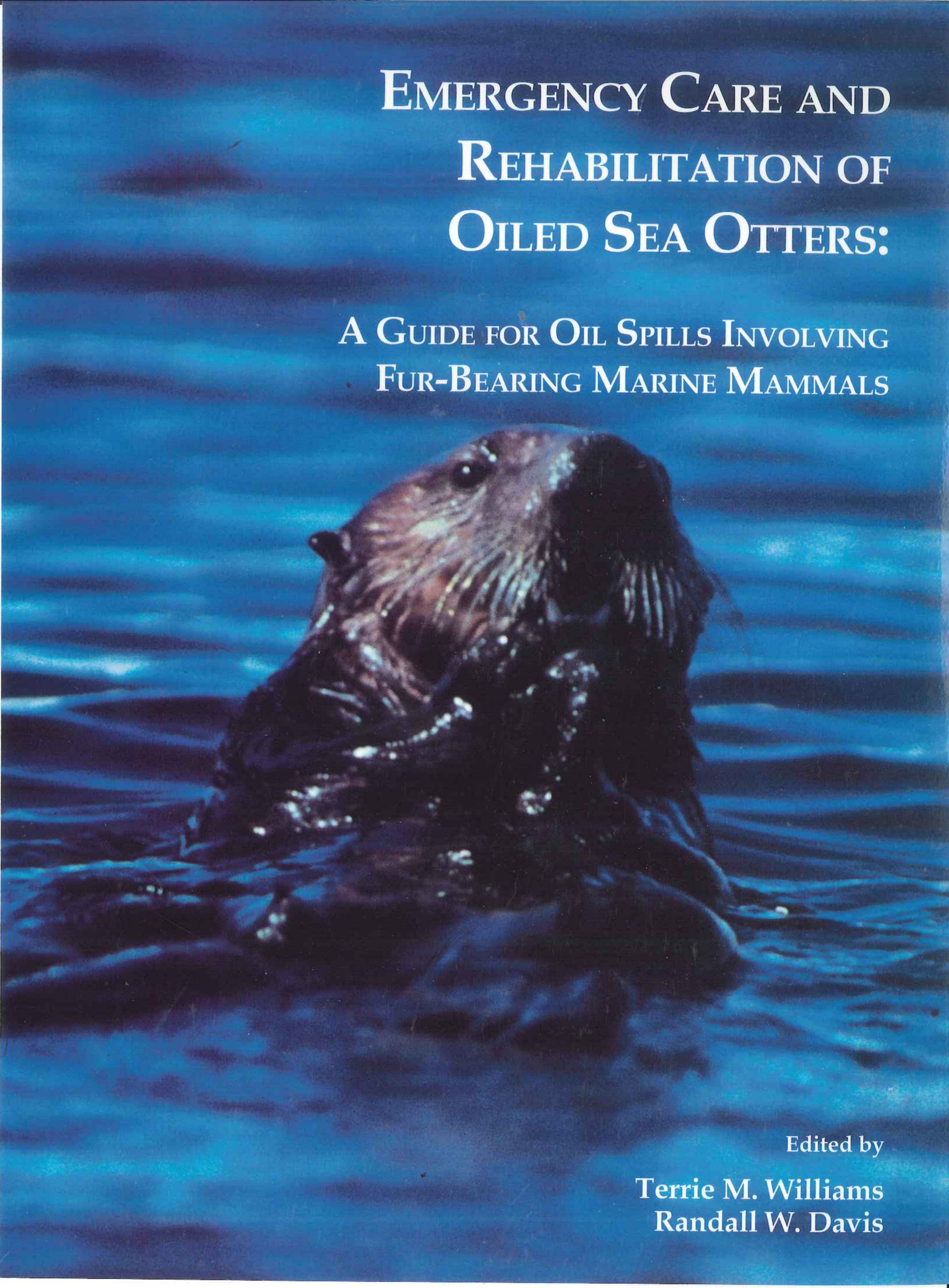
# Emergency Care and Rehabilitation of Oiled Sea Otters:

## A Guide for Oil Spills Involving Fur-Bearing Marine Mammals



Edited by

Terrie M. Williams
Randall W. Davis

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# PREFACE

The motivation for this book arose from the Sea Otter Rehabilitation Program conducted following the 1989 *Exxon Valdez* oil spill (EVOS). Although an understanding of sea otter husbandry, clinical care, and techniques for cleaning oiled fur existed before 1989, they had never been compiled into a single volume for the rehabilitation of oiled sea otters. Earlier research had identified sea otters as the marine mammal most vulnerable to the detrimental effects of oil, yet the existing literature wholly underestimated the severity of the clinical effects of oil contamination and the logistical problems of rehabilitating large numbers of oiled sea otters. The problem was compounded by the lack of realistic oil spill contingency plans for sea otters. When the EVOS occurred on March 24, 1989, the Sea Otter Rehabilitation Program was initiated with little advance organization or preparation. During the six months that followed, 357 sea otters were treated at three response centers in Alaska and at seaquariums in San Diego, Tacoma, and Vancouver. We quickly realized that the tremendous amount of new information generated during this program would be useful for responding to future oil spills involving sea otters and should be assembled as a single volume. After nearly five years of hard work, we have finally achieved our goal.

Many people and organizations contributed to the Sea Otter Rehabilitation Program and the subsequent preparation of this book. Although it is not possible to recognize all of them by name, the reader should understand that the book is the cumulative effort and thinking of a great many people.

We would like to begin by thanking the Minerals Management Service for supporting our initial research at the Sea World Research Institute in the mid-1980s. This research led to the development of a method for cleaning oiled sea otters. After the EVOS, the Minerals Management Service provided support for data analysis and the preparation of this book. We would especially like to thank Fred Piltz, Gordon Reetz, Carol Fairfield, William Lang, Sandra McLaughlin and others who had the foresight to support our efforts before and after the EVOS.

We also thank Exxon Company, USA for generously funding the Sea Otter Rehabilitation Program, the subsequent analysis of data, and the preparation of this book. Their commitment and support throughout this effort enabled us to establish an impressive wildlife rehabilitation program and to share our knowledge with the scientific and wildlife rehabilitation communities.

Special thanks goes to Pamela Bergmann of the U.S. Department of the Interior and Everett Robinson Wilson of the U.S. Fish and Wildlife Service (USFWS) for their support and professionalism during the many difficult periods of the oil spill and the preparation of this book. Many people at USFWS were supportive. We would like to recognize Walter Stieglitz (Alaska Regional Director), Keith Bayha, Anthony Degange, Calvin Lensink, Jon Nickles, Carl Benz, Ron Britton, and Glen VanBlaricom; also Sarah Hurley, Dan Mulcahy, Victor Nettles, Thomas Thorne, Thomas Roffe, Larry Pank, John Ramsey, and Mark Udevitz. From the California Department of Fish and Game, we gratefully acknowledge the long hours of service and support from Jack Ames, Bob Hardy, Kim McCleneghan, and Mike Herlache. John Twiss, Robert Hofman and Robert Elsner of the Marine Mammal Commission provided valuable suggestions. From the Armed Forces Institute of Pathology, we acknowledge the assistance of John Pletcher, Keith Harris, and Thomas Lipscomb.

Many organizations placed valuable resources and personnel at our disposal during the Sea Otter Rehabilitation Program and assisted in the subsequent preparation of this book. We would like to thank the Alyeska Pipeline Service Company, Sea World, the Sea World Research Institute, the Vancouver Aquarium, the Point Defiance Zoo and Aquarium, the Monterey Bay Aquarium, the Shedd Aquarium, the California Marine Mammal Center, the University of Alaska, the University of California at Davis, the U.S. Environmental Protection Agency, Zenith Corporation, Hewlett-Packard Corporation, and Proctor & Gamble.

We gratefully acknowledge the people who served on our Scientific Review Board and spent many hours reviewing the manuscript: Jack Ames, Keith Bayha, Pamela Bergmann, Dennis O'Connor, Ellen Faurot-Daniels, and William Medway. Special thanks to Tamela Thomas, who spent long, difficult hours assembling the computer data base and maintaining the original records from the Sea Otter Rehabilitation Program. Her skills and patience enabled the authors of this book to utilize the enormous amount of data that was collected during the EVOS. We also benefited greatly from discussions and the workshop at the Sea Otter Symposium sponsored by the USFWS in Anchorage on April 17-19, 1990.

As with any multi-authored technical book, some people will disagree with our conclusions and recommendations. We have attempted to use the best available expertise to analyze and interpret the data in an objective fashion. Our primary goal is to provide the reader with the best advice on the care and rehabilitation of oiled sea otters. If any errors have been made, we alone are responsible.

Finally, we would like to recognize the many people that worked at the rehabilitation centers and aboard the capture boats during the Sea Otter Rehabilitation Program following the EVOS. Their hard work and sacrifice made this book possible. At the same time, we all learned something about ourselves and how to better care for our wildlife.

*—Terrie Williams*
*Randall Davis*
*Kailua, Hawaii*

# Introduction

# History, Perspectives, and Goals

Terrie M. Williams

In April 1989, fifteen exhausted people crowded around a table at the Valdez Sea Otter Rescue Center. We had spent the previous two weeks caring for dozens of sea otters that had been oiled when the T/V *Exxon Valdez* ran aground in Prince William Sound, Alaska. Our group consisted of physiologists, biologists, veterinarians, toxicologists, nutritionists, and wildlife rehabilitators from the United States and Canada. Despite our diverse backgrounds, we were dedicated to a single goal: save as many oiled sea otters as possible.

Each of us realized the magnitude of our task. We also recognized that the knowledge and experience gained from this, the largest marine mammal rehabilitation project ever attempted, should be preserved in a handbook. In preparing the book, our primary objective was to provide future rehabilitators with the knowledge gained from our experience. Rather than publish the results piecemeal in scientific and veterinary journals, we wanted to assemble a single volume of information for rehabilitators, veterinarians, wildlife managers, and representatives from the oil industry and state and federal agencies responsible for oil spill contingency planning. We recognized that preparedness was the key to successful oil spill response programs in the future. A handbook summarizing our findings and recommendations would be our contribution toward that goal.

Preparation of the book gained support from the Minerals Management Service (U.S. Department of Interior) and Exxon Company, USA. A review board with representatives from academia, government agencies, the oil industry, and environmental interest groups was established to ensure the quality and accuracy of the data and recommendations. In addition, each chapter was peer reviewed by recognized experts.

At the time of the *Exxon Valdez* oil spill (EVOS), there was little published information about the effects of oil on sea otters. A handful of scientific studies (Costa and Kooyman, 1982; Williams et al., 1988; Siniff et al., 1982; Davis et al., 1988) warned of the serious consequences if expensive delays in rehabilitation during the initial days of a large spill. By providing space requirements and detailed floor plans, Chapter 12 enables rehabilitators to design and build an effective rehabilitation facility. Chapter 13, by Davis, Styers, and Otten-Stanger, describes the management structure and personnel requirements for operating a rehabilitation facility for 50–200 sea otters. During a large spill, people with little experience often wish to volunteer at the rehabilitation facility. Training and coordinating volunteers is facilitated by prespill training programs and a well-designed management plan. Chen-Valet and Camlin address occupational health and safety issues for rehabilitation center personnel in Chapter 14.

The effects of oil contamination and rehabilitation on pinnipeds and polar bears (Chapter 15) are described by Gales and St. Aubin in the third section of the book. Results from previous oil spills and experimental studies are used to illustrate types of health and husbandry problems a rehabilitator should anticipate. These authors also address the additive nature of stresses associated with oiling and the rehabilitation process. A conservative approach is suggested for rehabilitation programs involving pinnipeds.

Each chapter contains Quick References in the margins that allow the reader to obtain important recommendations and treatment protocols at a glance. The basis for these recommendations are described in greater detail in the corresponding text. A glossary has been provided to define abbreviations and medical terminology. To save space in the text, the 1989 T/V *Exxon Valdez* oil spill is abbreviated as EVOS. To prevent confusion, citations for Terrie M. Williams are listed as T. M. Williams; citations for Thomas D. Williams are presented as T. D. Williams. To comply with standard use, we have used metric units of measure for reporting scientific results and for drug dosages. However, we have used English units of measure when describing the design and construction of rehabilitation facilities.

Rather than a history of the EVOS and other spills involving marine mammals, this monograph was written as a practical guide for responding to future oil spills. Our intention is to neither promote nor prevent future rehabilitation efforts involving oiled wildlife. Certainly, the ethical considerations and controversies surrounding such efforts (Estes, 1991) are beyond the scope of this book. However, with the increasing frequency of oil spills affecting marine mammals, many national and international groups are facing difficult decisions involving wildlife rehabilitation.

In the United States, the U.S. Fish and Wildlife Service (USFWS) has the authority and responsibility under the Marine Mammal Protection Act and the Endangered Species Act (for the Southern sea otter) to respond to oil spills involving sea otters. In Alaska, the Regional Response Team's (RRT) Wildlife Protection Guidelines for Alaska specify the response strategy for sea otters and other marine mammals that are threatened during an oil spill. These guidelines were formulated with the assistance of the USFWS, National Marine Fisheries Service, and the Alaska Department of Fish and Game. The response strategy is divided into three parts. The primary response emphasizes controlling the release and spread of spilled oil at the source, or reducing contamination of animals and their habitat. The primary response strategy also includes the removal of oiled debris, particularly contaminated food sources. The secondary response involves keeping potentially affected animals away from the spill area, through the use of deterrents and by preemptive capture and temporary holding in oil-free areas. The tertiary response involves the capture and rehabilitation of oiled animals. Tertiary response is considered a last resort strategy. Any secondary or tertiary response activities must have the approval of appropriate federal and state wildlife trustee agency representatives who have management authority for those wildlife resources. Final approval must be given by the Federal On-Scene Coordinator. In California, the RRT, USFWS and Office of Spill Prevention and Response (OSPR) are formulating Wildlife Protection Guidelines for Southern sea otters.

This book is intended to help rehabilitators, the oil industry, and government trustees conduct a successful rehabilitation effort for sea otters, should such a program be deemed appropriate. If an effort is undertaken, the recommendations here will provide the rehabilitation team with the basic information for effective rescue and care of oiled mammals. Eventually, the value of this publication will be measured by the increased number of animals that survive future marine spills.

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# Care and Handling of Oiled Sea Otters

# Chapter 1

# The Effects of Oil on Sea Otters: Histopathology, Toxicology, and Clinical History

Terrie M. Williams
Dennis J. O'Connor
Svend W. Nielsen

The thermoregulatory and metabolic consequences of external contamination have been well documented for oiled sea otters (Costa and Kooyman, 1982; Williams et al., 1988; Davis et al., 1988). In contrast, there has been little evidence of toxicological effects following crude oil exposure in these marine mammals. Geraci and Williams (1990) reviewed the effects of accidental spills and experimental oiling on sea otters and found little indication of organ damage. In several spills involving wild river otters *(Lutra lutra, Lutra canadensis)*, it was not possible to correlate the cause of death with oil contamination (see Chapter 15).

With so little information about the systemic effects of oil on sea otters, it has been difficult to determine the cause of the high mortality in otters contaminated during the *Exxon Valdez* oil spill (EVOS). Moreover, the effects of external oiling are not easily distinguishable from the possible toxicological effects of hydrocarbon exposure. The purpose of this chapter is to evaluate the primary factors that may contribute to mortality in oiled sea otters. Specifically, the physical and chemical effects of oil exposure and the stress of capture and rehabilitation are discussed. The conclusions of this chapter are based primarily on data from wild sea otters captured for rehabilitation or found dead on beaches following the EVOS. Clinical evaluations, necropsy results, histopathologic assessments, and tissue residue analyses were used to evaluate the cause of death. Because tissues taken during necropsy are critical for these investigations, we first review the procedures for tissue sample collection and storage, histopathology, and toxicology.

## NECROPSY PROTOCOLS AND TISSUE COLLECTION

Postmortem and toxicological evaluations of animals that die in rehabilitation centers provide valuable information for determining the primary and contributing causes of death. The results can be used by veterinarians to improve the care of animals during an oil spill. Furthermore, the evaluation of data following the event provides the basis for improving the overall care of animals in future spills. To differentiate between the various causes of mortality, it is important to include data from the clinical history, necropsy results, histopathology, and toxicology of each animal. Therefore, organized record keeping and tissue labeling are critical.

The following procedures were used for the postmortem examination of sea otters during the EVOS and are recommended for future spills. We list the tests in order of importance. Ranking is based on the probability that the procedure will contribute to understanding the cause of mortality in oiled sea otters.

## General

*Clinical blood parameters, gross necropsy and histopathology of the major organs should be evaluated for sea otters that die in rehabilitation centers.*

Hematology, serum chemistry, necropsy results, and histopathology of select tissues should be evaluated for each sea otter that dies in a rehabilitation center. Because of the expense, toxicological analyses will probably be limited to a representative sample of animals. The degree of external oiling, reproductive status, age, and sex of the animal should be recorded, as these factors may affect the response to contamination. External oil exposure should be categorized as heavy (> 60% body coverage), moderate (30–60% body coverage), light (< 30% coverage or light sheen on fur) or unoiled (no visual or olfactory detection of oil). (See Chapter 4 for further discussion.)

*External oil exposure may be categorized as heavy (>60% body coverage), moderate (30–60% body coverage), light (<30% coverage or light sheen on fur) or unoiled (no visual or olfactory detection of oil).*

Complete necropsies should be performed on all sea otters that die during rehabilitation and on fresh carcasses found in the wild. Necropsies should be performed within two hours of the animal's death. If this is not possible, the carcass should be refrigerated until postmortem examination. Standard veterinary procedures for the necropsy of small mammals are recommended. Geraci and Lounsbury (1993) provide an excellent guide for conducting necropsies and collecting tissues from marine mammals. A pathology team consisting of a veterinary pathologist assisted by a veterinary clinician or a laboratory technician should be established. All necropsy records should be summarized and entered on standardized forms (Appendix 2, Forms A, B; Haebler et al., 1990) and into a computer data base. Photographic or videotaped documentation should be included and annotated.

*Necropsies should be performed within two hours of the animal's death. If this is not possible, the carcass should be refrigerated until postmortem examination.*

The carcasses are first examined externally. After opening the abdomen and thorax, the presence or absence of abnormalities should be noted for each organ or tissue. All major organs should be weighed during necropsy. However, special care must be taken to avoid contaminating tissues that will be collected for residue analysis for petroleum hydrocarbons. To avoid cross-contamination, stainless steel or titanium dissecting instruments should be cleaned with dichloromethane. Samples of liver, lung, kidney, brain, muscle, and fat (bile, urine, stomach contents, intestinal contents, and placenta when possible) should be collected for complete petroleum hydrocarbon analyses. Samples from each tissue should also be obtained for histopathological examination. Additional samples will be required for microbiology, parasitology, and virology.

Tissue samples may be requested by the state and federal trustees (i.e. USFWS or the Department of Fish and Game). These agencies will provide the investigators with the permits required for collecting, handling, and analyzing tissues from marine mammals.

### Histopathology

Pathologic changes in tissues provide important information for determining the cause of death. Tissue samples for histopathology should be collected from major organ systems at the time of necropsy, and should include normal appearing tissues as well as abnormal tissues (Table 1.1). Samples for histology should be less than 1 cm thick and preserved in 10% neutral buffered formalin. Several parallel slits in larger samples will facilitate penetration by the preservative. After fixation, the tissues should be embedded in paraffin and sectioned at four microns (Junqueira et al., 1986). Mounted sections are usually stained with hematoxylin and eosin, and then examined microscopically.

*Tissue samples for histopathology should include normal appearing tissues as well as abnormal tissues. Samples should be less than 1 cm thick and preserved in 10% neutral buffered formalin.*

Table 1.1
Sea otter tissues that should be collected during necropsy for histopathological evaluation.

| | |
|---|---|
| Thyroid/Parathyroid | Pancreas |
| Cross section trachea and esophagus | Adrenals |
| Thymus | Kidney |
| Heart | Urinary Bladder |
| Lung | Skeletal Muscle |
| Liver | Bone Marrow |
| Diaphragm | Eyes |
| Gallbladder | Brain w/Optic nerves |
| Stomach | Pituitary |
| Small Intestine | Skin |
| Large Intestine | Lymph Nodes |
| Spleen | Gonads |

### Residue Analyses for Petroleum Hydrocarbons

Tissue samples (> 50 gm) for residue analysis should be trimmed with a clean titanium knife and frozen individually in acid washed (I-Chem™) jars with teflon lid inserts. Fluids such as urine and bile should be placed in amber-colored jars to prevent photodegradation. The samples should be kept frozen at -70 °C. Warmer temperatures during storage could cause a breakdown of organic contaminants (Geraci and Lounsbury, 1993).

*Tissue samples (>50 gm) for residue analysis should be trimmed with a clean titanium knife and frozen individually in acid washed (I-Chem™) jars with teflon lid inserts. The samples should be kept frozen at -70 °C.*

The evaluation of petroleum hydrocarbons in tissues is expensive and provides limited information. Unlike many of the chlorinated hydrocarbon pesticides, petroleum derived hydrocarbons are metabolized and do not bioaccumulate to significant levels in many tissues. Without detailed information about the duration of oil exposure and the previous health of the animal, it is difficult to interpret the results of tissue residue analyses. Oiled sea otters may succumb to the lethal effects of hypothermia or stress before there is a significant toxicological effect of petroleum hydrocarbons in the tissues (Mulcahy and Ballachey, 1993, 1994). In view of this, we recommend limiting residue analyses to selected tissues from animals with the most complete medical records and history of oil exposure.

