsible for writing, coordinating, and maintaining the state’s oil spill contingency plan and for promulgating administrative rules for HRS Chapter 128D.

In addition to federal and state-mandated advisory groups in Hawaii, there is also the local industry-sponsored cooperative, Clean Islands Council. Their primary responsibility is to respond to local spills on behalf of their members.

Liability

OPA limits liabilities for vessels and on-shore and offshore facilities except in cases of gross negligence. The federal liability limit is set at the greater of $1,200 per gross ton or $10 million for tankers over 3000 tons, the greater of $1,200 per gross ton or $2 million for tankers under 3000 tons, and the greater of $600 per ton or $500,000 for non-tanker vessels. OPA does not restrict states from passing more stringent requirements than contained in the federal legislation. Florida, for example, has set a $50 million dollar limit for vessel liability for cleanup cost and an unlimited liability for damage to natural resources. Hawaii has no limits with the exception of interisland barges. (See Chapter 6 discussion under subsection on “Provisions under OPA that define state authority.”) Washington has no limits on liability for cleanup or damage.

Liability is one of the most important considerations for oil spill legislation. Without liability caps, the oil and shipping industries will find it difficult to obtain the insurance coverage they need in order to operate in state
waters. Few shipping companies may be able or willing to deliver oil to ports in states that have unlimited liability. ARCO Marine no longer delivers oil to Hawaii and PRI and Chevron, USA announced the cessation of their inter-island tanker barge operations for delivering No. 6 fuel oil in March 1992 due to unlimited liability. Logically, liability limits should be in line with levels that will pay for the cost of cleanup and compensation for damages in a worst case scenario. That amount may be difficult to determine because of the uncertainties associated with less than perfect cleanup technologies and with determining the value of damages incurred by natural resources and the compensation to wage earners who would be negatively impacted by a large oil spill. However, the Hawaii State Legislature has begun grappling with the issue of liability caps by setting a limit for interisland tank barges. Act 130, signed into law in July 1992, sets a limit of $700 million for clean up and damages for any oil spills caused by interisland tank barges carrying less than 60,000 gallons of heavy fuel oil (Number 6 grade).

The federal limits imposed by OPA may be too low for tankers calling on Hawaii’s ports. A catastrophic spill that could impact Waikiki, the heart of the state’s tourist industry, may be far costlier than the federal limit of $1,200 per gross ton per vessel. A tank vessel calling at Hawaii’s port that weigh 80,000 tons would have a maximum liability of $96 million. Estimates of damages from a large oil spill could exceed $300 million, based on our analysis of the economic impact (see Chapter 2). Somewhere between the federal limit and the unlimited amount of liability, lies a reasonable level of financial responsibility that can be imposed on vessels operating in Hawaiian waters.

Another issue concerning liability is who should be liable in the event of an oil spill. The responsible party, under OPA and most state legislation, including Hawaii’s, is the vessel or facility owner or lessee. Washington’s statutes extend liability to the owner of the product. Florida makes the owner of the product liable to the extent that the vessel or facility owner cannot meet the liability requirements.

Financial Responsibility

OPA requires vessel and facility owners to have coverage that meets the maximum federal liability. Florida and Louisiana likewise require vessels to have sufficient coverage to meet the maximum requirement and furnish proof of coverage. Washington has no limits on liability and requires tankers to have $500 million in liability coverage and other vessels to have a minimum of $500,000. The amount of coverage needed for onshore and offshore facilities has not been determined.

At present, Hawaii does not require any proof of financial responsibility nor has it established the minimum level of insurance coverage other than what is required under federal law. Under OPA, vessels and facilities would have to furnish proof that they can meet the liability limits set forth in federal legislation. Since there is no limit on liability for damages under Hawaii state statutes, it seems reasonable that some level of insurance coverage is required over the limits set under OPA.

Funding

Each of the four states and OPA include a special fund for cleanup and compensation of damages. The state funds vary in amount and the federal Oil Spill Liability Trust Fund, under OPA, is set at $1 billion. The Hawaii fund differs significantly from those set up by the other states and the federal government in that it does not collect a fee from oil companies to provide income to the fund. Hawaii’s “Superfund,” mandated by Chapter 128D, relies on penalties and fines collected by the state from violators and monies from the general fund. The fund is limited to receiving only $3 million in fines but no upper limits are placed on funding from other sources.

Washington and Louisiana allow part of their oil spill funds to be used for the administration of their oil spill program. Louisiana also allows up to $750,000 a year to be used for oil spill prevention and cleanup related
research. The Hawaii fund can not be used for administration or research. The primary difference between Hawaii's fund and those of Louisiana, Washington, and Florida is the imposition of a fee on petroleum products to provide revenue for the fund. Such a fee on petroleum products shifts the burden of providing funding to those that profit from the trade — the oil companies. Since Hawaii imports nearly 160,000 barrels a day of oil and oil products (Department of Business and Economic Development, 1991) a substantial revenue base exists. If, for example, a fee of $0.05 per barrel was levied, it would generate an annual revenue of approximately $3 million dollars.

Natural Resource Damages

Most states have similar language in their oil spill legislation requiring the states' natural resource agency to assess damages to natural resources. Reimbursements to those suffering damages can be made from the federal fund (up to $500 million dollars) or from state funds, depending on the nature and magnitude of damages. Up to $50 million of the trust fund may be used to conduct the assessment, but the states require that this cost be recovered from the responsible party. Florida and Washington require a screening process to determine compensation payments. Hawaii and Louisiana leave the process of compensation to rulemaking.

On-Board Response Equipment

By 1993, OPA regulations will require all tank vessels to carry appropriate oil removal equipment. Louisiana, Florida, and Washington have additional requirements. Louisiana requires proof that equipment is available, and that personnel are trained in prevention and control techniques prior to the vessel’s entry into port. Florida and Washington require: 1) containment and recovery equipment to be available during unloading operations, 2) ships unloading or refueling to be surrounded by an oil containment boom, and 3) an oil spill officer must be available during unloading and refueling operations. Hawaii has no special provision for on-board equipment or availability of trained personnel beyond the OPA requirements.

Drug and Alcohol Abuse (Programs)

OPA requires mariners license applicants to provide data from the National Drivers Register to determine whether the applicant has ever been convicted of driving under the influence (DUI) or driving while intoxicated (DWI). The mariner’s license may be revoked for conviction of a serious driving violation or if found to be operating a vessel while under the influence.

Washington requires vessel and facility prevention plans to describe alcohol and drug awareness programs that have been instituted. It has also made the operation of a vessel under the influence a felony, setting the legal limit of blood alcohol at 0.06 percent (which is 0.04 percent lower than the standard for automobiles in Hawaii). Hawaii, Louisiana, and Florida have no additional requirements.

Enforcement — Penalties

Each state has roughly similar civil and criminal penalties in line with federal penalties. These are presented in Appendix A.

Hawaii’s Preparedness for Major Oil Spills

In accordance with Title III of the Superfund Amendments and Reauthorization Act of 1986, the Hawaii State Emergency Response Commission (HSERC) (comprised of government officials, civil defense, fire department, and university personnel) has prepared the Oil and Hazardous Substances Emergency Response Plan,
which outlines the projected response actions of various state agencies in the event of an oil or hazardous material spill. The plan outlines the official state policy on oil spill preparedness.

There are two other contingency plans which deal with oil spill preparedness in the state: the Oceania Region Oil and Hazardous Substances Pollution Contingency Plan and the U.S. Coast Guard Marine Safety Office. Honolulu Oil and Hazardous Substance Pollution Contingency Plan. Furthermore, under the provisions of the OPA, oil transfer facilities and vessels will be required to draw up their own individual contingency plans. However, having a plan and being able to implement it efficiently are two different things. In the absence of any practical large-scale experience, it is difficult to predict how well these plans translate into action in the event of a major oil spill.

The U.S. Coast Guard Plan

The U.S. Coast Guard is the primary agency for emergency oil spill response in Hawaiian waters. As such, they have put considerable energy into planning for oil spills. The U.S. Coast Guard contingency plan has the stated purpose of:

- Providing a framework for a coordinated and integrated response by the U.S. Coast Guard and other federal, state, territorial, local, and civilian forces to actual or potential discharges of oil and releases of hazardous substances with the purpose of:
  1. Developing appropriate preventive and preparedness measures and effective systems for discovering and reporting the existence of a polluting discharge;
  2. Instituting prompt and effective actions to restrict the further spread of the pollutant;
  3. Ensuring that the public health and welfare are provided adequate protection from such discharges;
  4. Minimizing damage to wildlife and the marine environment from oil and hazardous substance discharges;
  5. Providing techniques for removal and locations for the disposal of collected pollutants;
  6. Providing a list of trained personnel capable of responding to major discharges and lending expertise to the Federal On-Scene Coordinator (FOSC) in specific areas;
  7. Providing lists of available equipment for removal operations and sources of logistical support;
  8. Initiating actions for the recovery of cleanup costs and conduct enforcement actions as necessary.

The Plan outlines the duties and responsibilities of the on-scene forces and provides for standard policy and procedures among them. It is designed to encourage the development of response capabilities by both local governments and private interests. It contains much information vital to an appropriate response, including directories of potential spill sources, areas to be protected, sources of services and supplies, and agencies which have a responsibility or interest in response operations.” (Marine Safety Office Honolulu Oil and Hazardous Substance Pollution Contingency Plan, 1990, pp. 100–101)

The U.S. Coast Guard plan also includes a “worst-case scenario” of a catastrophic oil spill, and outlines the steps that would be taken in the event of such a spill. The strategy for dealing with a catastrophic spill is found in Section 934 of the U.S. Coast Guard plan.

The State Plan

Hawaii lacks the resources and capability to investigate or respond to offshore oil spills. The state has neither the vessels, nor the trained manpower to respond to at-sea spills. Under the state plan, the state’s role in oil spill response is essentially limited to regulatory activities: notification, evaluation, assessment, coordination, and determination of responsibility.
All reports of ocean oil spills received by state and local agencies are reported to the Marine Safety Office (MSO) of the U.S. Coast Guard. When a spill report is received, the U.S. Coast Guard MSO determines the seriousness of the spill and, what, if any, action should be taken. The party responsible for the spill is legally responsible for cleaning it up. The local oil companies have some capacity to perform small cleanup operations through the Clean Islands Council (CIC) which is a cooperative of oil companies operating in Hawaii. If the oil is spilled from a ship not belonging to one of the oil companies, the responsibility falls on the owner of the vessel, who will most likely have to rely on local contractors to clean up a spill. The CIC does respond to spills originating from non-member ships.

If, in the opinion of the U.S. Coast Guard investigators, appropriate action is not being taken by the legally responsible party or by non-federal agencies, the FOSC will take control and federalize the response activity. This individual (the Commanding Officer of the MSO) has the ultimate authority to direct response and cleanup actions. The U.S. Coast Guard plan prescribes notification of the Oceania Regional Response Team (RRT), a group composed of regional personnel from 14 federal agencies and representatives of state agencies with emergency responsibilities, within one hour if a spill has the potential of being medium or major (>10,000 gallons) or for smaller spills under certain circumstances. The RRT’s duties include providing coordination, support, and advice to the FOSC in responding to an oil spill. In addition, the RRT provides a mechanism whereby the resources of various federal agencies, such as the Navy, can be brought to bear on an emergency situation. The membership of the Oceania RRT can be found in Annex II of the Oceania Region Oil and Hazardous Substances Pollution Contingency Plan.

In the event of a large spill, a unified incident command post would be set up where representatives from federal, state, and county governments meet to plan and coordinate response strategies. One of the state’s roles would be to send an on-scene coordinator (OSC) to this command center, to direct state activities at the site and work in cooperation with the FOSC who would have the ultimate authority in most matters; however, he would seek the advice and input of the state OSC and other state and county representatives.

State Agencies Responsibilities Under the State Oil and Hazardous Substances Emergency Response Plan

Several state agencies have duties and roles to play according to the state contingency plan. These are summarized below.

Department of Health (DOH):
- acts as lead state agency in the event of a spill. The DOH has been appointed the state’s representative agency in the event of an oil spill. The Office of Hazard Evaluation and Emergency Response is the DOH office that responds to oil spills.
- notifies affected Local Emergency Planning Committees (LEPCs)
- notifies other affected state agencies
- sends a state on-scene coordinator who oversees state response activities and consults with U.S. Coast Guard personnel and state agency representatives
- provides technical assistance and advice on protective actions
- provides assistance in hazard determination, evaluates environmental implications of a spill
- evaluates possible public-health effects of a spill
- coordinates state on-scene support in cooperation with Civil Defense
- investigates the cause of the spill and pursues enforcement actions
- collects environmental samples
• coordinates with the governor's office to exercise the governor's authority to protect the public's health and the environment
• identifies clean-up requirements and works with government and private agencies to ensure that clean-up/restoration is done to standards to be determined by the DOH in cooperation with other state agencies and the FOSC
• insures that collected oil is disposed of in an appropriate manner
• collects and maintains data on oil and hazmat response incident for evaluation and planning
• under CERCLA, the DOH Director was appointed to be the Natural Resources Trustee
• under OPA, the DOH Director shares the responsibility of being the Natural Resources Trustee with the Director of DLNR

Department of Transportation (DOT):
• notifies State Emergency Response Commission and local emergency response personnel if first on scene
• closes state harbors and re-routes traffic if necessary
• provides technical assistance regarding oil and hazardous substances transportation incidents
• coordinates the clean-up operations for spills that occur in state harbors in cooperation with the DOH

Department of Land and Natural Resources (DLNR):
• notifies State Emergency Response Commission and local emergency response personnel if first on scene
• provides advice and guidance
• assists with responder support, such as communications, provision of food, etc, if requested by state on-scene coordinator
• responds to incidents that could degrade state parks, land, or waters and/or threatens fish, wildlife, or their habitats
• coordinates the clean-up operations for spills that occur on DLNR lands and waters in cooperation with the DOH
• under OPA, co-trusteeship (with the DOH Director) for natural resources

Office of State Planning (OSP):
• provides support for information and expertise on coastal resources and accesses through the coastal zone management program

State Civil Defense:
• provides and/or coordinates statewide emergency communications and data systems
• coordinates all state disaster and emergency actions, in the event that a State Disaster Proclamation is made by the Governor, and disaster response and relief with and through the Federal Emergency Measures Act (FEMA), in those disasters covered by a Presidential Disaster Declaration.
Labor and Industrial Relations:
- provides support for air monitoring to emergency responders and ensures that occupational safety and health are not compromised

Department of Business, and Economic Development and Tourism (DBED):
- provides support for information on economic impacts of an incident and remedial actions

In addition to outlining the roles of these state agencies, the plan contains further provisions to ensure the readiness of the state to respond to an oil spill, including the following:
- each person occupying a position identified in the plan must have appropriate training
- each department specified in the plan shall develop supplemental procedures to implement the plan; DOH will coordinate with the other response agencies to ensure that the procedures are compatible
- the plan should be evaluated through exercises to see if the required activities are effective in practice
- HSERC shall develop minimum equipment usage and maintenance standards
- HSERC shall review and revise the plan annually
- exercises will be held to evaluate the efficacy of the plan

The latest draft of the state plan was formulated in 1989, and as of May 1992, was undergoing review and revision. While the plan is fairly inclusive in its descriptions of the various agencies' roles, it appears that many of the provisions of the plan have not been implemented, primarily because of a lack of resources. The implementation of some of these provisions (such as training exercises) is crucial to ensure preparedness. If its provisions are not implemented the state contingency plan is of little value.

Training:
- all parties identified in the Contingency Plan must be aware of their responsibilities under the plan
- the dates by which these persons shall be trained should be specified
- name of staff to receive training at each state and county agency should be specified
- the oil spill response training curriculum should be specified and standardized; refresher training should be scheduled at regular intervals in order to keep staff up-to-date with advances in technology
- exercises and drills should be held regularly to meet the requirements of the plan
- the dates by which training exercises and drills will be completed should be specified
- during an oil spill, large numbers of persons may be required for non-specialized response duties requiring no special training (e.g. posting beaches). Procedures for utilizing state and county employees should be developed

Planning:
- state agencies should be required to produce their supplemental procedures which complement the state contingency plan by a specified date
- the dates and procedures by which the state plan will be reviewed and revised should likewise be specified
- on all matters which may require cooperation between federal, state, and city and county agencies, memoranda of understanding (MOU) should be developed so that there will be no delays when prompt action is required. Specifically, it is recommended that such memoranda be developed to facilitate:
1. Burning of oily wastes at H-power or other incinerators
2. Disposal of non-burnable oily waste at county landfills
3. Storage of oily materials which may or may not be classified as hazardous
4. Use of City and County Public Works Department machinery for cleanup operations
5. Authorization to remove sand from beaches when oil contamination of beaches is imminent
6. Use of U.S. Navy resources for in situ burning operations

Although it may be assumed that there would be cooperation between agencies during the crisis, it may also be assumed that there would be confusion. During the Exxon Valdez oil spill in Alaska, much time was lost from attempts by various state and federal agencies trying to take control of the response activities. Political and media pressure is expected to be high during an oil spill. Therefore, roles must be very well defined prior to the event. Legally binding pre-agreements will minimize difficulties when the crisis comes. Such agreements can be included as annexes to the contingency plan for Hawaii that is being prepared currently by the Area Committee.

One of DOH's responsibilities under OPA is to advise the FOSC on protective actions during an oil spill. While no separate prioritization has yet been done for protection of the shoreline, a response prioritization scheme will be established in the Regional Response Team's, established under OPA, contingency plan for Hawaii.

The State Contingency Plan needs to clarify the decisionmaker or decision process for declaring cleanup sufficiency and the criteria for determining clean-up sufficiency. At present, the determination of cleanup sufficiency is officially made by the DOH, however, as the overall supervisor of cleanup operations, the FOSC would have a large say in deciding when a spill has been sufficiently cleaned up. Because no legally mandated guidelines exist for oil spill cleanup levels or standards, suspension of cleanup operations will necessarily be a judgment call. The decision will probably be made by the FOSC with the input of DOH. This seems to be understood by both parties. In the event of a dispute over cleanup sufficiency, the FOSC, as the ultimate authority in an oil spill response, would have the final say.

The state plan specifies no preventive measures over and above those prescribed by the U.S. Coast Guard, which will be amended when administrative rule-making is completed under OPA. There are many areas in which the state could exercise its influence to lessen the likelihood of spills. It may be prudent for the state to do so since all of the provisions of OPA will not be implemented for some years. The state could be looking at accelerating the adoption of some of the simpler strategies where feasible, such as adopting a more active policy aimed at reducing the large number of small spills through regulation of fuel transfer activities. Periodic review of the state plan with input from other states, oil industry personnel, and the U.S. Coast Guard would be useful.

Cleanup Equipment and Resources Assessment of Oil Spill Cleanup Capability in Hawaii

While the state has no cleanup responsibilities under OPA, it must still be concerned as the trustee of its resources. The U.S. Coast Guard Plan identifies the material and manpower that it anticipates would be required to respond to a catastrophic spill, and points out that extreme shortfalls that would exist for most types of equipment in the islands. Although it is an attractive concept to think that the state can prepare for an oil spill simply by having plenty of equipment and manpower around to clean it up, this is not the case. Even given
unlimited amounts of equipment, cleaning up oil spills is very difficult. Moreover, there are limits to the amount of equipment that can be reasonably stockpiled for an event that may never occur.

Moreover, state of the art in at-sea oil recovery technology is not very good. Optimistic estimates of oil spill cleanup efficiency range from 10–15 percent recovery of spilled oil under ideal conditions. Conditions around the Hawaiian Islands are seldom ideal and cleanup efforts are likely to be mostly futile in the event of a large spill. Cleanup efficacy is highly dependent on the ability to respond without delay. Therefore, although much equipment is ostensibly available to be flown in from the west coast for use in Hawaii, it is likely to be of questionable value by the time it arrives here 24–48 hours after the oil spill. Similarly, the transport of the in-state cleanup materials from one island to another may encounter delays.

Nevertheless, there is a considerable amount of material stockpiled around the islands (mostly on Oahu) which may be useful in containing the frequent small spills which result from fuel loading mishaps in calm nearshore waters. More equipment is being stockpiled by the Marine Spill Response Corporation and others. The U.S. Coast Guard has prepared an inventory of available equipment in the islands, based in part on the list compiled by Sea Grant researchers (Appendix C), to be included in the MRO Honolulu Oil and Hazardous Substance Pollution Contingency Plan. Agencies in the state having stocks of material which could be used to cleanup an oil spill include:

- the Clean Islands Council
- the oil companies
- the U.S. Navy
- Pacific Environmental Corporation (PENCO)
- Unitek Environmental Services
- P&S Pacific, Industrial Technologies
- Industrial Purifications
- Smith Services

In the absence of any experience of large scale cleanup efforts in Hawaiian waters, it is difficult to estimate how effective such efforts might be. After a certain amount of equipment has been stockpiled, the efficacy of cleanup actions depends more on a large number of variable factors and less on the amount of available sorbent materials and workers. Such determining factors include weather and tidal conditions, type of product spilled, the location of the spill, time of day, etc. Each spill is different. There is no way of estimating precisely the magnitude of spill that can be effectively responded to with the existing resources.

It can be assumed that there would be extensive oiling of beaches in the event of a large spill. Response would then become a matter of trying to remove the oil and contaminated material and dispose of it. Small to medium spills (under 40,000 gallons) can probably be dealt with fairly well with the resources available in the state, under favorable conditions. However, the state could consider setting a target level of cleanup resources to be stored in the islands. A policy of “more is always better” may result in the acquisition of material that would have marginal utility in the event of a spill.

**Oily Waste Disposal**

The issue of oily waste disposal is not adequately addressed in the state contingency plan. It is unlikely that more than a small fraction of the oil recovered from the ocean would be suitable for recycling. The remainder will have to be disposed of in some manner. Several possible options for dealing with the large amount of oily waste that could be generated have been mentioned; among these are: landfilling, stockpiling, burning at incinerators, and shipping to a site away from Hawaii for disposal.
A critical look at these options reveals that they all have restrictive shortcomings, which are likely to limit their usefulness in an actual large oil spill. DOH has indicated that landfilling is the least favorable option while incineration is the most preferred. Unfortunately, no agreement exists between the state and the City and County of Honolulu to permit either the landfilling or the incineration of oily materials and sand at the city facilities.

From discussions with City and County of Honolulu Refuse Collection and Disposal administrators, it has become clear that burning the volume of oily waste that would be generated by a large oil spill, would be problematic at both the H-Power plant and the Waipahu incinerator on Oahu. Problems cited include: disruption of processing regular municipal waste; difficulties in handling fine grained material such as sand, which would be sieved out of the present systems; difficulties in handling liquid materials; difficulties disposing of the large quantities of ash that burning sand would generate; ropes, nets, and similar stringy materials may clog up the flail mills which process the refuse prior to burning; possible pre-ignition of oily materials in the blower manifolds of the H-Power plant; and the necessity to feed the oiled material into the furnaces gradually, with the stream of refuse, in order to keep burning temperatures stable. Extensive modifications to the existing incinerators would be required to permit the burning of such oily wastes as would be generated by a large oil spill. If incineration of oily sand and other wastes is to be considered as a viable disposal option, a considerable amount of pre-planning is required.

Landfilling of oil and oily wastes is a very unfavorable option for several reasons. The potential for leaching of hydrocarbons into the underlying aquifers and the use of increasingly scarce landfill space are the principal problems with landfilling.

If the wastes are to be shipped away for disposal, this must be pre-planned. Arrangements should be made to contract shipping companies or find some other way to transport the wastes to their destination. Possible disposal sites should be identified and arrangements made for the acceptance of the oily wastes. Shipping the waste to the mainland would be an expensive option that would add significantly to the cost of cleanup operations. Interim in-state holding sites for oily waste should be identified and prepared.