*We recommend limiting toxicological analysis to selected tissues from animals with the most complete medical records and history of oil exposure.*

Following the EVOS, we examined four tissues (liver, lung, brain, and kidney) from twenty-two sea otters that died in rehabilitation centers. The study groups included heavily (n = 7), moderately (n = 5), and lightly (n = 6) oiled animals, as well as unoiled sea otters (n = 4). Because the high lipid content of the brain samples interfered with the standard analyses used for petroleum hydrocarbons, the results were considered unreliable. Future attempts to assess petroleum hydrocarbon levels in samples of brain and blubber must consider such difficulties associated with analyzing lipid-rich tissues.

Standard protocols for measuring petroleum hydrocarbons in tissues have been established and are used by many analytical laboratories. Approximately five grams of tissue are homogenized, extracted, and concentrated. The extracts are analyzed for individual petroleum hydrocarbons by gas chromatography and mass spectrometry.

*Toxicological analyses must be performed by a laboratory experienced in analyzing mammalian tissues for petroleum hydrocarbons.*

Selection of a commercial laboratory for petroleum hydrocarbon analyses should be based in part on experience with protocols specific for biological tissue samples. Many laboratories that analyze nonbiological samples may not be suitable for tissue analysis. Problems routinely encountered during tissue residue analyses include interference from lipids and other naturally occurring hydrocarbons, and focal areas of contamination within tissues. The analysis should include a quantitative discrimination of individual polycyclic aromatic hydrocarbons (PAHs) and saturated petroleum hydrocarbons (PHCs). The laboratories that were used for tissue residue analysis during the EVOS are listed in Table 1.2.

Table 1.2
Clinical laboratories for the analysis of petroleum hydrocarbons in biological tissues.

| **Biological Tissues** | **Blood** |
|---|---|
| Battelle Ocean Sciences<br>397 Washington Street<br>Duxbury, Mass 02332<br>(617) 934-0571 | National Medical Services, Inc.<br>2300 Stratford Ave., PO Box 433A<br>Willow Grove, PA. 19090<br>(215) 657-4900 |
| **Biological Tissues and Blood** | |
| Geochemical and Environmental Group<br>Texas A&M University<br>833 Graham Road<br>College Station, TX 77845<br>(409) 690-0095 | |

## MORTALITY OF OILED SEA OTTERS

Even with extensive postmortem examination and tissue analysis, it is difficult to differentiate between the pathological effects of hypothermia, stress, and petroleum hydrocarbon toxicity for oiled otters. Mortality can result from a combination of these factors. Consideration must be given to the direct effects of oil contamination as well as to indirect effects associated with the rehabilitation process (i.e. stress of capture, transport, and captivity). The mortality rate for adult sea otters will also depend on degree of oiling and duration of contami-

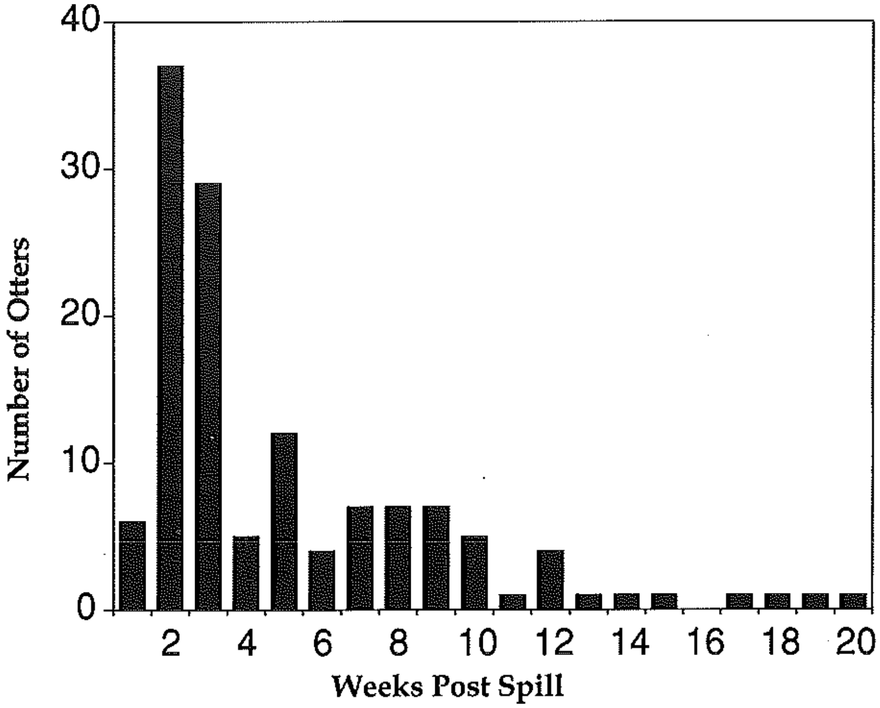


Figure 1.1
The number of sea otters that died at rehabilitation centers in relation to time following the EVOS. The height of each bar represents the total number of otters per seven-day period.

nation following a spill. During the first three weeks following the EVOS, over 60% of the sea otters arriving at rehabilitation centers died; mortality declined sharply after this initial period (Figure 1.1). Overall, 34% of the sea otters brought to rehabilitation centers died. Heavily oiled otters showed the highest mortality (75%). By comparison, 41% of the moderately oiled and 25% of the lightly oiled otters died (Figure 1.2). A 25% mortality rate also occurred for sea otters that were unoiled or for which the degree of oiling could not be determined. The similarity in mortality rates for lightly oiled, unoiled, and unclassified animals suggests that factors other than oil exposure contributed to mortality in minimally contaminated animals.

The physical and chemical effects of oil contamination on sea otters will vary according to the chemical composition of oil and the duration of the spill. In an acute event such as the EVOS, the otters' response to contamination changed as the fresh crude oil weathered during the first two to three weeks (Chapter 4). In a chronic situation, such as long-term exposure in harbors, marine terminals, areas of natural oil seeps, or an oil platform blowout, the effects of contamination may be cumulative.

*The physical and chemical effects of oil contamination on sea otters will vary according to the chemical composition of oil and the duration of the spill.*

## Physical Effects of Oil

In many ways, the physical effects of oil contamination appear to be more damaging to sea otters than the toxicological effects. Many petroleum products, including fresh crude oil, may contain chemicals that are irritating to the interdigital webbing of the hind flippers and

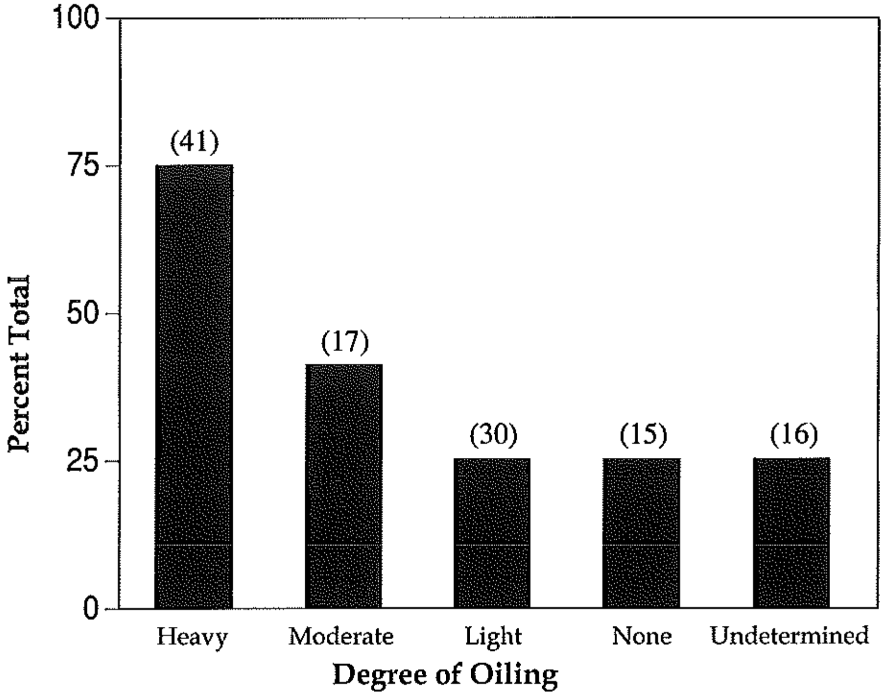


Figure 1.2
Mortality in relation to the degree of external oiling. Otters in the undetermined category were either unoiled or so lightly oiled that the staff could not make a determination. Note that these figures do not include mortality rates for sea otter pups, which in captivity show high mortality that is independent of oil exposure (T. Goff, Sea World, personal communication). Values in parentheses represent the number of sea otters examined in each category.

sensitive membranes around the eyes, nose, mouth, and urogenital tissues of the otters. Also, excessive grooming of irritated areas has been found to cause permanent damage including corneal damage, scarring, and alopecia (baldness) (Williams, 1990).

*Hypothermia is a major cause of 1) vascular congestion, 2) gastrointestinal lesions, 3) centrilobular liver necrosis, and 4) mortality in heavily and moderately oiled sea otters. Note that an oiled animal may survive the hypothermic event, but suffer impaired organ function as a result of ischemic hypoxia.*

Heavily and moderately oiled sea otters often become hypothermic following contamination of their pelage. (See Chapter 5.) Crude oil rapidly penetrates the fur and destroys its water repellency. This leads to saturation of the pelt and compensatory increases in metabolic rate (Costa and Kooyman, 1982, Williams et al., 1988; Davis et al., 1988). The loss of thermal insulation initiates a suite of physiological, biochemical, and behavioral changes associated with hypothermia. Aside from the mortality directly associated with a decrease in core body temperature, a hypothermic event may also lead to long-term organ damage and dysfunction due to vascular system collapse and congestion. In humans and experimental animals, sudden decreases in core body temperature (acute hypothermia) result in decreased cardiac function, circulatory collapse, and severe congestion in many organs (Paton, 1991). Vascular congestion can lead to hypoxia and ischemic necrosis in organs such as the liver, kidneys, brain, and lungs. The extent of tissue damage will depend on the duration and severity of the hypoxia. An oiled animal may survive the hypothermic event, but suffer impaired organ function as a result of hypoxic damage.

Vascular congestion within specific organs was evident in many of the sea otters that died during the EVOS. The incidence of congestion was site specific and depended on the degree of external oiling. Thus, tissues from heavily and moderately oiled otters (Figure 1.3) were more likely to exhibit congestion than those from lightly or unoiled otters (Figure 1.4). The most prevalent sites of congestion were the lungs and liver. More than 77% of the heavily and moderately oiled sea otters showed hepatic congestion, and nearly 85% showed congestion in the lungs. By comparison, 55% of the lightly oiled and unoiled otters showed hepatic congestion, and 45-64% exhibited lung congestion.

*The lungs and liver show the highest incidence of tissue damage in oiled sea otters.*

In humans, pancreatitis and gastric hemorrhages are considered characteristic lesions of hypothermia (Paton, 1991). If the patient survives, elevated serum amylase and superficial ulceration (erosion) of the stomach mucosa may develop. Pancreatic injury was not observed in oiled sea otters. However, gastrointestinal hemorrhaging and ulceration occurred frequently and correlated with the degree of external oiling. Similar to findings for hypothermic humans, the gastrointestinal lesions of oiled sea otters were located primarily in the stomach, and occasionally in the duodenum (Williams and Davis, 1990). Gastric erosions may also occur in stressed sea otters, whether the animal is hypothermic or not. In view of this, and because of the focal nature of the lesions, it is likely that the combined effects of hypothermia, stress, shock, captivity, and oil contamination rather than oil ingestion per se were the primary factors leading to gastrointestinal injury in these animals (Lipscomb et al., 1993, 1994).

*The combined effects of hypothermia, stress, shock, captivity and oil contamination rather than oil ingestion per se were the primary factors leading to gastrointestinal injury.*

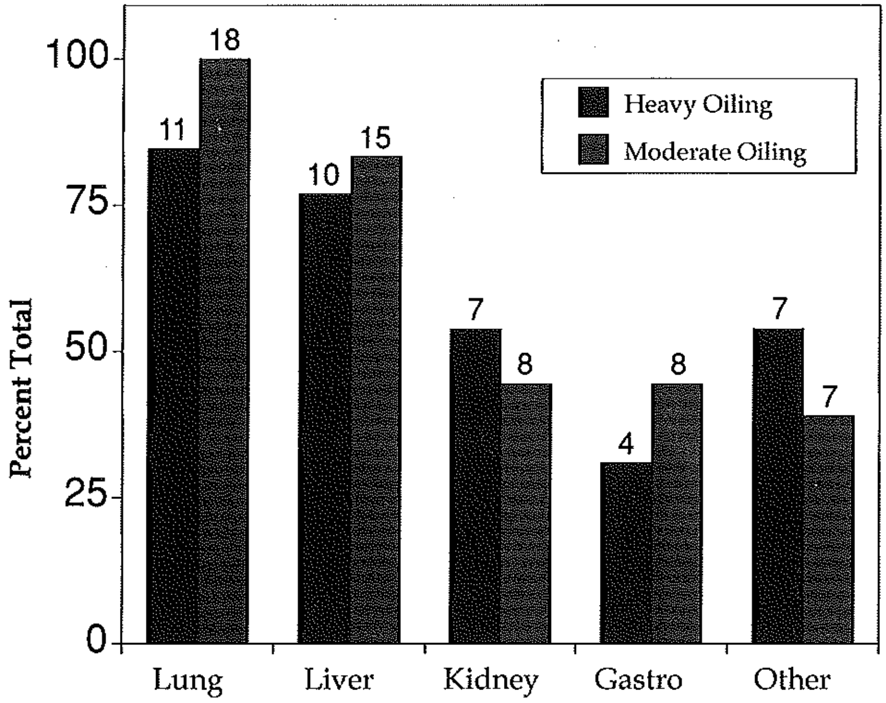


Figure 1.3
The incidence of organ congestion in heavily oiled (black bars) and moderately oiled (shaded bars) sea otters. Congestion was determined by histopathologic examination of tissues obtained during necropsy after the EVOS. Numbers above the bars represent the number of sea otters examined in each category.

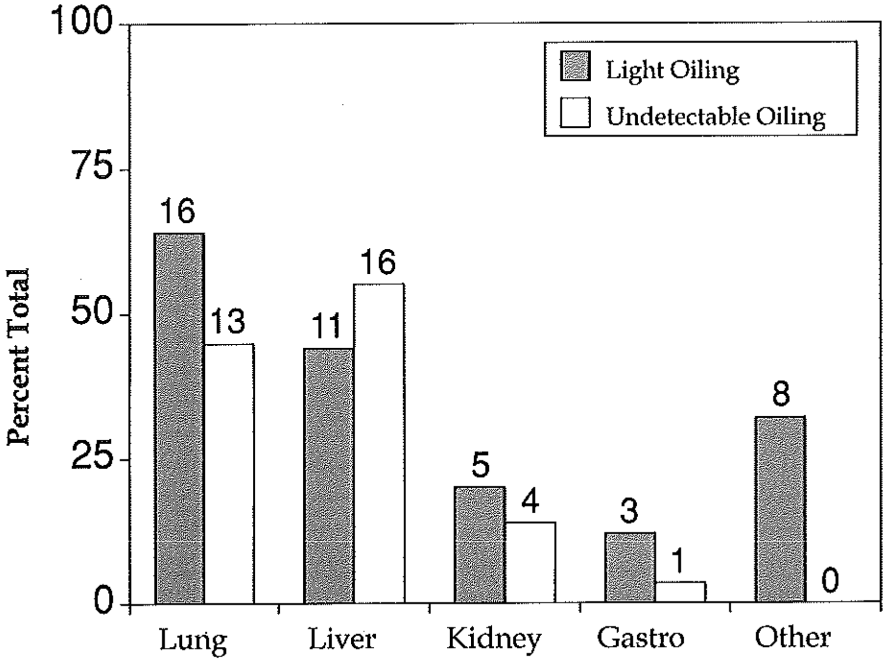


Figure 1.4
The incidence of organ congestion in lightly oiled otters (shaded bars) and animals in which the degree of oiling could not be determined (open bars). Legend is the same as for Figure 1.3.

### Chemical Effects of Oil

The toxicological effects of oil contamination are not fully understood for marine mammals. This is due in part to uncertainties about the duration, degree, and route (inhalation, transdermal, oral) of exposure during an oil spill. When phocid seals were placed in oil-covered water or fed small quantities of crude oil, gastrointestinal irritation, renal tubular necrosis, and liver degeneration were observed (Smith and Geraci, 1975; Engelhardt et al., 1977; Geraci and St. Aubin, 1990). In polar bears, immunosuppression and anemia were also observed (Øritsland et al., 1981).

Following the EVOS, the concentration of petroleum hydrocarbons (PAH, PHC) in tissues was highly variable in oiled sea otters (Figures 1.5, 1.6, 1.7). In general, tissue PHC and PAH levels correlated poorly with the degree of external oiling (2 way ANOVA, PHC: $F_{3,53} = 0.36$, $p = 0.78$; PAH: $F_{3,52} = 0.35$, $p = 0.79$). Animals from all oiling categories had elevated petroleum hydrocarbons in their tissues. In contrast, PHC and PAH levels varied significantly with tissue type (2 way ANOVA, PHC: $F_{2,53} = 4.69$, $p<0.01$; PAH: $F_{2,52} = 24.02$, $p<0.001$; tissue x oil: $F_{6,56} = 0.94$, $p = 0.48$). With the exception of one unoiled animal, only heavily oiled sea otters showed elevated petroleum hydrocarbon levels in two or more organs.

## PATHOLOGY AND TOXICOLOGY OF INDIVIDUAL ORGAN SYSTEMS

The absorption, distribution, and excretion of petroleum hydrocarbons involve many organ systems (Figure 1.8). Primary routes of exposure to petroleum hydrocarbons are ingestion, inhalation, and

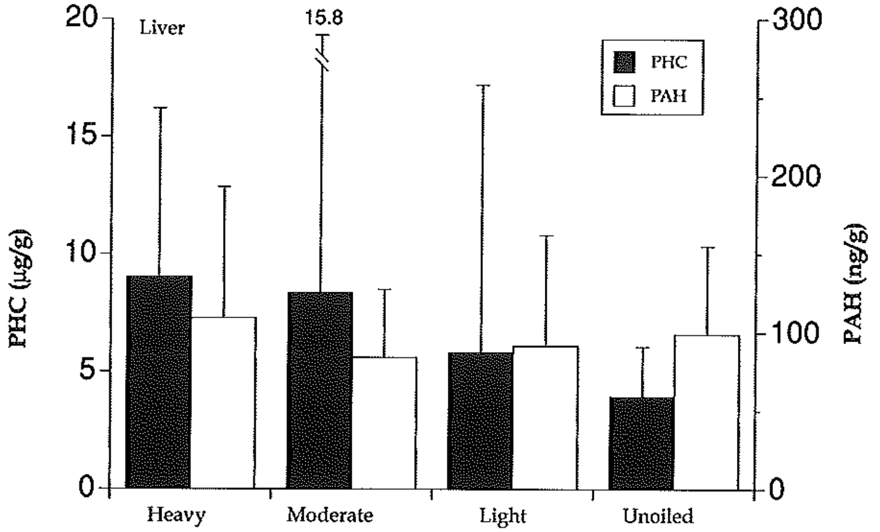


Figure 1.5
PHC (shaded bars) and PAH (open bars) concentrations for liver tissue of oiled (Heavy, Moderate, Light) and unoiled sea otters. Mean values ± 1 SD are shown for four categories of external oiling. The number above the moderate bar represents 1 SD for this category and illustrates the variability in PHC values. The number of samples in each category is presented in the text.

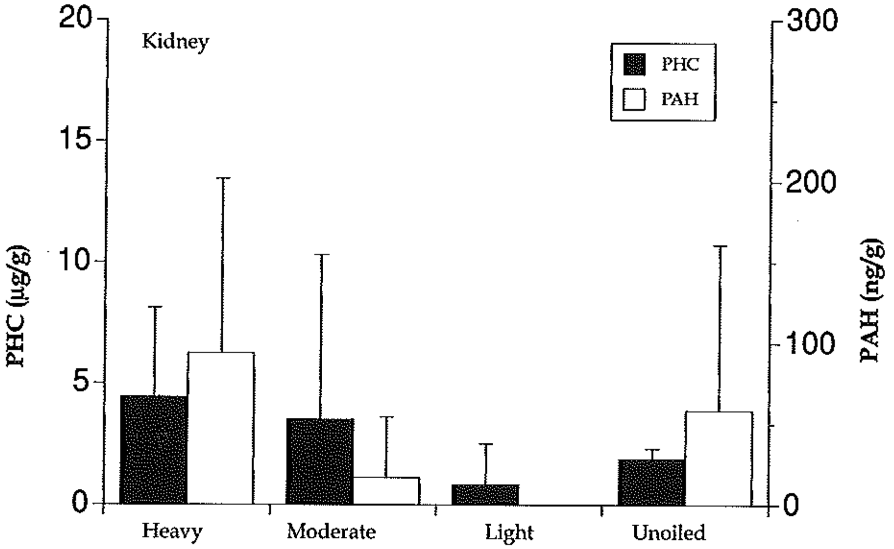


Figure 1.6
PHC (shaded bars) and PAH (open bars) concentrations for kidney tissue of oiled (Heavy, Moderate, Light) and unoiled sea otters. Mean values ± 1 SD are shown for four categories of external oiling. The number of samples in each category is presented in the text.

dermal absorption involving the gastrointestinal system, lungs, and skin, respectively. The liver and kidneys have a high capacity for binding toxicants and are considered major sites of toxicant concentration and accumulation (Klaassen and Rozman, 1991). Enzymes for the biotransformation of toxicants are located in these organs as well as the lungs and intestine (Sipes and Gandolfi, 1991). Petroleum hydrocarbons may be excreted through feces, urine, expired air, and, to a

***Primary routes of exposure to petroleum hydrocarbons are ingestion, inhalation, and dermal absorption involving the gastrointestinal system, lungs, and skin, respectively.***

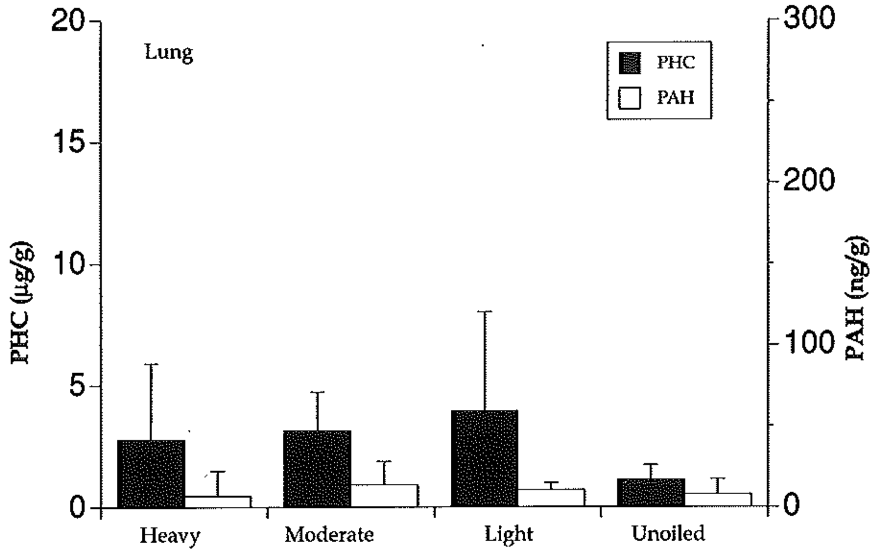


Figure 1.7
PHC (shaded bars) and PAH (open bars) concentrations for lung tissue of oiled (Heavy, Moderate, Light) and unoiled sea otters. Mean values ± 1 SD are shown for four categories of external oiling. The number of samples in each category is presented in the text.

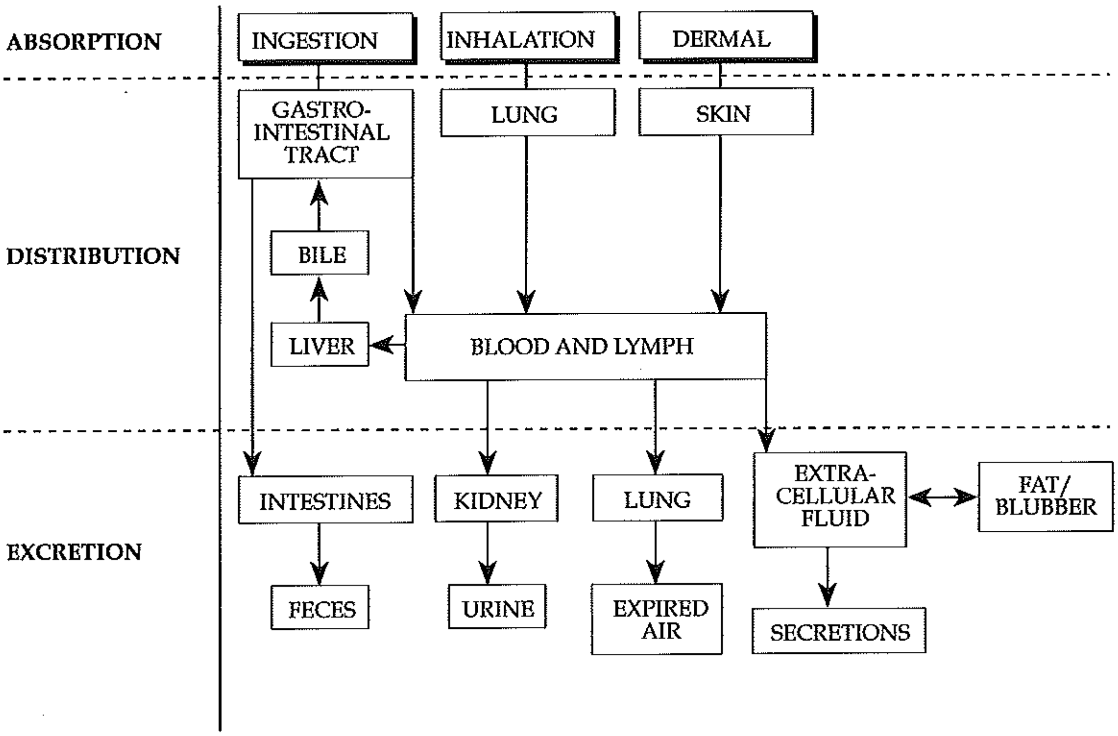


Figure 1.8
Major pathways for the absorption, distribution, and excretion of petroleum hydrocarbons in sea otters. (Redrawn from Klaassen and Rozman, 1991.)

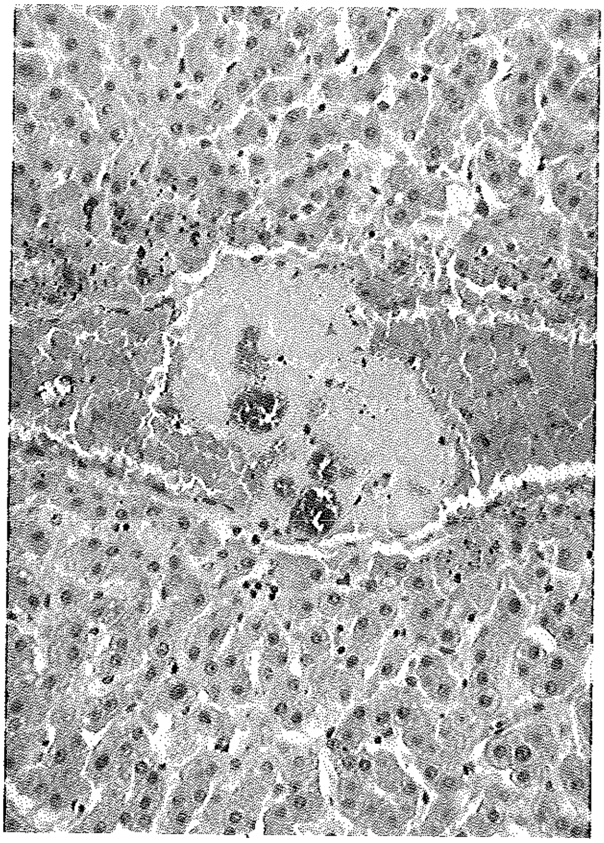

Figure 1.9
Photomicrograph of the liver of an oiled sea otter showing area of thrombosis. (S. W. Nielsen.)

Figure 1.10
Lung tissue of a heavily oiled sea otter. Light grey areas show primary areas of air accumulation and bullae formation. (T. M. Williams.)

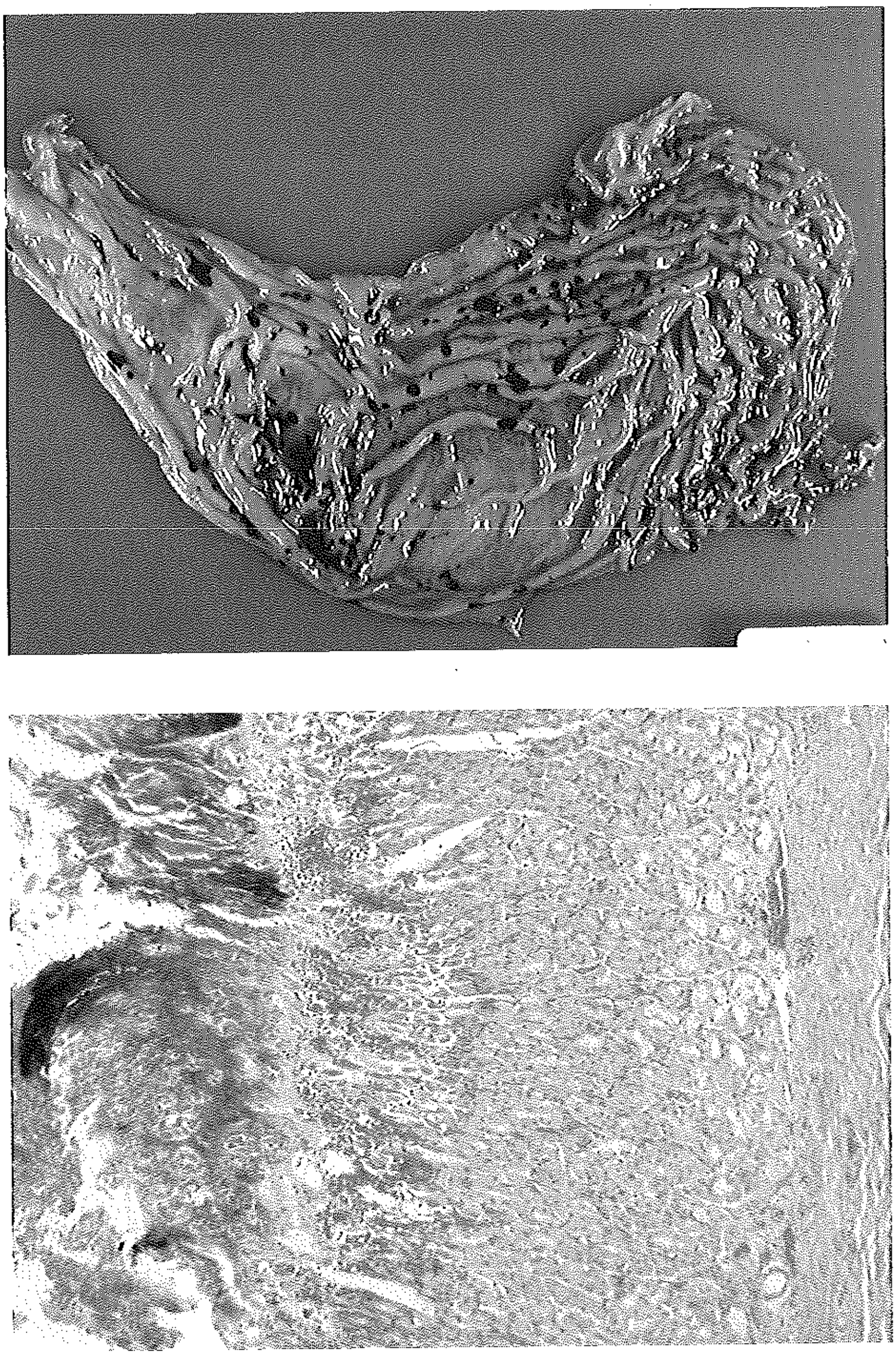

Figure 1.11
Photograph (top) and photomicrograph (bottom) of the stomach of an oiled sea otter showing areas of focal hemorrhage. (S. W. Nielsen.)

lesser extent, other secretions. Alternatively, petroleum hydrocarbons may be stored, and hence accumulate, in lipid rich tissues such as fat or blubber.

Macroscopic and microscopic evidence suggests that in contaminated sea otters, the liver, kidneys, gastrointestinal tract, and lungs are particularly vulnerable to oil damage. Of the organ systems examined, the lungs had the highest incidence of lesions. Nearly 70% of the otters that arrived at rehabilitation centers during the first two weeks of the spill showed evidence of pulmonary damage (Williams et al., 1990). Other gross lesions included: 1) liver abnormalities in 55% of adult and juvenile otters, 2) gastrointestinal lesions in more than 50% of the otters, 3) cardiac lesions in 42% of the animals, and 4) kidney and spleen abnormalities in approximately 20% of the sea otters. Similar patterns are described for oiled sea otters by Lipscomb et al. (1994) and Mulcahy and Ballachey (1994). Specific lesions observed in sea otters during the EVOS are described below for each major organ system.

***Macroscopic and microscopic evidence suggests that in contaminated sea otters, the liver, kidneys, gastrointestinal tract, and lungs are particularly vulnerable to oil damage.***

## Liver

*(a) Necropsy Observations.* Because of its central role in metabolism, detoxification, and excretion of foreign chemicals, the liver is more likely to be exposed to petroleum hydrocarbons and their metabolites than other organs. Livers from oiled otters had a high incidence of lesions. Gross abnormalities included abnormal color and texture, enlarged lobes with prominent rounded edges, and atrophy. Livers were often friable and pale yellowish or reddish-brown in color with pale green mottling. There was no correlation between the degree of external oiling and the incidence of these lesions. Almost 75% of the unoiled animals examined had liver congestion, hemorrhage, necrosis, friable texture, or discoloration.

*(b) Histopathology.* Lesions of the liver were more impressive histologically than grossly. The histologic changes included congestion, hemorrhage, and a variety of degenerative changes such as hydropic degeneration, fat accumulation, and centrilobular necrosis. Necrosis was occasionally severe, with confluence of adjacent lobules to form larger areas. Generally, the centrilobular areas showed the most damage (Figure 1.9, see plate facing page 12). Periportal to diffuse hepatic lipidosis has been reported previously in oiled sea otters from the EVOS (Lipscomb et al., 1993, 1994).

*(c) Toxicology.* Of the tissues examined, the liver generally contained the highest concentrations of PHC and PAH (PHC range = 0–36.4 ug/g; PAH range = 0–234.9 ng/g; n = 21 oiled and unoiled animals). The levels of petroleum hydrocarbons in the liver did not correlate with the severity of external oiling or histologic lesions (Figure 1.5). For example, the liver from one heavily oiled animal with high concentrations of PAH and PHC appeared normal, with the exception of minor discoloration. Histopathological findings for this animal were also minor and consisted of periportal fatty change. In contrast, marked-to-severe congestion and necrosis of the liver was often accompanied by undetectable-to-moderate accumulation of petroleum hydrocarbons in other oiled and unoiled animals.

*Blood chemistry panels indicated hepatic dysfunction for many of the oiled otters that died during the EVOS.*

*(d) Clinical Pathology.* Blood chemistry panels indicated hepatic dysfunction for many of the oiled otters that died (Appendix 3, Figure E). Plasma concentrations of alanine aminotransferase (ALT) and aspartate aminotransferase (AST) were elevated in these animals. Also, oiled otters were often hypoglycemic, although this may have been caused by many factors. (See Chapter 5.)

*The pattern of liver necrosis and congestion in oiled otters is compatible with both cardiovascular and toxicological damage. Shock and hypothermia are the probable causes of the cardiovascular insufficiency which led to these patterns of liver damage.*

*(e) Summary.* The pattern of liver necrosis and congestion in oiled otters is compatible with both cardiovascular and toxicological damage. Cellular damage was often located in centrilobular rather than periportal areas (Figure 1.9). We found thrombi formation leading to vessel occlusion and local congestion in the livers. As a result, the centrilobular hepatocytes, which are located furthest from oxygen-carrying blood vessels, were the most likely to become hypoxic and necrotic. This pattern was evident in the majority of sea otters regardless of the degree of external oiling or level of petroleum hydrocarbon accumulation. Shock and hypothermia are the probable causes of the cardiovascular insufficiency which led to these patterns of liver damage. These findings suggest that liver damage and dysfunction in oiled sea otters results primarily from vascular congestion with systemic petroleum hydrocarbon toxicity playing a secondary role.

### Kidneys

*(a) Necropsy Observations.* Macroscopic examination of the kidneys revealed few abnormalities in oiled and unoiled sea otters. Cortical streaking, pale coloration, and mild congestion were occasionally noted, but these did not correlate with the degree of external oiling or histologic findings.

*Kidneys from heavily and moderately oiled otters typically show moderate to severe levels of congestion.*

*(b) Histopathology.* In contrast to the macroscopic findings, the microscopic renal lesions correlated well with the degree of external oiling. Kidneys from heavily and moderately oiled otters typically showed moderate to severe levels of congestion (Figure 1.3). Severe to moderate tubular lipidosis was commonly observed in these animals (present study, Lipscomb et al., 1993, 1994). Fewer remarkable lesions were observed in otters with less severe degrees of oiling.

*Petroleum hydrocarbons appear to be cleared rapidly in the sea otter kidney.*

*(c) Toxicology.* PHC and PAH levels in the kidneys (Figure 1.6) were generally lower than reported for the liver (Figure 1.5). As observed for the liver, there was no apparent correlation between the concentration of petroleum hydrocarbons in the kidneys and the degree of external oiling. Likewise, the level of petroleum hydrocarbons did not always correspond to histopathological findings. Petroleum hydrocarbons appear to be cleared rapidly from the sea otter kidney. Samples of kidney from oiled otters that survived at least eleven days showed no evidence of petroleum hydrocarbon accumulation regardless of the degree of external oiling.

*Acute renal insufficiency was evident for oiled sea otters and was manifested as elevations in serum concentrations of blood urea nitrogen (BUN), phosphorus, and creatinine.*

*(d) Clinical Pathology.* Acute renal insufficiency was evident for oiled sea otters and was manifested as elevations in serum concentrations of blood urea nitrogen (BUN), phosphorus (Appendix 3, Figures C, D) and creatinine. A complete description of this condition is provided in Chapter 5.

*(e) Summary.* Despite the importance of the kidneys as a site for biotransformation and excretion of toxicants, there was little accumulation of PAH or PHC in this tissue. Renal lipidosis was found only in otters that had hepatic lipidosis (Lipscomb et al., 1993). Many factors including infection, petroleum hydrocarbon exposure, mobilization of fat reserves during periods of reduced caloric intake, and hypoxia induced by vascular collapse may have contributed to this condition.

**Lungs**

*(a) Necropsy Observations.* One of the most common lesions observed in otters captured during the first three weeks of the EVOS was bullous interstitial emphysema, which was characterized by the accumulation of interlobular air bubbles. In its most severe form, air was trapped along the trachea, mediastinum, and subcutaneous areas of the thorax. Emphysematous areas were patchy in distribution with no apparent preferential site. They ranged in size from a few millimeters to bullae formation of several centimeters in diameter (Figure 1.10, see plate facing page 12). The lungs typically appeared normal in color. Cases of subcutaneous emphysema were generally present only in animals with the most severe bullae formation in the lungs. The incidence and severity of emphysema generally correlated with the level of external oiling. Heavily oiled adult animals showed gross or histologic evidence of moderate to severe emphysema, usually involving interstitial tissues. In contrast, only mild forms of emphysema were noted for thirteen lightly oiled adult otters. Emphysema was also observed in one otter that was apparently unoiled but had sustained traumatic injuries during a fall. Depending on the severity, subcutaneous emphysema was detectable by palpation and correlated with macroscopic lesions observed during necropsy.

***One of the most common lesions observed in otters during the first three weeks of the EVOS was bullous interstitial emphysema, which was characterized by the accumulation of interlobular air bubbles.***

*(b) Histopathology.* Although histopathological examination of lung tissues demonstrated focal areas of congestion, edema, and alveolar distension, there was little indication of alveolar emphysema characteristic of chronic emphysema in humans. The histologic alveolar changes were fairly mild and subtle despite the incidence of severe interstitial and subpleural emphysema with bullae formation. There was no morphological evidence of damage to the airways or alveolar walls. Subpleural, interstitial, or subcutaneous bullous emphysema, rather than pulmonary or alveolar emphysema per se, are more appropriate terms for the conditions observed in oiled sea otters.

Pneumonia induced by the aspiration of oil, a characteristic respiratory lesion of petrochemical poisonings (Hatch, 1988), was not apparent in oiled sea otters during the EVOS.

*(c) Toxicology.* The levels of PAH and PHC were comparatively low in the lungs (Figure 1.7). Mean PHC levels in oiled otters were 31–68% of the mean levels for liver. PAH concentrations were less than 20% of the values for liver samples. Unlike the kidneys and liver, there was a good correlation between petroleum hydrocarbon accumulation and tissue injury (i.e. emphysema). The average hydrocarbon concentrations in

***There was a good correlation between petroleum hydrocarbon accumulation and emphysema.***

the lungs of otters showing severe congestion or emphysema were $3.68 \pm 3.19$ ug/g for PHC and $21.14 \pm 14.01$ ng/g for PAH (n = 5). In animals with mild or moderate congestion or emphysema, PHC levels were $1.42 \pm 1.00$ ug/g and PAH concentrations were $4.13 \pm 5.45$ ng/g (n = 9). Likewise, circulating levels of paraffinic hydrocarbons correlated well with the severity of emphysema (Chapter 4).

*(d) Clinical Pathology.* None of the standard tests for hematology or blood chemistry provided insight into lung damage. In the future, the partial pressures and concentrations of blood gases may prove useful in assessing the severity of respiratory injury in oiled sea otters.

*(e) Summary.* The pathogenesis of emphysema in oiled otters is not understood. Contributing factors may include weakening of the respiratory mucosa by petroleum hydrocarbon vapors and mechanical damage associated with respiratory exertion during capture, diving, coughing or agonal death. Damage associated with exposure to oil is supported in part by the positive correlation between blood and tissue petroleum hydrocarbon concentrations and the severity of emphysema. Because the incidence of emphysema was greatest during the first three weeks of the spill, exposure to the volatile aromatic hydrocarbons in fresh crude oil may have contributed to the development of the lesions. Twenty-five of forty-one cases of emphysema occurred within fourteen days of the EVOS. Only two instances of severe bullous interstitial emphysema were recorded after the first three weeks of the spill. Histopathological findings provide little insight into the pathogenesis of the lung lesions. Bullous emphysema has not been previously reported as a major injury in oiled marine mammals, except for a brief reference to the condition in one of four experimentally oiled polar bears (Øritsland et al., 1981).