While in situ burning of oil has been suggested as a possible response action, the applicability of this technique has not been extensively researched and it has not been tried in Hawaii. As the ignition of spilled petroleum on the ocean will be seen as a rather drastic step that could result in a considerable amount of air pollution, it is probable that there will be some opposition to its adoption as a response option. The adoption of in situ burning would require that more research be done, particularly in Hawaiian waters, personnel be trained in the techniques, and needed materials be acquired. In order to be effective, in situ burning must be initiated while the petroleum product is concentrated enough to ignite. Because burning must take place soon after the spill has occurred, interagency/intergovernmental agreements should be in place (e.g., MOU) with the U.S. Coast Guard and possibly the U.S. Navy for use of its equipment. It may be appropriate for the state to develop a policy of where and under what circumstances in situ burning would be permitted.

Regardless of the disposal option(s) chosen, a large oil spill would generate large volumes of oily waste material which will overwhelm the capabilities of the incinerators, landfills, and shipping companies. Clearly, provisions for the safe on-shore storage of this material while awaiting disposal are required. Once the material is safely sequestered, the disposal options can be evaluated under more relaxed circumstances.

Letter of Agreement Regarding Dispersants

This letter was promulgated with the intent of allowing the FOSC to use dispersants with discretion; however, it sets a number of conditions and guidelines which must be followed in using dispersants. Unless their use will prevent damage to human life, pre-approval of dispersant use is not given in areas:

- where the water is less than 60-feet deep
• in any location where the dispersed oil may reach a shoreline, marine sanctuary, national or state wildlife refuge, state marine life conservation district, or estuarine sanctuary
• over shellfish propagation or harvesting waters
• waters over reefs
• waters designated as aquatic preserves
• waters over nursery areas of indigenous aquatic species
• waters in coastal marshes or waters in mangrove forests

Therefore, the use of dispersants is not pre-approved for most inshore waters in Hawaii, and would be limited, for the most part, to areas of deep water away from shore where their negative impacts would be minimized. The improper use of dispersants may cause considerable environmental damage because the dispersants are oftentimes more toxic than the petroleum product they are intended to disperse.

Conclusions

Federal laws and Hawaii laws differ somewhat on the entities subject to the provisions of each. OPA focuses on vessels transporting crude or refined petroleum products and on-shore and offshore facilities. HRS, Chapter 128D includes on-shore and offshore facilities and all vessels fitting a broadly drawn definition. Hawaii’s statutes do not have specific requirements for vessels to meet other than to report spills of hazardous substances covered in HRS, Chapter 128D. However, if Hawaii is to require safety and prevention measures similar to requirements imposed in other states, a more precise definition of “vessel” would be needed. For example, if the state were to require vessel contingency plans for response to oil spills, it would have to define the type of vessel(s) that are subject to that requirement.

If vessels and facilities not covered by OPA are required to develop oil spill response plans by state law, the industry co-op, the CIC, could be an important source of expertise for assisting local vessel owners to develop oil spill response contingency plans. The CIC could charge a fee for this service or require membership in the co-op as a condition for their assistance in preparing contingency plans.

Both federal and state agencies appear to understand their roles in an event of an oil spill, and their responsibility for the subsequent cleanup. In determining sufficiency of a cleanup effort, state and federal agencies should determine the process for making that decision and formalizing it in a memorandum of understanding or as an addendum to the federal contingency plan.

Hawaii’s policy differs significantly from that of the federal policy and other states in the lack of emphasis on prevention of oil spills. OPA and the laws of Washington, Florida, and Louisiana all contain language addressing oil spill prevention. The state would be wise to consider mandating prevention schemes in order to reduce the potential of a major oil spill. Prevention issues are discussed in Chapter 6.

Another area where Hawaii differs significantly with the three states, is the source of revenue for their oil spill cleanup fund. Washington, Louisiana, and Florida derive revenue for their funds from a fee levied on all petroleum products brought into the state and from fines collected for violations. Hawaii’s “Superfund” revenue comes from legislative appropriation as well as fines and penalties levied.

Hawaii also prohibits the use of revenue in its “Superfund” for any other purpose but hazardous waste and oil cleanup. Louisiana and Florida allow a portion of their oil spill cleanup fund to be used for research, training, education, and administrative costs. Washington created a second fund to handle these costs.
Recommendations

Policy Recommendations

Editor's note: The recommendations that follow are based on the findings of our research. As indicated in italics, the DOH notes that some of the recommendations are already in the process of being implemented by the appropriate agencies.

Departmental action in terms of oil spill prevention and cleanup is dictated by state statute and regulations. OPA provides the framework for oil spill prevention and cleanup but leaves room for states to address areas of their particular concern, which may not be covered under the federal statute. Hawaii has moved cautiously in defining a new policy regime as compared to other states. This has given Hawaii the advantage of being able to evaluate its needs and to examine innovative state legislation proposed elsewhere. However, the state should examine existing policies in several areas, including closer consultation with county agencies and instituting fees on oil imports. Foremost among our recommendations is the need for the state to move more aggressively in the area of oil spill prevention. State policy is based on the notion of being able to respond adequately to oil spills. A sound oil spill policy is one that is geared both to prevention and response.

Overall, the following policy adjustments are recommended:

1. Amend state statutes to reflect a greater emphasis on planning for oil spill prevention rather than cleanup. The state should require the petroleum and marine transportation industry to prepare oil spill prevention plans that reduce the risk of a spill. The plans should consider the cost and benefits of various levels of environmental protection and outline a list of prevention measures that will be implemented. The state should consider offering incentives for the development and implementation of prevention measures.

   OPA 90 and existing regulations address oil spill prevention. The state is authorized to be more stringent. The recommendations should be more explicit as to how the state should be more aggressive.

   33 CFR 156 addresses spill prevention requirements. I am unsure that “plans” will accomplish any additional preventative measures.

2. Impose a fee on all oil brought into the state to help build the state superfund up to an established ceiling. A fee of $0.05 per barrel on petroleum places the burden of paying for future oil spill cleanups on those profiting from the sale of petroleum products and would raise approximately $3 million per year. The fee should also have minimal impact on consumers since it amounts to $.0012 per gallon of petroleum crude or product. A percentage of the fee, perhaps 5-10%, should be used for personnel education, training, monitoring, oil spill planning, and administration of an environmental response capability. This could be accomplished by amending section 128D2-4 to allow for expenditures from the fund for these purposes. The amount used in any one year may be limited by a cap on the use of the fund for administrative purposes.

3. Define mechanisms for working with the counties and the federal government in deciding how to certify the end of a cleanup effort. An interagency memorandum of understanding (MOU) between the state of Hawaii and U.S. Coast Guard could outline the process for determining when an oil spill cleanup effort can be discontinued. The MOU can be made a part of the regional response plan. County governments must also be represented in the cleanup decisionmaking process.

   Law states that the Federal On-Scene Coordinator (FOSC) can make the call. Regulations are being developed to address state access to the fund in cases where the state does not agree with the FOSC.

4. Institute liability limits in line with the cost of cleanup and damage reimbursement in a worst case oil spill. The vessel liability should be higher than the federal level now in place, since it is likely that the damage resulting from a catastrophic oil spill will be greater than the limits imposed by the
federal government. Liability limits in line with those applying to interisland barges under Act 130 1992 may be a guide to setting limits for all types of vessels.

5. Redefine the term “vessel” in the definition section of Chapter 128D, HRS. The extant definition subjects all vessels to the act whether the vessel is an ocean liner, or a motorized dinghy. If additional requirements were added requiring vessel contingency plans and cleanup equipment on-board, the inclusion of all vessels would adversely impact small vessel owners. The full impact of the law should fall on large vessels with large fuel or cargo capacity.

6. Require tankers, large vessels and facilities prevention plans, and vessels not specifically covered by federal law, to prepare prevention plans. Large vessels such as cargo ships and passenger liners carry great quantities of oil as fuel and could cause a substantial spill were an accident to occur. Where federal law and regulation requires these plans to be prepared, they can be substituted for those mandated by the state. All other vessels could be made to follow federal guidelines.

*Federal law covers vessels or facilities which have the capacity for an oil spill that could cause “substantial harm” or “significant and substantial harm.” The state can be more stringent; however, the economic impact on small boat owners may be too onerous.*

7. State should wait until Coast Guard formulate regulations for contingency planning and documentation for vessel financial responsibility before requiring its own contingency plans or documentation.

**Preparedness Recommendations:**

1. MOU’s should be drafted on all matters that will require cooperation between the different levels of government.

   *The U.S. Coast Guard and the state are currently working on a MOA [MOU] for marine protection. As specific issues arise which need additional MOAs [MOUs], they will be developed. In addition, the Area Planning Committee is working to identify these issues.*

2. The state contingency plan should be reviewed periodically. Input from other states, the oil industry, and the U.S. Coast Guard should be sought.

   *The State Contingency Plan (I am assuming the “Oil and Hazardous Substances Emergency Response Plan”)* is reviewed periodically by the Hawaii State Emergency Response Commission.

3. It should be the specific duty of someone in the state government to keep abreast of the state-of-the-art in oil spill cleanup and prevention technology. This person should have a part in reviewing and updating the state plan. If at present, the state lacks a position to fulfill this role, additional personnel should be hired.

4. The Department of Health requires additional staffing to take a more active role in ensuring that the provisions of the contingency plan are followed. There are areas in which greater commitment to the plan and a more positive direction might be appropriate. An operations manual covering procedures for handling problems in training, planning, and communication could serve as a guidebook for ensuring readiness and coordination of all state/county agencies.

**Response Recommendations**

1. Exercises and drills should be held regularly.

   *OPA 90 requires exercises and drills be held regularly. Additional drills may not accomplish any additional prevention.*

2. A MOU should be drafted with the counties to permit the use of their earth-moving machinery in response to a spill incident.

   *The U.S. Coast Guard is working with the counties to access their equipment.*
3. A MOU should be drafted with the counties to permit the removal of sand when oil contamination of beaches is imminent.

Law states that the Federal On-Scene Coordinator (FOSC) can make the call. Regulations are being developed to address state access to the fund in cases where the state does not agree with the FOSC.

4. It should be decided and clearly stated who has the final responsibility for declaring cleanup sufficiency.

Law states that the Federal On-Scene Coordinator (FOSC) can make the call. Regulations are being developed to address state access to the fund in cases where the state does not agree with the FOSC.

**Waste Disposal Recommendations**

1. A strategy for oily waste disposal should be formulated.

   *The Subcommittee on the disposal of oily waste is addressing this issue.*

2. A MOU should be drafted with the counties regarding the use of their landfills for disposal of oily waste.

   *This is being investigated by one of the Subcommittees. In fact, OPA mandates that there will be a storage and disposal plan.*

3. A MOU should be drafted with the counties regarding the incineration of oily wastes at their facilities.

   *This is being investigated by one of the Subcommittees. In fact, OPA mandates that there will be a storage and disposal plan.*

4. The technical aspects of oily waste incineration at City and County of Honolulu facilities should be addressed.

   *This is being investigated by one of the Subcommittees. In fact, OPA mandates that there will be a storage and disposal plan.*

5. A memorandum of understanding should be drafted with the federal authorities to permit the indefinite storage of oily waste.

   *This recommendation is too specific. We do not necessarily need a MOA (MOU) with the federal authorities. What we need is a place to store oily waste. This could be state land, private land, county land, or federal land. This problem is being addressed.*

6. Interim storage sites for oily waste should be identified and prepared.

   *This recommendation is too specific. We do not necessarily need a MOA (MOU) with the federal authorities. What we need is a place to store oily waste. This could be state land, private land, county land, or federal land. This problem is being addressed.*

**References**


CHAPTER 6

ANALYSIS OF THE CAUSES AND PREVENTION OF OIL SPILLS

Rose T. Pfund, Ph.D.
Introduction

The seemingly insatiable corporate and individual demand of industrialized nations for fuel is met by the daily transport of 31.5 billion gallons of oil by ship from oil producing regions to oil consumers (Etkin, 1990). Hawaii’s portion of this global pool of oil-in-transit is a daily average of about seven million gallons destined for terminals or ports on Oahu, Maui, Kauai, Molokai, and Hawaii. While petroleum has the potential for fueling explosive fires, the use of tankers and supertankers with cargo capacity in the tens of millions of gallons, introduces a human-generated destructive force of fearsome magnitude that can pollute hundreds of miles of coastline in a single catastrophic oil spill. However, the volume of oil and oily waste being dumped into the ocean from municipal sources, ship operations, and natural seeps exceeds the amount that is introduced into the marine environment by tanker accidents (M’Gonigle and Zacher, 1979). The difference in the level of public outrage between frequent low-volume spills and an infrequent large spill lies in the visibility of a catastrophic oil spill. The public’s perception of frequent low-level oil spills and a single large spill is similar to its acceptance of the annual national mortality of more than 25,000 from highway accidents, but its outrage when an airliner crashes and kills 250 passengers, which is only one percent of the highway mortality.

William O’Keefe, vice-president and chief operating officer of the American Petroleum Institute, observed that “despite the best preventative measures, tanker transport of oil is always subject to the vagaries of weather and human error” (Etkin, 1990). This view was taken as a challenge in designing this study. Interestingly, our statistical analysis found that the frequency distribution of oil spill accidents is spread randomly throughout the year, rather than in high concentration during winter months when storms are common. Weather, therefore, is a contributing factor, but it is not a statistically significant cause of oil spills. What is a statistically significant cause of oil spills worldwide is human error. However, when Hawaii’s historical record of oil spills was analyzed, it showed that oil spills caused by human error were overshadowed by those caused by mechanical and structural failures.

For Hawaii, where so much of the state’s well-being rides on a pristine environment, any oil spill is bad news, particularly because of two conditions: 1) environmental damage; and 2) ineffective oil spill response technology. When an at-sea oil spill occurs, damage to coastal and intertidal zones and bottom sediments is inevitable. John Bennett, Bennett Environmental Consultants, Ltd., summarizes the ineffectiveness of known response technology (Etkin, 1990):

...[E]very time there’s a spill, it’s a major disaster ... It’s very rare that we ever collect even 10 percent of the oil — I think we’ve reached our limit on what we can do with equipment.

These conditions and the potential catastrophic economic impact of a major oil spill added a sense of urgency and provided the motivation for exploring all possible prevention measures. It is well known, though not well-documented, that the cost of oil-damaged beaches is particularly high for tourism-related activities. There are some historical anecdotal observations, e.g., a temporary 20 percent drop was reported in Santa Barbara (leakage from an offshore well) and an undesignated level of tourism revenue losses lasted for a year along the United Kingdom’s southern coast (Torrey Canyon oil spill) (M’Gonigle and Zacher, 1979). For Hawaii, as discussed elsewhere in this report, the magnitude of the economic impact of a major oil spill on tourism revenues, based on the U.S. Coast Guard’s worst case scenario, could be catastrophic.

Research Methodology

In developing the strategy for studying the prevention of oil spills, one of the assumptions made was that given the volume of oil shipments, oil spills are inevitable, but they could be minimized. The 1989–1990 data on major oil spills worldwide >10,000 gallons, obtained from the Oil Spill Intelligence Report (1991a), were statistically analyzed to determine the frequency, causes, and location of these spills which dumped more than
77 million gallons of oil into the oceans of the world. The Hawaii oil spill data, obtained from the U.S. Coast Guard headquarters in Washington D.C., were also statistically analyzed to ascertain frequency, cause, and location of the reported oil spills. Additionally, the Hawaii Revised Statutes and institutional infrastructure and the implications of OPA on the state’s role for responding to and/or mitigating oil spill accidents were examined to identify avenues which could be used to implement preventive measures.

A caveat needs to be added here on the Hawaii oil spill data. When several discrepancies were found, we verified, to the extent possible, the major entries in the database we used. We were unable to locate an agency that keeps a consistent and verified record of historical oil spills in Hawaiian waters. It is only within the last two or three years that record keeping by the U.S. Coast Guard, Honolulu Office, appears to have become more comprehensive, but even today, records are largely based on the spiller’s report, except when there is a major oil spill. As the Federal On-Scene Coordinator, the Captain of the Port, U.S. Coast Guard, 14th District, prepares a report of all large oil spills.

This section begins with an assessment of what can be called the anatomy of an oil spill. The two sets of data on oil spills, worldwide and Hawaii accidents, were examined to identify and characterize frequency, causes, and location of oil spills.

**Causes of Major Oil Spills Worldwide**

In determining the influence of weather on oil spill accidents, it was assumed that adverse weather would be more prevalent in the winter and consequently there would be a higher frequency of accidents during the winter months (December–February). When the 1989 and 1990 data were plotted, the randomness of the frequency distribution for the two seasonal cycles negated statistical significance of weather as a cause of oil spills (Figure 6.1). However, weather had a significant impact on shipboard fatalities. Of the six fatalities that were recorded for the two years, five occurred during the winter months.

One of the more significant aspects of the oil spill data, shown in Table 6.1, was the location of accidents. The surprising finding is that more than half of the major accidents occurred away from loading and offloading facilities. (However, judging from other statistics, e.g., those for Hawaii, numerous small spills, which were not included in the worldwide oil spill data, are likely to occur at ports and terminals.) In other words, these statistics indicate that 56 percent or one out of two major accidents occurred on the open ocean and one out of ten accidents occurred in the congested terminals and ports. A related aspect of these statistics, the effect of fatigue on open-ocean accidents is discussed below in the section on OPA, Title IV.

![Figure 6.1. Worldwide oil spill statistics: 1989 and 1990](image-url)
Table 6.1. Distribution of location of major oil spills worldwide (>10,000 gallons): 1989–90*

<table>
<thead>
<tr>
<th>Accident sites</th>
<th>Percent of all accidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offshore locations</td>
<td>35</td>
</tr>
<tr>
<td>Nearshore locations</td>
<td>21</td>
</tr>
<tr>
<td>Rivers</td>
<td>10</td>
</tr>
<tr>
<td>Ports/harbors/terminals</td>
<td>9</td>
</tr>
<tr>
<td>Other</td>
<td>25</td>
</tr>
</tbody>
</table>

*Data Source: Oil Spill Intelligence Report, 1991a

Analysis of the relationship of accident location and types of vessel indicated that tankers were involved in 65 percent of all offshore accidents, 50 percent of near-shore accidents, and 53 percent of ports/harbors/terminals accidents. Barges accounted for 71 percent of all accidents along rivers and 67 percent of the accidents in channels and waterways. When the data were analyzed to determine the cause of the accidents, there was no question as to the major cause of oil spills at sea. Human error and human error-related vessel guidance accidents — groundings and collisions — were responsible for 58 percent of oil spills in excess of 10,000 gallons that occurred worldwide during 1989 and 1990 (Table 6.2).

Table 6.2. Oil spills worldwide (>10,000 gallons): 1989–90*

<table>
<thead>
<tr>
<th>Type of accident</th>
<th>Percent of all accidents (avg.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grounding</td>
<td>20</td>
</tr>
<tr>
<td>Collision</td>
<td>31</td>
</tr>
<tr>
<td>Human error</td>
<td>4</td>
</tr>
<tr>
<td>Spillage</td>
<td>1</td>
</tr>
<tr>
<td>Dumping</td>
<td>2</td>
</tr>
<tr>
<td>Undetermined sinkings</td>
<td>11</td>
</tr>
<tr>
<td>Mechanical/other</td>
<td>31</td>
</tr>
</tbody>
</table>

*Data Source: Oil Spill Intelligence Report, 1991a

Although it was not possible to ascertain the number of sinkings that were caused by human error, nevertheless, there is high probability that at least some of the 11 percent attributed to sinking could have resulted from human error. It is probable that human error was the cause of as much as two-thirds or more of all major oil spills in the world.

The large number of accidents caused by human error is substantiated by historical data. The statistics for the 1969–72 oil spills worldwide that occurred less than 50 miles from land indicate that 74 percent were caused by human error-related guidance accidents (Beyer and Painter, 1977):

- Collision: 33%
- Groundings: 33%
- Ramblings: 8%
- Total: 74%
A comparison of the volume of spill per accident, tabulated for the two periods, shows an increase of more than three-fold over the 20-year period for collisions and groundings:

<table>
<thead>
<tr>
<th></th>
<th>1969-72</th>
<th>1989-90</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gallons/accident</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collisions</td>
<td>424,008</td>
<td>1,533,947</td>
</tr>
<tr>
<td>Groundings</td>
<td>419,588</td>
<td>1,404,615</td>
</tr>
</tbody>
</table>

The increase in the size of oil spills is probably due to the increased usage of supertankers. Further corroboration of the relationship between larger tanker capacity and larger oil spills is evident in the doubling of the average size of oil spills during the 20-year interval:

<table>
<thead>
<tr>
<th></th>
<th>1969-72</th>
<th>1989-90</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gallons/accident</td>
<td></td>
<td></td>
</tr>
<tr>
<td>426,216 gallons per accident</td>
<td>891,272 gallons per accident</td>
<td></td>
</tr>
</tbody>
</table>

The 1989-90 data were averaged and analyzed to determine the types of vessels involved in human error-related accidents which accounted for about 57 percent of all accidents (Table 6.2):

<table>
<thead>
<tr>
<th></th>
<th>Collisions</th>
<th>Groundings</th>
</tr>
</thead>
<tbody>
<tr>
<td>(%) of all collisions</td>
<td>(%) of all groundings</td>
<td></td>
</tr>
<tr>
<td>Tankers</td>
<td>51</td>
<td>55</td>
</tr>
<tr>
<td>Barges</td>
<td>30</td>
<td>16</td>
</tr>
</tbody>
</table>

Human error-related accidents caused more than half of all tanker accidents, i.e., one in two accidents. On the other hand, accident statistics for barges showed that they are more than twice as likely to be involved in collisions, which are multi-vessel accidents, than single-vessel accidents like grounding. This is probably explainable by the fact that barges mostly operate in channels, waterways, and rivers which tend to be narrow and congested. It is noteworthy that non-oil cargo carrying vessels caused 15 percent of the collisions and 35 percent of the groundings that resulted in spills of more than 10,000 gallons. This statistic should justify Hawaii’s consideration of requiring large passenger and fishing vessels that carry more than 10,000 gallons of fuel to develop contingency plans for oil spill response.

An interesting sidelight to oil spills is a study cited in Oil Spill Intelligence Report (1991) that found a higher number of oil spills occurred on Saturday than on other days. Eban Goodstein who analyzed listings of accidents in several sources found that oil spills were caused by what he calls the “Saturday effect.” Goodstein noted that accidents were more prevalent on Saturday than on other days and offers some explanations:

- Increased recreational traffic
- Alcohol abuse and late hours
- Reduced staffing as crew leaves ship

Goodstein states that if the “Saturday effect” could be eliminated, there would be a nine percent decrease in oil spills of about 163,000 gallons. He suggests imposing a harsh penalty for Saturday spills and levying a per-gallon tax on Friday night clearances and Saturday entrances and clearance.