*Interstitial and subcutaneous emphysema were common findings in heavily oiled otters during the first two weeks of the EVOS. It is likely that the primary cause of emphysema was exposure to volatile components of fresh crude oil.*

Ventilatory exertion has been implicated in the development of spontaneous subcutaneous cervical and mediastinal emphysema in humans (Parker et al., 1990). Similarly, altered respiratory mechanics may also contribute to respiratory injury in oiled sea otters. Irritation of bronchial airways by volatile petroleum hydrocarbons may cause bronchial constriction. Extraordinary ventilatory exertion during such spasms could result in pulmonary distension and induce bullae formation. Predive inspiration, exercise-induced hyperventilation, extraordinary inspiratory effort due to blocked nares, and agonal breathing at death also may cause airway distension. Most likely, the cause of emphysema in oiled sea otters is a combination of chemical factors such as exposure to fresh or irritating crude oil, and mechanical factors including forced ventilatory expiration coupled with bronchial constriction.

### Gastrointestinal System

*(a) Necropsy Observations.* Gastrointestinal lesions were observed in sea otters throughout the rehabilitation process. The most frequently observed gastrointestinal lesions were areas of focal hemorrhage, ulceration, inflammation, and parasitism (Figure 1.11, see plates facing page 13). Gastrointestinal mucosal ulcerations, primarily involving

the pylorus and the proximal small intestine, were a common finding. The consistency of the gastric and intestinal contents varied from a watery to a viscous dark brownish-green to reddish-black fluid. Several animals had dark black, tarry intestinal contents, although tests were not conducted to confirm the presence of oil or blood in the feces. In a related study, Mulcahy and Ballachy (1993, 1994) reported petroleum hydrocarbon levels indicative of oil ingestion in three of ten otters examined from the EVOS. Intestinal parasitism, primarily due to acanthocephalans, was a common finding. Cestode and nematode infestation frequently occurred. Ulceration of the oropharyngeal mucosa, especially the gingival mucosa, was observed, and intestinal intussusception occurred in several animals.

***Gastrointestinal lesions were found in both unoiled and oiled otters. Stress, hypothermia, shock, parasite infestation, and oil contamination are all considered contributing factors of gastrointestinal lesions in oiled sea otters.***

*(b) Histopathology.* Because of the focal nature of these lesions, histopathologic observations did not always correspond to macroscopic reports. Thus, a higher incidence of ulceration was reported during postmortem examinations than from the histopathology. Gastrointestinal lesions were found in both unoiled and oiled otters. The gastric mucosa showed acute focal changes; these ranged from necrosis and ulceration to acute hemorrhaging with free hemolyzed blood in the intestinal lumen.

*(c) Toxicology.* No toxicological tests were conducted on tissues from the gastrointestinal tract. In the future, petroleum hydrocarbon analyses of stomach contents and bile could prove valuable by providing information about the ingestion and excretion of crude oil.

*(d) Clinical Pathology.* Anemia may have been a secondary effect of gastrointestinal hemorrhaging. This is discussed in Chapter 5.

*(e) Summary.* It is difficult to relate the degree of external oil contamination to gastrointestinal abnormalities in oiled sea otters. There was a positive correlation between the degree of oiling and the incidence of stomach ulcers, but not for intestinal ulcers (Williams and Davis, 1990). Gastrointestinal hemorrhaging and superficial ulceration of the stomach mucosa may have been caused by shock, stress, or hypothermia (Paton, 1991). Stress induced gastrointestinal hemorrhaging is common in many mustelid species, including otters. In tests with laboratory animals, many components of crude oils are not considered ulcerogenic (Beck et al., 1984). Therefore, it is unlikely that petroleum hydrocarbon exposure alone would cause the degree of gastric erosion observed. Because lesions were evident throughout the rehabilitation process, stress, hypothermia, shock, parasite infestation, and oil contamination are all considered contributing factors of gastrointestinal lesions in oiled sea otters.

### Other Organs and Tissues

Adrenal hyperplasia, immunosuppression, and anemia have been identified as potential problems for oiled wildlife placed in rehabilitation centers (Leighton, 1991; White, 1991). The cause of these problems has been attributed to the combined effects of stress and oil toxicosis.

Adrenal hyperplasia, one manifestation of chronic stress, could not be confirmed macroscopically or microscopically in sea otters.

Although enlarged adrenals were frequently noted at necropsy, that they were not weighed prevented a quantitative comparison with normal glands. However, hyperplasia of adrenal tissue was noted histologically for six of the animals examined. The incidence of hyperplasia did not correlate with the duration of captivity or degree of oiling. Histological examination showed that 60% of the otters (n = 32 animals) had no remarkable adrenal lesions.

Immunosuppression may be caused by a variety of petrochemicals. The polycyclic aromatic hydrocarbons (PAHs) in particular may produce a marked and prolonged depression in both primary and secondary serum antibody responses (Dean and Murray, 1991). Indirect evidence of immunosuppression has been observed for oiled polar bears (Øritsland et al., 1981) and oiled sea otters (Williams and Davis, 1990). Indications included abnormal inflammatory responses to sterile injections and to routine cuts and abrasions. Lesions were observed in the lymph nodes of approximately 45% of the heavily and moderately oiled sea otters. Moderate atrophy, histiocytosis, congestion, and hemorrhaging of lymph tissues were reported. The mechanisms by which immunosuppression develop are numerous and difficult to assess based on hematology; white blood cell counts were highly variable for all sea otters (Appendix 3, Figure H). Detailed examination of the cellular components of the bone marrow were not conducted. Although immunosuppression may occur in oiled sea otters, further research is needed to determine the incidence and the severity of the problem. Many factors, including exposure to petroleum hydrocarbons, hypothermia, stress, nutritional changes, and captivity, may challenge the immune systems of oiled animals during rehabilitation.

Anemia occurred frequently. Heavily and moderately oiled otters showed a higher incidence of anemia than lightly oiled animals. In general, the packed cell volume (PCV) of newly captured otters was within the normal range of 40–66% for healthy adult sea otters (Thomas Williams, in press); the values did not correlate with the degree of oiling or survivorship. Decreases in PCV occurred after several weeks in captivity, with a return to normal levels within four months (Williams, 1990). (See Chapter 5 for a discussion on anemia in oiled sea otters.)

## CLINICAL, TOXICOLOGICAL, AND HISTOPATHOLOGIC PROFILES OF OILED SEA OTTERS

There is no typical clinical, macroscopic, and microscopic profile for oiled sea otters. Not all otters will exhibit the same spectrum of lesions in all organs susceptible to damage. However, there are several noteworthy trends concerning the incidence of tissue injury for sea otters exposed to oil (Figure 1.12). The incidence of each condition will vary with: 1) type of oil and degree of weathering, 2) duration and extent of exposure, 3) age, sex, and reproductive status of the animal, 4) nutritional state and health of the animal before contamination, and 5) environmental conditions and stressors (temperature, captivity, etc.).

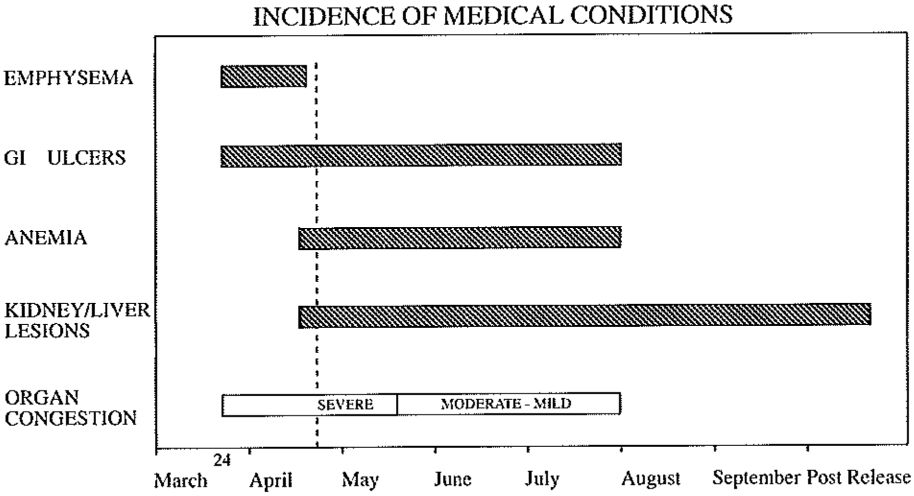


Figure 1.12
The incidence of injury to organ systems of sea otters during the EVOS rehabilitation program. The vertical dashed line denotes the division between Early and Late Phases of the spill (see Chapter 4).

*Anemia may develop after the first week of captivity and persist for several months. Gastrointestinal hemorrhaging can occur throughout the rehabilitation process.*

Interstitial and subcutaneous emphysema will usually occur during the first weeks of a spill, when the greatest concentrations of volatile hydrocarbons are present. If a heavily or moderately oiled otter becomes hypothermic, vascular congestion can occur at this time in many organs. The effects of vascular congestion on organ function may persist long after the hypothermic event. The resulting liver and kidney dysfunction, as indicated by serum chemistry, may persist for several months. Although not usually evident upon capture, anemia may develop after the first week of captivity and persist for several months. Gastrointestinal hemorrhaging can occur throughout the rehabilitation process as a result of many factors, including oil ingestion, hypothermia, parasite infestation, and stress.

Chronic and acute exposure to oil will also result in different pathologic profiles. Table 1.3 compares the macroscopic, microscopic, and toxicologic evaluations for an aged otter that resided in an active boat harbor in Alaska to those of an adult otter that was heavily oiled during the EVOS. Both animals showed lung congestion and distension, gastrointestinal ulceration, and hepatic lesions. There was evidence of petroleum hydrocarbon accumulation in the livers of both otters. In addition to these findings, the acutely oiled otter showed an accumulation of petroleum hydrocarbons in the lungs and the kidney. Emphysema and lesions within the lymph nodes were also apparent in this animal. While the harbor animal succumbed to the cumulative effects of organ failure associated with old age, the heavily oiled otter died within two weeks of the EVOS.

## SUMMARY

Our experience during the EVOS demonstrated the value of performing macroscopic and microscopic examinations on oiled sea otters that died. It also indicated the importance of baseline measurements for wildlife before an oil spill. Detailed postmortem examinations, histopathologic assessment, and blood chemistries provide the most valuable information for veterinarians caring for sea otters in the rehabilitation centers. Conversely, toxicological tests are comparatively expensive, time consuming, and often yield ambiguous results.

*Major factors contributing to the mortality of oiled sea otters appear to be: 1) hypothermia, 2) shock and secondary organ dysfunction, 3) interstitial emphysema, 4) gastrointestinal ulceration, and 5) stress.*

Major factors contributing to the mortality of oiled sea otters appear to be: 1) hypothermia, 2) shock and secondary organ dysfunction, 3) interstitial emphysema, 4) gastrointestinal ulceration, and 5) stress during captivity. Direct oil toxicosis may be a contributing factor, but is difficult to verify in otters contaminated during an oil spill.

Table 1.3
Comparison of histopathologic, toxicological, and clinical blood chemistry values for two adult sea otters. One animal was a resident of an active boat harbor area and presumably chronically exposed to oil through boat spillage. The cause of death for this animal was age related. The remaining otter had been oiled within the first two weeks of the EVOS.

| | Chronic<br>Aged male sea otter, resident of harbor area | Acute<br>Adult female, captured 13 days after the EVOS |
|---|---|---|
| **External Appearance** | Unoiled | Heavily Oiled |
| **Macroscopic Evaluation** | GI Ulceration<br>Oral Ulceration<br>Friable Liver | GI Ulceration<br>Emphysema<br>Ascites<br>Peritonitis |
| **Histopathology** | | |
| Liver | Necrosis, moderate | Congestion, diffuse severe |
| Kidney | Not remarkable | Autolysis, cortical diffuse |
| Lung | Congestion, moderate alveolar distension | Congestion, severe alveolar distension |
| Spleen | Not remarkable | Atrophy, lymphoid |
| **Toxicology** | | |
| Liver | Mod PHC, high PAH | Mod PHC, high PAH |
| Kidney | Insignificant | Low PHC, high PAH |
| Lung | Insignificant | High PHC, mod PAH |
| **Clinical Pathology** | Elevated AST, ALT | Elevated BUN, Phos, LDH, CPK decreased WBC, Glucose |

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# Chapter 2

# Sea Otter Capture

Carl T. Benz
Ronald L. Britton

The ability to successfully rehabilitate sea otters during an oil spill depends on a rapid and efficient response. Such a response requires trained personnel familiar with the techniques and regulations for safely capturing and transporting sea otters. Because sea otters often inhabit remote areas of coastline (Kenyon, 1969; Calkins and Schneider, 1985), knowledge about the geographic distribution and life history of the otter is invaluable to the response effort. The purpose of this chapter is to outline the basic knowledge and techniques required for capturing oiled sea otters. We emphasize the importance of prespill planning and training to ensure the success of the program and the safety of animals and personnel.

***The ability to successfully rehabilitate sea otters during an oil spill depends on a rapid and efficient response.***

## PRESPILL PLANNING

In waters under United States jurisdiction, the U.S. Fish and Wildlife Service (USFWS) under the Marine Mammal Protection Act has lead management responsibility for sea otters. In Alaska and Washington State, the capture of oiled sea otters must be conducted or supervised by personnel from the USFWS. In California, the Department of Fish and Game (CDFG) will supervise the capture of oiled sea otters with the USFWS retaining oversight responsibility; both will participate in sea otter captures.

To quickly and efficiently implement a capture operation, prespill planning should include: 1) an agency-approved response plan, 2) formation of a task force to review and update response plan strategies, 3) trained capture personnel, 4) identification of capture boats and crews, and 5) assembly of equipment and supplies. Members of the task force should include resource trustees, marine mammal experts, and veterinarians from wildlife rehabilitation programs. The members should be able to meet on a regular basis.

***Prespill planning should include:***
***1) an agency-approved response plan,***
***2) formation of a task force to review and update response plan strategies,***
***3) trained capture personnel,***
***4) identification of capture boats and crews, and***
***5) assembly of equipment and supplies.***

A capture strategy should be prepared for the various geographical regions inhabited by sea otters. It should incorporate information on the seasonal abundance and distribution of sea otters, coastal geography, port and harbor facilities, and seasonal weather and sea conditions. To be most effective, a rescue program should be able to respond within six hours. This is only possible if personnel are trained and the capture boats are under contract before a spill occurs. The success of a rescue and rehabilitation program will depend on capturing oiled sea otters quickly and transporting them to a rehabilitation center, and/or moving uncontaminated sea otters to a protected, clean environment.

## TRAINING

Wildlife biologists from the USFWS and the CDFG have extensive experience in capturing and transporting sea otters. Their expertise has been developed through years of sea otter management and research. These experts have obtained an understanding of the sea otter's biology and ecology, the skills required to effectively conduct capture operations, and the ability to use this knowledge for successful captures. As a result, these resource agency biologists will conduct or supervise sea otter capture and will be responsible for training additional capture personnel.

New personnel should be trained prior to an oil spill through programs approved by the USFWS or the CDFG. A training video, "How to Capture Sea Otters," has been prepared by the USFWS. Additional training videos concerning sea otter natural history, husbandry, and rehabilitation methods (Table 2.1) are currently available. To maintain proficiency in the capture and handling of sea otters, trained personnel should participate in regular oil spill exercises conducted by USFWS, the oil industry, and wildlife task groups.

Table 2.1
Introductory sea otter oil spill response training programs.

1) "How to Capture Sea Otters," U.S. Fish and Wildlife Service (15-minute video)
2) "Sea Otters in Alaska," U.S. Fish and Wildlife Service (22-minute video)
3) "Completing Field Forms," U.S. Fish and Wildlife Service (24-minute video)
4) "Rehabilitating Sea Otters," International Wildlife Research (26-minute video) including: "Washing and Drying," "Feeding and Nutrition," and "Husbandry and Veterinary Care"
5) "Handling and Husbandry," McCloskey Group and Wildlife Rapid Response Team, Inc., (2-day seminar)
6) "Emergency Care and Husbandry of Oiled Sea Otters," International Wildlife Research, (2-day seminar)

Three levels of expertise may be involved in a capture operation: volunteer or amateur participants, technical professionals, and scientific professionals. The volunteer or amateur has no previous training in either oil spill response or in marine mammal biology, capture, handling, or rehabilitation. They should not be directly involved in capture operations. However, they may be assigned to assist specific technical or scientific personnel who will be responsible for their training and supervision.

Technical professionals include vessel operators, marine electricians, marine mechanics, etc. They are responsible for vessel and aircraft operation, safety and navigation, as well as mechanical repairs, net repairs, and maintaining supplies. Animal handling by this group must be supervised by the scientific professionals.

Scientific professionals are those trained in such disciplines as biology, ecology, veterinary medicine, etc. They are responsible for capturing the sea otters and coordinating all record keeping. If proficiency training is necessary, capture personnel should participate in annual government and industry-sponsored oil spill drills involving sea otter capture scenarios.

*Capture personnel should participate in annual government and industry-sponsored oil spill drills involving sea otter capture scenarios.*

To prevent injury to personnel and animals, newly trained members of the capture team should be supervised by experienced wildlife biologists. Only experienced professionals should operate boats and aircraft. All personnel should be trained in first aid, water safety, and cardiopulmonary resuscitation through U.S. Coast Guard, and American Red Cross courses. This basic knowledge is mandatory for all sea otter capture personnel.

## SAFETY

Safety should always be the number one priority when capturing sea otters. Capture operations should never be conducted when weather or sea conditions present a danger to personnel. To prevent injuries, the following regulations should be implemented: U.S. Department of Transportation, U.S. Coast Guard, and state regulations for vessel operation; the U.S. Department of Transportation, Federal Aviation Administration, and state regulations for aircraft safety; the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA), and state regulations for handling hazardous substances.

*Safety should always be the number one priority when capturing sea otters.*

## OSHA REGULATIONS FOR HANDLING HAZARDOUS SUBSTANCES

Wildlife capture teams may operate in the immediate area of an oil spill and be exposed to fresh crude oil and other chemicals. (See Chapter 14 for a discussion of the properties and potential hazards of petroleum hydrocarbons.) The OSHA requirements for capture teams in the spill area are covered by the "Hazardous Waste Operations and Emergency Response—HAZWOPER" standard (29 CFR 1910.120). In addition to many other requirements, the standard regulates worker safety and health during postemergency response operations. The standard defines postemergency response as "that portion of an emergency response performed after the immediate threat of a release has been stabilized or eliminated, and clean-up of the site has begun."

*The OSHA requirements for capture teams in the spill area are covered by the "Hazardous Waste Operations and Emergency Response - HAZWOPER" standard (29 CFR 1910.120).*

The hazards to employees during an oil spill vary widely in terms of the potential severity of injury or illness. For job duties and responsibilities with a low magnitude of risk, such as oiled wildlife capture, fewer than twenty-four hours of training may be appropriate. Although the number of hours of training may vary, a minimum of four hours is adequate in most situations. The U.S. Coast Guard and other concerned parties have requested flexibility in the amount of employee training required for petroleum spill clean-ups and other types of response operations following emergency situations. The OSHA Regional

Response Team representative will determine the acceptable training requirements for various job duties on a case-by-case basis.

OSHA has not specifically defined the HAZWOPER training requirements for wildlife capture teams, but general requirements should include: 1) initial or refresher training on the hazardous nature of petroleum hydrocarbons and methods to reduce exposure, 2) use of protective clothing and equipment to prevent absorption through the skin, and inhalation or ingestion of petroleum hydrocarbons, 3) medical examinations before and after the capture operation, and 4) regular decontamination of capture equipment and clothing.

## CAPTURE EQUIPMENT AND TECHNIQUES

### Logistical Support

A capture program for sea otters requires specialized equipment (Appendix 6) and personnel knowledgeable about its operation. Key equipment for the logistical support of the program include state-of-the-art communications equipment, capture boats and support vessels, and aircraft.

*(a) Communications.* Communication between capture teams, transport vessels, and rehabilitation facilities is essential for a successful sea otter rescue program. During a capture operation, the communications equipment aboard each support vessel should provide reliable contact with emergency assistance, the rehabilitation center, other capture vessels, and aircraft. Marine band radios, single side band radios, handheld radios, and cellular telephones vary in effectiveness, depending on the location of the capture operation, coastal geography, and shore-based relay equipment. Prior knowledge of the available frequencies for radio communications within the home range of sea otters will facilitate communications during a spill.

***Good communication is very important for a successful sea otter capture program.***

*(b) Capture Boats and Support Vessels.* The location of the oil spill will determine the most efficient way to capture sea otters. If the spill is close to a harbor or area with easy boat access, daily excursions with small capture boats are best. For spills not quickly accessible by small boats, the safest and most efficient way to capture sea otters is to deploy larger support vessels (i.e. 40- to 60-foot fishing boats) with one or two skiffs each. The total number of support boats will depend on the size of the spill, the number of otters at risk, and the coastal geography. During the *Exxon Valdez* oil spill (EVOS), twenty large support vessels were used. Support boats should have 240 square feet of deck space to store 20 large kennel cages, communications equipment compatible with those employed on other capture vessels, and U.S. Coast Guard approved marine safety equipment. If the support boats remain at sea for several days or longer, they should have sleeping accommodations, adequate fresh water and provisions for the crew and capture team, seawater pumping capacity to clean equipment and rinse down otters, and adequate fuel storage. Each boat also should have a freezer that can store 200 lbs of seafood for feeding the otters.

Sea otters should be captured using 18- to 20-foot skiffs. Unless hazardous sea conditions warrant the use of inflatable boats, rigid-hull skiffs are recommended because they provide a more stable working platform. When operating without a support vessel, the capture boat should be equipped with a marine radio and directional finder, plus a hand-held radio. In some areas cellular phone service may be available. When the capture boat operates in association with a larger support vessel, a hand-held radio is adequate for communication. For safety, each skiff should have reserve outboard motors and standard marine safety equipment. Outboard motors are less reliable in oil-contaminated water because oily debris may be sucked into the water intake/cooling system. Consequently, we recommend frequent maintenance checks for motors to ensure uninterrupted capture operations.

*(c) Aircraft.* If the capture operation is more than fifty miles from the rehabilitation center, helicopters and airplanes should be used to transport the sea otters. This will reduce the transport time for the otter, thereby improving the animal's chances of survival. The support vessels should deliver kennel cages containing the otters to a suitable shore location where they can be transferred to a helicopter or airplane. Ideally, the aircraft should be large enough to carry five or more large kennel cages and an animal care specialist, although smaller aircraft have proven useful.

*If the capture operation is more than fifty miles from the rehabilitation center, helicopters and airplanes should be used to transport the sea otters.*

**Capturing Sea Otters**

The techniques and equipment for capturing sea otters have been refined in recent relocation programs. Three methods are currently used for the nonlethal capture of adult sea otters: dip net, tangle net, and Wilson trap. The method of choice will depend on location and activity level of the otter, level of expertise of the capture personnel, and ocean conditions. Alternative methods such as deterrents and herding to move sea otters away from a spill site have been attempted with only limited success (Davis et al., 1988a).

*Three methods are currently used for the nonlethal capture of adult sea otters: dip net, tangle net, and Wilson trap.*

*(a) Dip Net Technique.* This method requires the least amount of specialized equipment. It is best suited for capturing sea otters that have hauled out and young sea otters that are resting or grooming in open water. Adult sea otters that are feeding or otherwise attentive are least likely to be captured with a dip net. The method requires: 1) a maneuverable skiff (generally 18 to 20 feet in length), 2) a stout, long-handled salmon dip net (Figure 2.1), 3) an experienced boat driver, and 4) a strong person to handle the dip net. The person holding the dip net should crouch in the bow of the boat and hold onto a bow rope. The skiff operator approaches the sea otter at high speed and then throttles-back as the person scoops the animal into the net. The netted otter should be held against the side of the boat at the surface of the water until the skiff operator or an assistant can help bring the animal into the boat.

*Young, inexperienced, and resting sea otters may be captured with a long-handled salmon dip net.*

During the capture operation, the sea otter may become aware of the boat's approach and attempt to escape. Otters that assume a defensive, pawing posture or swim away by backing up on the water's surface are the easiest to capture. A sea otter that evades the first capture attempt will become wary and more difficult to capture on subsequent attempts. Although oiled sea otters may be lethargic and

*A sea otter that evades the first capture attempt will become wary and more difficult to capture. No more than five attempts should be made to capture an otter.*

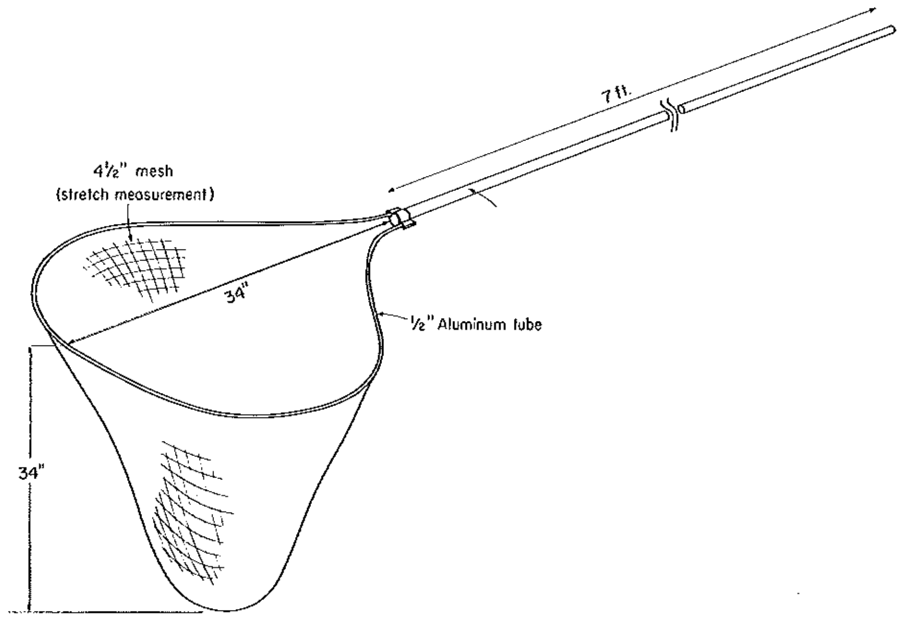



Figure 2.1
Long-handled salmon dip net for capturing sea otters.

easier to capture than healthy otters, no more than five attempts should be made to capture an otter. If the animal is vigorous enough to evade easy capture with a dip net, then it probably does not require rehabilitation. The physiological stress experienced by the otter during a prolonged chase may be as harmful as the oil. Thus, the duration of pursuit must be weighed against the following factors: 1) the likelihood of the animal surviving present oiling, 2) the potential for future oiling, 3) the possibility for future capture, and 4) the threat to the animal of continued pursuit. If capture is warranted but the dip net technique is unsuccessful, then other capture methods should be considered.

*(b) Tangle Net Technique.* This passive method of capture should be used around kelp beds or in areas of predictable or regular sea otter movements. Tangle nets may also be used in open water, especially in areas of predictable otter movements, but are generally less successful. A large number may be captured with time and patience, but this method is the least selective capture technique and requires constant monitoring. The tangle net should be a modified gill net made of 10 inch (23 cm) stretch-mesh netting, a foam core float line, a one inch (3 cm) nylon rope serving as a lead line, and a single anchor line (Figure 2.2). Foam core (corkless) float line is preferred over surface cork (peanut) floats, which are often chewed by entangled otters. The nets should be 18 feet (6 m) deep and 100 to 300 feet (33–100 m) long. Equipment and facilities for repairing and cleaning nets will also be needed.

Tangle nets should be deployed with the anchor up-current so that the net will be stretched out by the flow of water. Nets are set in open channels or swaths cut within the kelp canopy, around the kelp boundary, or within otters' routine travel areas. In areas with kelp, the down-current end of the net can be wrapped loosely around kelp fronds and marked with a small buoy to aid in net recovery. Certain oceanographic circumstances may require the placement of anchors on both ends of the net. The nets should have enough scope on the anchor line and a large enough buoy to prevent the anchored end of the net from being pulled underwater by currents or tides.

If a small skiff with a hydraulic net spool is available, the net can be deployed more quickly and efficiently using the Klinkhart/Hecht Method (Figure 2.3). For this method, a site is selected along the shore or near a small island. The anchor line of the tangle net is secured to the shore, and the boat is backed away allowing the net to reel off the spool. The free end of the net is marked with a buoy and dropped into the water. Otters tend to follow the shoreline and become entangled in the net. If the natural movement of otters does not result in a capture, the boat can be used to slowly herd the otters in the direction of the net. This technique is also effective in offshore kelp beds. To recover the net, the process is reversed. The free end of the net is secured to the spool and slowly wound in, drawing the boat toward the shore until the anchor is recovered.

*Tangle nets are effective for capturing large numbers of sea otters. Equipment for this procedure includes:*
*1) modified gill nets with a foam core float line,*
*2) net spool fitted on a modified vessel,*
*3) net repair equipment, and*
*4) net cleaning facilities.*

Sea otters can drown once they become entangled. Therefore, tangle nets should be continuously monitored and the entangled otters quickly removed. To avoid disturbing sea otters in the capture area, the nets should be monitored from shore using a spotting scope or binoculars. If it is not possible to quickly retrieve the otters, then tangle nets should not be used. Tangle nets should not be deployed under the following conditions: 1) in shallow water where nets can snag on rocks, 2) in stormy weather and rough sea conditions, 3) in nursery areas with many females and pups, or 4) overnight in areas with abundant sea otters or pinnipeds.

An exception to the last precaution occurs in areas of low sea otter abundance, where the nets may be left overnight. The nets should be

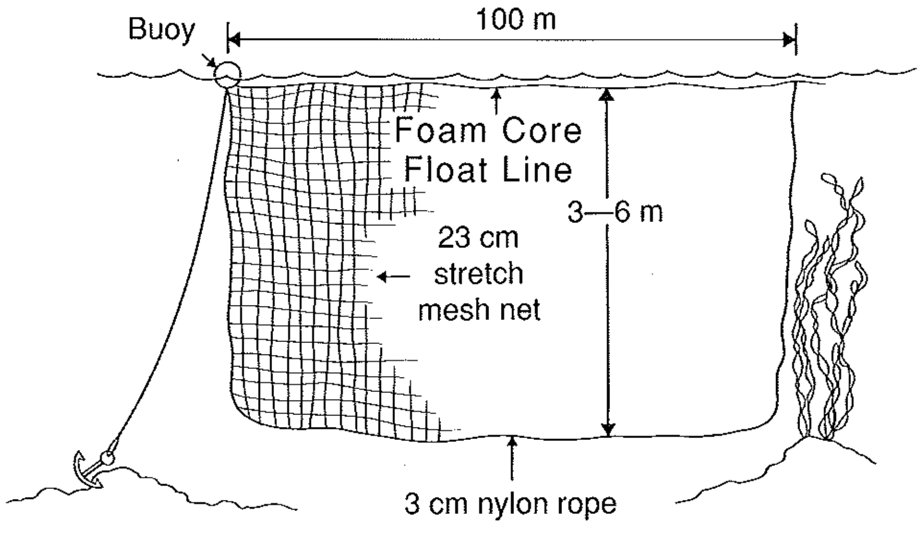



Figure 2.2
Modified gill net for entangling sea otters.

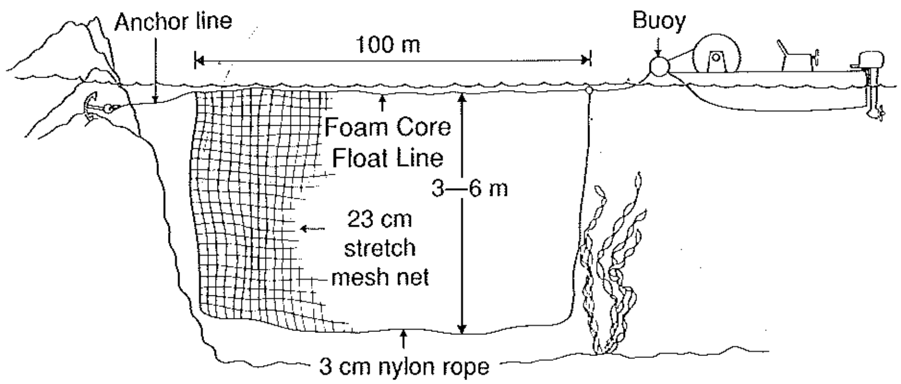



Figure 2.3
Modified gill net deployed from a spool fitted on the bow of a skiff.

checked every two hours during the day, beginning at first light and ending at dusk. Because most sea otters are entangled at night, a capture boat should be used to check the nets early in the morning. If two otters are entangled within reach of each other, they should be removed first to prevent fighting and injuries.

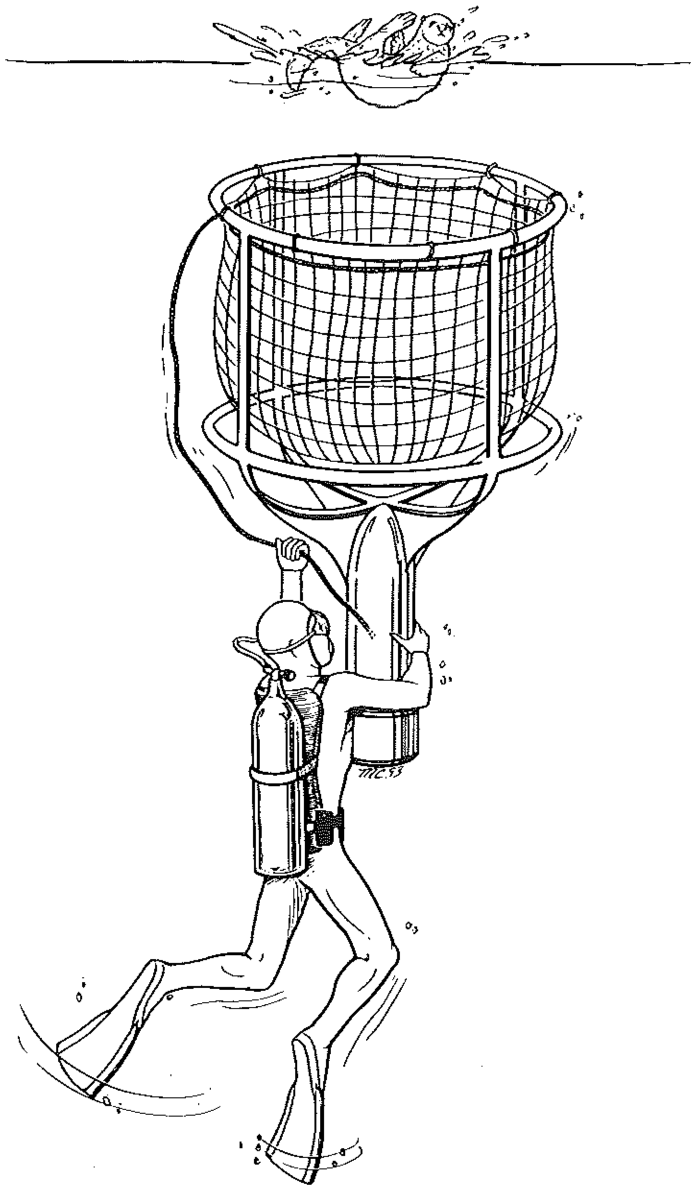
*To remove an otter from a net, a stuff bag should be pressed firmly against the otter's chest while it is untangled or the net is cut away.*

To remove an otter, the net should be pulled across the bow of the boat. The entangled animal is lifted onto the boat and placed into a restraint box (see Figure 3.1). A stuff bag (a nylon duffle bag filled with foam rubber or rags) should be pressed firmly against the otter's chest while it is untangled or the net is cut away. Care should be taken to avoid injuring the otter or personnel when cutting the net. This physically demanding process requires two experienced people.

Tangle nets need constant maintenance by someone skilled in net repair. Holes should be repaired after each capture. During an oil spill, nets often become contaminated and should be washed with Dawn™ (Proctor & Gamble) dish washing detergent. Nets can be cleaned on board the support vessel by scrubbing portions of the net in a container partially filled with the detergent solution.

*(c) Wilson Trap Technique.* The diver-operated Wilson trap was developed in California for capturing sea otters (Figure 2.4). It is very effective for capturing a specific animal. The trap consists of a cone-shaped, aluminum frame (30–35 inches long, 32 inches in diameter) which supports a net bag. The metal frame is attached to a diver-operated underwater propulsion vehicle (UPV). The trap and UPV may be operated by divers using open-circuit, Self Contained Underwater Breathing Apparatus (SCUBA) or closed-circuit SCUBA (rebreathers). The latter is more effective with the Wilson trap, because no air bubbles are produced to alert the otter of a diver's approach. Personnel with extensive diving experience are mandatory. The divers should have underwater navigation skills, underwater propulsion vehicle experience, and be physically capable of long-distance underwater swims with bulky equipment. Once proficient in these skills, the diver can consider additional training in the use of rebreather equipment. Training in the use of the Wilson trap with rebreathers is available through the USFWS and the CDFG.

The Wilson trap is designed to capture sea otters resting on the water's surface. Experienced capture teams can often catch more than one otter at a time. The capture team requires a minimum of four people; at least two divers, a dive tender, and a boat operator. Whenever possible, capture teams should be in communication with an on shore observer who monitors the location of the otters. The dive boat should be anchored at least 150 feet downwind of the target animals. In general; the two divers maneuver their UPV and Wilson trap to a position below the target. The UPV is then driven straight up at full speed to trap the otter(s) at the surface. A drawstring is used to close the net bag once an otter is in the trap. Two



*Wilson traps are used for the capture of individual otters. They require both specialized equipment and training. Equipment for this method of capture includes:*
*1) Wilson trap with diver operated underwater propulsion vehicle,*
*2) open circuit SCUBA equipment, and*
*3) closed circuit SCUBA (rebreather) equipment.*

Figure 2.4
Wilson trap and diver operated underwater propulsion vehicle. A purse string is used to close the net bag once the otter is entrapped.

carbon-dioxide-filled cartridge floats can be attached to the trap to float the captured animal at the surface while the divers await the boat's arrival.

*(d) Deterrents and Herding.* Several attempts have been made to control sea otter movements in order to decrease the number of otters contaminated during a spill (Davis et al., 1988a). Unfortunately, no current method consistently deters sea otters from entering an oil spill area. Sea otters will avoid boats and respond to cracker shells, horn blasts and killer whale vocalizations, but the animals rapidly habituate to these stimuli. Despite slight modifications in behavior, the duration of response to deterrents and attractants is inadequate for protecting sea otters from potential contamination during an oil spill.

**Handling**

Sea otters are highly susceptible to capture-related stress; therefore, handling should be minimized. Health problems may result from capture, handling, transport, and holding of the animals (see Chapter 5). At least one member of the capture team should be experienced in recognizing stress and capture myopathy syndrome, and be able to initiate treatments.

Despite their sensitivity to stress, sea otters have sharp claws and powerful jaws that can inflict serious wounds. Only experienced wildlife biologists should handle sea otters. The following equipment is required for handling these animals: 1) net bags, 2) restraint boxes (see Chapter 3, Figure 3.1), 3) leather gloves, 4) kennel cages, and 5) capture forms.

Also, food and ice should be available for otters awaiting transport. Scales for weighing the animals, equipment for tagging them, and capture forms (Appendix 2, Forms C, D, E) should be accessible on the support boat. Daily record keeping is essential; daily journals should include date and time of activities with detailed descriptions of capture locations and methods. A copy of each otter's capture form should be attached to the kennel cage.

Once an otter has been captured, it should be transferred to a kennel cage as soon as possible. This can take place either aboard the support vessel or on shore. Otters captured with a dip net or a Wilson trap can be placed directly into a kennel cage. An otter captured in a tangle net should be brought aboard the skiff and placed in a restraint box. Restraint boxes come in a variety of sizes and designs, including simple boxes with and without lids, and wedge-shaped boxes. Preferably, restraint boxes should have a sliding lid and a sliding vertical door at one end. (See Chapter 3, Figure 3.1.) Otters placed in restraint boxes are transferred to kennels by placing the sliding door of the box next to the open door of a kennel cage. The sliding vertical door is opened, and the otter walks into the kennel cage.

If the restraint box does not have a sliding door, a small net bag with a drawstring closure is useful for transferring the otter from the box to a kennel cage (Figure 2.5). The net bag is draped over the opening of the box before the otter is released from the capture device. The captured otter is placed directly onto the net which drops into the box. By quickly pulling the draw string the net bag is closed around

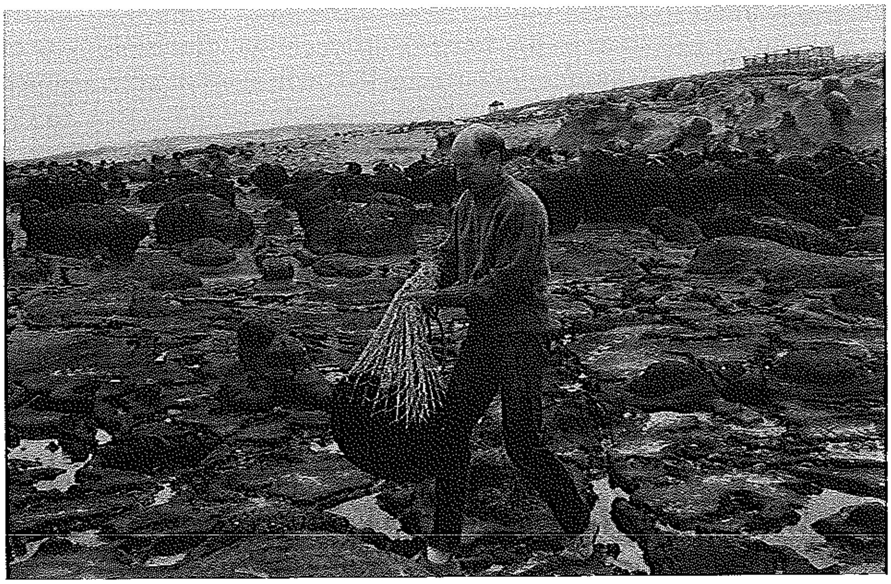


Figure 2.5
Transporting a sea otter using a net bag with draw string enclosure. This method is useful for moving otters between cages or over short distances.

the otter. The box restricts the movements of the netted otter and facilitates handling for examination or transfer to a kennel cage.

Small, lethargic otters may be moved by picking the animal up by its hind legs. The animal is held upside down, twelve inches or more in front of the handler, with its head facing away from the handler. Because the suspended otter tends to roll forward, its teeth and front paws should remain out of reach of the handler. From this position, the otter can be placed directly into a restraint box or kennel cage.

Each animal is weighed and visually examined before transfer from the net bag or restraint box to the kennel cage. Weight, sex, estimate of age class, state of vitality, and estimated degree of oiling are recorded on the capture data forms. Identification tags should be attached to the hind flippers. This is accomplished by pulling the hind flippers through the sliding, vertical door at the end of the restraint box. (See Chapter 3.)

*Weight, sex, estimate of age class, state of vitality and estimated degree of oiling are recorded on the capture data forms. Identification tags should be attached to the hind flippers.*

If a veterinarian or animal care specialist is aboard the support vessel, the otter should be examined for signs of hypothermia, hyperthermia, or other medical problems. If veterinary support is unavailable, biologists should monitor captured otters for significant changes in behavior or health. In particular, body temperature, seizures, and respiratory distress should be recorded on the capture form (Appendix 2, Form C). This should accompany information on the capture time, date, location, and the specific information for each animal. One copy of the capture form should remain with the otter, one should be sent to the USFWS, and one should remain on the capture boat.