**Causes of Oil Spills in Hawaii**

As shown in Table 6.3, 11 oil spills larger than 5,000 gallons and four of the five oil spills larger than 25,000 gallons occurred off the south and southwestern coastline of Oahu that stretches from Honolulu Harbor to Barbers Point (Figure 6.2). Indeed, this strip of coastline accounts for 59 percent of the reported oil spills during the 9-year period covered by U.S. Coast Guard data which was used as the basis for the analysis of oil spills in Hawaii.
Table 6.3. Major oil spills in Hawaii (>5,000 gals): 1983–91

<table>
<thead>
<tr>
<th>Year</th>
<th>Amount of Spill</th>
<th>Cause</th>
<th>Spill Site</th>
</tr>
</thead>
<tbody>
<tr>
<td>1987</td>
<td>120,000</td>
<td>Ruptured pipeline</td>
<td>Pearl Harbor</td>
</tr>
<tr>
<td>1984</td>
<td>48,000</td>
<td>Grounding</td>
<td>Pearl Harbor</td>
</tr>
<tr>
<td>1987</td>
<td>42,000</td>
<td>Equipment failure</td>
<td>Kalahui Channel</td>
</tr>
<tr>
<td>1989</td>
<td>33,800</td>
<td>Grounding</td>
<td>Barbers Point</td>
</tr>
<tr>
<td>1989</td>
<td>26,000</td>
<td>Structural failure</td>
<td>Honolulu</td>
</tr>
<tr>
<td>1991</td>
<td>18,000</td>
<td>Tank overflow</td>
<td>Honolulu Harbor</td>
</tr>
<tr>
<td>1989</td>
<td>15,000</td>
<td>Structural failure</td>
<td>Pearl Harbor</td>
</tr>
<tr>
<td>1989</td>
<td>10,000</td>
<td>Structural failure</td>
<td>Pearl Harbor</td>
</tr>
<tr>
<td>1985</td>
<td>9,800</td>
<td>Structural failure</td>
<td>Pearl Harbor</td>
</tr>
<tr>
<td>1991</td>
<td>6,500</td>
<td>Spillage</td>
<td>Pearl Harbor</td>
</tr>
<tr>
<td>1990</td>
<td>5,000</td>
<td>Human error</td>
<td>Pearl Harbor</td>
</tr>
<tr>
<td>1989</td>
<td>5,000</td>
<td>Discharge</td>
<td>Honolulu Harbor</td>
</tr>
<tr>
<td>1989</td>
<td>5,000</td>
<td>Unknown</td>
<td>Molokai</td>
</tr>
</tbody>
</table>

![Histogram of reported oil spills in Hawaii](image)

(Data source: U.S. Coast Guard)

Figure 6.3 shows the dramatic increase in the number of spills reported to the U.S. Coast Guard. It is possible that the increase is an artifact of greater awareness of the need to report oil spills, but as noted in Chapter 1, more oil is imported today than 10 years ago. Of the known size of spills (the size of about 53 percent of the reported spills are unknown), more than 40 percent were under 1,000 gallons. However, over the nine-year period, there were 13 oil spills ranging in volume from 5,000 to 120,000 gallons with 11 of the large spills occurring during the last five years (1987–1991). Of these, only five (about one-third) were caused by human error-related accidents and seven by structural and equipment failure.

Statewide distribution of oil spills given in Table 6.4 shows that Oahu far outstrips the other islands as the site of oil spills, including major spills shown above in Table 6.3. The concentration of spills on Oahu is undoubtedly due to the location of major oil handling and refinery facilities along the island's southern coast, including Honolulu Harbor, the state's major port, Pearl Harbor, and the two refineries, Chevron, USA and Hawaiian Independent Refinery, Inc. (Figure 6.2).
Table 6.4. Frequency distribution of oil spills by island (1983–91)

<table>
<thead>
<tr>
<th>Island</th>
<th>Frequency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hawaii</td>
<td>9</td>
</tr>
<tr>
<td>Kauai</td>
<td>3</td>
</tr>
<tr>
<td>Maui</td>
<td>6</td>
</tr>
<tr>
<td>Molokai</td>
<td>1</td>
</tr>
<tr>
<td>Oahu</td>
<td>81</td>
</tr>
<tr>
<td>Unknown</td>
<td>1</td>
</tr>
</tbody>
</table>

*Total exceeds 100 due to rounding of the percentages

Data Source: U.S. Coast Guard

Honolulu Harbor and Pearl Harbor were the sites of about 30 percent of the reported oil spills in Hawaii. Nearly all oil products are received and/or shipped from 14 facilities within the Honolulu Harbor complex. Piers 29A, 30-34, 51A are interconnected by a pipeline system that extends to storage tanks. Bunkering service is also provided at these piers. The Chevron, USA facility and Pacific Resources, Inc. are connected by pipeline to their refineries at Barbers Point.

Pearl Harbor has been a major naval base and shipyard for the U.S. Navy’s Pacific fleet since the 1800s when it was a coaling station for the steam-powered U.S. North Pacific fleet. The wide array of structural/mechanical causes of oil spills suggests the existence of aged infrastructure that needs to be replaced or upgraded. The long-term effect of these continuous low-level oil spills on the indigenous birds and the nehu bait fishery in Pearl Harbor’s estuarine environment is unknown.

While only 11 percent of the reported spills were cited as human error or human error-related accidents (Table 6.5), the known volume of oil spill caused by these accidents (absolute number = 22) totalled 106,684 gallons or an average of 4,849 gallons per accident. What is striking, however, is the predominance of mechanical/structural failure-related accidents which account for nearly 40 percent of the accidents. While the total spill volume caused by structural and equipment failure is unknown, reported oil spills caused by such accidents totalled about 55,000 gallons in Honolulu Harbor and 154,800 gallons in Pearl Harbor over the nine-year period. The significant number of oil spills caused by structural and mechanical failure at these facilities points to a need for better facility maintenance and/or replacement of aged equipment and pipelines. Both Honolulu Harbor and Pearl Harbor still utilize old fuel lines and have a network of abandoned pipelines. Oil spills from structural and mechanical failure can be eliminated or reduced to very low levels if equipment and facilities are regularly maintained or replaced and rigorous risk management and loss prevention programs are instituted.
Table 6.5. Causes of oil spills in Hawaii: 1983–91

<table>
<thead>
<tr>
<th>Cause</th>
<th>Percent of reported spills*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discharge**</td>
<td>4</td>
</tr>
<tr>
<td>Dumping**</td>
<td>3</td>
</tr>
<tr>
<td>Grounding**</td>
<td>1</td>
</tr>
<tr>
<td>Human error**</td>
<td>3</td>
</tr>
<tr>
<td>Collision**</td>
<td>(&lt;1)</td>
</tr>
<tr>
<td>Burping</td>
<td>1</td>
</tr>
<tr>
<td>Corrosion</td>
<td>4</td>
</tr>
<tr>
<td>Inclement weather</td>
<td>1</td>
</tr>
<tr>
<td>Leak</td>
<td>10</td>
</tr>
<tr>
<td>Mechanical failure</td>
<td>6</td>
</tr>
<tr>
<td>Pumping</td>
<td>4</td>
</tr>
<tr>
<td>Sinking</td>
<td>1</td>
</tr>
<tr>
<td>Structural failure</td>
<td>5</td>
</tr>
<tr>
<td>Overflow</td>
<td>7</td>
</tr>
<tr>
<td>Unknown</td>
<td>47</td>
</tr>
</tbody>
</table>

* Total does not equal 100 due to rounding of percentages
** These are human error or human error-related causes

Data Source: U.S. Coast Guard

Based on the nine-year record of oil spills in Hawaii, the statistical probability of oil spill occurrence has been projected (Lee, 1992):

<table>
<thead>
<tr>
<th>Oil spill volume</th>
<th>Probability of occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–20,000 gallons</td>
<td>once in 2.25 years</td>
</tr>
<tr>
<td>40–50,000 gallons</td>
<td>once in 4.5 years</td>
</tr>
<tr>
<td>10–11,000,000 gallons</td>
<td>once in 135 years</td>
</tr>
</tbody>
</table>

Based on simulated results using an optimization model, a trade-off can be made between prevention and response. Results indicate that response capability should be increased for each unit of reduction in prevention measures to maintain cost savings (Lee, 1992).

While it may be possible to strike a nice balance between response and prevention using cost savings as the motivation, questions can be raised on the utility of stockpiling equipment and supplies capable of responding to very large spills of a million gallons or more. Since the spiller, the facility owner or shipowner, is charged with the responsibility of responding to oil spills under OPA and not the state, the basic issue state government faces is defining the level of risk the public is willing to accept. Cost of response is not a factor to be entered into the state's decision matrix, except indirectly. There are, however, costs associated with developing an institutional infrastructure to effectively manage the potential catastrophic disaster. The required institutional framework is yet to be developed. The Hazard Evaluation and Emergency Response Office under the Department of Health (DOH) currently serves as the agency that monitors releases of all hazardous substances and is responsible for developing and implementing relevant provisions under OPA.
There is already in place what is referred to as the Hawaii Superfund Law, enacted in 1991, that gives the state the power to order immediate cleanup of an oil spill and to pay for the cleanup costs and be reimbursed from the trust fund established under OPA (Section 4201(d)(H)). In addition, the law allows criminal penalties to be levied on the polluter and there are no liability limits. Since the provisions of the state’s superfund law that deviate from OPA may not be preempted by the federal law, unlimited liability under Hawaii’s statutes, therefore, prevails for all oil spills that occur in Hawaiian waters. There is a temporary ceiling of $700 million for inter-island barge shipments of No. 6 fuel oil provided in Act 130 (enacted in 1992).

Channel Waters

There apparently have been near collisions between “tug vessels” and recreational boats in the narrow channels between the four islands that comprise Maui County. As is shown in Figure 1.1 in Chapter 1, these channels — Pailolo, Kalohi, and Auau — are used as transit lanes by tanker barges and dry cargo barges to deliver oil and other goods to Molokai, Maui, Lanai, and Hawaii. The 1992 session of the Sixteenth Legislature adopted House Resolution 137, HD1, which requests a study of the conflict between recreational boaters and tug vessels particularly in the waters of Maui County. From the standpoint of overall safety, the designation of mandatory barge traffic lanes, passive radar reflection devices, appropriate communication equipment, and local traffic rules appears to be in order because of the high use of the channel waters by recreational boaters and tourist charter boats.

If the issue of safest possible transit time for tanker barges were to be considered solely on the potential for the occurrence of an accident, all night channel crossing should be prohibited. But given the volume of traffic in the channel waters and the near misses that are being reported, the mandatory routing of all barge traffic to daylight hours would increase the probability for collision. The other extreme option is to designate the channels as tanker barge-free zones. Here again, what appears to be the logical answer does not stand up to the test of reality. The well-known turbulence of the open seas surrounding the islands constitute a greater hazard, according to mariners, than the occasional recreational boater at night.

Pilotage Waters and Pilotage

The designation of harbors and access channels as pilotage waters has a long standing. Pilotage waters are areas which can only be entered with a licensed pilot and/or tug assistance. The Sixteenth State Legislature adopted HB3049, HD1 which was signed into law by the Governor on April 22, 1992, as Act 25. It amends the HRS, Section 462A-17, by redefining boundaries of the pilotage waters near Barbers Point because “it is too confining, in that, it provides inadequate space for ships to anchor should they have to wait for entry into the harbor or should they call to obtain bunkers at anchor.” The expanded waters will include the area within the northernmost refinery tower, 2503 true, to the intersection of a line drawn tangentially to Maile Point, 1653 true.

As a result of the Exxon Houston near-accident at Barbers Point in 1989, the refineries and the U.S. Coast Guard have jointly developed more stringent regulations aimed at preventing vessel guidance accidents. A standby tug assistance and live watch are required during offloading operations at the offshore mooring at Barbers Point. The state’s Harbor Master issued regulations shifting the anchorage of laden tankers offshore from off-port Honolulu to anchorage off Barbers Point Naval Air Station. In addition, all off-port bunkering is now confined to anchorages ewa (west) of Kalihi Channel and the offshore anchoring area was designated ewa of the Honolulu main channel, but clear of the Sand Island sewage outfall and Kalihi Channel (Figure 6.2).

Because pilots are critical to the safety of ships in shallow coastal waters and in congested harbors, the state’s requirements and procedures for licensing pilots were reviewed. Chapter 462A, HRS, gives the director of the
Department of Commerce and Consumer Affairs (DCCA) the power to grant licenses and to revoke licenses. The director may convene a panel of knowledgeable individuals to assist in evaluating credentials of applicants and port pilots and in matters related to piloting (Admin. Rules 16-96-28.5). Currently, such a panel has not been appointed.

In general, the DCCA director is charged with the responsibility for “maximum efficiency in navigating vessels entering or leaving the waters of this State; maintain a piloting system devoted to the preservation, and protection of lives, property and vessels entering or leaving waters of the state; and ensure an adequate supply of qualified pilots.” The director is also charged with investigating violations of “the rules” and “any provisions of this chapter [426A]” (HRS, Chapter 426A-3).

Pilot's licenses expire on even-numbered years. Renewal of licenses cannot be denied as long as an application is submitted and the applicant or pilot follows “all applicable rules of the Department [DCCA] and remains in active service.” Licenses may be denied, suspended or revoked for the following causes by the DCCA director (HRS, Chapter 426A-8):

1. Violation of this Chapter [462A] or any rule adopted by the [DCCA] director;
2. Loss, damage, or injury due to negligent piloting;
3. Habitual use of any substance rendering a pilot unfit to be entrusted with the charge of a vessel;
4. Inability to physically or mentally perform the duties of a pilot;
5. Failure to maintain active service as a pilot in the state;
6. Procurement of a license through fraudulent misrepresentation or deceit;
7. Participation in any unfair or deceptive act or practice as prohibited by section 480-2;
8. Violation of any law or regulation intended to promote marine safety or protect navigational waters;
9. Failure to report marine accidents in accordance with the rules of this chapter;
10. Failure to maintain a current and valid federal pilots license in accordance with Title 46, United States Code, Chapter 71.

In addition, a license or renewal of a license may be denied or revoked for: 1) incompetence, including but not limited to, solo piloting a vessel that is beyond the capability of the pilot; and 2) noncompliance with the statewide piloting system.

The pilots are part of a central scheduling system established by the director under Administrative Rules 16-96-62 through contracts with the two pilots’ association — HPBS, Inc. and Hawaii Pilots Association. Section 462A-15 allows the pilots to form an independent non-profit association with each member explicitly excluded from sharing the liability that may be incurred by the association. Before any license can be revoked or denied, the applicant is given a hearing (Section 462A-20(a)). Any adverse action can be appealed to the circuit court (Section 462A-20(h)) within 60 days (Admin. Rules 16-96-29).

All vessels are required to take on a pilot while in the state's piloting waters, except vessels that are under the direction of a federally licensed pilot, public vessels, and fishing vessels with a fishing license or endorsed registry under federal laws (Section 462A-19).

There appears to be inadequate rules for the enforcement of substance abuse (HRS, Chapter 462A-8(3)) in Administrative Rules, Title 16, Chapter 96. While a physical examination is required, there is no requirement for obtaining certification that the pilot (or applicant) has no police DUI or DWI record. Moreover, under Administrative Rules 16-96-41, it is the pilot himself who must report that he is mentally or physically impaired. This procedure appears to be predicated on a rather naive assumption that the individual who is suffering from mental impairment will always recognize his/her disability. Physical impairment may be more easily recognized, but even here, there is still a question as to the level of impairment that would make it mandatory for the pilot to take a leave of absence.
A 60-day physical or mental impairment requires a physician's certification of fitness before resuming piloting. It is not clear as to who is to monitor the time taken off from piloting duties. Furthermore, there is no provision for the investigation of chronic absenteeism. Under the administrative rules, no physician's certification is required unless there is a continuous 60-day absence because of physical or mental impairment.

Although there is a mandatory requirement for participation in a training program (Administrative Rules 16-96-63), a clearly defined statement of purposes and criteria is absent.

### Inadequacies of Response Technology

If this report has a bias, it is toward prevention of oil spills rather than response because of the ineffectiveness of currently known technologies to contain and/or recover oil at sea. A detailed evaluation of these technologies is given in Appendix B. Table 6.6 graphically illustrates the poor recovery rate for large oil spills, which ranges between 1.6 percent and 11 percent. Along with the poor technology, response efforts have been hampered by the "inability to mobilize people and equipment under the chaotic circumstances that surround a major emergency...and sufficient response equipment is not always readily available and there are often not enough experienced people available to deploy it effectively" (Natural Resources Defense Council, undated).

<table>
<thead>
<tr>
<th>Vessel</th>
<th>Spill date</th>
<th>Location</th>
<th>Spill amount (Million Gallons)</th>
<th>Amount Rec'd (Gallons)</th>
<th>Amount Rec'd (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Puerto Rican</td>
<td>10/84</td>
<td>San Francisco</td>
<td>1.50</td>
<td>63,000</td>
<td>&lt;5</td>
</tr>
<tr>
<td>Apex Houston</td>
<td>2/86</td>
<td>Cent. Calif.</td>
<td>2</td>
<td>420</td>
<td>1.6</td>
</tr>
<tr>
<td>Glacier Bay</td>
<td>7/87</td>
<td>Cook Inlet</td>
<td>.13</td>
<td>14,994</td>
<td>11</td>
</tr>
<tr>
<td>Pacific Baroness</td>
<td>9/87</td>
<td>St. Barbara Ch.</td>
<td>.38</td>
<td>14,700</td>
<td>3.9</td>
</tr>
<tr>
<td>Exxon Valdez</td>
<td>3/89</td>
<td>Prince Wm. St.</td>
<td>10.80</td>
<td>714,000</td>
<td>&lt;7</td>
</tr>
</tbody>
</table>


One of the critical issues related to response readiness is the amount of response equipment and number of trained personnel that need to be in a state of readiness. Most common response technologies for at-sea treatment include boom, skimmers, sorbents, and dispersants (a summary of response technologies is given in Appendix B). The effectiveness of all of these technologies diminish when wave heights exceed more than three feet (Natural Resource Defense Council, undated; Etkin, 1990).

**Mechanical Methods.** Booms and skimmers are mechanical means of containing oil and removing oil. Special offshore booms are available to withstand waves up to about six feet and current speed of less than one knot. While most effective in calm waters, belt skimmers have been used in 10-foot waves. Because the effectiveness of skimmers and booms are limited to an optimal speed of .5 knot, no more than .5 square mile can be skimmed off in one day (Natural Resource Defense Council, undated).

**Dispersants.** Dispersants are most effective when applied to thick unweathered slicks in areas that are subject to vigorous wave action. Instead of removing oil, dispersants break up the oil into small droplets and transfer the oil from the surface to the water column (Natural Resource Defense Council, undated). None of the toxic elements in the oil is removed by this method. The potential impact of toxic elements in the oil as well as in the dispersants can damage wildlife and especially the sedentary fisheries. This fact is recognized in the memorandum of understanding between the Hawaii Department of Health and the U.S. Coast Guard by
prohibiting use of dispersants in nearshore waters less than 60-feet deep. The memorandum is an annex in the Oceanic Regional Contingency Plan for Hawaii.

**Sorbents.** There are several different types of sorbents, including organic materials such as straw and sawdust, polypropylene (synthetic organic sorbents), and mineral-based sorbents such glass wool and volcanic rock. All have disposal problems because the sorbents become oil-soaked waste of major magnitude in a large oil spill that must be disposed of in some appropriate manner. Others become sinking agents and carry the oil to the sea floor. Sorbents are considered to be most useful for small cleanups or for doing the finish work after cleaning up a large spill.

**In situ burning.** In situ burning is a technology that falls in the category of at-sea response before the oil reaches land. The first large-scale deliberate burning of oil, about 20,000 tons, was done in 1967 when the cargo of the *Torrey Canyon* was burned (Wardley-Smith, 1983). This technology was discussed at a workshop sponsored by the U.S. Environmental Protection Agency on May 21-22, 1991 in Sacramento, California and at the Region IX Regional Response Team workshop held on November 13-15, 1991 in Honolulu (Pester, 1991; U.S. Coast Guard, Oceanic Regional Response Team, undated). While still in the testing stage, experiments under controlled conditions have shown that it is possible to remove 98-99 percent of the oil (Pester, 1991). Studies conducted by the Office of Technology Assessment and the National Institute of Standards and Technology noted that in situ burning becomes more acceptable option, if the other is oil-coated beaches (Etkin, 1990). (Indeed, this viewpoint was voiced by the tourism industry panel convened for the present research.) Ongoing studies include determination of the volume of toxic gases that are released in a black plume. However, it should be noted here that toxic gases are released from the spilled oil through natural evaporation with or without burning.

**Bioremediation.** Bioremediation has been used at Prince William Sound and Galveston Bay and elsewhere with mixed results (U.S. Coast Guard, Oceanic Regional Response Team, 1991; Keeler, 1991). This technology includes fertilizing in situ bacteria and/or importing bacteria from elsewhere. Perhaps least intrusive, there is still disruption and damage to the environment during the application process. Other negative aspects of bioremediation are the release of gases by the bacteria, the potential for production of PCBs/chlorophenyls (U.S. Coast Guard, Oceanic Regional Response Team, 1991), and the long period of time required for the bacteria to do their work. Unlike other oil spill response technologies, bioremediation actually removes some toxic compounds, particularly the aliphatic fraction (U.S. Coast Guard, Oceanic Regional Response Team, 1991). It is also simple to apply and is inexpensive.

**Provisions Under OPA that Define State Authority**

Prompted by the Exxon Valdez oil spill, OPA is Congress' response for preventing such accidents through punishment and regulatory control. It also addresses oil spill cleanup through a $1 billion trust fund and requirement for evidence of response capability and/or adequate liability insurance coverage. A history of major oil spills has put shipments of oil, the vital commodity that fuels all urban centers, on the list of potential high risk hazards. New meanings of “liability” have evolved to address the establishment of penalties and damages attributable to catastrophic oil spills through the courts. This makes several provisions of OPA important to the state in establishing local levels of acceptable risk and standards of sufficiency of response which could ultimately become factored in the definition of oil spill liability.

It is significant that state trial courts are given jurisdiction over claims for removal costs and damages (Title I, Section 1017(c)). This provision and the definition of “venue” as the district in which the injury or damages occurred (Title I, Section 1017(b)) provides windows for infusing local values, for example, on level of cleanup sufficiency, into judicial decisions that could become legally binding standards for the state, especially in establishing the level of recovery for environmental damages. Three other sections strengthen the state’s authority in addressing the impacts of oil spills.
The first is the authority given the state and its sub-governments to impose additional liability or requirements beyond those established under OPA (Title I, Section 1018(c)(1)). The state under this section can impose a higher liability than the $1,200 per gross ton or $10 million per tanker (>3,000 gross tons), whichever is greater, imposed under OPA (Title I, Section 1004(a)(1)(A)(B)). In the event of gross negligence or willful misconduct or violation of applicable federal safety, construction, or operating regulation, the limits under Section 1004(a) will not apply. The responsible party will incur unlimited liability.

The second section authorizes the state to impose or determine additional fines or penalties for any spill violation (Title I, Section 1018(c)(2)). Locally set fines and penalties allow the state to weigh options to reflect its values and to promote certain behavior through penalties.

The third section names the state and its political subdivisions as trustees of the natural resources under their jurisdiction (Title I, Section 1006(a)(2)). In the event of an oil spill, the state is required to assess natural resource damages and to develop and implement a plan for the restoration, rehabilitation, replacement, or acquisition of the equivalent natural resources that suffered damages (Title I, Section 1006(c)(2)(A)(B)). These responsibilities are jointly shared by the state's DOH and Department of Land and Natural Resources.

Whether it was deliberate or not, by including provisions in OPA that give the states the authority to exceed federal standards, Congress is allowing for regional and local differences in valuation of natural resources. These provisions on liability and fines, coupled with those which set the venue in the jurisdiction in which the damage was incurred, materially strengthen diversity in defining liability for setting monetary damage assessments against the polluter. OPA does not attempt to exercise federal pre-emption powers in setting liability limits and thereby standardize the definition of liability. Instead OPA promotes diversity by explicitly giving states the authority to exceed federal limits.

Since the state trial courts are given jurisdiction over claims for removal costs and damages, standards by which local valuation is affixed for natural resources, for example, would prevail. While the strength of the trial courts' rulings could be tested in the appellate courts, the provisions in OPA that recognize state and local governments as trustees over their natural resources would appear to make it difficult for trial court judgments to be overturned nor would the Circuit Courts be in a position to overturn challenges of fines and standards that exceed those in OPA.