Sea otters that are heavily or moderately oiled are susceptible to hypothermia and should be placed in sheltered areas on the support

*Oiled otters are susceptible to hypothermia and should be placed in sheltered areas on the support vessel.*

*Seafood should be offered to captured otters every three hours as they await transport.*

vessel. Seafood should be offered to all of the otters every three hours as they await transport to the rehabilitation center. The time, type of food, and amount eaten should be recorded on the capture form which is sent with the otter to the rehabilitation center.

### Transportation

*Oiled sea otters can be transported by air, sea, or land. If transport is delayed by several hours, the otters should be offered food and water. The amounts should be recorded accurately and the information provided to veterinarians at the rehabilitation center.*

Transportation of the sea otters from the support vessel to the rehabilitation center may occur by boat, aircraft, or truck (Cramer, 1990). The goal is to move the sea otter to the rehabilitation facility as quickly and safely as possible, minimizing the time between capture and treatment. Newly captured sea otters should be taken to a convenient beach or harbor for transfer. If there is a delay in transport, the otters should be placed in a quiet area and monitored regularly for signs of hyperthermia (panting, warm hind flippers) or hypothermia (shivering, cold hind flippers). Access to water and food should be provided. A veterinarian or veterinary technician should advise the capture crews on the triage, standard care, and emergency care needed for otters during the holding period (see Chapter 4). The air temperature of the holding area and in the transport aircraft or vehicle should not exceed 60 °F (15 °C). Unless an otter shows signs of hypothermia, approximately five pounds of crushed ice should be added to the cage. A water sprayer or hose may also be used to cool healthy otters and prevent further fouling of the fur.

*The air temperature of the holding area and in the transport aircraft or vehicle should not exceed 60 °F (15 °C).*

Transport kennels containing otters should be secured to the decks of vessels or the floor of the aircraft. At least one person accompanying the otters should be an animal care specialist.

## DISCUSSION

Following an oil spill, the decision to initiate a capture effort for sea otters must not be made lightly. The authorities legally responsible for conserving and protecting sea otters must be contacted. They will determine the best response option. For all oil spills, it is important to emphasize that the primary response option should be to prevent contamination of animals. Spill diversion and skimming techniques should be used to keep oil away from sensitive sea otter habitat—especially kelp beds, rafting areas, and intertidal mussel beds. Response options such as hazing, herding and other deterrent measures, have been unsuccessful for protecting sea otters (Davis et al., 1988a), but additional research is warranted. If prevention measures fail, it may be necessary to implement a sea otter capture operation.

Factors that should be considered include: 1) influence of environmental, meteorological, and oceanographic conditions, 2) specific characteristics of the spill, such as the type, amount and distribution of oil, and 3) vulnerability of the sea otter population to the spill (Baker et al., 1981; Siniff et al., 1982). Local weather and marine conditions will also affect capture efforts and must be factored into any proposed field operation. Areas where effective capture efforts have taken place include embayments, protected waters, and kelp beds during calm weather. Weather and sea conditions must be safe for capture teams and the associated support operations. If safety can not be ensured, then the emphasis for protecting sea otters must be placed on prespill and preventative spill measures.

Once the above factors have been considered and the decision is made to capture sea otters, program effectiveness will depend on the spill size, timeliness of captures, and availability of rehabilitation facilities. During small spills, the most appropriate response may be limited to notifying trained personnel and basic preparation of equipment in case otters become oiled. A capture program may be unnecessary due to adverse environmental factors or movement of oil out of the sea otter area. Large spills may involve enormous numbers of personnel and, undoubtedly, most of the available response resources. In order to initiate the most effective capture effort, the risk of the spill to sea otters must be assessed and reassessed with respect to its size and direction of movement. All decisions to conduct a capture operation must balance the potential threat of the oil to otters and the risks associated with capturing and handling wild animals (Stulken and Kirkpatrick, 1955).

*All decisions to conduct a capture operation must balance the potential threat of the oil to otters and the risks associated with capturing and handling wild animals.*

If the probability of sea otter contamination is remote, initial efforts should consist of daily surveys to determine the distribution of sea otters relative to the movement of oil. Selected areas should be surveyed daily for oiled sea otters and evidence of environmental contamination. Throughout the response period, these areas should be monitored for notable changes. Until the threat of oiling is past, any changes in sea otter behavior and significant population shifts with respect to the location of oil should be recorded. Only experienced biologists with knowledge about the natural behavior of sea otters should conduct these surveys.

When otters are in danger of oiling, preemptive captures may be considered. The term *preemptive capture* refers to the capture of healthy, uncontaminated sea otters preceding the spread of oil into their range. Uncontaminated otters are captured for their protection and placed in holding pens at predetermined sites or relocated to a safe habitat as determined by federal and state authorities. The techniques for conducting a preemptive capture include Wilson traps, dip nets, and entangling nets. Entangling nets are especially useful because they are capable of quickly capturing large numbers of healthy sea otters. Preemptive captures may be limited by weather conditions, inaccessible habitats, or during a catastrophic spill.

It is important to initiate capture operations quickly once oil moves into the sea otter's habitat and animals become contaminated. Oiled sea otters captured in contaminated areas are designated *contaminated captures*. Attempts should be made to capture as many oiled animals as possible in order to: 1) remove contaminated animals and carcasses from the environment, 2) obtain immediate medical care for oiled otters, and 3) survey areas that appear to be threatened or heavily affected. Dip nets and entangling nets will generally be used for contaminated captures. Because contaminated areas are not safe for divers, diving operations should be suspended or limited to clean capture areas. Dip net techniques will be most effective in the early phase of a spill when the oil is most toxic. During this period contaminated animals will often be sick, lethargic and may exhibit a variety of unusual behaviors (Davis et al., 1988b). Aberrant behaviors include aggressive grooming by pawing and chewing at the skin, shaking the head violently, and floating low in the water. Otters may also haul out on land, presumably in an effort to reduce heat loss associated with decreased insulation in water (Costa and Kooyman, 1982; Williams et al., 1988). Heavily oiled sea otters will have pelage with a spiked or pointy appearance; they may be less attentive and more sluggish than healthy otters, and therefore, easily captured with dip nets. Moderately to lightly contaminated animals may not demonstrate significant differences in behavior or appearance.

The acute medical problems associated with oil contamination diminish as the more volatile toxic components of the spilled oil evaporate (see Chapter 4). This results in a decreased percentage of moribund animals. As sea otters become more active and more difficult to capture with dip nets, the effort should shift to entangling nets. The size of the spill and the number and distribution of otters still at risk will determine the number of capture teams needed.

Sea otters that do not appear to be oiled or show only a minor amount of oiling are occasionally taken during a capture operation. These captures are termed *clean captures* to differentiate them from preemptive captures and contaminated captures. This nomenclature facilitates record keeping and allows all animals to be categorized for the natural resource damage assessment process. Veterinarians in the field and at the rehabilitation facility will determine the health status of these animals. Examination results should be reported daily to the field personnel. This information will help capture teams decide the most appropriate capture areas and when to terminate capture operations.

Some animals will not need to be cleaned and may be moved directly to long-term holding facilities or released into suitable habitats. If the local environment is not safe and regulatory authorities permit, the otters may be translocated. If a significant amount of oil remains in or threatens an area, then clean otters may be captured and held until the threat is past. For example, beached oil may become resuspended in the coastal currents with each tidal cycle and poses a continuous threat. Oil that passes by one area can be redirected quickly by changing winds and currents. Thus, local clean areas cannot be considered safe havens. They must be constantly monitored so that capture operations can be initiated if a threatening situation arises. Such situations can occur days or even weeks after the immediate threat appears to have passed. Daily surveys conducted by federal and state resource agency personnel should be adequate for assessing the threat.

When oiled sea otter carcasses are recovered, the specimens must be documented and turned over to the appropriate agency's law enforcement officers for evidence. The carcasses are retained for possible litigation and federal natural resource damage assessment. Carcasses should be designated as *contaminated carcasses*. Carcasses appearing unoiled should be retained for necropsy to determine the cause of death. All specimens should be documented and necropsied before they are turned over to law enforcement officers for evidence. Uncontaminated carcasses should be designated as *clean carcasses* and disposed of under the appropriate federal and state guidelines for marine mammals.

## SUMMARY

The effectiveness of a capture operation depends on prespill planning, quick notification of trained personnel, the ability to rapidly assess the number of otters at risk, and the efficient mobilization of well-equipped response teams. Experience from the EVOS indicates that the first several weeks of a spill pose the greatest risk to sea otters. An immediate response during this critical period will ensure that the capture operation will provide the greatest benefit to the otter population, especially when the threatened population is small or endangered.

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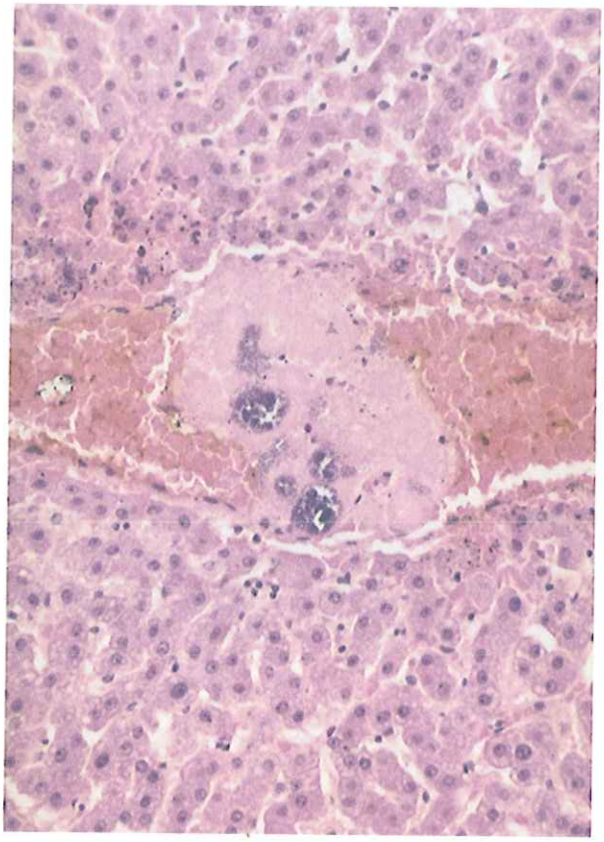

Figure 1.9
Photomicrograph of the liver of an oiled sea otter showing area of thrombosis. (S. W. Nielsen.)

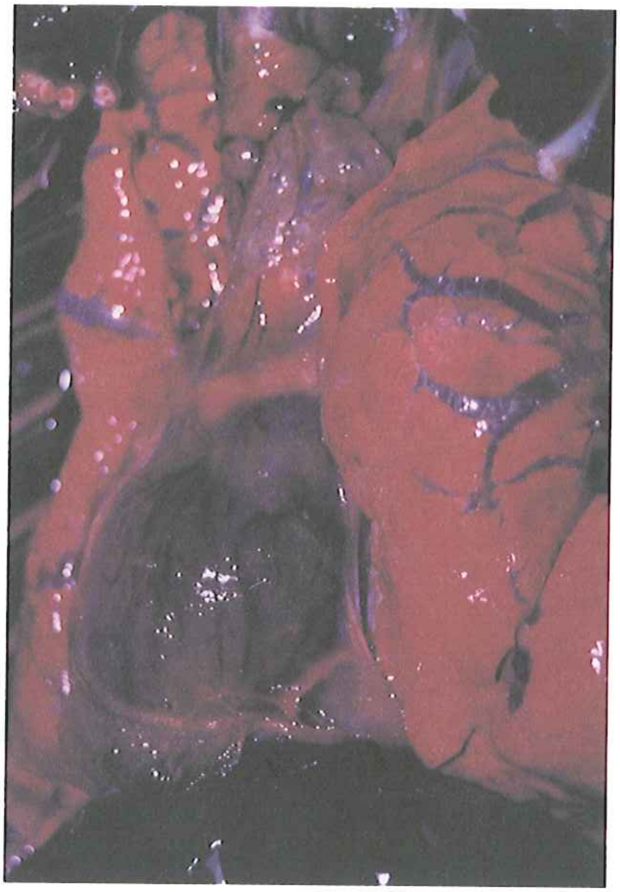

Figure 1.10
Lung tissue of a heavily oiled sea otter. Light grey areas show primary areas of air accumulation and bullae formation. (T. M. Williams.)

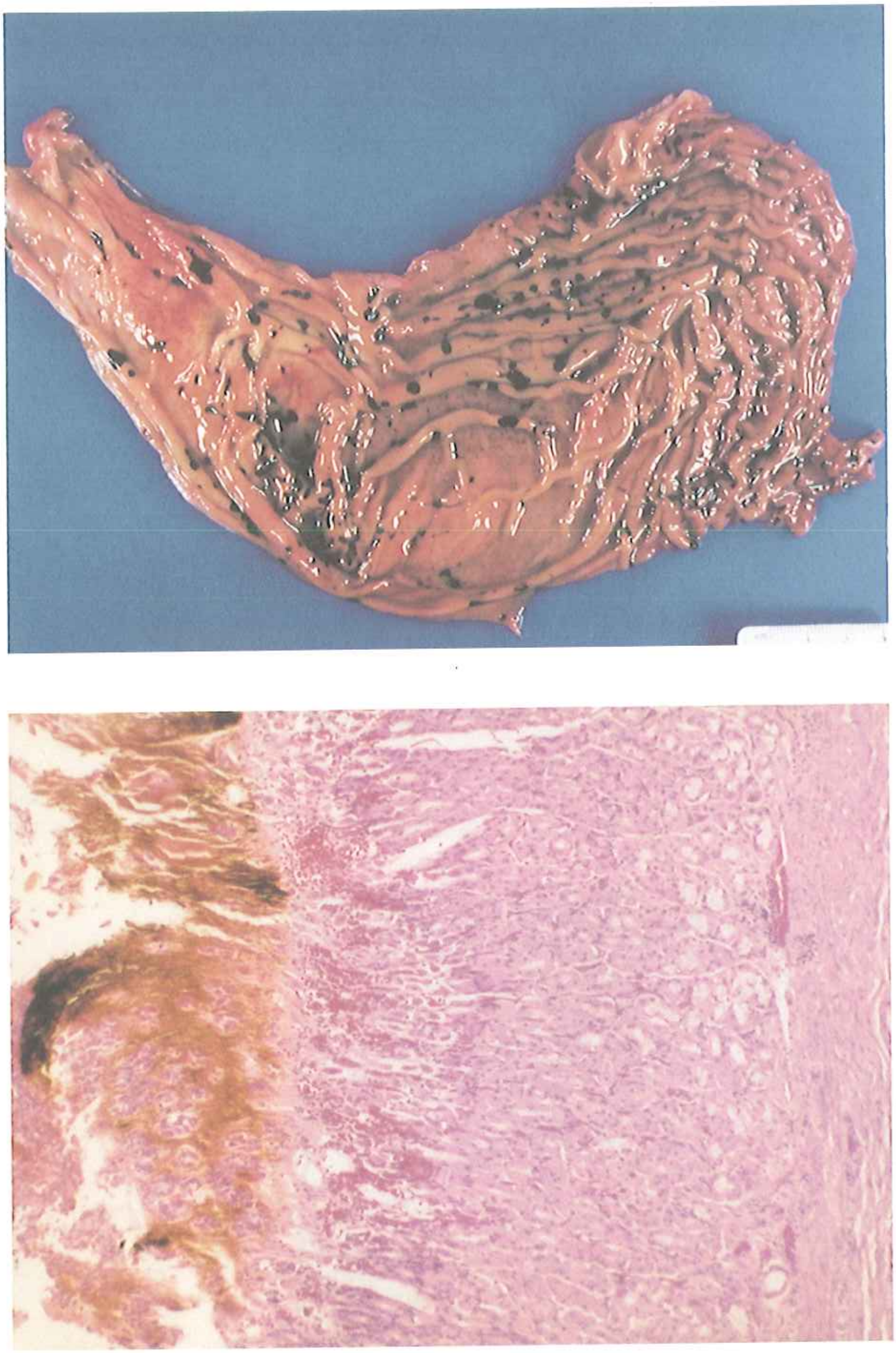

Figure 1.11
Photograph (top) and photomicrograph (bottom) of the stomach of an oiled sea otter showing areas of focal hemorrhage. (S. W. Nielsen.)

# Chapter 3

# Physical and Chemical Restraint

Thomas D. Williams
Donald C. Sawyer

The sea otter has an aggressive temperament characteristic of other mustelids (i.e. river otters, skunks, weasels). Its large canine teeth and strong jaws are extremely dangerous, and the retractable nails on the front paws can inflict serious scratches. Therefore, the handling of a sea otter should only be undertaken with caution and adequate physical or chemical restraint. The decision to use either physical or chemical restraint will depend on the health of the animal, the procedures to be performed, and the duration of immobility required.

This chapter provides the basic information for handling and restraining adult sea otters. Various techniques for physical and chemical restraint were tested on oiled sea otters brought to rehabilitation centers during the *Exxon Valdez* oil spill (EVOS). The evaluation of each procedure was based on safety for animals and personnel, and the otter's response during recovery. We present the recommended procedures based on these evaluations.

## PHYSICAL RESTRAINT

Short duration physical restraint of sea otters is recommended for:

1) venipuncture,
2) intramuscular injections,
3) flipper tagging,
4) inserting subcutaneous transponder tags,
5) abdominal palpation,
6) rectal temperature measurements, and
7) swabs for rectal cultures.

Physical restraint is also recommended for longer procedures, such as cleaning, if the otter is lethargic, unconscious, or otherwise unable to tolerate chemical restraint. (See Chapter 5 for a discussion of medical conditions that preclude chemical restraint.)

The best method to physically restrain a sea otter is to use a squeeze box (Figure 3.1) (Ames et al., 1986; Cornell, 1986; Geraci and Sweeney,

***Use a squeeze box and stuff bag for short duration physical restraint for venipuncture, intramuscular injections, flipper tagging, inserting subcutaneous transponder tags, abdominal palpation, rectal temperature measurements, and swabs for rectal cultures.***

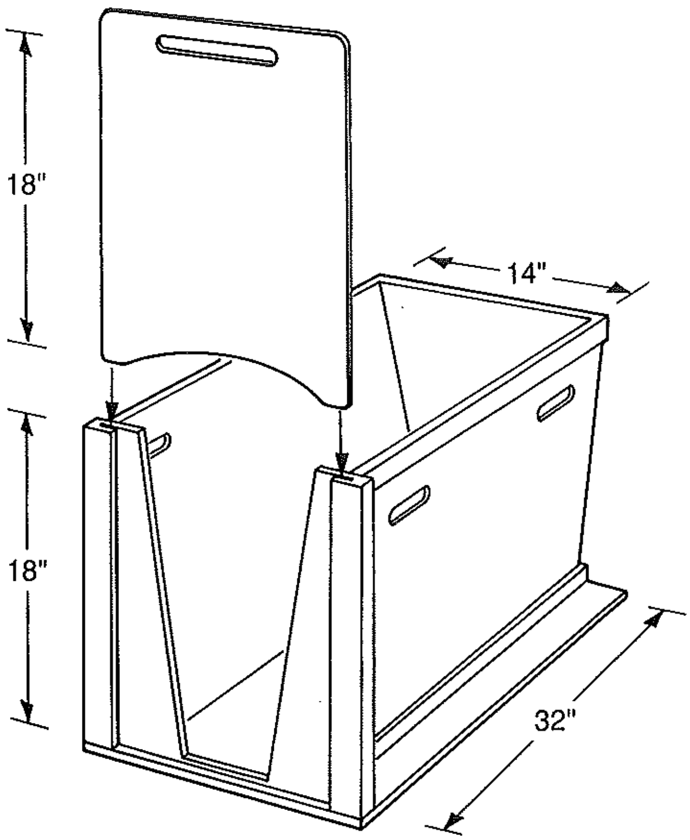


Figure 3.1
Squeeze box for the physical restraint of sea otters. Many clinical procedures (i.e. blood sampling, flipper tagging, rectal temperature measurements, injections) may be conducted safely by extending the hind quarters of the animal through the end opening.

1986; Ridgway, 1972; Williams, 1986). The squeeze box is open at the top and has tapered sides so that the otter can be wedged in the bottom with a stuff bag. Stuff bags (3 feet long, 1.5 feet diameter) are made of ripstop nylon or canvas filled with large pieces of foam rubber or other soft material. A sliding door at one end of the box allows the animal's abdomen and rear flippers to be extended for veterinary procedures. The box is made of ¾-inch-thick polyvinylchloride (PVC), fiberglass, or marine plywood, which can be cleaned after each use. All joints are bonded with PVC adhesive or epoxy and reinforced with corner molding and stainless steel screws.

Alert and active sea otters should be handled only by experienced personnel. To use the squeeze box, the otter is removed from its pen or pool with a salmon dip net (4.5-inch stretch mesh, Figures 2.1 and 3.2). Capture personnel should wear heavy leather gloves (welder's gloves) to protect their hands from bites and scratches. While in the net, the otter is placed on its back in the squeeze box. For more experienced animal handlers, the otter can be lifted out of the dip net by its hind flippers and placed in the squeeze box. During this procedure the otter's face is positioned forward, away from the handler. Once the otter is in the box, a stuff bag is pressed against its chest so that the animal is firmly wedged into the box. Although the otter may bite and scratch at the stuff bag, it will be unable to injure the handler. When the otter is firmly restrained, the sliding door at the end of the squeeze box can be opened and the otter's hind quarters extended for manipulation. When properly used, the squeeze box provides safe restraint for sea otters and protects the handlers from harm.