The 1992 session of the State Legislature has grappled with the issue of imposing liability caps on oil spills by amending its present "Superfund" law which imposes unlimited liability on the spiller. The required liability coverage set for OPA for tankers that transport crude oil to Barbers Point would range between $84 million and $180 million (70-150,000 DWT) and liability coverage for product tankers would range between $36 million and $72 million (30-60,000 DWT). In viewing oil spill liability costs as a "bottom line" issue, the projected cost of cleanup becomes important. The cost of oil spill clean-up is projected to range between $210 and $305 million, excluding costs for wildlife cleanup and damages to private coastal properties. It should be clearly stated here that the projections are based on expert opinion since there are no actual data on oil spills in Hawaii. If the high end of cost of $305 million were used as the cost of responding to a 10-million gallon oil spill, the limits imposed under OPA are not sufficient to cover cleanup costs. Act 130, enacted on June 8, 1992, provides relief specifically for inter-island tanker barge shipment of residual fuel oils by temporarily limiting liability to $700 million. Section 1 of Act 130 limits the liability cap only to "tank barges carrying heavy fuel oil interislands, which release is subject to the federal Oil Pollution Act of 1990, and which tank barge can carry not more than 60,000 barrels of heavy fuel oil..." Section 1 will expire on June 30, 1996 to allow the 1993 session of the Legislature to study the options available to utility companies now using residual fuel oils.

Finally, basic to the determination of liability are two principals of law: standard of duty or care and customary practice. Customary practice is a significant aspect of liability but not as critical as standard of care because "the reasonable man" principle kicks in to over-ride a negligent practice, even if it is used universally by the
industry. Since the potential danger of an oil spill is so great to the marine environment and its living resources and to humans, one of the policy issues that needs to be addressed either politically or judicially is "standard of care" to be imposed on the operation of a large tanker. Under OPA's strict liability principles, standard of care may only serve as ancillary defense against liability, but it is an important principle in promoting prevention. As such, should the standard of care be as high as that defined for common carriers? The potential for catastrophic economic impact that could be caused by human error is not unlike that affecting common carriers, for example, an airline crash could kill hundreds of passengers. Likewise, while not in terms of human life, an oil spill can kill thousands of wildlife and pollute miles of a coastline and ultimately cost the spiller as much or more than a major airline crash. There is good reason to support the view that the stringent human factors policies and regulations that govern common carriers might well be applied to personnel training and operation of tankers.

While falling far short of placing strict duty of care on tanker operators and operations, as a measure for eliciting a high level of control on all procedures, OPA attempts to minimize human error in several ways under Title IV A:

- Review of alcohol and drug abuse in issuing licenses, certificates of registry, and merchant mariners' documents (Sections 4101–4105)
- Manning standards for foreign tank vessels (Section 4106)
- Vessel traffic service systems (Section 4107)
- Great Lakes Pilotage (Section 4108)
- Overfill and tank level or pressure monitoring devices (Section 4110)
- Study on tanker navigation safety standards (Section 4111)
- Use of liners (Section 4113)
- Tank vessel manning (Section 4114)
- Establishment of double hull requirements (Section 4115)

Sections 4101–4105 attempt to control substance abuse, such as use of alcohol and controlled drugs. For example, Captain Hazelwood's intoxication was a contributing factor to the Exxon Valdez accident. OPA forbids the Secretary of Transportation to issue licenses or certificates of registry to an applicant who has a record or offenses in the National Driver Register for drug or alcohol abuse offenses. In addition, OPA also requires mandatory pre-employment, periodic, random, reasonable cause, and post-accident testing for the "use of dangerous drugs in violation of law or federal regulation."

Section 4106 requires foreign tankers to be manned by seamen who meet U.S. standards for licensing and certification. The standards for manning, training, qualification, and watchkeeping of a foreign country require periodic and post-accident evaluation.

Section 4114 establishes ceilings on the length of watches, a problem among ship officers and crew, particularly on modern supertankers with their automated instrumentation. However, the 15-hour per 24-hour ceiling established in OPA still does not appear to allow for sufficient number of hours of rest, even if the watch is divided into two segments. While vastly improving the accuracy of navigation, the use of the autopilot contributes to boredom since once the course is set, there is little for the crew to do. The human factors problems of fatigue and boredom are further exacerbated by the minimal crew operating tankers with little or no redundancy for backup. A 1990 report of the National Transportation Safety Board (NTSB) concluded that fatigue contributed to the inability of the third mate, who was in control of the Exxon Valdez when it ran aground, to maneuver the ship around a massive ice floe. The NTSB also noted that Exxon "manipulated" the overtime reports of crews who manned tankers with reduced crews. Deck officers of Exxon tankers routinely operated with inadequate rest (Briscoe, 1990).
The move to what they call "modernized ships" which are automated and manned by reduced crews has also been implemented in Japan. Under this management scheme, container ships and bulk carriers are manned by 11 crew members. Seamen did not complain of the reduced crew but indicated that they did not like the "modern ships" because of "considerable amount of on-board management from ashore" (Anonymous, 1992).

OPA attempts to control accidental spills by mandating the use of physical barriers such as liners and double hulls. Double hulls will be required for all single hull vessels after January 1, 2010 (Section 4115(c)(A)) and for all double bottom vessels after January 1, 2015 (Section 4115(c)(B)). A U.S. Coast Guard study found that there would have been a 25–60 percent reduction of the oil spill if the Exxon Valdez had been equipped with a double hull (Natural Resources Defense Council, undated).

Mechanical devices to prevent overfill are also an effort to augment human capability to avoid backflow accidents and to monitor tank pressure.

A 5.2 million gallon oil spill off the coast of Australia on July 21, 1991 has raised international concern on the adequacy of tanker inspection procedures, especially of older tankers. The owners of the *Kirki* were in compliance of the MARPOL (the international convention for the prevention of pollution from ships) regulations and had all the required certificates. However, there were serious structural flaws and safety violations that were overlooked by the classification society, the owners, and the Australian Maritime Safety Authority. Closer to home, a 1990 New York *Times* article printed by *Honolulu Star Bulletin* indicates that an internal U.S. Coast Guard study, done after several major oil spills, reported on the severe shortage of trained inspectors. This situation allows the inspectors to make "barely adequate" inspections of tankers and "the quality of the inspections is suffering." The U.S. Coast Guard personnel were also suffering from the effects of an overloaded system which is not reducing oil spill risk from tanker operations in U.S. ports.

**The Human Factor Dimension in Oil Spills: The Prevention and Mitigation of Social Dysfunction**

It is striking that in most emergency management responses to oil spills, little time and effort is devoted to the human dimension. And yet, this is probably where there can be the most sustained and long-term effects of a man-made or natural disaster. The prevention of human misery should be as much an area of legitimate concern of government in emergency response as the prevention of negative impacts on wildlife. It would be imprudent for government to focus solely on wildlife mitigation and ignore the human dimension in oil spill response planning.

The response of the National Academy of Science's Socioeconomic Panel on the impact of outer continental shelf oil and gas leasing and development has application for any emergency management planning purpose dealing with the coastal environment (Fallat and Scholl, 1991). These areas include:

1. The human environment including potentially affected systems
2. The activities producing socioeconomic impacts
3. The dimensions of potential socioeconomic impacts
4. The distribution of various impacts across human systems

The post-Exxon Valdez observations of the Alaska Oil Commission (1990) are particularly instructive. The Commission calls for the states to develop a system of emergency economic maintenance for persons impacted by a major oil spill. This program should include those who are not covered under workmen's compensation insurance and should be funded by spill impact funds. Many individuals whose lives were severely disrupted had no recourse for compensation because their cases were not legally recognized as having legitimate claims against Exxon.
In Hawaii, the projected layoff of over 60,000 tourism service workers, based on the U.S. Coast Guard's worst case scenario, will severely impact state and county social services, public safety, and public welfare agencies. The unionized hotel workers have established channels for emergency services, but the impact of the hotel closures will spill over and affect the hundreds of small businesses that also rely on tourism. It is this sector that is most vulnerable because the workers are often not covered by workmen's compensation or other forms of insurance for lost compensation. Even if this sector had the means to institute a lawsuit, it is unlikely that they could recover from the spiller. For many hotel workers, their employment as dishwasher or maid is a necessary second or third job. The impact of layoff on these workers is not known.

With proper pre-planning, the social dislocation and economic and psychological damage to affected individuals can be minimized or prevented. What is needed to effect a smooth transition to emergency operation is a well-conceived plan that is developed jointly by the state, county, and federal governments and the private sector. While the primary revenue sector to be affected by beach closures is tourism, which produces about 40 percent of the gross state product, over time, no one in the state is immune to the far-reaching negative impacts of an oil spill.

There is another category of individuals who will be affected by a major oil spill. These are private individual and corporate owners of waterfront properties. The plan for addressing human impacts needs to consider the methodology to be used for calculating compensation for damages to both physical and non-use or existence values of public vistas. This is a critical aspect too often overlooked until the courts are flooded with lawsuits totalling billions of dollars as has happened in Alaska in the wake of the Exxon Valdez oil spill. If done prior to disaster hysteria, there will be a greater chance for achieving consensus on damage and mitigation costs allocations without incurring the delays and costs of the legal system.

**Recommendations**

*Editor's note: The recommendations that follow are based on the findings of our research. As indicated in italics, the DOH notes that some of the recommendations are already in the process of being implemented by the appropriate agencies.*

The purpose of this section is to recommend prevention measures that address the causes of oil spills that have been identified by a review of historical oil spills, OPA, and state statutes and administrative rules and regulations. This information can be used by the state, in its role as the trustee of its natural resources, to promulgate statutory and administrative rules for establishing public policies that could minimize the risk of oil spills in Hawaiian waters. The cost of prevention would not approach the projected $210-$305 million range of cleanup costs of a major oil spill. Perhaps, more damaging over the long term is the potential loss of the widely held image of Hawaii's pristine environment — the critical element to Hawaii's popularity as a resort destination. This "non-use" value, currently not factored in as a recoverable cost under OPA, may have the greatest impact on deterring the recovery of Hawaii's economy. Media impact studies indicate that startling or emotion evoking imagery is retained for a long period after being viewed and may not be erasable from the viewers' memory (Pfund, in preparation). Hawaii may forever lose its attractiveness and its mystique as an untainted tropical paradise.

**Tanker Liability**

It is interesting that marine insurance, once centered on safe arrival of cargo, was a hedge against acts of nature and possible piracy. The widespread use of sophisticated instrumentation and more accurate meteorological data that forewarn ship operators of storm fronts have minimized weather as a major cause of cargo loss. Although there are reported cases of piracy in southeast Asia, high seas hijacking of ships is not a common occurrence in other parts of the world. What oil companies and shippers now insure and will continue to insure under OPA's coverage for the cost of damages, cleanup, and mitigation of oil spill accidents on the natural environment and wildlife.
The debate at the 1992 session of the State Legislature on putting a ceiling on interisland tanker barge liability is as much about insurance as it is about limiting the cost of private risk. In essence, the oil industry and barge owners are balking at the cost of the state’s conservative zero risk policy and are demanding that the state change its no-risk policy. Since Hawaii lacks land-based oil transport options, it is held hostage by the willingness of the oil and shipping industries to internalize the cost of the risk of an oil spill. It is hard to fault Hawaii’s refineries and interisland shippers for not being willing to assume the risks of an oil spill when such oil industry giants as the Royal Dutch Shell Group limits its crude shipments to only one U.S. port, a Louisiana offshore oil port (Sidel, 1990).

Should the state become the deep pocket? What are the risks? A framework for analyzing risks and benefits is provided for decisionmakers:

The facts:

- The ratio of vessel-related spills to equipment/structural failure is approximately 1:4
- By worldwide oil spill standards, Hawaii’s historical vessel-related oil spills have been “small” — 48,000 gallons and 33,800 gallons
- The largest tanker calling at Barbers Point has a cargo capacity of 37,800,000 gallons (Chevron, USA) — nearly four times the oil spill in the U.S. Coast Guard’s worst case scenario and more than three times the 11 million gallons spilled by the Exxon Valdez
- The largest barge in interisland service has a fuel oil carrying capacity of 2,226,000 gallons and the smallest has a cargo capacity of 1,344,000 gallons

Recommendations:

1. Routing tanker traffic from the U.S. mainland through the Kauai Channel will minimize at-sea oil spill damage and should reduce the high-end response cost of $305 million; the prevailing currents of the Kauai Channel cut crosswise across the channel and flow westward out to the open sea, with the exception of the Kauai Channel, all other channels of the Hawaiian Islands should be designated tanker-free channels

So are you saying that, by routing the tankers through the Kauai Channel, the cost of a catastrophic oil disaster is only $305 million? If this is so, then we could cap liability at $350 million. [Editor’s note: The $305 million is not total liability. It is our projection of the response cost of a 9.8 million gallon oil spill.]

2. Rigorous risk management and loss prevention programs which can be instituted almost immediately will minimize structural and equipment failure accidents; (Existing pipelines in Honolulu Harbor and Pearl Harbor, valves, and couplings on all pipelines should be checked for leakage; unused pipelines should be checked for leakage and sealed.)

Existing U.S. Coast Guard regulation in 33 CFR 156 cover many preventative measures. In addition, response plans are required under OPA 90.

3. Tanker barges should undergo a complete check on towlines/cables/couplings, hatch covers, etc. prior to each sailing; loading and unloading operations should be routinized like airplane pre-flight checks

Existing regulations cover this area.

4. Coupling and uncoupling operations at the offshore mooring or during bunkering should be patterned after airline pre-flight check — no part of the operation should be left to the operator to “remember” (or forget)

The Operations Manual for offshore moorings cover this area.

5. Live watch and pilot on all laden tankers and during air transfer operations should be mandatory

Regulations are already in place requiring live watch.
6. Oil transfer operations in Honolulu Harbor should be boomed and be completely monitored by a mooring master. This type of operation is occurring within the harbor area. It would be too inefficient at the offshore mooring area.

7. A federally licensed pilot should be on board tankers at all times while they are in pilotage waters. It is inherent in the definition to have pilots in pilotage waters. [Editor’s note: Unfortunately, “federally-licensed” was inadvertently dropped.]

8. All submerged rocks, reefs, and other hazards should be clearly marked with a lighted buoy(s). For the most part all hazards in the nearshore are adequately marked. The large tankers do not enter waters with submerged hazards sufficient to cause any damage. [Editor’s note: The Exxon Houston was grounded and there was a near miss with the Star Connecticut. The latter could have been Hawaii’s Exxon Valdez oil spill.]

9. No offloading operations should be conducted during storm conditions or when swells pose a danger to oil transfer operations — decision to be made by the respective harbor master. This is already a part of the Operations Manuals and these manuals are reviewed by the U.S. Coast Guard.

10. Tanker barge transit lanes and local traffic plans should be designed cooperatively by all user groups in the Aua, Kalo, and Pilolo Channels; ongoing public education program on transit lanes and on tanker barges is needed; all recreational boats should have passive radar reflectors and appropriate communication equipment; all recreational boaters should be licensed. It is difficult to designate transit lanes due to changing weather conditions. I am assuming this is to avoid collision with recreational boats. It would be more appropriate to provide a good education program for recreational boaters so that they know about the dangers of crossing commercial boat traffic. International and inland law already requires lighting (COL Regs). [Editor’s note: Both barge operators and recreational boaters indicate that there is a problem.]

Pilots and Pilotage

The review of OPA and oil spill accidents caused by human error point to the wisdom of doing all that is possible to promulgate laws and regulations that will implement procedures to minimize the impact of fatigue and errors in judgment. The state has no control over the crew hiring practices of the shipowners. It can, however, ensure that properly licensed pilots and operators are aboard tankers during transit in state waters and while offloading the oil at the Barbers Point offshore moorings or Honolulu Harbor. In addition, the facility personnel who take charge of the oil transfer operation should be trained and certified to respond to an emergency oil spill.

The distinction between requirements imposed on pilotage of vessels in domestic and foreign trade should be ended. All vessels should have a federally licensed pilot onboard while in state pilotage waters.

A federal pilot is required during mooring. A state pilot is required in state pilotage waters; I do not see the reason for having a federal pilot. [Editor’s note: The distinction between state and federal licensing should be eliminated. All pilots should be federally licensed.]

The state should establish a pilotage board that will actively participate in the licensing and disciplinary procedures. It is critical that relicensing and new applications for a pilot’s license include certification from the Police Department that the applicant has no DUI or DWI arrests during the previous two years. Routinely, a check should be made for DUI, DWI, and criminal offenses in the National Driver Register when applications for licensing and relicensing are received. All pilots should be required to take and pass appropriate “road tests” for the license they are seeking or for relicensing. Mandatory continuing education
and refresher courses should be developed and attendance should be a requirement for obtaining a license or for relicensing. The content of the mandatory refresher courses should be standardized and regularly updated to include new technology, instrumentation, etc.

This is already required. [Editor's note: There is no pilotage board at present. It is important that a board be established. State regulations as of May 1992 have no specific requirements or standards spelled out for continuing education. The existing regulations do not call for a National Drivers Register check. There are no existing requirements for "road test" for relicensing.]

Interisland Tanker Barge Traffic

Data on global oil spills indicated that tanker barges are more likely to be involved in collision than grounding. Barge traffic is vulnerable to accidents because it traverses narrow waterways. Given these conditions, thought should be given to restricting tanker barge traffic during adverse weather (if not already being done by the barge owners) and controlling tanker barge traffic in the Aua, Kalihi, and Paliolo Channels of Maui County by designating barge transit lanes through the channels. Such designation should be developed jointly with recreational boaters and commercial charter vessel owners.

Although the very limited window of opportunity to address an oil spill should preclude the transit of the state’s channel waters at night, such a policy needs to be weighed against the risk of daylight sailing among recreational boaters who may not be knowledgeable about the rules of the road. Because the risk of accidents increases with the number of boats, night channel crossings are probably safer than dodging boaters.

Additionally, recreational boat owners should be licensed and all boats should have appropriate communication equipment and passive radar reflector devices to allow the tug’s radar to locate them.

Other Vessels

Passenger vessels and fishing vessels that carry more than 10,000 gallons of fuel should be required to post a liability insurance certificate. The volume of fuel they carry poses a threat in the event of an accident. Worldwide, these non-tanker vessels accounted for 15 percent of the collisions and 35 percent of the groundings that spilled more than 10,000 gallons per accident in 1989–90.

Oil Spill Database

This research was hampered by errors in the oil spill data obtained from the national headquarters of the U.S. Coast Guard. Verification of the data was difficult. We found that there is currently no easily accessible information on oil spills in Hawaii. The Honolulu District Marine Safety Office does keep records of reported oil spills, but the information is only accessible by their personnel. In other words, the only available oil spill information is held by the U.S. Coast Guard and this database is not designed to be used to support a management information system. Without historical data it is impossible to track accident trends and to evaluate the effects of mitigation programs.

If the state government is serious about promoting prevention, it is absolutely critical that an accurate database be developed as the core of the management information system for monitoring oil spills and the prevention programs that the oil shippers, refineries, and public and private facilities need to implement to reduce the number of oil spills. Perhaps even more important is that there be adequate human resources to analyze the data being collected so that they can be used by decision-makers.

In your discussion you mentioned the need for accurate data in relation to the 47 percent of unknown oil spills. If your concern is that almost half of the spills are from unknown sources and this represents inaccurate
information, you must consider that every reported sheen is considered an oil spill. No matter how accurate your database is, it is impossible to identify the cause and source of every oil sheen. [Editor's note: The present database is inadequate and hence inaccurate. The U.S. Coast Guard’s database is not accessible, nor is it accurate. There is need for a uniform terminology to describe oil spills.]

**Unused Pipelines**

Honolulu Harbor has extensive underground and underwater pipelines that are unused. They should be inspected for leakage and where there is leakage, the pipes should be slurried and sealed.

**The Human Dimension**

The development of an economic recovery contingency plan that can address not only oil spills but other disasters, including catastrophic natural disasters, is critical. There are, however, two ancillary plans that need to be developed to properly address the human factors aspect of disasters:

1. A plan for compensating workers who are laid off is needed to minimize economic disruptions that could affect a worker’s social and psychological well-being.

2. Joint state, county, and federal governments and private sector plans for mitigating the social and economic impact of mass layoffs and furloughs caused by a major oil spill are required to ensure equitable and prompt response to the people. Can existing agency and private sector staff be deployed to cover needed services? Who pays for additional staff? The emergency response plan for social services should include psychological and legal counseling.

A formula for damage compensation to private water/beachfront landowners should be developed to avoid costly lawsuits. The compensation algorithm should include existence or non-use values, if an acceptable method for establishing such values can be found. This should be of particular concern to beachfront resort owners because it is probable that Hawaii will lose its image of a pristine tropical paradise and the mystique that goes with that image. Hence, the impact of an oil spill on non-use value may well extend beyond the cleanup period.

The state should explore the possibility of developing a direct draw agreement with the federal government to enable the governor to obtain funds for responding to cleanup and other spill-related costs, including compensation for lost income.

**Future Research**

1. Information on the recreational and commercial use of the Auau, Kalahihi, and Pailolo Channels is critical for decisionmaking on tanker barge traffic through the channels. Research on the potential hazard of high use by recreationists, fishermen, and charter operations on safe tanker barge transit is needed.

2. Research on existence and non-use valuation of Hawaii’s coastal resources is needed in addition to identifying and/or developing a damage assessment methodology that government agencies and the affected private sector can agree on. These data are needed to develop response plans and for socioeconomic and environmental mitigation.

3. A comprehensive study is needed on the liability issue that has been raised in relation to the tug-tanker barge operators’ objection to unlimited liability. Should the state place a limitation on all liabilities to $700 million? If liability is capped permanently at $700 million for all oil shipments, who pays for damages exceeding $700 million? Would it be cost effective for the state to become the shipper of fuel oil to the neighbor islands? Can the state waive its public trust responsibility under the constitution and OPA? These are only few of the legal and public policy questions that need to be resolved by the state’s decision-makers.
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CHAPTER 7

FINAL WORDS: A SYNTHESIS
This final chapter synthesizes the results of the study conducted under the Department of Health — University of Hawaii contract and presented in the first six chapters of this report. The scope of work was divided into six study areas to enable the researchers to focus on a given issue area in some depth. This chapter provides a synoptic view of the significant impacts of a catastrophic oil spill on Hawaii’s economy and environment.

There is no question that economics is the driving force that will continue to steer the actions of both the public sector and private sector decisionmakers in considering oil spill impacts just as it drives and steers actions related to other public policy issues. Economics is the bottomline that triggered the unwillingness of the interisland shipper, Hawaiian Tug and Barge Corp., to continue transporting residual fuel oils to the neighbor islands. Economics is at the base of the fear that if a barge had a residual fuel oil cargo spill, it could severely damage coastal sites and resources, and the cost of the cleanup of such an accident could economically devastate not only the subsidiary, Hawaiian Tug and Barge Corp., but would reach into the multi-billion dollar assets of its parent company, Hawaiian Electric Industries, Inc.

It was also the bottomline that prompted the 1992 State Legislature to enact Act 130 to provide a temporary ceiling of $700 million for oil spill liability to enable the neighbor island counties to continue to have affordable power. However, if a major oil spill were to occur, it is doubtful that the cleanup of such a spill could be done without federal involvement. Once an oil spill is federalized, federal rules under the Oil Pollution Act (OPA) of 1990 will be imposed on the cleanup procedures. This includes the charge back of all costs incurred by the federal government or any state or local agency involvement in wildlife mitigation, etc. to the barge owner(s).

The legislative intent contained in Conference Committee Report No. 135 of the 1992 session of the State Legislature specifically limits the application of Act 130’s ceiling only to shipments of fuel oil by interisland tanker barges that have a capacity of not more than 60,000 barrels. The shipments must also be subject to OPA regulations because the state would be able to obtain funding for cleanup from the $1 billion oil spill liability trust fund under the National Contingency Plan (Section 4201(b)(H)). In the event of gross negligence or violation of applicable federal safety, construction, or operating regulation (Section 1004(c)(1)(A,B)), all limits on liability will no longer apply. Moreover, since OPA is predicated on the “polluter pays” principle, regardless of the state’s $700 million cap on liability, any funding obtained from the Oil Spill Liability Trust Fund by the state for expenses incurred would be charged back to the barge owners. There is explicit language under Section 1004(c)(3) which pertains to Outer Continental Shelf facilities or vessels carrying oil as cargo from such facilities that states:

Notwithstanding the limitations established under subsection (a) [which outlines a schedule of liability limits] and the defenses of section 1003, all removal costs incurred by the United States Government or any State or local official or agency in connection with a discharge or substantial threat of a discharge of oil from any Outer Continental Shelf facility or a vessel carrying oil as cargo from such a facility shall be borne by the owner or operator of such facility or vessel. (Emphasis added.)

The application of Section 1004(c)(3) to vessel discharges is appropriate because, under OPA, a mobile offshore drilling unit which is used as an offshore facility is “deemed to be a tank vessel with respect to the discharge, or substantial threat of discharge, of oil on or above the surface of the water” (Section 1004(b)(1)). (Emphasis added.)

However, the $700 million liability coverage available through the P & I Clubs should be sufficient to cover even the total discharge of an interisland tanker barge of 2.52 million gallons. Our study determined that the cost of cleanup for the U.S. Coast Guard’s worst case scenario of a 9.8 million gallon spill would be $305 million at the high end and the cleanup costs for a 1.26 million gallon discharge (one-half of the cargo of a 60,000 barrel capacity barge) is $30 million. There may be substantial additional costs in the damages to
natural resources and private property. In addition, if the oil spill occurred in the much used Kaiwi Channel and coated the southern coastline of Oahu, there would be substantial impact on the state's tourism revenues.

This study contributed to the U.S. Coast Guard’s proposed establishment of a tanker-free zone in the Kaiwi Channel by routing all tanker traffic through the Kauai Channel. The advisory is now before the International Maritime Organization for adoption. This action could reduce the potential risk of tanker accidents which could oil much of Oahu’s southern coastline and spread to the east and west shorelines as well.

Based on reported spills, the statistical probability of a small spill (<20,000 gallons) is once in 2.25 years; mid-range spill (40-50,000 gallons) is once in 4.5 years; and a catastrophic spill of 10-11,000,000 gallons is once in 135 years. Between 1984 and 1991, the largest single oil spill in Hawaii that released 120,000 gallons into the ocean was caused by a ruptured pipeline at Pearl Harbor. The largest grounding accident that dumped 48,000 gallons into the ocean also occurred at Pearl Harbor. The most likely accident in Hawaii will be structural failure, which accounted for nearly 40 percent of all oil spills. Pearl Harbor appears to be the most likely site (53 percent of the oil spills >5,000 gallons occurred there). Honolulu Harbor has been the site of 23 percent of oil spills >5,000 gallons caused by non-vessel accidents. Barbers Point was the site of only one large oil spill (33,800 gallons) caused by grounding. Nearly 60 percent of all reported oil spills occurred off the southern coast of Oahu, between Honolulu Harbor and Barbers Point.

While the historic data identifies Pearl Harbor as the likely site of oil spills (one in two oil spills occurred there), the good news is that with advanced preparation, spills can be contained within the lagoons because of the narrow entrance. Oil spills in Honolulu Harbor can also be contained, but the danger might be the toxicity and/or volatility of the refined oil products. About 17 percent of the 81 oil spills off Oahu during 1983-91 occurred at Barbers Point. In absolute numbers, there was an average of about four spills (<1,000 gallons) per month over the nine years. Because of the nature of the off-loading system of crude oil at the two offshore moorings 2 and 2.5 miles from shore, oil spills at Barbers Point will always be “at-sea.” Even with the designation of the Kaiwi Channel as a tanker-free zone, Barbers Point could be the site of an oil spill as catastrophic as any in the Kaiwi Channel. Easterly currents, enhanced by Kona weather conditions, could carry the crude oil from the offshore mooring site to Waikiki and the Waianae coast and through the Kaiwi Channel to the windward coast of Oahu.

Overall, there are compelling reasons for preventing oil spills. However, if one were to occur, extraordinary methods need to be taken to keep the oil from reaching the site of the state’s prime source of revenue — Oahu’s southeastern coastline from Diamond Head to Honolulu Harbor. One of these technologies is the controversial in situ burning. Before this technology is adopted or rejected, a thorough study should be done to evaluate its usefulness to Hawaii. Existing studies are inappropriate because decisionmakers must consider the technology within a unique set of circumstances, including Hawaii’s mid-Pacific location, proximity of deep water to the shoreline, significance of a pristine coastal environment to the state’s $10 billion tourism industry, and prevailing oceanic and meteorological conditions. Because of the very limited optimal response time, in situ burning is to be considered as an oil spill response option, formal pre-agreements, such as a memorandum of understanding between the state and federal governments, need to be in place. Without such action, the oil industry will not invest in the equipment and supplies necessary to optimize response. As extreme as in situ burning may seem, when the trade off is a $3 billion loss in state revenues and over $1 billion in household income, a pragmatic consideration needs to be given to this technology. There is no question that if it were possible to tow the Exxon Valdez to the open ocean and to set it afire before the oil reached the coastline along Prince William Sound, even if the tanker and its entire cargo were destroyed, the cost would have been a fraction of the more than $2 billion Exxon paid in cleanup costs.

A second technology that appears to have potential for keeping oil from reaching the coastal areas is dispersants. While there is a memorandum of understanding on the use of dispersants in waters more than 60 feet deep, there needs to be a shorter connect time between the decision to use and the actual application of
the dispersants by aircraft. Although application by ship is possible, it is far less efficient than overflight application. As with nearly all oil spill response technology, the window of opportunity is narrow. The effectiveness of this and other response technologies rapidly diminishes with the passage of time. If this technology is to be effectively used in Hawaii, there must be a drastic reduction in the lag between the decision to use and actual overflight application at sea.

In addition, there are other preventive measures that can be implemented by vessel and facility owners under the OPA-mandated requirements to reduce oil spill accidents. These range from retrofitting mechanical or structural changes to the tightening of licensing requirements for ships’ crew and vessel manning provisions. This study examined the state’s statutes and administrative rules that pertain to oil spills and found that there were substantial gaps. In the area of state response to an oil spill (or discharge of other hazardous materials), the state contingency plan lacks provisions for promoting prevention. This report identified administrative rules and statutes that could serve as the starting point for adding prevention to the contingency plan. These include:

1. Developing an oil spill database that can be used to establish a MIS for the prevention of oil spills; this effort should include clear definition of terms used to record causes, etc. of oil spills and should be jointly developed with the U.S. Coast Guard.
2. Mapping and sealing of all unused pipelines buried in state, county, and federal lands and in water, including those on military installations.
3. Expanding use of Hawaii’s superfund to include monitoring, research, and public education or exploring the option of creating a special oil spill fund by assessing a $.05/barrel fee on all imports of oil and oil products.
4. Incorporating the results requested in Resolution 137 to the study on the conflict between tug vessels and recreational boaters in Maui County’s channel waters into Hawaii Revised Statutes (HRS) or administrative rules for promoting recreational boater safety.
5. Designating vessel transit lanes in the Auau, Kalohi, and Pailolo channels of the county of Maui.
6. Studying and revising the physical and mental disability provisions for pilots under HRS, Chapter 462A and Administrative Rules 16, Chapter 96; tightening the relicensing procedures for pilots and ships’ crew; establishing a credential evaluation panel.
7. Requiring the inclusion of risk management and loss control procedures and inclusion of facility and equipment maintenance and replacement schedules in facility contingency plans.

While this study did not examine damage assessment, this issue will be the subject of debate until precedence is established through the courts. It is in this issue area that local values can have great significance. The designation of local and state governments as trustees of their natural resources and the non-preemption provisions in OPA allow for local input. However, establishing monetary values for non-market goods is a difficult exercise. To compound the difficulty associated with valuation of the environment, for Hawaii and other tourist destinations, there are non-use or existence values of the marine environment and its resources that are a significant component in the attractiveness of a tourism destination that could have a far greater monetary value than the actual consumptive use value of the natural resources. The long-lived imagery of a devastated environment would probably preclude Hawaii from fully regaining its mystique as a pristine paradise on earth. The success or failure of the Italian government in pressing its case for damages associated with loss of non-use values currently being considered by an international tribunal for payment from an international oil spill fund will add to the support or denial of the legitimacy of claims for recovery based on non-use values.

Finally, there is the issue of response prioritization. A panel of biologists indicated that there were no critical habitats as such because of the wide distribution of wildlife and fisheries throughout the archipelago.
However, they placed sites frequented by endangered species and embayments as high priority areas from the standpoint of wildlife and natural resources. The tourism panel fully recognized the importance of a pristine environment to tourism, but they indicated that Waikiki was the single most important site if tourism revenues were to be protected. Figure 1.1 in Chapter 1 identifies in gross detail the important ecological and economic sites. These sites are being plotted on more detailed maps and will be prioritized for response in the event of an oil spill by the Area Committee, in compliance with OPA. (The local Area Committee was created under OPA to develop a Contingency plan for Hawaii.) However, it is important that the priority ranking is validated by the public.

**Recommendations**

While recommendations addressing the salient problems raised and discussed are included in each chapter, they do not provide an overview and synthesis of the fit of Hawaii’s extant oil spill response plan with the Oil Pollution Act of 1990. It is clear that oil spills are not as yet a significant public policy issue even though a major oil spill off Hawaii’s southern coast could trigger a significant downward economic spiral that would cut deeply into the state’s economy. Given the fickleness of consumer choice, the mystique of a pristine environment which lures visitors to pay higher transportation costs to stay in upscale beachfront resort hotels could be shattered, if the news media were to transmit worldwide pictures of Hawaii’s coastal vistas coated with black oil.

Given these serious consequences of a major oil spill, we concluded that as the trustee of its natural resources, the state needs to give prevention of oil spills its highest priority. Our analysis identified two critical recommendations that would enable the state to address oil spill prevention effectively:

1. **A comprehensive oil spill prevention plan to augment the plans currently being developed under the auspices of the U.S. Coast Guard, as mandated by OPA, and the “Hawaii Energy Strategy Plan,” being developed by the state Energy Office.** The state’s extant “oil spill contingency plan” identifies state agencies that will play a role in responding to a major at-sea oil spill, but it stops short of precisely defining and operationalizing its OPA-mandated trusteeship functions.

2. **A small staff in the Hazards Evaluation and Emergency Response (HEER) office responsible for responding solely to oil spills.** Unless HEER is provided additional staff positions with specific responsibility for oil spill monitoring and prevention, it is unlikely that adequate attention can be given to developing a plan for the prevention of oil spills or to address fully the complex institutional issues surrounding the implementation of OPA.

**A Comprehensive Plan**

*We recommend the development of a comprehensive strategic plan for the prevention of oil spills to be developed in tandem with efforts currently underway by the state’s Energy Division and the U.S. Coast Guard’s Area Committee.*

The cost of prevention will never exceed the cost of response and damage of an oil spill to public and private properties. The most critical issues that need to be addressed in the comprehensive oil spill prevention plan are:

1. **Articulation and definition of the roles of county and state governments vis-a-vis each other and with the federal government formalized in memoranda of agreement.** Because OPA precludes the federal government from preempting state’s rights, to avoid inaction, there needs to be formal pre-agreements on where and how each jurisdiction’s responsibilities interface with those of the other two. When oil is sweeping shoreward there is little time to debate these issues.
2. **Pre-agreed uniform statewide standards for establishing acceptable levels of** "clean," **based on wide input from the public and special interest groups.** This is, perhaps, one of the most complex issues that needs to be addressed. A long lead time will be required to reach consensus among governments, the public, and special interest groups on acceptable levels of "clean." Should the standards be subjective or objectively established? The nature of subjective decisionmaking raises still other basic issue of values. Whose values should prevail? Should the standards be based on esthetics or ecology? Or can standards be based on some objectively derived threshold levels of key compounds in the sand/sediment or on dosage tolerance?

3. **Institutional infrastructure to operationalize pre-agreements on appropriate response technologies and to designate and manage holding/disposal sites.** Response efforts and technology are costly and their effectiveness for recovering oil at sea is time dependent. As such, mobilization procedures, inter-jurisdictional memoranda of understanding for establishing conditions for use of response technologies of choice, and disposal/holding sites need to be pre-determined.

4. **Identification and mapping of all significant institutional and non-governmental linkages and the inter-related reciprocal and triggering impacts of the linkages that affect the import and distribution of oil.** Because the Hawaii Energy Strategy Program, projected for completion in 1994, will not adequately map the energy policy field or examine the full impacts of OPA on oil and oil product production and consumption, the oil spill prevention plan must consider ways to reduce demand through public education on energy conservation. In addition, the plan should include a realistic assessment of the state’s options for alternative energy and a critical evaluation of the state’s energy policy in relation to OPA. Without a comprehensive analysis of OPA within the context of the state’s energy policy, tinkering with one area could generate unexpected negative consequences in another. For example, the curtailment of interisland shipments of “cheap” No. 6 fuel oil was an unexpected consequence of OPA’s oil spill liability provisions and the state’s unlimited liability statutes on hazardous materials pollution.

5. **Regulations and administrative rulemaking for fulfilling the state’s role as trustee under OPA.** An inventory of the state’s coastal resources is needed to serve as the baseline for damage assessment. A pre-approved methodology for determining non-market value for coastal sites and wildlife will materially reduce damage assessment costs resulting from litigation. Regulations and procedures for evaluation the adequacy of safeguards in the loss prevention and risk management procedures in the tanker and facility contingency plans mandated by OPA also need to establish a priori.

**Oil Spill Evaluation and Monitoring Staff for Hazard Evaluation and Emergency Response Office**

We recommend a uniformly applied fee/barrel on oil and oil products to provide HEER with the required staff dedicated to dealing with oil-related problems.

Such a fee internalizes the cost of prevention; response costs are already a part of the price paid by consumers for fuel and energy. The oil industry indicated support for the imposition of a fee (with fund cap) provided that the fee is used for oil-related purposes only.

Hawaii has escaped the ravages of a major oil spill largely because of low historic demand for oil and oil products during the pre-statehood years. However, the scenario has changed dramatically in the past three decades. The burgeoning state economy and population, following statehood in 1959, sharply increased the demand for energy and the risk of at-sea oil spills because of increased tanker and other ship traffic. The oil industry responded by increasing their capacity to supply the nearly three billion gallons of oil and oil products now required to meet the state's transportation, commercial/industrial, and residential fuel and energy
demand. Unlike the ready market response, the state’s monitoring and oversight infrastructure and administrative rulemaking have not kept pace with the growth in the demand and risks associated with imported oil, undoubtedly because no catastrophic oil spills have occurred to make them an urgent public policy issue.

This study clearly showed the vulnerability of the state to a major oil spill because of its reliance on maritime shipping and its lack of viable alternative energy sources. In addition, there is a high statistical probability of a large oil spill caused by human error and outdated or malfunctioning equipment or facilities. Although the state must be prepared to function as the trustee of its natural resources when OPA kicks into gear in 1993, it is currently not fully prepared to assume this responsibility.

The HEER office lacks staff to monitor and evaluate current procedures used by private and public sectors to maintain coastal facilities and pipelines and to provide the aggressive leadership needed to develop and implement a plan for the prevention and mitigation of oil spills. Staff is also needed to ensure the smooth integration of state plans and policies with the federally mandated OPA.

A small staff will enable the state to carry out its responsibilities as trustee of its natural resources and to develop a comprehensive strategic plan for oil spill prevention. The staff can also conduct much needed public education programs, maintain an oil spill database, oversee the testing of new response technologies in Hawaiian waters, and coordinate field and table-top oil spill response drills.

The impact of OPA will be far-reaching. It has already had an impact on Hawaii’s interisland shipping of fuel oil. The final outcome of fuel for the neighbor island counties’ power generation is far from settled. But whatever policy is instituted, there will be an increase in the price of electricity in all the neighbor island counties as the cost of retrofitting the power plants to utilize diesel or other cleaner fuel oil is internalized, especially where the power plants are currently not equipped to burn the lighter oils. Even if the decision is to continue use of No. 6 fuel oil, the increased cost of insurance coverage incurred by the shipper would be passed on to the power consumer, or if insurance is unavailable to completely cover total costs and the state assumes the excess, the cost will be distributed to all Hawaii taxpayers. In addition, there will be added cost to the consumers as oil carriers and producers incur higher costs to comply with other safety requirements under OPA because not to do so will mean that the shippers and producers will incur unlimited liability and stiff fines. As the required changes in operational procedures, vessel structure, and management are made by the oil industry, there will also be an escalation in the price of all oil products including gasoline.

In the final analysis, the added costs reflect the cost of internalizing the protection of the environment and wildlife. Prior to the development of the supertankers to keep pace with demand for oil and oil products, oil spills and operational discharges were relatively small and localized because tankers were small. With the grounding of Torrey Canyon in 1967, world attention was focused on catastrophic oil spills and their potential as a source of widespread environmental pollution. OPA is Congress’ recognition of the need to minimize accidental oil spills by instituting more stringent prevention measures and to punish polluters. Since accidents by their nature are random occurrences, there is no way to exempt any shipper or facility owner. Therefore, while OPA is essentially predicated on the “polluter pays” principle, the bottom line is, it is not the oil company but the consumer who pays.
APPENDICES
## Appendix A: Comparison of OPA and State Statutes

### Entities Subject to Provision

<table>
<thead>
<tr>
<th>HAWAII</th>
<th>LOUISIANA</th>
<th>FLORIDA</th>
<th>OPA 90</th>
<th>WASHINGTON</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vessels or other artificial contrivance used as a means of transportation.</td>
<td>Owner or operator of a tank vessel carrying oil as fuel or cargo. Any motor vessel, rolling stock or pipeline used for product-handling, storing, etc. Applies to vessels and facilities operating within Louisiana’s jurisdiction. Terminal facilities including pipelines, pumping equipment and storage areas, etc.</td>
<td>Owners and operators at terminal facilities, vessels operating in state waters carrying more than 10,000 gallons of fuel or cargo, bulk product facilities and cargo owners to the extent damages not covered by vessel insurer.</td>
<td>Applies to all vessels operating within U.S. jurisdiction which are capable of carrying oil in bulk, including barges but excepting vessels owned or operated by a government entity (including foreign). Includes all on-shore and offshore facilities, including pipelines, trucks, and rail cars, used for the transportation, storage, or processing of oil.</td>
<td>Additionally includes public tank vessels and all passenger and cargo vessels greater than 300 Gross Tons. Limited to vessels operating within Washington jurisdiction. Includes only those facilities which could discharge oil into navigable waters and which transfer oil to or from tank vessels in quantities greater than 3000 gallons. Trucks, rail cars, gasoline stations, marinas, etc. are also excluded.</td>
</tr>
<tr>
<td>Owner and/or operator of vessels or facilities.</td>
<td>Facilities - any building or structure.</td>
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<td></td>
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</tbody>
</table>

### Coordination of State and Federal Responsibilities

- State contingency plan shall complement the National Contingency Plan (NCP).
- Several sections cite particular federal laws as basis for definitions and description.
- Act requires the Louisiana statute to be consistent with federal OPA.
- There are no specific references to coordination with federal processes. However, it recognizes particular action required by OPA such as vessel and facility prevention plans, etc.
- Specifically maintains state prerogatives for: setting financial liability limits, enforcing federal financial responsibility requirements, imposing taxation to create funds for mitigating damages, setting standards for removal of oil, etc. Directs the inclusion of state representatives in planning activities. Directs NCP to provide for state response activities and reimbursement. However, President is required to direct spill response when a discharge (or potential discharge) poses a substantial threat to public health or welfare, including that of natural resources. State response activities directed to be in accordance with the NCP, but does not pre-empt state action.
- Stated purpose of Act is to complement OPA. Act contains many instances of directives that consistency with federal regulations be maintained "to the greatest extent practicable", to include federal agency representatives on committees implementing state response procedures, to coordinate with federal activities, to accept documentation prepared in response to federal requirements when they are responsive to state requirements, etc.
Prevention Plans

Not a feature of HRS 128D.

All vessels and facilities are required to have prevention plans. Facilities cannot operate without a discharge prevention and response certificate which requires a prevention and response plan and the facility can provide for the cleanup of unauthorized oil discharges. Statewide oil spill prevention and contingency plan.

Requires vessel with storage capacities of more than 10,000 gallons must have spill prevention and control contingency plans. Plans that are in compliance with federal plans will meet state requirement.

Each vessel must have an individual to serve as a spill officer who will train crew and ensure that vessel has up-to-date plan and equipment.

Regulations to be promulgated for use of autopilot, requirements for tug escorts (including in Puget Sound and Rosano Straits), vessel structures, radio communications, studies to be performed on subjects, including: enhancement of vessel traffic control, use of simulator training, crew size, safety of navigation under various conditions, inspection programs, etc.

Double hulls required. Crew duty hours limited.

Prevention Plans required for vessels and facilities demonstrating the incorporation of the best available technology for prevention. Training is required or indicated, including: for pilots (simulator training and progressive responsibility), key employees in facilities, employees engaged in bunkering and lightering, alcohol and drug awareness, small spill prevention for the public.

Regional Marine Safety Committees (4) to be established to create safety plan for their areas of operation. Marine Oversight Board to independently study and make recommendations on safety issues.

State to create tanker vessel inspection program to supplement U.S. Coast Guard, if deemed necessary.

Reporting system to record accidents and serious incidents to be established. Data base of casualty history for cargo and passenger vessels to be created to identify high-risk vessels.

Emergency response system to be established in the Strait of Juan de Fuca.

Economic incentives to be studied to reward the implementation of specific safety features on vessels.
Government Contingency Plans

Hawaii Oil and Hazardous Substances Emergency Response Plan (Draft 5 Oct. 1989). State handles land-based emergency. Coast Guard handles oil spill. State supports federal agencies. Plan is established for both oil spill and chemical releases.

State oil spill contingency plan for response and cleanup for unauthorized spill will be promulgated by the oil spill coordinator. Dept. of Environmental Quality (DEQ). Dept. of Natural Resources, Dept. of Public Safety in cooperation with the oil spill coordinator. Proposes new hatchet. Plan formulation includes consultation with local government.

Florida Coastal Pollutant Spill Contingency Plan — being developed by the Department of Natural Resources.

National Contingency Plan: modification to address “worst case discharges” and “substantial threats of discharge”, use of spill-mitigating procedures having least effect on the environment and coordination of federal spill-response entities.

Area Contingency Plan: to be prepared by Area Committees to address worst case spill, or substantial threat thereof, from vessel or facility, and considering the vessel or facility, and the following:
- Environmental Sensitive Areas
- Responsibilities of all potential participating entities (including state agencies)
- Decisions on use of dispersants; description of integration with other plans; and availability of response personnel, equipment, and supplies.

State Master Oil and Hazardous Substance Spill Prevention and Contingency Plan for vessels and facilities modified to address “worst case spill” (essentially the same definition as federal) to include consultation with U.S. Coast Guard, EPA, British Columbia, and Oregon, to consider prevention responsibilities, and to establish an Incident Command System (re: Federal mode of operation.)

DOE authorized to make rules defining circumstances in which dispersants, coagulants, and bioremediation may be used.

Vessel and Facility Contingency

None specifically required by state law or regulation. State contingency plans covering both marine and shoreside spills of any hazardous waste including oil covered in state plan.