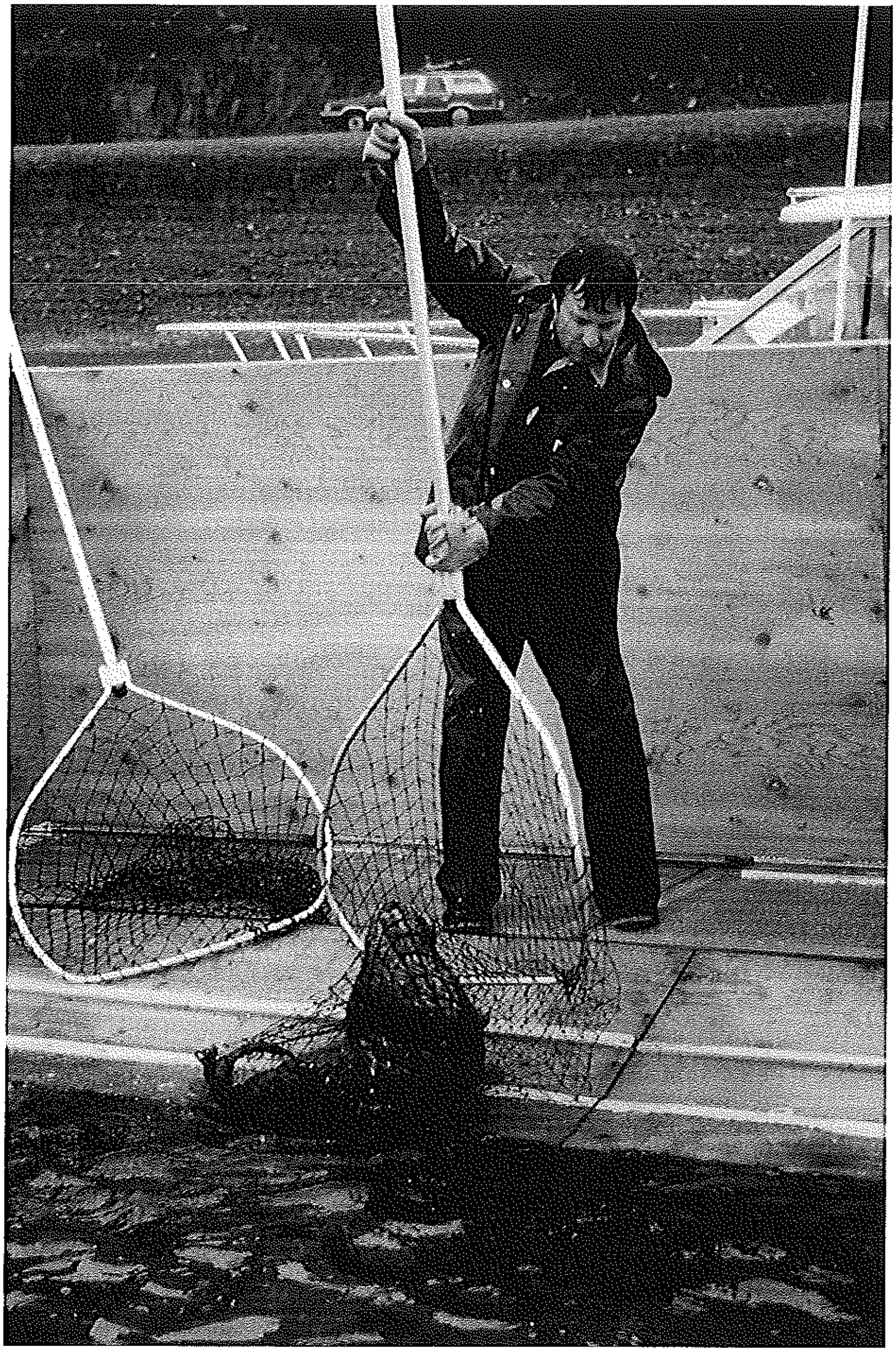

Figure 3.2
Dip net used to capture sea otters. By suspending the frame from a hanging scale, the net also provides short term restraint during weighing.

## CHEMICAL RESTRAINT

Chemical restraint is recommended for the following procedures: 1) cleaning oiled sea otters, 2) administration of solutions via stomach tube, and 3) treatments requiring 2–3 hours of immobilization.

*For cleaning oiled sea otters or for procedures requiring 2–3 hours of immobilization, use a combination of fentanyl (0.2 mg/kg), acepromazine (0.05 mg/kg), and diazepam (0.5 mg/kg) administered intramuscularly.*

The preferred drug combination for safe neuroleptanalgesia in adult sea otters is fentanyl (0.2 mg/kg), acepromazine (0.05 mg/kg), and diazepam (0.5 mg/kg) (Williams and Kocher, 1978; Williams et al., 1981). An intramuscular injection is given in the large muscle mass of the hind limbs while the otter is physically restrained. To reverse the anesthetic effects of fentanyl, naloxone (1 mg/kg) is administered intramuscularly. The type, dose, and time of all injections should be noted in the medical records of each otter (Appendix 2, Form G). Suppliers of the recommended drugs are listed in Table 3.1.

Dissociative anesthetics such as ketamine are not recommended because they may affect the sea otter's normal thermoregulatory response, and several deaths have been reported (Williams and Kocher, 1978). Inhalant anesthetics such as isoflurane are not recommended for heavily oiled sea otters because they may aggravate lung damage associated with the exposure to fresh crude oil (see Chapter 1).

If a sea otter has been heavily oiled or is otherwise unhealthy, its tolerance to chemical restraint is improved by pretreating the animal with normal saline (20 ml/kg SQ or IV), enrofloxacin (2.5 mg/kg bid IM or PO) for mature animals or amoxicillin (12 mg/kg bid IM) for immature otters, and vitamin B-complex (0.1 ml/kg SQ). Chemical restraint is not recommended for otters that are hypothermic, severely lethargic, or unconscious.

*Diazepam is not recommended in combination with fentanyl and acepromazine when release of the otter is imminent.*

Diazepam is not recommended in combination with fentanyl and acepromazine when release of the otter is imminent, because the animal may be too sedated and lethargic to be left unattended. Minor seizures associated with the neuroleptanalgesia produced by fentanyl and acepromazine alone are not usually life threatening. If cyanosis is observed, gentle chest compression should be initiated to stimulate breathing.

Fentanyl is an opioid drug that can cause profound sedation or unconsciousness, bradycardia, respiratory depression, and death, if accidentally sprayed into the conjunctiva of the eye or injected into a person. Consequently, only qualified staff should be allowed to administer drugs used for chemical restraint. Protective glasses should be worn when handling fentanyl; naloxone should be available to re-

Table 3.1
Suppliers of recommended drugs for use in the chemical restraint of sea otters.

| **Substance** | **Supplier** |
|---|---|
| fentanyl (10 mg/ml) | Sigma Chemicals, St. Louis, MO |
| acepromazine (2 mg/ml) | Fort Dodge Laboratories, Fort Dodge, IA |
| diazepam (5 mg/ml) | Roche Laboratories, Nutley, NJ |
| naloxone | Pitman Moore Inc., Mundelein, IL |

verse the depressant effects of fentanyl. A strict drug security system must be in effect to avoid potential abuse of controlled drugs by personnel working in or around a rehabilitation center.

***Safety note: Fentanyl is a synthetic opioid that can cause profound sedation or unconsciousness, bradycardia, respiratory depression, and death if accidentally sprayed into the conjunctiva of the eye or injected into a person.***

## SUMMARY

Sea otters can be safely handled if proper physical and chemical restraint are used. The best method for physically restraining an otter is the squeeze box. The preferred method of safe chemical restraint is a combination of fentanyl, acepromazine, and diazepam. Naloxone should be used to reverse the anesthetic effect of fentanyl. These drugs are dangerous to humans and should be handled only by veterinarians and animal care specialists. To reduce physiological and behavioral stress to the otter, the period of restraint should be minimized. The type and duration of restraint will depend on the health of the otter and the purpose for handling.

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# Chapter 4

# Initial Clinical Evaluation, Emergency Treatments, and Assessment of Oil Exposure

Terrie M. Williams
James F. McBain
Pamela A. Tuomi
Riley K. Wilson

Sea otters are subject to both external and internal petroleum hydrocarbon exposure during an oil spill. External oiling is the most obvious condition, and usually the first point of contamination. Internal exposure to oil can occur via several routes including dermal absorption, inhalation of hydrocarbon vapors, and ingestion by eating contaminated prey or licking oiled fur. All three routes can contribute to systemic petroleum hydrocarbon toxicity. Sea otter grooming behavior exacerbates the situation and increases the degree of oil exposure. In an effort to clean their fur, they often spread the area of contamination and may actively inhale or ingest oil (Mulcahy and Ballachey, 1993; T. M. Williams, personal observation).

*Sea otters are subject to both external and internal petroleum hydrocarbon exposure during an oil spill.*

This chapter focuses on the immediate actions required when oiled animals arrive at rehabilitation centers. We describe the methods for stabilizing oiled otters, determining the degree of oil contamination, conducting clinical evaluations, and initiating treatments. A method for assessing petroleum hydrocarbon toxicity using paraffinic hydrocarbon concentration in the blood is presented. We also describe the major medical problems of oiled sea otters. The incidence and initial treatment of these conditions are discussed with respect to the type and age of the spill. Subsequent treatment regimens and methods for cleaning the animals are addressed in Chapter 5 and Chapter 6, respectively.

## ESTABLISHING PHYSIOLOGICAL STABILITY IN OILED SEA OTTERS

The period of stabilization begins at the moment of capture and ends when the animal is ready for cleaning at the rehabilitation center. The goal of stabilization is to correct immediate life-threatening conditions (i.e. hypothermia, hyperthermia, hypoglycemia, shock, severe dehydration, sepsis) so that the otter can tolerate stresses associated with transport, handling, and cleaning. Heavily oiled sea otters should be cleaned as soon as they are clinically stable to minimize further absorption of oil. Cleaning may be postponed twenty-four

*Heavily oiled sea otters should be cleaned as soon as they are clinically stable to minimize further oil absorption.*

hours for otters that are lightly oiled and have no serious clinical disorders. Criteria for determining the duration of a stabilization period are presented in Chapter 11.

All sea otters should receive a physical examination as soon as possible after capture. A veterinarian or animal care specialist should diagnose and treat symptoms that are immediately life-threatening. Oiled sea otters may exhibit signs of hyperthermia or hypothermia, dehydration, shock, lethargy, seizures, and depression. Respiratory and cardiovascular function should be evaluated and stabilized first, with subsequent treatments dependent on alleviating the underlying cause of the dysfunction. The normal heart rate of adult sea otters is 144–159 beats/minute, but the average heart rate can increase to 199 beats/minute during agitated grooming (T. M. Williams, unpublished data). Respiratory rate ranges from 17–20 breaths/minute for adult sea otters (Appendix 1).

*The normal heart rate of adult sea otters is 144–159 beats/minute. Respiratory rate ranges from 17–20 breaths/minute.*

### Initial Assessment Parameters

Along with heart rate and respiratory rate, the following parameters should be assessed immediately for otters arriving at a rehabilitation center. Most can be determined very quickly by palpation or visual observation.

*(a) General Body Condition.* Oiled otters may not eat in the wild, and therefore may be dehydrated and underweight. Normal body weights for adult Alaskan sea otters range from 27–48 kg for males and 16–32 kg for females. California sea otters are slightly smaller. Oiled otters often exhibit symptoms of hypoglycemia, including depression, seizures, muscular weakness, and hypothermia. A naturally high metabolic rate makes otters susceptible to hypoglycemia when deprived of food for more than several hours. To avoid or mitigate hypoglycemia and dehydration, food and ice should be offered to sea otters at least every three hours, except when they are asleep at night. Food and fluids should be withheld from otters for one hour before sedation to prevent vomiting and aspiration.

*Normal body weights for adult Alaskan sea otters range from 27-48 kg for males and 16-32 kg for females.*

*Food and ice should be offered to captive sea otters at least every three hours, except when they are asleep at night.*

*(b) Activity Level.* The responsiveness of oiled sea otters can range from agitated to lethargic, and will depend on the duration and degree of exposure to oil. Early in a spill, the oil may be irritating to the skin and sensitive membranes around the eyes, nose, and flippers. In such instances, the otter may scratch its cornea and the membranes surrounding the eyes, or chew on the interdigital webbing of the hind flippers. In severe cases, cartilage on the edge of the ears or between the toes will be exposed. Excessive grooming will damage the fur by promoting hair breakage and shedding. With reduced levels of contamination, the otters will usually remain alert, groom, and accept food. Normal grooming behavior includes rubbing the ears, muzzle, and forearms, as well as licking and nuzzling the abdomen.

*The responsiveness of oiled sea otters can range from agitated to lethargic and will depend on the duration and degree of exposure to oil.*

*(c) Body Temperature.* Oiled sea otters are thermally unstable and may be hypothermic or hyperthermic. If the animal is lethargic or unconscious, its core body temperature should be measured using an electronic digital thermometer with a flexible probe inserted fifteen

cm into the rectum. Normal core temperature for sea otters ranges from 37–39 °C (98.6–102 °F). If the flexible probe cannot be easily inserted into the rectum, abnormally low or high core temperatures can be qualitatively verified by feeling the hind flippers and by observing behavioral signs. Shivering may be indicative of hypothermia, while panting and flipper expansion are commonly observed for hyperthermic otters. A hypothermic otter (core temperature less than 35 °C or 95 °F) will have cold hind flippers. In severe cases, the animal may be unconscious. Treatments for mild hypothermia during the stabilization period should be limited to placing the animal in a well-ventilated, warm (20 °C or 68 °F) area and drying the fur vigorously with towels and a pet dryer (set at room temperature). More aggressive treatments for hypothermia should be conducted under the controlled conditions of the rehabilitation center (see Chapter 5). Hyperthermic otters (core temperature greater than 40 °C or 104 °F) will have hot hind flippers, pant, and may exhibit agitated behavior. In severe cases, the overheated otter will be lethargic or unconscious. Chipped ice placed in the bottom of the cage will help cool hyperthermic otters awaiting cleaning.

*Core body temperature for adult sea otters should be 37–39 °C or 98.6–102 °F.*

*(d) Coat Condition.* Degree of oiling and water repellency should be assessed (see below and Chapter 6). Normal pelage will have a brown striated appearance. The underfur of the healthy coat remains dry even after submergence.

*(e) Hydration.* Exposure to crude oil is known to contribute to dehydration in marine mammals, often as a result of gastrointestinal disturbances (St. Aubin, 1990). Because 50–100% of the water intake of sea otters is derived from food (Costa, 1982), the inability to feed will lead to dehydration. Dehydration may be detected through physical examination by decreased skin elasticity, sunken globes, and dry mucous membranes. If dehydration is diagnosed or suspected, prophylactic fluid therapy is recommended. Normal saline or a 1-to-1 mixture of 5% dextrose solution and normal saline (20 ml/kg/day SQ or IV) should be given.

*(f) Signs of Pulmonary Distress (diaphragmatic breathing, hyperventilation, congestion).* Following exposure to oil, the animals may show labored breathing and congestion associated with emphysema and inflamed nasal, pharyngeal, and bronchial membranes. Nasal discharges should be noted.

*(g) Evidence of Shock.* Signs of shock include muscle weakness, hyperventilation, cold hind flippers, pale coloration or mottling of the gums, and reduced capillary refill time following compression.

*Standard stabilization protocol for oiled sea otters:*
*1) Physical examination and weight.*
*2) Place hypothermic otters in a well-ventilated, warm (15 °C or 60 °F) area. Dry their fur with towels or a pet dryer set at room temperature. Monitor rectal temperature.*
*3) Place hyperthermic otters on a layer of chipped ice in their cage or in a seawater pool at normal seasonal ocean temperatures.*
*4) Prophylactic administration (20 ml/kg/day SQ) of normal saline or a 1-to-1 mixture of 5% dextrose solution and normal saline.*
*5) Prophylactic administration of broad spectrum antibiotics: enrofloxacin (2.5 mg/kg bid IM) for mature animals and amoxicillin (12 mg/kg bid IM) for immature otters.*
*6) Prophylactic administration of corticosteroids: dexamethasone (1-2 mg/kg/day IM).*
*7) Prophylactic administration of vitamins and minerals including vitamin E (400 IU/day), vitamin B-complex and selenium (Seletoc™, 0.1 ml/kg).*

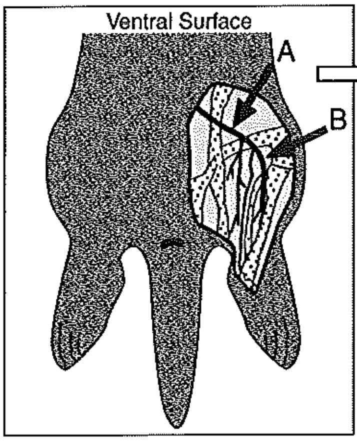
Following the general examination, blood samples from the femoral, jugular, or popliteal veins should be taken before cleaning or treatment (Figure 4.1). Blood glucose should be measured immediately using reagent strips (Chem Strips™, BG Boehringer Mannheim, Indianapolis, Ind.), a desktop analyzer, or diagnostic units designed for at-home use by diabetics. Basic hematological and blood chemical constituents (glucose, blood urea nitrogen, hematocrit, erythrocyte sedimentation rate, white and red cell counts) are easily assessed with

***Blood samples obtained during initial examinations should be assessed immediately for blood glucose, blood urea nitrogen, and hematocrit.***

manual techniques utilizing desktop blood analyzers (Eastman Kodak, Inc.; Abbot Laboratories). These parameters provide rapid biochemical profiles which should be determined at the rehabilitation center to provide immediate diagnostic information for the veterinary staff. Comprehensive blood panels may be obtained later by sending the remainder of the blood sample to a veterinary diagnostic laboratory or appropriate facility with automated diagnostic equipment.

**Sampling Blood From Adult Sea Otters**

| Sampling Technique | Analysis | Sample Size | Tube |
|---|---|---|---|
| 1. Place otter in dorsal recumbancy.<br>2. Palpate hind leg.<br>3. Sample sites are the proximal third of the femoral vein (A) or the popliteal vein (B) approximately 1 cm posterior to the femoral condyles. | CBC and Differential | 5 ml | EDTA (purple top) |
| | Hepatic/Renal Panel, CPK, Triglyceride | 10 ml | Sterile serum separation tube (SST, tiger top) |
| | Petroleum Hydrocarbons | 5–7 ml | Potassium oxalate (grey top)<br>*Analyze whole blood sample |




CBC = WBC, RBC, HGB, PCV, MCV, MCHC, PLT, MPV
DIFFERENTIAL = SEGS, BANDS, LYMPHS, MONOS, EOS
HEPATIC/RENAL PANEL = ALKPHOS, LDH, AST, ALT, GGTP, TOTAL BILIRUBIN, GLUCOSE, TOTAL PROTEIN, BUN, CREATININE, URIC ACID, CALCIUM, PHOSPHORUS, SODIUM, POTASSIUM, CHLORIDE

Figure 4.1
Anatomical sites and procedures for sampling blood from sea otters. Animals are positioned in dorsal recumbancy with the hind legs slightly extended. Samples are drawn approximately 1 cm posterior to the femoral condyles (popliteal vein). Alternate sites include the femoral vein and jugular vein. (Redrawn from Geraci and Lounsbury, 1993.) Colors in parentheses denote the stopper color of Becton-Dickinson vacutainer collection tubes.

Results from the initial clinical evaluation should be entered on admissions forms (Appendix 2, Forms F and H) which will remain with the animal throughout the rehabilitation process. Data recorded on the forms will be used in rating each animal during triage and will provide the basis for subsequent treatments.

Treatments during stabilization should include the prophylactic administration of:

1) enrofloxacin (2.5 mg/kg bid IM or PO) for mature animals and amoxicillin (12 mg/kg bid IM) for immature otters to prevent or treat infections,
2) dexamethasone (1–2 mg/kg/day IM or IV) to prevent or treat shock,
3) vitamin and mineral supplements including vitamin E (400 IU/day), vitamin B-complex, and selenium (Seletoc™, 0.1 ml/kg single dose IM or SQ in two sites).

These supplements can be given as a multivitamin tablet (SeaTabs™),

4) cimetidine (5-10 mg/kg tid PO or 10 mg/kg qid IV or IM) or ranitidine (1-4 mg/kg tid PO) for gastric ulcers, and
5) diazepam (0.2 mg/kg PO or 0.1 mg/kg IM) to reduce stress and stimulate appetite. This treatment is optional.

## ASSESSING THE DEGREE OF OIL CONTAMINATION

The composition and toxicity of crude oil changes as it degrades following a spill. The rate of degradation depends on ambient temperature and ocean conditions, with fresh crude oil often remaining toxic for approximately three to seven days (Neff, 1990). In sea otters, the internal and external consequences of contamination are different for fresh and weathered oil (Williams et al., 1988; Williams and Davis, 1990). Consequently, the condition of oiled otters may vary over the course of an oil spill. From the perspective of wildlife, it is helpful to subdivide catastrophic oil spills into two phases; an Early Phase comprising the first two to three weeks of most spills, and a Late Phase consisting of the remainder of the clean up effort or rehabilitation program. During the Early Phase, the oil contains the greatest concentration of aromatic petroleum compounds (volatiles) and is considered the most toxic. Animals which arrive at a rehabilitation center during this period will show the highest incidence and severity of medical problems (Williams, 1990). During the Late Phase, the number of animals requiring rehabilitation will diminish. These animals also show less external oiling and fewer medical conditions.

*The composition and toxicity of crude oil changes as it degrades following a spill. In sea otters, the internal and external consequences of contamination are different for fresh and weathered oil.*

The division between Early and Late Phases of an oil spill is less distinct for chronic events involving long term oil release such as an oil platform blowout or leaking transport vessel. During these events, wildlife responses to contamination will depend on the composition of the oil encountered, degree of weathering, and the duration of exposure.