Vessel and facility contingency plans required. Terminal facilities must have discharge and response plans in order to obtain a discharge and prevention certificate. Vessel must have a contingency plan on board and personnel and equipment to implement the plan. Vessel must submit to the oil spill coordinator with a copy of the contingency plan required by OPA 1990 Sect. 4202(8)(5). Vessel may be required to show the coordinator that they have a vessel discharge prevention and response plan in order to gain entry into Louisiana’s ports.

Ship Specific Spill Prevention and Control Contingency Plan: plans required for all ships carrying over 10,000 gallons or more of pollutants as fuel or cargo. Contingency requirements outlined in the guideline for the plans. Contingency plans are supported out in Regulations 16N-16.015.

Terminal Facility Spill Prevention Plan: by 1992 all facilities over 10,000 gallons must have a specific plan for responding to spills, means and equipment for cleanup. Plans must be in compliance with federal requirements for the worst case oil spill. Contingency plans are supported out in Regulations 16N-16.035.

Facilities under 10,000 gallons have similar requirements.

Tanker and facility response plans required to show capability for response to worst case spill, describe personnel assignments and training, equipment availability and readiness testing, and demonstrate consistency with National and Area Plans.

Vessel and facility contingency plans required to contain:
- measures for reducing probability of spill
- description of method of response to worst case spill
- consideration of environmental sensitivity; personnel, equipment, and material availability; personnel qualifications and training; use of dispersants; and integration with other plans.
Response Planning Organization

No new response organizations are created by state law.

Oil Spill Coordinator position created within the Office of Governor to coordinate planning for oil spill prevention and response.
Interagency council including four members chosen outside of government and department heads of various agencies to assist in planning and coordination.

Pollutant Spill Technical Advisory Council: advise the Dept. of Natural Resources and Dept. of Environmental Regulation on matters relating to pollution control response. DNRC will chair the council. Group meets at least quarterly and includes representatives from shipping, bunkering, terminal facilities, port pilots, environment, wildlife recovery, spillage control cooperative and others.

Area Committee, directed by Federal Area On-Scene Coordinator, created, consisting of representatives of state, local and federal agencies appointed by the president. Prepares Area Contingency Plan and ensures preplanning of joint federal, state and local response efforts.

National Response Unit created to maintain comprehensive list of available equipment and personnel, provide technical assistance, coordinate public and private resources, and administer U.S. Coast Guard Strike Teams.

DOE directed to create an Advisory Committee representing diverse interests, including U.S. Coast Guard and the EPA, State agencies, local governments, etc. to assist in preparing the Statewide Contingency Plan.
Washington State Maritime Commission exists for purpose of providing response capability for vessels not otherwise having access to such resources and may submit Contingency Plans on behalf of subscribing vessels.
Regional Marine Safety Committees are created to evaluate methods for improving the safety of marine operations and navigation, and to submit plans for implementation.

Liability

Applications: Applies to owners and operators of a facility or vessel.
Purpose: Liability is for costs of removal and for damages.
Limits: Liability is unlimited.
Defense: Act of God, sabotage or war, natural disasters etc.

“Good Samaritan”: Same exemption as in federal legislation for person rendering care, assistance or advice consistent with federal or state on-scene coordinator.

Application: Applies to owners and operators of vessels and facilities.
Purpose: Liability is for costs of removal and for damages.
Limits: Same as federal limits.
Defense: Act of God or terrorism, violence of nature, act of government, negligence or willful misconduct of a third party.

“Good Samaritan”: Same exemption for person rendering care, assistance or advice consistent with NCP, federal or state on-scene coordinator.
Responsible party responsible for the exempted liability.

Application: Applies to owners and operators of vessels and facilities and owners of product to the extent that the owner or operator cannot pay.
Purpose: Cleanup costs and damages to natural resources.
Limits: $50 million for vessels or $625 per gross ton of vessel, whichever is less for cleanup.
$14 million for terminal facilities.
Vessel or facility's operator or owner has unlimited liability for damages.
Liability for cleanup and abatement unlimited in case of negligence.
Defense: Act of God or negligence by government or act of a third party.

Application: Applies to owners and operators of vessels and facilities.
Purpose: Liability for costs of removal and damages to property, subsistence use, revenues, earning capacity, public services, and natural resources.
Limits: $1200 per gross ton or $2 million for vessels up to 3000 gross tons or $10 million for vessels over 3000 gross tons.

Other Vessels: The greater of $600 per gross ton or $500,000.
Offshore Facilities: $75 million for damages plus unlimited liability for cleanup costs.
On-shore Facilities: $350 million.

Application: Applies to owners and operators of facilities and covered vessels, and to owner of oil.
Purpose: Liability is for costs of removal and for damages.
Limits: Liability is unlimited in all cases.
Defense: Spills due solely to Act of God, sabotage or war, or negligence by federal or state governments.
“Good Samaritan”: Same exemption, for persons rendering care, assistance or advice consistent with NCP, federal or state On-Scene Coordinators.
Responsible Party responsible for the exempted liabilities.
"Good Samaritan": Are exempt for liability when rendering assistance as long as no willful or negligent damage.

 LIABILITY IS UNLIMITED IN CASES OF GROSS NEGLIGENCE, WILFUL MISCONDUCT, VIOLATION OF FEDERAL STANDARDS, OR FAILURE TO REPORT, COOPERATE, OR COMPLY.

President authorized to lower liability limits for on-shore facilities to as low as $8 million, based on a required study. Liability limits also to be modified every three years to account for inflation.

Defenses: Act of God or war; or to third party; but defenses not available in cases of failure to comply.

"Good Samaritan": Persons acting consistent with National Contingency Plan, or under direction of federal On-Scene Coordinator, are not liable, except for gross negligence, willful misconduct, personal injury, or wrongful death.

All liability accrues to Responsible party.

Financial Responsibility

None required specifically by state law.

Owners or operators of tank vessel with capacity for 10,000 gallons of oil or fuel or cargo must furnish and maintain evidence that it can cover the limits set by OPA '90.

After an oil discharge a vessel must remain in the jurisdiction of the state until the vessel owner or operators show proof of financial responsibility.

All owners and operators of vessels transporting pollutant must have insurance equal to or greater than their liability. Document proof must be kept on board.

Adequate to cover maximum liability. Owner of multiple vessel or facilities need only have coverage adequate for the single vessel or facility having maximum liability.

Tank vessels, $500 Million; other regulated vessels, the greater of $600 per gross ton or $500,000. On-shore and Offshore Facilities amount to be determined by DOE, based on hazardous potential damages, and availability of insurance.

Financial responsibility requirements may be reduced for tank vessels meeting safety standards established by the Office of Marine Safety.
## Funding

<table>
<thead>
<tr>
<th>Fund Type</th>
<th>Hawaii</th>
<th>Louisiana</th>
<th>Florida</th>
<th>OPA 90</th>
<th>Washington</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fund Type: Environmental response revolving fund</strong></td>
<td>Environmental response revolving fund is created to recover cost of cleanup and used in remedial action. No funds from the revolving fund may be used for administration of statute and regulation.</td>
<td>Fund Type: Oil Spill Contingency Fund, created to cover the cost of cleanup from gas and damages to natural resources. Fund to be used for administrative cost of the office of the coordinator not to exceed $250,000. Funds can be used for grant for research not to exceed $750,000 in any one year.</td>
<td>Fund Type: Coastal protection trust fund. Created to pay for all costs and expenses of the cleanup, restoration and rehabilitation of waterfowl, wildlife, and other natural resources damaged including cost of assessing damage. Person claiming to have suffered damage as a result of discharge within 180 days may be reimbursed.</td>
<td>Fund Type: Oil Spill Liability Trust Fund (OSLTTF) created to cover expenses of removal costs (consistent with NCP) and natural resource damage assessments. State immediate draw for removal of up to $250 thousand, uncompensated damage claims, studies mandated by OPA, research and development costs of National Response Unit and System, and general administrative costs.</td>
<td>Fund Type: Oil Spill Administration Account: created to cover costs of administering programs of DOE and OMS and response to “routine” spills. Oil Spill Response Account created: to cover costs of spill responses when likely to exceed $50 thousand, including natural resource damage assessments. Coastal Protection Fund: (existing) to be used for restoration of natural resources, research into long-term effects of pollution.</td>
</tr>
<tr>
<td><strong>Revenue:</strong> State treasury and fines and penalties collected.</td>
<td>Revenue: Oil Spill Contingency Fee imposed on person owning crude oil in the vessel. Fee set at $0.02/barrel until the fund reaches $15 million. If the fund falls below $8 million, fee is re-imposed. In the case of large discharges the fee can be doubled to $0.04/barrel until the fund reaches $15 million.</td>
<td>Revenue: Revenue from two cents per barrel tax on oil and oil products off-loaded or produced in the state. Monies received from responsible party is split between fund and general fund to pay any cost taken from those sources.</td>
<td>Revenue: Revenues from $0.05/barrel tax on oil produced domestically or imported and penalties collected under oil pollution legislation.</td>
<td>Revenue: Revenues from $0.05/barrel tax on oil off-loaded from a vessel in state, and not exported from state, include $0.03/barrel for administration of oil spill legislation and $0.02/barrel for response costs. All response costs reimbursed by responsible parties are deposited in the response account, which is meant to provide quick access to funds if federal funds (from the OSLTF) are not available.</td>
<td>Revenue: Revenues from $0.05/barrel tax on oil off-loaded from a vessel in state, and not exported from state, include $0.03/barrel for administration of oil spill legislation and $0.02/barrel for response costs. All response costs reimbursed by responsible parties are deposited in the response account, which is meant to provide quick access to funds if federal funds (from the OSLTF) are not available.</td>
</tr>
<tr>
<td><strong>Amount:</strong> None specified (no lower or upper limit for fund.)</td>
<td>Amount: Fee shall not exceed $30 million.</td>
<td>Amount: Account maintained at $50 million. When the fund has $50 million, tax is not collected. If fund drops below $50 million, tax to resume.</td>
<td>Amount: Fund has $1 billion capacity.</td>
<td>Amount: Response account maintained between $15 million and $25 million. Administration account maintained adequate to cover appropriation, and Coastal Protection has no criterion for limitation.</td>
<td>Amount: Response account maintained between $15 million and $25 million. Administration account maintained adequate to cover appropriation, and Coastal Protection has no criterion for limitation.</td>
</tr>
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</table>
## Natural Resources Damages

<table>
<thead>
<tr>
<th>HAWAII</th>
<th>LOUISIANA</th>
<th>FLORIDA</th>
<th>OPA 90</th>
<th>WASHINGTON</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Reimbursement by responsible party to be pursued via authorized legal action.</strong></td>
<td><strong>State trustee agencies for resources damaged conduct direct assessment.</strong></td>
<td><strong>Dept. of Natural Resources (DNR) responsible for assessing damages and recovering cost of damages. Costs recovered go into state trust fund.</strong></td>
<td><strong>Assessment of damages performed by federal, state, tribal, and foreign Trustees.</strong></td>
<td><strong>Preassessment Screen Committee decides method of assessment. Compensation Table of Direct Assessment of Damages.</strong></td>
</tr>
<tr>
<td><strong>Natural resource trustee (under NCP, OPA) shall act on behalf of the state to determine natural resource damages.</strong></td>
<td><strong>Reimbursement by responsible party to be pursued through legal action initiated by oil spill coordinator.</strong></td>
<td><strong>DNR in consultation with Dept of Environmental Regulation and the Game and Freshwater Fish Commission establish — by rule — compensation schedules for restoration value of injured and destroyed natural resources and to coastal water, estuaries, tidal flats, etc., and for non-restorable natural resources.</strong></td>
<td><strong>Schedule of compensation to be developed by NOAA.</strong></td>
<td><strong>State trustee agencies for resources damaged conduct direct assessments.</strong></td>
</tr>
<tr>
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<td><strong>DNR may use trust fund to help determine amount of damages.</strong></td>
<td><strong>$50 million available from Trust Fund for assessment. Maximum of $500 million per incident available from Fund for restoration, etc.</strong></td>
<td><strong>Compensation Table based on relative hazard to environment of discharges and sensitivity of areas affected to be developed with assistance of Scientific Advisory Board, and involved state agencies.</strong></td>
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<td><strong>Federal Officials with authority to obligate fund to be designated by regulation.</strong></td>
<td><strong>Coastal Protection Fund available for disbursement by Steering Committee.</strong></td>
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<td></td>
<td><strong>Reimbursement by responsible party to be pursued via authorized legal action.</strong></td>
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</tbody>
</table>

## On-Board Response

<table>
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<tr>
<th>HAWAII</th>
<th>LOUISIANA</th>
<th>FLORIDA</th>
<th>OPA 90</th>
<th>WASHINGTON</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>No special provisions under state law.</strong></td>
<td><strong>Evidence of equipment availability and trained personnel for all vessels must be available prior to entry to port.</strong></td>
<td><strong>Containment and recovery equipment must be available during unloading operations. Ships must be boomed. Each ship must have a person in charge of spill control available at unloading.</strong></td>
<td><strong>Within two years of enactment, tank vessels operating in the navigable waters of the U.S. must carry appropriate removal equipment incorporating best economically feasible technology.</strong></td>
<td><strong>Containment and recovery equipment must be available during refueling or lightering operations and participating personnel must be trained in their use.</strong></td>
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</tbody>
</table>

## Drug and Alcohol Abuse

<table>
<thead>
<tr>
<th>HAWAII</th>
<th>LOUISIANA</th>
<th>FLORIDA</th>
<th>OPA 90</th>
<th>WASHINGTON</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>No special provisions under state law.</strong></td>
<td><strong>No specific requirements.</strong></td>
<td><strong>None outlined in law.</strong></td>
<td><strong>Applicants for Mariner's licenses must release data from National Drivers' Register. Licenses may be revoked or denied for conviction for serious driving violations, or for operating a ship while intoxicated.</strong></td>
<td><strong>Prevention Plans require description of Alcohol and Drug Awareness programs.</strong></td>
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<td><strong>Applicants and holders of licenses must submit to testing.</strong></td>
<td><strong>Operation of a vessel under the influence of drugs or alcohol is a Class C felony.</strong></td>
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<td><strong>Criterions for &quot;under the influence of alcohol&quot; set at 0.08 per cent blood alcohol.</strong></td>
</tr>
<tr>
<td>HAWAII</td>
<td>LOUISIANA</td>
<td>FLORIDA</td>
<td>OPA 90</td>
<td>WASHINGTON</td>
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<tr>
<td><strong>Enforcement — Penalties</strong></td>
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<tr>
<td>Civil penalty of not more than $10,000/day for knowingly releasing a hazardous substance - Class C felony.</td>
<td>Similar to the penalties in OPA 90.</td>
<td>Spill prevention and response certificate must be obtained by owner of terminal facility which outlines facility's plan for prevention and states equipment on hand. Violations of provisions of the Act are punishable by a fine of up to $50,000 per violation per day. Other penalties include: person with two or more spills in 12-month period must pay $1,000 for over five gallons and fifty cents for under five gallons.</td>
<td>Administrative, Civil, and Criminal penalties available: Up to $25,000 per day for operation without required financial responsibility. Up to $25,000 per violation per day (or up to $1,000 per barrel) for discharge of oil. At least $100,000 (or up to $3,000 per barrel) if gross negligence or willful misconduct involved. Up to $500,000 for failure to report discharge. Up to $25,000 per day for failure to remove oil or comply with an order or regulation. Sanctions such as seizure of ship, removal or limits on liability, or denial of use of defenses against liability apply in certain cases. Negligent operation of a vessel is a Class A misdemeanor.</td>
<td>Civil and criminal penalties, including: Up to $100,000 per day, each, for operation without a valid prevention and contingency plan and adequate financial responsibility. Up to $100,000 per day for doing business with a vessel or facility which lacks any of them. Up to $100,000 per day for reckless discharge of oil. Existing law provides for: Up to $10,000 per day penalty for discharge of oil. Up to $20,000 per day if discharge was the result of negligence. Up to $100,000 per day if due to recklessness or intent. Reckless operation of a vessel is a Class C felony.</td>
</tr>
</tbody>
</table>
Appendix B: Description of Oil Spill Response Technology

Three major options for responding to oil spills are discussed including:
1. mechanical containment and collection,
2. chemical technology, and
3. others, including burning, bioremediation, etc.

1. Mechanical technology

Mechanical spill response technology includes mechanical devices used to confine an oil spill near its source, or divert it to some other area where spreading can be reduced, thereby increasing the thickness of the oil to recover or remove it from the surface of the water. Recovery rate of these devices is affected by ocean conditions and weather, including currents, waves and wind, and by the nature of the oil slick. In the case of the open sea for example, recovery is only possible in relatively calm water.

Booms are the most common containment barrier, especially for biologically sensitive areas. They are vertical curtain-like floating devices which extend above and below the surface of the water and are designed to prevent or divert the spread or movement of an oil spill. Booms are used to: 1) to enclose oil slicks to reduce spreading and build thickness; 2) to protect specific areas, such as entrances to harbors, rivers, and regions known or expected to contain biologically important or sensitive resources; and 3) to divert the oil to areas where recovery is possible.

As with other mechanical spill response technology, successful use of booms depends on wind, waves and current conditions. The most common type of failure is their inability to prevent oil from escaping under the curtain. Use of booms in open water should take into account dimensions of the boom, flexibility, and strength.

Skimmers are mechanical devices used to remove oil from the surface of the water without causing major alterations to the oil’s physical or chemical properties. Design, capacity, and efficiency vary from skimmer to skimmer. For example, there are stationary skimmers, mobile devices, those requiring currents to carry oil to the device when it is stationary, and skimmers which are attachments to other vessels.

Among the various factors that affect mechanical spill response devices, local climatic conditions have the strongest influence on the efficiency of skimmers. Wind can cause the slick to move away from the skimmer or toward it. Wave action on the other hand, can reduce the mobility of some types of skimmers and decrease the recovery efficiency of nearly all types.

Debris or ice on the surface of the water may cause some skimmers to stop operating or suffer a substantial decrease in operating efficiency once these are picked up from the surface of the water. The same is true for the intake of air. In addition, some skimmers also have difficulty with water-in-oil emulsions and heavy oils, especially in cold water since these may prevent intake of the oil by conventional vacuum pumps.

2. Chemical technology

Dispersants are part of an assortment of chemical agents which can be added to oil to facilitate its clean-up or removal from the surface of the water. Specifically, they are chemicals that reduce the surface tension between oil and water, thereby, facilitating the break-up and dispersal of the oil throughout the water column in the form of an oil-in-water emulsion. In some cases, they are also used to prevent oil from adhering to solid surfaces such as piers.

Its use for oil spill recovery remains highly controversial. Those in favor of its use argue that dispersants increase the opportunity for oxidation, biodegradation, and other weathering processes and reduce immediate damage to waterfowl or other wildlife which could be adversely affected by a surface slick. On the other hand, there are those who believe that the toxic effects of dispersants far outweigh the benefits from its use, especially since older dispersants contained a substantial proportion of toxic hydrocarbon-based solvents such as kerosene, mineral spirits, and naphtha.

Gelling agents are chemicals which increase the viscosity of the oil slick either by converting oil to a cellular-like foam or coating the oil with a material having the consistency of plastic thread. In this way, oil is converted to a jelly-like form and can prevent the spread of oil over the
surface of the water and prevent oil in tankers from escaping during leaks. To date, gelling agents are rarely used owing to cost considerations and the substantial amount of mixing energy required.

Sinking agents are generally fine-grained, high-density materials (e.g., treated sand, brick dust, cement, silicone-treated materials, fly ash, chalk and special types of clay) that are used to sink floating oil. The principle behind the use of sinking agents is simple. The oil-sinking agent combination is heavier than water and therefore sinks. Efficiency varies across sinking materials, although it has been observed that efficiency is highest with heavy or viscous oils.

This technique has been recognized as a mere “cosmetic” approach to oil spill clean-up where the problem is transferred from the surface to the bottom of the water column. Concern over damage to bottom-dwelling organisms (especially in environmentally sensitive areas) has been raised. Other limitations in the use of sinking agents include, required large quantities of sinking agents relative to the size of the slick and low efficiency with low viscosity oils.

3. Other technology

Under appropriate conditions, (e.g., isolated location, limited human exposure from burning), in situ burning at sea may be an option to consider. There are, however, several problems which need to be addressed when considering the use of in situ burning. For example, there is a difficulty in lighting crude oil that is not fresh and lighting the floating oil would more often than not also include burning the vessel. Also, the usual thin layer of oil makes it difficult to raise the temperature to an ignitable level. Although, where spilled oil cannot flow well, as in the Arctic and on ice, there has been effective use of in situ burning. It should be noted that even under ideal conditions, combustion is not complete and air pollution remains a concern.

Bioremediation involves the use of hydrocarbon oxidizing microorganisms which are relatively abundant in nature (e.g., bacteria, algae, protozoa, marine fungi and other bioengineered microbes) to hasten the degradation of oil after a spill. This extremely slow process occurs only on the surface layers. Therefore, success of microbiological degradation is more likely with a surface spill or with thin layers of dispersed and weathered oil. Other factors which affect the efficiency and rate of degradation include temperature, nutrients, and oxygen availability. Over 100 species of micro-organisms have been identified to utilize hydrocarbons as an energy source, however, no single specie can degrade more than two or three of the many compounds normally found in oil.

Combustion promoters are compounds used to ignite and sustain the combustion of weathered, spilled oil (e.g., gasoline, light crude oils and various flammable commercial products) since volatile, low flashpoint hydrocarbons are rapidly lost through evaporation. Burning agents are of two generic types, sorbents and pyrotechnical compositions.

Sorbents are materials used to recover oil either by allowing oil to adhere to the surface of the material or penetrate its internal structure. In addition, sorbents are used to promote combustion by collecting oil in thicker masses to assist in burning. The three general classes of sorbents are:
1. natural organic materials such as peat moss, straw, hay and sawdust;
2. mineral-based materials such as vermiculite, perlite and volcanic ash; and
3. synthetic organic sorbents such as rubber, polyester foam, polystyrene and polyurethane.

The latter class of sorbents are most often favored because of their greater capacity for oil per unit volume and the fact that many are reusable.

Performance of sorbents depend on the size of their surface area, porosity, specific gravity, and viscosity of the spilled oil. To improve performance, sorbents are in some cases treated with compounds that attract oil and/or repel water. These compounds also prevent sinking of the sorbents once they have absorbed oil.

Pyrotechnical compositions, otherwise known as wicking agents, increase oxygen availability and insulate the burning oil from the water. Various substances such as straw, wood chips, glass beads and treated silica are used as wicking agents.
State of the Art in Oil Spill Response Technology

<table>
<thead>
<tr>
<th>Response Tech</th>
<th>Description</th>
<th>Evaluation of Capabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Mechanical Spill Response Technology</td>
<td>• Primary oil spill response methods in the U.S. are mechanical containment and recovery methods • While new designs have appeared over the years, the basic technology has not changed in the past decade. • Has improved marginally over the past two decades, but private and Federal research efforts in the U.S. have decreased greatly in the 1980s. • One prospect for reducing the high cost of more effective containment and recovery equipment for large spills is to employ dual purpose vessels (e.g., U.S. Army Corps of Engineers’ dredges). Such an approach may also offer the advantage of keeping more equipment in strategic locations.</td>
<td>• Can be deployed in almost any region without concern about additional environmental damage</td>
</tr>
<tr>
<td>1. Booms/Containment Barriers</td>
<td>• Floating devices generally resembling short curtains that restrict an oil slick from spreading beyond the barrier. • Generally have five operating components: float, freeboard, skirt, tension member and ballast. • Several designs have been produced for conditions ranging from protected waters to open ocean. • Some are designed to be towed while others remain stationary. • Vertical dimension: under one foot for protecting calm water areas—seven feet for offshore applications. • Smaller booms: less expensive, lighter and easier to deploy • Large offshore booms: require larger boats, heavier equipment to deploy and recover • Barriers designed for protected waters are more easily deployed than offshore booms</td>
<td>• Effective in relatively calm conditions</td>
</tr>
</tbody>
</table>

- Limited in capacity and capability (e.g., limited in effectiveness to waves of less than six feet winds of less than 20 knots and currents less than one knot)
- Little margin for effective use (since average wind and current conditions in many U.S. port areas, not to mention offshore areas, often exceed these limits)
- Low recovery rate (e.g., even under ideal conditions with equipment, trained personnel nearby and good weather, recovery of oil from a major spill will not be more than 30 percent)
- Cannot be deployed at the site without provision of significant support resources (e.g., forklifts and cranes, boom and skimmer handling vessels, storage vessels, surveillance airplanes and trained personnel)
- Ineffective in currents over one knot and wave heights over six feet (oil escapes the boom); problems of: 1. containing oil in a current due to the hydrodynamics of oil in moving water and 2. entrainment or dispersion of oil droplets in the water as it flows past oil held against a barrier
- Barriers designed for protected waters would be less effective in strong currents or heavy waves
<table>
<thead>
<tr>
<th>Response Tech</th>
<th>Description</th>
<th>Strengths (+)</th>
<th>Weaknesses (-)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• In wind and currents, must be designed with proper ballast to remain vertical and to maintain effective height in the water</td>
<td>• Movement of the skirt away from the vertical does not necessarily mean loss of freeboard</td>
<td>• If current and wind roll a fence boom away from the vertical, there is loss of freeboard and draft</td>
</tr>
<tr>
<td></td>
<td>• Probably reached their practical limits in terms of the maximum wind and wave conditions in which they can be expected to retain oil</td>
<td>• Effective in calm waters or enclosed waters</td>
<td>• Rarely accounted for recovery of more than a few percent of oil from large spills</td>
</tr>
<tr>
<td></td>
<td>• Future development: Toward ease of deployment and possible development of new, lighter weight, durable materials and not in greater ability to operate under harsher sea conditions</td>
<td>• Prospects for recovery devices (since efficiency of oil recovery devices is improved by increasing thickness or depth of an oil slick)</td>
<td>• Development efforts are unlikely to result in dramatic increases in total oil recovered from a catastrophic spill</td>
</tr>
<tr>
<td></td>
<td>• Major difference between the two types of booms lies in the way in which they respond to waves, current and wind</td>
<td>• Several types; no single type is best for all situations or types of oil</td>
<td>• In general, the improvements that are likely to offer greater effectiveness involve larger, more costly equipment strategically located for quick response</td>
</tr>
<tr>
<td>a. Fence</td>
<td>• Have rigid or semi-rigid materials as a containment screen for oil floating in the water</td>
<td>• Performance varies widely depending on viscosity of oil being recovered</td>
<td>• Improvements can be expected from stepped up research</td>
</tr>
<tr>
<td>b. Curtain</td>
<td>• Have a flexible skirt held down by ballast weights or tension chain or cable</td>
<td>• Improvements can be expected from stepped up research</td>
<td>• Improvements can be expected from stepped up research</td>
</tr>
<tr>
<td>2. Recovery Devices/Skimmers</td>
<td>• Developed to collect oil from the surface</td>
<td>• Simple to operate, shallow draft and can be used nearly everywhere, even under piers</td>
<td>• Do not discriminate well between oil and water, thus have low recovery efficiency particularly in thin slick</td>
</tr>
<tr>
<td></td>
<td>• Frequently used in combination with containment barriers (since efficiency of oil recovery devices is improved by increasing thickness or depth of an oil slick)</td>
<td>• Fairly high pumping rate</td>
<td>• Do not work well in thin slick</td>
</tr>
<tr>
<td></td>
<td>• Several types; no single type is best for all situations or types of oil</td>
<td>• Work best in the recovery of light oil</td>
<td>• Do not work well in thin slick</td>
</tr>
<tr>
<td></td>
<td>• Performance varies widely depending on viscosity of oil being recovered</td>
<td>• Simple, reliable and commonly available</td>
<td>• Most (especially rigid types) do not work well in waves</td>
</tr>
<tr>
<td></td>
<td>• Improvements can be expected from stepped up research</td>
<td>• High recovery rate (e.g., recovery efficiency)</td>
<td>• Conventional types become clogged with debris</td>
</tr>
<tr>
<td>a. Suction</td>
<td>• A simple suction head acting somewhat like a weir used on a floating hose from a vacuum truck or portable suction pump</td>
<td>• Simple to operate, shallow draft and can be used nearly everywhere, even under piers</td>
<td>• Do not discriminate well between oil and water, thus have low recovery efficiency particularly in thin slick</td>
</tr>
<tr>
<td>b. Weir</td>
<td>• A skimmer that has an interior basin with a slightly submerged lip over which oil floats and is</td>
<td>• Fairly high pumping rate</td>
<td>• Do not work well in thin slick</td>
</tr>
<tr>
<td></td>
<td>• Simple to operate, shallow draft and can be used nearly everywhere, even under piers</td>
<td>• Work best in the recovery of light oil</td>
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<td></td>
<td>• Simple, reliable and commonly available</td>
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</tr>
<tr>
<td>Response Tech</td>
<td>Description</td>
<td>Evaluation of Capabilities</td>
<td>Weaknesses (-)</td>
</tr>
<tr>
<td>---------------------</td>
<td>------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>c. Boom Skimmer</td>
<td>• A recovery system with one or more skimmers mounted in the face of a spill containment boom, regardless of the skimmer type, although the recovery device is generally a weir</td>
<td>• Work best if the edge of the weir is right at the oil/water interface, but in practice, this adjustment is difficult to achieve and maintain</td>
<td>• Are large pieces of equipment with many working parts needing maintenance</td>
</tr>
<tr>
<td>d. Vortex</td>
<td>• Draws oil and water into a collection chamber and separates it by centrifugal force</td>
<td>• High recovery rate in general</td>
<td>• Adversely affected by the same debris problems as other weirs</td>
</tr>
<tr>
<td>e. Moving Surface</td>
<td>• Utilize a moving material that absorbs or causes oil to adhere to it in preference to water</td>
<td>• Since weir is employed in the collection pocket of the boom, recovery efficiency is increased</td>
<td>• Fairly low efficiency</td>
</tr>
<tr>
<td>i. Disk or Drum</td>
<td>• Any disk or drum that rely on the adhesion of oil to a solid surface</td>
<td>• Relatively more effective in waves due to the large vertical dimension of disks</td>
<td>• Vulnerability to becoming clogged with debris; some disk skimmers have vanes or screens to keep out debris</td>
</tr>
<tr>
<td></td>
<td>• Disk type devices have a series of vertical disks that are rotated through the oil surface</td>
<td>• Some large skimmers are effective in fairly high sea states</td>
<td>• Ineffective with mousse</td>
</tr>
<tr>
<td></td>
<td>• Drum skimmers have a horizontal drum that rotates through the slick</td>
<td>• High recovery efficiency</td>
<td>• More complicated design (making it more likely to break down)</td>
</tr>
<tr>
<td>ii. Brush</td>
<td>• Skimmer with a horizontal brush that rotates through the oil and past a scraper which removes the oil into a sump</td>
<td>• Large disk skimmers are likely to be more durable</td>
<td></td>
</tr>
<tr>
<td>iii. Rope Mop</td>
<td>• Have a long loop of absorbent oleophilic (oil loving material) that floats on water surface and is then pulled through a wringer to remove oil along with some water</td>
<td>• Designed for recovering highly viscous oil and oil in ice</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Can be deployed from shore and the rope guided around a pulley that has been secured offshore or can be operated from boats</td>
<td></td>
<td></td>
</tr>
<tr>
<td>iv. Belt</td>
<td>• Identical in that they all employ a moving belt which may or may not be of absorbent material</td>
<td>• High recovery efficiency</td>
<td>• Likely to have problems in short period waves</td>
</tr>
<tr>
<td>iv-a. Paddle Belts</td>
<td>• Paddles are attached to the belt to lift oil out of the water</td>
<td>• Easy to deploy off the side of a vessel</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Relatively easy to maintain</td>
<td></td>
</tr>
<tr>
<td>iv-b. Sorbent Belts</td>
<td>• One that has a continuous flat belt that moves</td>
<td>• Can operate in shallow water, water filled with debris, water mixed with ice and under ice</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Most effective in medium viscosity oils</td>
<td></td>
</tr>
<tr>
<td>Response Tech</td>
<td>Description</td>
<td>Evaluation of Capabilities</td>
<td></td>
</tr>
<tr>
<td>---------------------</td>
<td>------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------</td>
<td></td>
</tr>
</tbody>
</table>
| iv-c. Sorbent Lifting Belts | • Horizontally over the water in the well of the collection vessel  
• Has a belt inclined to the water's surface and lifts the oil out of the water  
• Made of porous oleophilic material that allows water to pass through  
• Often mounted on fairly large vessels and are intended for use in harbors and offshore | • Excellent in handling debris  
• High recovery rate and efficiency |
| iv-d. Brush Lifting Belts                        | • Have a chain of brushes that lift the oil from the water  
• Instead of carrying the oil up out of the water, the submersion belt moves along a plane forcing the oil under water and oil then surfaces in a collection sump | • Particularly useful in large spills of highly viscous oil  
• Work best in low viscosity oil and thin sticks |
| iv-e. Submersion Belts                           | • Have a submersion belt that also acts as a sorbent  
• Work best in calm seas or seas with a swell up to three feet | • Effective in light to heavy oils in thickness of several millimeters  
• Work best in light to medium viscosity oils |
| f. Submersion Plane                                | • Has a fixed plane which is advanced through the oil, submerging it and directing it into a collection area aft | |
| II. Chemical Technology  
1. Dispersants                                | • A dispersant is sprayed onto a slick to reduce cohesiveness of the slick so that oil can be broken into small droplets by wind, wave and current action. Oil droplets disperse into the water column where they become diluted to low concentrations and are subject to natural processes such as biodegradation  
• Most efficient system for large spills is the Airborne  
• Dispersants that are effective on higher viscosity oils are being developed  
• Major consideration in applying dispersants: achieve a relatively uniform application on the oil without undue wind drift loss  
• Most require an application of dispersant to oil in | • Primary biological benefits: reduce hazard to birds (unless sprayed directly on them) and prevent oil from stranding on shorelines  
• Rapidly deployed (by aircraft) over a large area  
• May be used when sea conditions preclude  
• If successful, can be cost-effective  
• Can be applied to a large area in a timely manner  
• Most effective when applied early (because oil becomes less dispersible as its viscosity increases)  
• Controversy: Potential short-term environmental effects that may be increased by dispersants |
|                                                   | • Greater use has been hampered by concerns about toxicity and in part by concerns about effectiveness  
• The effectiveness of dispersants is perhaps of more concern than their toxicity. A number of experts disagree about the effectiveness of dispersants and there is as yet no reliable method to test effectiveness in field options  
• Although some dispersants have proved effective in ideal situations, ideal conditions rarely exist in the real world; research on improving dispersants is continuing and appears to be producing some encouraging results |
<table>
<thead>
<tr>
<th>Response Tech</th>
<th>Description</th>
<th>Strengths (+)</th>
<th>Weaknesses (-)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ration of about 1:10 – 1:20</td>
<td></td>
<td>effects of a treated slick versus possible long-term shoreline impacts and other effects of an untreated one (early dispersants were toxic, modern dispersants are less toxic than oil itself)</td>
</tr>
<tr>
<td></td>
<td>• As with mechanical equipments prepositioning of a dispersant is necessary to have early and effective response</td>
<td></td>
<td>• Sometimes aesthetic value is more protected (particularly if stranded oil is removed from beaches and rocky shorelines by high pressure hot water) at the expense of the local biological ecosystem</td>
</tr>
<tr>
<td></td>
<td>• The National Research Council approved its use and recommended they be considered as a potential first response option along with mechanical cleanup</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Effectiveness depends on sea conditions, application techniques and the chemical nature of both dispersants and oil</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Gelling Agents</td>
<td>• Change liquid oil into a solid to aid in recovery or are directed toward tanker accidents where pollution might be avoided or diminished by gelling remaining oil in the tanks</td>
<td></td>
<td>• Field tests show large amounts of gelling agents may be required (e.g., up to 40 percent of oil volume)</td>
</tr>
<tr>
<td></td>
<td>• Require mixing with oil and allowing adequate time for the gel to set</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Sinking Agents</td>
<td>• Used to prevent oil from reaching the shore (e.g., hydrophobic chalk)</td>
<td>• Successfully used off the Torrey Canyon oil spill in 1967</td>
<td>• Canadian tests of several sinking agents have shown that none were effective in holding oil after the initial sinking and that it slowly leached back to the surface over a few days</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>•Generally forbidden by environmental regulatory agencies because the sinking mass causes suffocation of bottom-life and exposes many bottom-dwelling organisms to oil</td>
</tr>
<tr>
<td>III. Other Technology</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. In Situ Burning</td>
<td>• Process of burning an oil spill in place with or without the use of a fire containment boom</td>
<td>• Burn efficiencies of over 90 percent can be obtained especially if oil is confined with booms or other means to keep oil layer as thick as possible</td>
<td>• Burning is probably limited in its applications</td>
</tr>
<tr>
<td></td>
<td>• Varying degrees of success</td>
<td>• More successful in cold areas</td>
<td>• Igniting and keeping a slick burning may be a problem in some circumstances; in others, burning may jeopardize the stricken vessel and any oil remaining on board, oil which might otherwise be off-loaded and the visible air pollution</td>
</tr>
<tr>
<td></td>
<td>• Not an important oil spill countermeasure at present, but is being investigated further in the U.S.</td>
<td></td>
<td>• Aesthetic trade-offs:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1. removing oil from water versus releasing products combustion into the atmosphere;</td>
</tr>
<tr>
<td>Response Tech</td>
<td>Description</td>
<td>Strengths (+)</td>
<td>Evaluation of Capabilities</td>
</tr>
<tr>
<td>---------------</td>
<td>-------------</td>
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<td>---------------------------</td>
</tr>
</tbody>
</table>
| 2. Bioremediation | • The application of nutrients to speed up the biodegradation of oil | • Use on impacted shorelines has been successful in some cases  
• Potentially the least damaging and least costly of the cleanup techniques, particularly for soiled beaches | 2. short-term impact of oil versus longer-term impact of oiled shoreline  
• Measurements show that combustion products released into the atmosphere are no more hazardous than those released by evaporating oil and that total environmental loading of toxic components remains the same or is reduced by combustion of crude oil spills on water  
• Tests have shown little or no enhancement over naturally occurring biodegradation  
• Use on water would appear limited except perhaps as a follow-up to other actions  
• Long time frame involved |
| 3. Miscellaneous Chemical Agents | | | |
| a. Combustion Promoters | • Developed to assist in combustion of oil | | |
| i. Sorbents | • Function by collecting oil in thicker masses to assist in burning | | |
| ii. Pyrotech. Compositions | • Keep the slick burning | | |
| | | | |
| References | | | |

156
## Appendix C: Oil Spill Equipment Inventory

### Oil Spill Equipment Inventory in Oahu¹

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Skimmers, skimming systems, and accessories</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>ASI 75 gpm hydraulic unit *</td>
<td>CIC</td>
</tr>
<tr>
<td>2</td>
<td>GT 185 hydraulic skimmer *</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>Mini-Walosep weir type skimmer with 11 HP hydraulic power pack</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>Skim pak skimmer with wand attachments</td>
<td>CIC</td>
</tr>
<tr>
<td>2</td>
<td>Oleo skimmers</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>GT 185 weir type skimmer with 25 gpm ASI ductz hydraulic unit</td>
<td>CIC</td>
</tr>
<tr>
<td>4</td>
<td>Skimmer (small)</td>
<td>CPB</td>
</tr>
<tr>
<td>1</td>
<td>Skimmer (medium)</td>
<td>CPB</td>
</tr>
<tr>
<td>1</td>
<td>Skimmer (small)</td>
<td>CPB</td>
</tr>
<tr>
<td>1</td>
<td>Skimmer (large DIP 3001)</td>
<td>CPB</td>
</tr>
<tr>
<td>1</td>
<td>36-ft skimmer vessel</td>
<td>NSS</td>
</tr>
<tr>
<td>1</td>
<td>skimpak unit</td>
<td>Penco</td>
</tr>
<tr>
<td>1</td>
<td>Swiss oleo skimmer</td>
<td>Penco</td>
</tr>
<tr>
<td>1</td>
<td>slurp skimmer</td>
<td>Penco</td>
</tr>
<tr>
<td>1</td>
<td>Walosep skimmer</td>
<td>ML</td>
</tr>
<tr>
<td>1</td>
<td>Walosep skimmer</td>
<td>ML</td>
</tr>
<tr>
<td>2</td>
<td>skimpak skimmer (18,000 gph; 300 gpm)</td>
<td>IT</td>
</tr>
<tr>
<td>2</td>
<td>Skimpak skimmers</td>
<td>P&amp;S</td>
</tr>
<tr>
<td>1</td>
<td>GT 185 oil skimmer</td>
<td>Hiri</td>
</tr>
<tr>
<td></td>
<td><strong>Booms, boom systems, and accessories</strong></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>600' OWOCRIS boom with without drive motor</td>
<td>CG</td>
</tr>
<tr>
<td>1</td>
<td>hydraulic boom reel with 1,500 ft. Expand 4300 boom *</td>
<td>CIC</td>
</tr>
<tr>
<td>2</td>
<td>100-ft, 30-in Trollboom oil curtain *</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>ASI Roto Pak hydraulic boom recovery system *</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>240 VAC electric powered boom reel with 3,000 ft, 6-in x 9-in harbor boom</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>240 VAC electric powered boom reel with 1,200 ft, 8-in x 12-in harbor boom</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>6,000-lb capacity 240 VAC davit with 14-ft boom</td>
<td>CIC</td>
</tr>
<tr>
<td>6</td>
<td>500-ft class I boom system</td>
<td>CPB</td>
</tr>
<tr>
<td>8</td>
<td>boom mooring systems</td>
<td>CPB</td>
</tr>
<tr>
<td>48</td>
<td>500-ft class I boom</td>
<td>CPB</td>
</tr>
<tr>
<td>5</td>
<td>500-ft permanent boom</td>
<td>CPB</td>
</tr>
<tr>
<td>4</td>
<td>boom mooring system</td>
<td>NSS</td>
</tr>
<tr>
<td>1</td>
<td>3,000-ft harbor boom</td>
<td>Penco</td>
</tr>
<tr>
<td>1</td>
<td>400-ft mini boom</td>
<td>Penco</td>
</tr>
<tr>
<td>100</td>
<td>bales 5-inch sorbent boom</td>
<td>Penco</td>
</tr>
<tr>
<td>50</td>
<td>bales 8-inch sorbent boom</td>
<td>Penco</td>
</tr>
<tr>
<td>1</td>
<td>4,300-ft boom</td>
<td>ML</td>
</tr>
</tbody>
</table>

Codes: CG-U.S. Coast Guard; CIC-Clean Islands Council; CPB-COMNAVBASE Pearl Harbor; NSS-U.S. Navy Supervisor of Salvage; Penco-Pacific Environmental Corp.; ML-Marine Logistics; IT-Industrial Technology; P&S-Pacific; Hiri-Hawaiian Independent Refinery, Inc.; UNTEK-Unitek Environmental Services, Inc.
<table>
<thead>
<tr>
<th>Quantity</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>hydraulic boom reel (on NAKUE)</td>
<td>ML</td>
</tr>
<tr>
<td>1</td>
<td>hydraulic boom reel (on NOHO LOA)</td>
<td>ML</td>
</tr>
<tr>
<td>1</td>
<td>1,500-ft Expand 3,000 boom</td>
<td>ML</td>
</tr>
<tr>
<td>1</td>
<td>ASI Rotopak and recovery system</td>
<td>ML</td>
</tr>
<tr>
<td>-</td>
<td>120-in sections oil curtain</td>
<td>ML</td>
</tr>
<tr>
<td>1</td>
<td>800-ft harbor boom</td>
<td>P&amp;S</td>
</tr>
<tr>
<td>1</td>
<td>4,000-ft, 43-inch boom</td>
<td>HIRI</td>
</tr>
<tr>
<td></td>
<td><strong>Water vessels</strong></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>16-ft rigid hull inflatable boat</td>
<td>CG</td>
</tr>
<tr>
<td>1</td>
<td>CGC JARVIS (WHEC-725)</td>
<td>CG</td>
</tr>
<tr>
<td>1</td>
<td>CGC MALLOW (WLB-396)</td>
<td>CG</td>
</tr>
<tr>
<td>1</td>
<td>CGC SASSAFRASS (WLB-401)</td>
<td>CG</td>
</tr>
<tr>
<td>1</td>
<td>CGC WASHINGTON (WPB-1331)</td>
<td>CG</td>
</tr>
<tr>
<td>1</td>
<td>Rigid hull inflatable boats</td>
<td>CG</td>
</tr>
<tr>
<td>2</td>
<td>41-ft utility boat</td>
<td>CG</td>
</tr>
<tr>
<td>1</td>
<td>10 ft Livingston workboats with 6 HP engines</td>
<td>CG</td>
</tr>
<tr>
<td>1</td>
<td>130-ft OSRV “Clean Islands”, 95,000-gal recovered oil holding capacity</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>12-ft skiff with 9.9 HP outboard *</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>21-ft aluminum Munson boomboat with 120 HP outboard and trailer *</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>12-ft sears gamefisher skiff</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>24-ft Marco platform workboat on trailer with 35 HP outboard</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>14-ft Acme workboat on trailer with 15 HP outboard</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>10-ft rowing skiff</td>
<td>CIC</td>
</tr>
<tr>
<td>3</td>
<td>18-ft utility boats</td>
<td>CPB</td>
</tr>
<tr>
<td>4</td>
<td>18-ft utility boats</td>
<td>CPB</td>
</tr>
<tr>
<td>4</td>
<td>SWOB barge</td>
<td>CPB</td>
</tr>
<tr>
<td>2</td>
<td>24-ft, 260 HP diesel boom handling boat</td>
<td>NSS</td>
</tr>
<tr>
<td>1</td>
<td>19-ft inflatable boom tending boat</td>
<td>NSS</td>
</tr>
<tr>
<td>1</td>
<td>18-ft rigid hull boom tending boat</td>
<td>NSS</td>
</tr>
<tr>
<td>1</td>
<td>70-ft tug boat</td>
<td>PENCOS</td>
</tr>
<tr>
<td>1</td>
<td>45-ft tug boat</td>
<td>PENCOS</td>
</tr>
<tr>
<td>2</td>
<td>17-ft Boston whaler with 1-70 HP outboard</td>
<td>PENCOS</td>
</tr>
<tr>
<td>1</td>
<td>12-ft tender with 5 HP</td>
<td>PENCOS</td>
</tr>
<tr>
<td>2</td>
<td>8-ft tender without motor</td>
<td>PENCOS</td>
</tr>
<tr>
<td>1</td>
<td>8-ft skiff with oars</td>
<td>PENCOS</td>
</tr>
<tr>
<td>1</td>
<td>8-ft skiff with 1-35 Hp outboard</td>
<td>PENCOS</td>
</tr>
<tr>
<td>1</td>
<td>18-ft Boston Whaler with trailer</td>
<td>ML</td>
</tr>
<tr>
<td>1</td>
<td>36-ft, 800 gal oil spill containment vessel (NAKUE)</td>
<td>ML</td>
</tr>
<tr>
<td>1</td>
<td>120-ft, 4000-gal oil spill response vessel (NOHO LOA)</td>
<td>ML</td>
</tr>
<tr>
<td>2</td>
<td>12.5-ft workboats</td>
<td>P&amp;S</td>
</tr>
</tbody>
</table>

**Code:** CG-U.S. Coast Guard; CIC-Clean Islands Council; CPB-COMNAVBASE Pearl Harbor; NSS-U.S. Navy Supervisor of Salvage; PENCOS-Pacfic Environmental Corp.; ML-Marine Logistics; IT-Industrial Technology; P&S-P&S Pacific; HIRI-Hawaiian Independent Refinery, Inc.; UNITEK-Unick Environmental Services, Inc.
<table>
<thead>
<tr>
<th>Quantity</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Fixed-wing C-130 planes</td>
<td>CG</td>
</tr>
<tr>
<td>3</td>
<td>HH-65 helicopters</td>
<td>CG</td>
</tr>
<tr>
<td>1</td>
<td>Emergency response trailer with 900-ft, 6-in x 9-in harbor boom and sorbents</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>Ford Cutaway van with accessories (e.g., sorbents, tools, first aid kit, etc)</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>1-ton Ford 350-series flatbed truck</td>
<td>CIC</td>
</tr>
<tr>
<td>4</td>
<td>Work trucks</td>
<td>PENCO</td>
</tr>
<tr>
<td>2</td>
<td>Motorized beach caddies</td>
<td>ML</td>
</tr>
<tr>
<td>1</td>
<td>Flatbed truck</td>
<td>ML</td>
</tr>
<tr>
<td>1</td>
<td>Emergency response van</td>
<td>ML</td>
</tr>
<tr>
<td>1</td>
<td>6,000-ft gallon tank truck</td>
<td>IT</td>
</tr>
<tr>
<td>4</td>
<td>Vacuum trailer</td>
<td>UNITEK</td>
</tr>
<tr>
<td>5</td>
<td>2,000-gal vacuum truck</td>
<td>UNITEK</td>
</tr>
<tr>
<td>3</td>
<td>Vacuum trucks (2000 gal)</td>
<td>P&amp;S</td>
</tr>
</tbody>
</table>

**Dispersants and dispersant application systems**

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>40-ft aluminum sweep arms port and starboard for dispersant spraying *</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>Gasoline-engine-driven dispersant metering pump *</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>Hydraulically powered dispersant metering pump *</td>
<td>CIC</td>
</tr>
<tr>
<td>2</td>
<td>25-ft plumbed sprayer nozzles for dispersant sprayer pump</td>
<td>CIC</td>
</tr>
<tr>
<td>23</td>
<td>55-gallon drums of COREXIT 9527 dispersant</td>
<td>HIRI</td>
</tr>
</tbody>
</table>

**Sorbents**

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Bales of sorbent sweep</td>
<td>CG</td>
</tr>
<tr>
<td>10</td>
<td>Bales of sorbent pad</td>
<td>CG</td>
</tr>
<tr>
<td>1</td>
<td>OMI 1-4D mop wringer with 300-ft mop</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>OMI 11-D mop wringer with 150-ft mop</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>OMI 111-D mop wringer with 100-ft mop</td>
<td>CIC</td>
</tr>
<tr>
<td>2</td>
<td>55-gal drum sorbent wringer systems</td>
<td>CIC</td>
</tr>
<tr>
<td>300</td>
<td>Bales grade 100 sorbent pads</td>
<td>PENCO</td>
</tr>
<tr>
<td>300</td>
<td>Bales grade 200 sorbent pads</td>
<td>PENCO</td>
</tr>
<tr>
<td>50</td>
<td>Bales grade 50 sorbent pads</td>
<td>PENCO</td>
</tr>
<tr>
<td>300</td>
<td>Bales sorbent sweeps</td>
<td>PENCO</td>
</tr>
<tr>
<td>20</td>
<td>Rolls blanket pads</td>
<td>PENCO</td>
</tr>
<tr>
<td>50</td>
<td>Boxes oil snares (pom-poms) sorbents</td>
<td>ML</td>
</tr>
<tr>
<td>-</td>
<td>Sorbent booms, sweeps, snares</td>
<td>UNITEK</td>
</tr>
</tbody>
</table>

**Storage systems**

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4,000-gal oil-water separator tank with filtration system *</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>500-gal hard wall oil-water separator</td>
<td>CIC</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Quantity</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>floating oil-water separator with 6-ft curtain and ballast</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>floating oil bladder</td>
<td>CIC</td>
</tr>
<tr>
<td>5</td>
<td>Texaboom oil bladders</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>2,000-gal fastank</td>
<td>CIC</td>
</tr>
<tr>
<td>20</td>
<td>26,000-gallon donuts, closed bottom type</td>
<td>CPB</td>
</tr>
<tr>
<td>6</td>
<td>26,000-gallon donuts, open bottom type</td>
<td>CPB</td>
</tr>
<tr>
<td>1</td>
<td>26,000 gallon oil storage bladder</td>
<td>NSS</td>
</tr>
<tr>
<td>1</td>
<td>500 gallon storage tank on trailer</td>
<td>Penco</td>
</tr>
<tr>
<td>1</td>
<td>800-gal oil-water separator (trailer)</td>
<td>Penco</td>
</tr>
<tr>
<td>1</td>
<td>300-gal oil-water separator</td>
<td>Penco</td>
</tr>
<tr>
<td>1</td>
<td>1,000-gal storage tank (skid)</td>
<td>Penco</td>
</tr>
<tr>
<td>1</td>
<td>2,000-gal storage tank (skid)</td>
<td>Penco</td>
</tr>
<tr>
<td>2</td>
<td>3,600-gal storage tank (sub?)</td>
<td>Penco</td>
</tr>
<tr>
<td>1</td>
<td>oil-water separator</td>
<td>Hiri</td>
</tr>
<tr>
<td>6</td>
<td>2,000-gallon storage bladders</td>
<td>Hiri</td>
</tr>
</tbody>
</table>

**Pumps and accessories**

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>150 gpm gas powered centrifugal pumps</td>
<td>CIC</td>
</tr>
<tr>
<td>2</td>
<td>pneumatic diaphragm pumps</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>Acme floating washdown pump</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>Acme floating washdown pump, 3 HP gas powered</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>Acme floating circulation pump, 3 HP gas powered</td>
<td>CIC</td>
</tr>
<tr>
<td>2</td>
<td>6-inch submersible pump</td>
<td>NSS</td>
</tr>
<tr>
<td>1</td>
<td>2-inch floating washdown pump</td>
<td>Penco</td>
</tr>
<tr>
<td>2</td>
<td>2-inch centrifugal pump (150 gpm)</td>
<td>Penco</td>
</tr>
<tr>
<td>1</td>
<td>2-inch jet pump</td>
<td>Penco</td>
</tr>
<tr>
<td>1</td>
<td>4-inch jet pump</td>
<td>Penco</td>
</tr>
<tr>
<td>4</td>
<td>2-inch electric submersible pump</td>
<td>Penco</td>
</tr>
<tr>
<td>4</td>
<td>2-inch diaphragm pump (150 gpm)</td>
<td>Penco</td>
</tr>
<tr>
<td>4</td>
<td>1-inch diaphragm pump</td>
<td>Penco</td>
</tr>
<tr>
<td>1</td>
<td>0.5-inch diaphragm pump</td>
<td>Penco</td>
</tr>
<tr>
<td>6</td>
<td>2-inch trash pump</td>
<td>Penco</td>
</tr>
<tr>
<td>2</td>
<td>double diaphragm spark proof pumps (200 gpm)</td>
<td>IT</td>
</tr>
<tr>
<td>1</td>
<td>pneumatic suction pump (50 gpm)</td>
<td>IT</td>
</tr>
<tr>
<td>2</td>
<td>diaphragm pump</td>
<td>Unitek</td>
</tr>
<tr>
<td>2</td>
<td>double diaphragm spark proof pumps (200 gpm)</td>
<td>P&amp;S</td>
</tr>
<tr>
<td>1</td>
<td>pneumatic suction pump (50 gpm)</td>
<td>P&amp;S</td>
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</table>

**Miscellaneous equipment**

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>portable generator, 1.5 kw</td>
<td>Penco</td>
</tr>
<tr>
<td>2</td>
<td>portable generator, 5.0 kw</td>
<td>Penco</td>
</tr>
<tr>
<td>1</td>
<td>portable generator, 10.0 kw</td>
<td>Penco</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Quantity</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>5 CFM electric compressor</td>
<td>PENCO</td>
</tr>
<tr>
<td>1</td>
<td>15 CFM gasoline compressor</td>
<td>PENCO</td>
</tr>
<tr>
<td>1</td>
<td>165 CFM diesel compressor</td>
<td>PENCO</td>
</tr>
<tr>
<td>2</td>
<td>265 CFM diesel compressor</td>
<td>PENCO</td>
</tr>
<tr>
<td>1</td>
<td>15-HP Evenrude outboard engine</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>twin light tower on trailer</td>
<td>CIC</td>
</tr>
<tr>
<td>3</td>
<td>25-watt ICOM handled VHF Marine band radios</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>blower, 1,400 cfm</td>
<td>PENCO</td>
</tr>
<tr>
<td>4</td>
<td>welding machine</td>
<td>PENCO</td>
</tr>
<tr>
<td>1</td>
<td>steam cleaner</td>
<td>PENCO</td>
</tr>
<tr>
<td>2</td>
<td>pressure washer</td>
<td>PENCO</td>
</tr>
<tr>
<td></td>
<td>- assorted rakes, scoop pans &amp; hand tools</td>
<td>PENCO</td>
</tr>
<tr>
<td>2</td>
<td>steam cleaners</td>
<td>PENCO</td>
</tr>
<tr>
<td>2</td>
<td>50-foot aluminum sweep arms</td>
<td>ML</td>
</tr>
<tr>
<td>1</td>
<td>high pressure water herder (360 gpm)</td>
<td>IT</td>
</tr>
<tr>
<td>2</td>
<td>high pressure water herder (360 gpm)</td>
<td>P&amp;S</td>
</tr>
</tbody>
</table>

Note: PLUS other companies for support equipment.

Inventory for U.S. Coast Guard, Clean Islands Council, PENCO and Marine Logistics were updated as of December 1991. Inventory of all other equipment sources are based on the 1989 Oil Spill Contingency Plan developed by the U.S. Coast Guard, Honolulu.

* on board the OSRV Clean Islands

Sources:
U.S. Coast Guard, 1989 Oil Spill Contingency plan
LCDR Mary Landry and staff, U.S. Coast Guard, MSO-Honolulu
Kim Beasley, CIC Manager

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## Oil Spill Equipment Inventory in Kauai

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Skimmers, skimming systems, and accessories</strong></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>skimpak with wand</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>swiss oleo skimmer</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>Skimpak with wand</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>Oela III skimmer with 20 ft x 2 in hose and gas pump</td>
<td>CHEVRON</td>
</tr>
<tr>
<td></td>
<td><strong>Booms, boom systems, and accessories</strong></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>300-ft mini boom</td>
<td>CIC</td>
</tr>
<tr>
<td>10</td>
<td>bales sorbent boom</td>
<td>CIC</td>
</tr>
<tr>
<td>10</td>
<td>bales sorbent boom</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>200-ft Kepner containment boom</td>
<td>CHEVRON</td>
</tr>
<tr>
<td>1</td>
<td>400-ft Kepner containment boom</td>
<td>KP</td>
</tr>
<tr>
<td>1</td>
<td>300-ft 6-inch Kepner boom</td>
<td>SHELL</td>
</tr>
<tr>
<td>1</td>
<td>1,000-ft trailered boom</td>
<td>SHELL</td>
</tr>
<tr>
<td>1</td>
<td>200 feet, 2-inch slick bar mini-boom</td>
<td>SHELL</td>
</tr>
<tr>
<td></td>
<td><strong>Water vessels</strong></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>CGC PT HARRIS (WPB-82376)</td>
<td>CG</td>
</tr>
<tr>
<td>1</td>
<td>17-ft Boston whaler with 90 HP outboard and trailer</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>17.5-ft McKee Craft boomboat with 88 HP outboard and trailer</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>10-ft fiberglass under pier skiff</td>
<td>CIC</td>
</tr>
<tr>
<td>2</td>
<td>Trailered boats</td>
<td>USNF</td>
</tr>
<tr>
<td>1</td>
<td>Recovery boat</td>
<td>USNF</td>
</tr>
<tr>
<td>1</td>
<td>Runabout</td>
<td>HD</td>
</tr>
<tr>
<td>2</td>
<td>Small boats</td>
<td>FD</td>
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<tr>
<td></td>
<td><strong>Aircraft</strong></td>
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<tr>
<td>2</td>
<td>Helicopters</td>
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<tr>
<td></td>
<td><strong>Trucks, trailers, and other land transportation</strong></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>emergency response trailer with 1000-ft, 6-in x 12-in harbor boom</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>emergency response trailer</td>
<td>CIC</td>
</tr>
<tr>
<td></td>
<td><strong>Sorbents</strong></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>bales sorbent pads</td>
<td>CIC</td>
</tr>
<tr>
<td>10</td>
<td>bales sorbent sweeps</td>
<td>CIC</td>
</tr>
<tr>
<td>10</td>
<td>bales sorbent pads</td>
<td>CIC</td>
</tr>
<tr>
<td>10</td>
<td>bales sorbent sweeps</td>
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</tr>
<tr>
<td>4</td>
<td>bales 3M type 151 sorbent sheets</td>
<td>CHEVRON</td>
</tr>
<tr>
<td>2</td>
<td>bales 3M type 151 sorbent sheets</td>
<td>KP</td>
</tr>
<tr>
<td>4</td>
<td>bales sorbent material</td>
<td>SHELL</td>
</tr>
<tr>
<td>2</td>
<td>bales sorbent sweeps</td>
<td>SHELL</td>
</tr>
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<table>
<thead>
<tr>
<th>Quantity</th>
<th>Description</th>
<th>Source</th>
</tr>
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<tr>
<td></td>
<td><strong>Storage systems and accessories</strong></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1,500 gal fastank</td>
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</tr>
<tr>
<td>1</td>
<td>500 gal towable bladder</td>
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<tr>
<td>1</td>
<td>25-ft storage container with 800-ft, 6-in x 12-in harbor boom</td>
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<tr>
<td>1</td>
<td>1,500-gal fastank</td>
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</tr>
<tr>
<td>50</td>
<td>empty 55 gallon drums</td>
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<td><strong>Pumps and accessories</strong></td>
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<tr>
<td>1</td>
<td>American pneumatic diaphragm pump</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>Homelite gasoline pump</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>Homelite diaphragm pump</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>12-inch portable self-priming centrifugal pump</td>
<td>KP</td>
</tr>
<tr>
<td></td>
<td><strong>Miscellaneous equipment</strong></td>
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</tr>
<tr>
<td>1</td>
<td>1.75 KW gasoline generator</td>
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</tr>
<tr>
<td>1</td>
<td>electric megaphone</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>JW type explosive vapor detection device</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>battery charger</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>solar trickle charger</td>
<td>CIC</td>
</tr>
<tr>
<td>12</td>
<td>pairs oil protective gloves</td>
<td>CIC</td>
</tr>
<tr>
<td>4</td>
<td>13-S Danforth type boom anchors</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>12 VDC battery charger</td>
<td>CIC</td>
</tr>
<tr>
<td>12</td>
<td>pair gauntlet oil protective gloves</td>
<td>CIC</td>
</tr>
<tr>
<td>2</td>
<td>13-S Danforth style boom anchors</td>
<td>CIC</td>
</tr>
</tbody>
</table>

**Note:** PLUS other companies for support equipment

"Inventory for U.S. Coast Guard and Clean Islands Council were updated as of December 1991. Inventory of all other equipment sources are based on the 1989 Oil Spill Contingency Plan developed by the U.S. Coast Guard, Honolulu.

**Sources:**
U.S. Coast Guard, 1989 Oil Spill Contingency plan
LCGR Mary Landry and staff, U.S. Coast Guard, MSO-Honolulu
Kim Beasley, CIC Manager

## Oil Spill Equipment Inventory in Hawaii

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Skimmers, skimming systems, and accessories</strong></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Skimpak with wand</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>Swiss Oleo skimmer</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>Swiss Oleo skimmer</td>
<td>CIC</td>
</tr>
<tr>
<td></td>
<td><strong>Booms, boom systems and accessories</strong></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>boom trailers with 1,000-ft, 6-in x 12-in boom each</td>
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</tr>
<tr>
<td>1</td>
<td>150-ft miniboom</td>
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</tr>
<tr>
<td>10</td>
<td>bales sorbent boom</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>Boom trailer with 600-ft 6-in x 12-in harbor boom</td>
<td>CIC</td>
</tr>
<tr>
<td>10</td>
<td>bales sorbent booms</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>300-ft sea curtain</td>
<td>HD</td>
</tr>
<tr>
<td>1</td>
<td>200-ft containment boom</td>
<td>HD</td>
</tr>
<tr>
<td>1</td>
<td>400-ft Kepner sea curtain</td>
<td>KHD</td>
</tr>
<tr>
<td>1</td>
<td>Type 270 sorbent boom</td>
<td>KHD</td>
</tr>
<tr>
<td>1</td>
<td>200-ft, 2-in slick bar mini boom</td>
<td>SHELL</td>
</tr>
<tr>
<td></td>
<td><strong>Water vessels</strong></td>
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</tr>
<tr>
<td>1</td>
<td>USCGC KISKA</td>
<td>CG</td>
</tr>
<tr>
<td>1</td>
<td>10 ft Livingston workboats with six HP engines</td>
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</tr>
<tr>
<td>1</td>
<td>21-ft Boston Whaler Outrage with twin 70 HP outboard and trailer</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>10-ft fiberglass under pier skiff with 4 HP outboard</td>
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</tr>
<tr>
<td>1</td>
<td>17-ft Boston Whaler Boom boat with 100 HP outboard and trailer</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>13-ft Boston Whaler with 20 HP outboard</td>
<td>HD</td>
</tr>
<tr>
<td>1</td>
<td>12-ft fiberglass boat</td>
<td>KHD</td>
</tr>
<tr>
<td></td>
<td><strong>Trucks, trailers, and other land transportation</strong></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>dump truck</td>
<td>USAPTA</td>
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<tr>
<td></td>
<td><strong>Sorbents</strong></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>bales sorbent pads</td>
<td>CIC</td>
</tr>
<tr>
<td>10</td>
<td>bales sorbent sweeps</td>
<td>CIC</td>
</tr>
<tr>
<td>10</td>
<td>bales sorbent pads</td>
<td>CIC</td>
</tr>
<tr>
<td>10</td>
<td>bales sorbent sweeps</td>
<td>CIC</td>
</tr>
<tr>
<td>-</td>
<td>3M Type 126 sorbent sweeps</td>
<td>CIC</td>
</tr>
<tr>
<td>-</td>
<td>3M Type 156 sorbent pads</td>
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<tr>
<td>2</td>
<td>bales 100-ft by 3/8-in sorbent sweep</td>
<td>HD</td>
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<tr>
<td>2</td>
<td>bales Type 157 sorbent pads</td>
<td>HD</td>
</tr>
<tr>
<td>2</td>
<td>bales sorbent sweep</td>
<td>KHD</td>
</tr>
<tr>
<td>3</td>
<td>bales sorbent material</td>
<td>SHELL</td>
</tr>
</tbody>
</table>

*Codes: CG-U.S. Coast Guard; CIC-Clean Islands Council; USAPTA-U.S. Army Pohakuloa Training Area; KHD-Kawaihae Harbors Division Warehouse; SHELL-Shell Oil Co.*
Storage systems and equipment
1  1,500-gal fastank  CIC
1  Kepner oil-water separator  CIC

Pumps and accessories
1  American pneumatic pump  CIC
1  ACME washdown pump  CIC
1  Homelite diaphragm pump  CIC
1  American pneumatic pump  CIC
1  75 gpm gasoline pump with hoses  HD
1  skimmer pump  KHD

Miscellaneous equipment
1  2.25-KW generator  CIC
1  gasoline generator  HD
1  JW type explosive vapor detection device  CIC
1  12 VDC battery charger  CIC
1  solar trickle charger  CIC
1  electric megaphone  CIC
12  pairs gauntlet oil protective gloves  CIC
2  13-S Danforth type boom anchors  CIC
12  pairs gauntlet oil protective gloves  CIC
2  13-S Danforth type boom anchors  CIC

Note: PLUS various other companies that can provide dump trucks, front end loaders, bulldozers, road graders, pumps and generators.

Inventory for U.S. Coast Guard and Clean Islands Council were updated as of December 1991. Inventory of all other equipment sources are based on the 1989 Oil Spill Contingency Plan developed by the U.S. Coast Guard, Honolulu.

Sources:
U.S. Coast Guard, 1989 Oil Spill Contingency plan
LCDR Mary Landry and staff, U.S. Coast Guard, MSO-Honolulu
Kim Beasley, CIC Manager.
## Oil Spill Equipment Inventory in Maui

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Skimmers, skimming systems, and accessories</strong></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>skimpak with wand oil recovery skimmer</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>Swiss Oleo skimmer</td>
<td>CIC</td>
</tr>
<tr>
<td></td>
<td><strong>Booms, boom systems, and accessories</strong></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1,500-ft, 8-in x 10-in harbor boom</td>
<td>CIC</td>
</tr>
<tr>
<td>10</td>
<td>bales sorbent boom</td>
<td>CIC</td>
</tr>
<tr>
<td></td>
<td><strong>Water vessels</strong></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>24-ft rigid-hull inflatable boat on trailer</td>
<td>CG</td>
</tr>
<tr>
<td>1</td>
<td>22-ft utility boat on trailer</td>
<td>CG</td>
</tr>
<tr>
<td>1</td>
<td>17-ft McKee Craft boom/recovery boat with twin 60 HP outboard</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>14-ft Aluminum under pier skiff</td>
<td>CIC</td>
</tr>
<tr>
<td></td>
<td><strong>Sorbents</strong></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>bales sorbent pads</td>
<td>CIC</td>
</tr>
<tr>
<td>10</td>
<td>bales sorbent sweeps</td>
<td>CIC</td>
</tr>
<tr>
<td></td>
<td><strong>Storage systems and accessories</strong></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1,500-gal portable fastank</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>Kepner oil-water separator</td>
<td>CIC</td>
</tr>
<tr>
<td></td>
<td><strong>Pumps and accessories</strong></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>American pneumatic diaphragm pump</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>Homelite gas powered diaphragm pump</td>
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</tr>
<tr>
<td>1</td>
<td>ACME washdown pump</td>
<td>CIC</td>
</tr>
<tr>
<td></td>
<td><strong>Miscellaneous equipment</strong></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1.75-KW generator</td>
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</tr>
<tr>
<td>1</td>
<td>gasoline powered blower</td>
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</tr>
<tr>
<td>1</td>
<td>gas detection device</td>
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</tr>
<tr>
<td>1</td>
<td>megaphone</td>
<td>CIC</td>
</tr>
<tr>
<td>1</td>
<td>12-volt battery charger</td>
<td>CIC</td>
</tr>
<tr>
<td>12</td>
<td>pairs gauntlet oil protective gloves</td>
<td>CIC</td>
</tr>
<tr>
<td>4</td>
<td>13-S Danforth type boom anchors</td>
<td>CIC</td>
</tr>
</tbody>
</table>

**Note:** PLUS other companies for support equipment.

*Inventory for U.S. Coast Guard and Clean Islands Council are as of December 1991.*

**Sources:**
- U.S. Coast Guard, 1989 Oil Spill Contingency plan
- LCDR Mary Landry and staff, U.S. Coast Guard, MSO-Honolulu
- Kim Beasley, CIC Manager

Codes: CG-U.S. Coast Guard; CIC-Clean Islands Council.