The initial assessment of oil contamination in sea otters is made by visual examination of the pelage. Four classifications are suggested:

1) heavily oiled (>60% body coverage with saturation to the skin),
2) moderately oiled (30-60% body coverage that includes areas of saturation),
3) lightly oiled (<30% body coverage or light sheen on fur), or
4) unoiled (no visual or olfactory evidence of oiling).

The contamination level in sea otters will change as the oil composition changes. For example, Figure 4.2 shows external contamination that occurred in sea otters during the *Exxon Valdez* oil spill (EVOS) (Williams et al., 1990). Almost 60% of the otters arriving at rehabilitation centers during the first two weeks of the spill were heavily oiled. By the fourth week, the majority of otters were lightly oiled. As the rehabilitation program continued, the number of otters

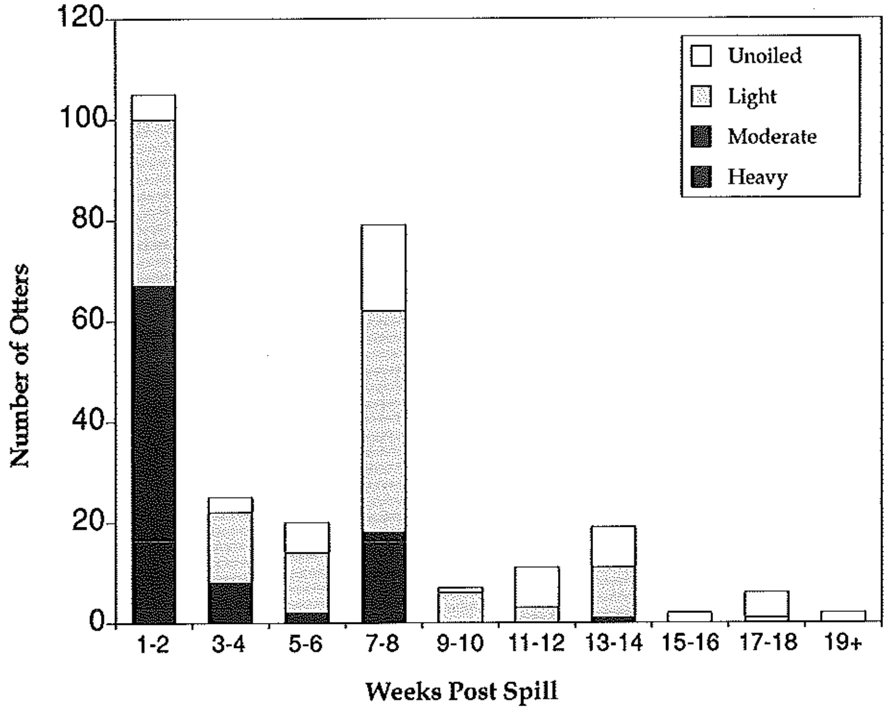



Figure 4.2
Degree of external oiling for sea otters on admission to rehabilitation centers during the EVOS. Shading denotes oiling category. The height of each bar shows the total number of sea otters received within two week periods following the spill. Note the rapid decline in the number of heavily oiled otters after four weeks. The increase in total number of otters received during weeks seven and eight corresponds to the opening of a second rehabilitation center.

arriving at rehabilitation centers and the degree of oiling decreased rapidly with time. While ninety-four otters were retrieved in the first two weeks, only forty-seven animals arrived during weeks three and four. Two months after the spill, less than one otter arrived per day at rehabilitation centers.

As the oil becomes more diffuse, detection on the fur becomes increasingly difficult. Sheen oil, in particular, is difficult to detect on sea otter fur. A noticeable petroleum odor or stickiness of the fur indicates contact with oil.

Internal exposure to petroleum hydrocarbons is comparatively more difficult to verify. Furthermore, the toxicity of ingested oil is not fully known. A quick, relative measure of systemic exposure for large numbers of animals may be obtained by measuring petroleum hydrocarbon levels in blood samples. The concentration of petroleum hydrocarbons provides important diagnostic information, if the sample is obtained within forty-eight hours of exposure to oil. Because some petroleum compounds may be cleared quickly from the blood, longer delays between exposure and blood sampling may lead to false negative results. To avoid lengthy, difficult, and expensive analyses, we suggest measuring total paraffinic hydrocarbons, rather than the more toxic polycyclic aromatic hydrocarbon (PAH) compounds (Neff, 1990). If a blood sample is taken soon after exposure to oil, paraffinic hydrocarbon levels for individual samples are proportional to PAH concentrations. This test was used during the EVOS and is recommended for assessing petroleum hydrocarbon exposure in oiled otters.

Five ml blood samples are drawn from the femoral, jugular, or popliteal veins (Figure 4.1) and placed in potassium oxalate vacutainers (Becton-Dickinson). Whole blood samples should be immediately transferred to acid washed vials, frozen, and stored at -10° C until analysis. National Medical Services, Inc. (Willow Grove, PA) and the Geochemical and Environmental Research Group of Texas A&M University (College Station, TX) conduct tests for petroleum hydrocarbons in blood samples (see Chapter 1, Table 1.2). Local hospitals may suggest additional analytical facilities near the site of the rehabilitation center. The choice will depend on cost, shipping time, and the laboratory analysis time. To provide the most benefit to the otters and attending veterinarians, test results should be available within two to three days of blood sampling.

*For assessing paraffinic petroleum hydrocarbons, 5 ml blood samples are drawn from the femoral, jugular, or popliteal veins and placed in potassium oxalate vacutainers. Whole blood samples should be immediately transferred to acid washed vials, frozen, and stored at -10 °C until analysis.*

The recommended analysis provides the veterinarian with a value for the total concentration of paraffinic hydrocarbons ($C_{3-36}$) in each blood sample. Baseline levels of these paraffins, determined from unoiled adult Alaskan sea otters held in seaquariums, are less than one ppm. Higher levels indicate acute exposure to petroleum hydrocarbons. The presence of paraffinic hydrocarbons in the blood is a signal for veterinarians to initiate more aggressive treatments for mitigating oil toxicosis. (See Chapter 5.)

*The presence of paraffinic hydrocarbons in the blood is a signal for veterinarians to initiate more aggressive treatments for mitigating oil toxicosis.*

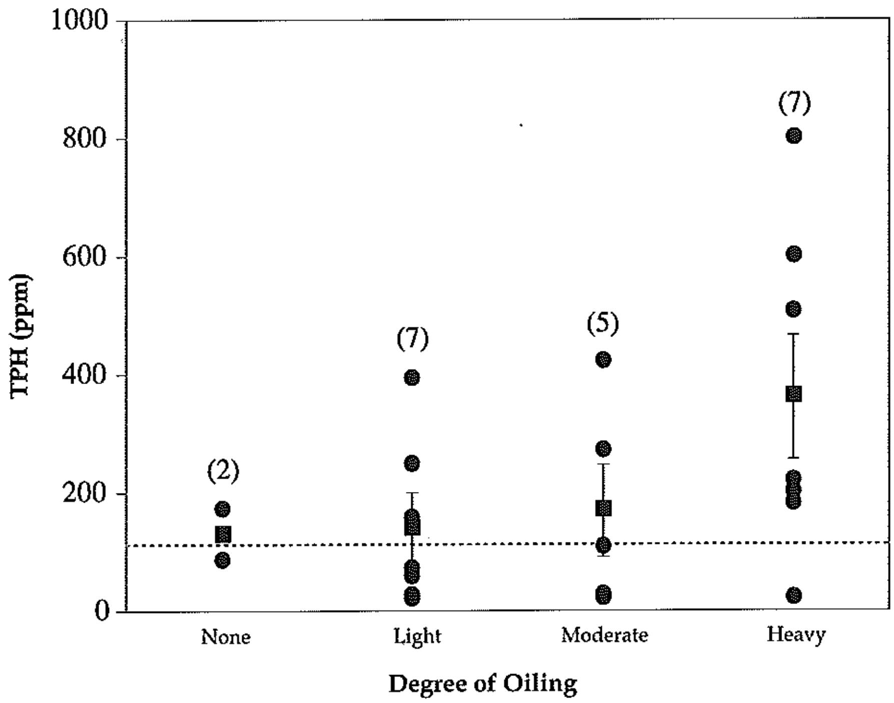



Figure 4.3
Total paraffinic hydrocarbon concentration (ppm) in whole blood in relation to degree of external oiling for adult sea otters during the EVOS. Note the wide range of values for each oiling category. Black boxes and vertical lines represent the mean + 1 SE for each category of oiling. Circles denote individual data points. Numbers in parentheses denote the number of animals. The calculated threshold dose (described in text) is represented by the stippled line.

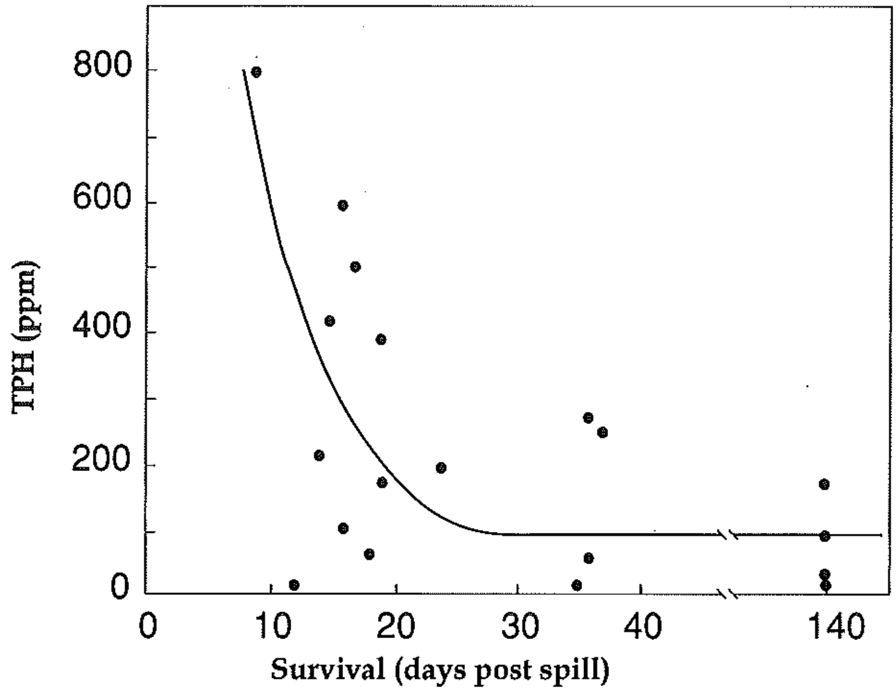



Figure 4.4
Total paraffinic hydrocarbon concentration (ppm) in whole blood versus survivorship for adult sea otters contaminated during the EVOS. Blood samples were taken on the day of admission to rehabilitation centers. Because the duration of exposure for individual animals is not known, survivorship is presented as days post spill. The solid line is the best fit curve through the data points ($y = 8617exp^{-1.2 \ln x}$ below the breakpoint, n = 15).

*Total paraffinic hydrocarbon (TPH) content in the blood is a useful indicator of systemic oil exposure. The threshold dose for TPH in crude oil during the EVOS was 112 ppm.*

Several trends were apparent following the analysis of paraffinic hydrocarbons in sea otters contaminated during the EVOS (Williams and Davis, 1990). First, total paraffinic hydrocarbon (TPH) concentrations in the blood were variable for oiled sea otters. TPH ranged from 19 ppm to 800 ppm in adult sea otters on admission to rehabilitation centers (Figure 4.3). Second, internal exposure based on TPH levels did not consistently correlate with the degree of external oiling. Rather, the primary correlation appeared to be between TPH concentration and when the animal was exposed to the oil (i.e. during the Early or Late Phases of the spill).

In view of this, the highest paraffinic hydrocarbon levels should be expected for heavily oiled animals captured during the first two weeks of a spill. The mean TPH concentrations for lightly and moderately oiled otters will probably be indistinguishable from one another. Low TPH levels can occur in animals from all four categories of oiling. In general, external contamination will be a poor indicator of internal contamination and should not be used as an index of systemic exposure.

The likelihood that a contaminated animal will survive can be assessed from the threshold dose (TD) of the contaminant (Klaassen and Eaton, 1991). The TD for North Slope crude oil during the EVOS was calculated from the relationship between the survivorship of oiled otters and the concentration of paraffinic petroleum hydrocarbons in the blood. In oiled sea otters, survivorship increased as TPH concentration decreased (Figure 4.4). Based on this curve and individual variation in TPH concentration for otters surviving at least twenty days after contamination, the mean TD for crude oil during the EVOS was 112 ± 92 SD ppm. Animals showing blood TPH levels below this value are more likely to survive than those with higher values. Note that the highest level of TPH measured for an oiled sea otter that survived to release was 171 ppm.

*The mean TD for crude oil during the EVOS was 112 ± 92 SD ppm. Animals showing blood TPH levels below this value were more likely to survive than those with higher values.*

The threshold dose also provides a useful index of systemic damage in acutely oiled sea otters. This is demonstrated by examining the relationship between TPH concentration and the incidence of emphysema for otters contaminated during the EVOS (Figure 4.5). Blood TPH levels of otters displaying emphysema were significantly higher (at $p<0.001$) than those for healthy otters. TPH levels also correlated well with the severity of emphysema. Sea otters without emphysema had a mean TPH level of 65 ± 57 SE ppm ($n = 10$), well below the calculated threshold dose. All animals diagnosed with subcutaneous emphysema had TPH levels greater than 224 ppm, more than two times the mean threshold value of 112 ppm.

*All animals diagnosed with subcutaneous emphysema had TPH levels greater than 224 ppm.*

Although the TPH concentration provides little information about exposure to specific petroleum hydrocarbons, it provides a relative index of toxicosis. Lethal thresholds based on TPH concentration will depend on the type of oil encountered, duration of contact, and the

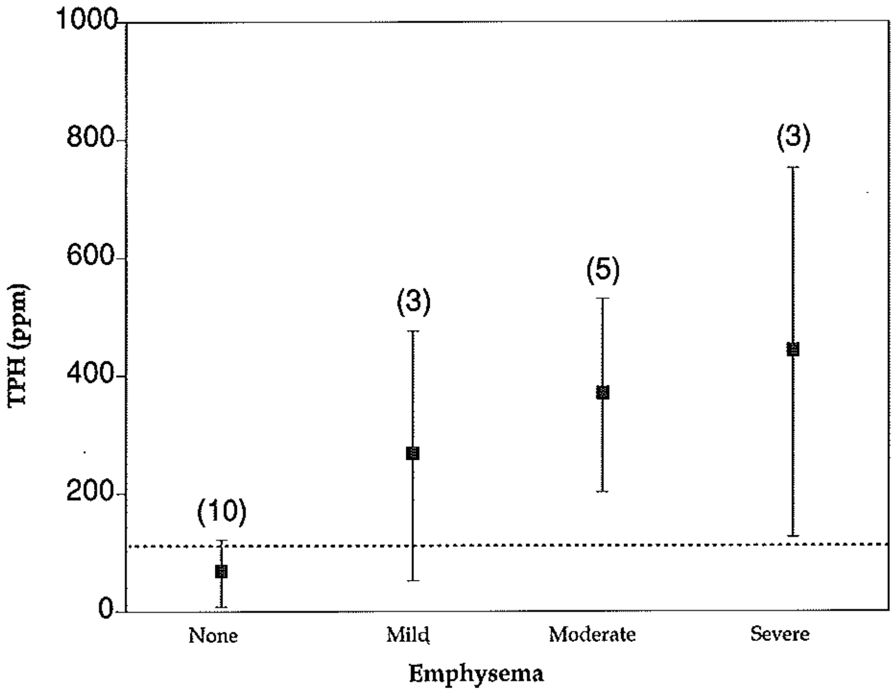



Figure 4.5
Total paraffinic hydrocarbon concentration in relation to the severity of emphysema in oiled sea otters from the EVOS. Sea otters without emphysema included unoiled ($n = 2$) as well as heavily ($n = 2$), moderately ($n = 1$), and lightly ($n = 5$) oiled animals. Mean + 1 SE are shown. Numbers in parentheses represent n for each category. The calculated threshold dose (from Figure 4.4) is shown by the stippled line.

species affected. Factors such as the origin and type of petroleum product and the state of weathering influence the petroleum hydrocarbon composition, and thus, toxicity of the oil. Acute exposure will yield different responses than chronic exposure. Furthermore, individual species may respond differently to oil contamination (see Chapter 15).

## TREATING THE MEDICAL DISORDERS OF OILED SEA OTTERS

*Oil spills are divided into Early and Late Phases. Otters oiled during the first three weeks of a catastrophic spill show the severest medical problems. As the oil dissipates and weathers, the incidence and severity of many medical disorders will decline.*

Oiled otters brought to rehabilitation centers present a wide range of medical conditions varying in severity (Williams and Davis, 1990). During the first weeks following the EVOS, more than 36% of the captured sea otters were hypothermic, 27% were hyperthermic after transport, and more than 45% of the animals showed blood glucose concentrations below the minimum normal value (88 mg/dl; Appendix 3). Also, nearly 70% of the otters that died during this period exhibited some form of emphysema.

Otters oiled during the first three weeks of a catastrophic spill show the severest medical problems, and consequently the highest mortality. As the oil dissipates and weathers, the incidence and severity of many medical disorders will decline. Therefore, treatment regimens differ for otters contaminated during the Early and Late Phases of a spill.

### Treatments for Early Phase Sea Otters

Otters arriving at the rehabilitation center during the Early Phase of an oil spill will require treatment for external and internal exposure to oil. Medical problems caused by exposure to oil will be exacerbated by the stress of capture, handling, and rehabilitation. However, it will be difficult to differentiate between the detrimental effects of oiling and the stress of captivity when treating oiled otters.

Treatment of Early Phase otters should begin during the cleaning process. The animals should be weighed and then sedated as required for handling. An ophthalmic ointment (Bacitracin) should be applied to the eyes to protect them from detergent and oily water. The flexible probe of an electronic digital thermometer should be inserted fifteen cm into the rectum to monitor core temperature.

*Animals with core temperatures below 35 °C (95 °F) should be treated for severe hypothermia. This includes intravenous infusion of warm (37–39 °C) fluids and warm water immersion.*

Animals with core temperatures below 35 °C (95 °F) should be treated for severe hypothermia (see Chapter 5 for details). This procedure includes the intravenous infusion of warm (37–39 °C or 98.6–102 °F) fluids and warm water (37 °C or 98.6°F) immersion. The animal's vital signs (respiratory rate, heart rate, blood oxygen saturation) should be monitored during rewarming. A portable electrocardiograph (EKG) and pulse oximeter with a flexible probe that can be attached to the animal's tongue are essential for monitoring heart rate and blood oxygen saturation, respectively. Ventricular arrhythmias and tachycardia may be treated with lidocaine hydrochloride (1–2 mg/kg IV bolus); atrial arrhythmias are controlled with propranolol (0.02–0.06 mg/kg slow IV infusion). Caution should be used when administering these drugs to hypothermic animals, because over-medication can occur when the animal rewarms. Hyperthermic otters (core temperature greater than 40 °C or 104 °F)

*Ventricular arrhythmias and tachycardia may be treated with lidocaine hydrochloride (1–2 mg/kg); atrial arrhythmias are controlled with propranolol (0.06 mg/kg slow IV infusion).*

should be cooled by placing ice packs on the hind flippers and by reducing the rinse water temperature to 10 °C (50 °F) during washing.

Hypoglycemia (plasma glucose less than 60 mg/dl) should be treated with 5% dextrose (20 ml/kg SQ) or 10–20% dextrose (10–20 ml/kg IV to effect). For a more sustained effect, a 50% dextrose solution (1 ml/kg) should be given by stomach tube; this is followed by the subcutaneous infusion of 5% dextrose to maintain the blood glucose concentration at normal levels.

*Hypoglycemia (plasma glucose less than 60 mg/dl) should be treated with 5% dextrose (20 ml/kg SQ) or 10–20% dextrose (10–20 ml/kg IV to effect).*

Oiled sea otters may be washed while their core temperature and blood glucose are being stabilized. Rinse water temperature should be adjusted to help maintain the otter's core temperature at 37–39 °C (98.6–102 °F). During rinsing, prophylactic fluid therapy for dehydration (normal saline or a 1-to-1 mixture of 5% dextrose solution and normal saline; 20 ml/kg/day) should be initiated with a subcutaneous line inserted between the shoulders or the loose skin behind the neck. Antibiotics, dexamethasone, and vitamin/mineral supplements should be administered as described under the previous section on stabilization.

*During rinsing, prophylactic fluid therapy for dehydration (normal saline or a 1-to-1 mixture of 5% dextrose solution and normal saline; 20 ml/kg/day) should be initiated with a subcutaneous line inserted between the shoulders or the loose skin behind the neck.*

Fecal samples are easily collected while the otters are being washed and may be used to assess the ingestion of crude oil by suspending the sample in water. To mitigate the effects of ingested oil, all animals from the Early Phase of a spill may be treated with a petroleum hydrocarbon adsorbent. A slurry of activated charcoal (Toxiban™, 6 ml/kg) can be administered via stomach tube just prior to anesthetic reversal after cleaning. Care must be taken to prevent aspiration and gastric reflux during intubation. (See Petroleum Hydrocarbon Ingestion and Exposure in Chapter 5 for more details.)

Sea otters that are exposed to oil during the Early Phase of a spill may exhibit signs of respiratory distress associated with interstitial or subcutaneous emphysema. This condition may be diagnosed during physical examinations. The axillary area and neck of the otters should be palpated and the presence and location of subcutaneous air recorded on the animal's medical chart. Crepitation in the axillary areas is an indicator of serious pulmonary damage (see Injuries to the Respiratory Tract in Chapter 5). Pulmonary distress, including hyperventilation, congested nasal passages, and diaphragmatic breathing, should also be noted. The interstitial form of emphysema can be confirmed only by radiography or during necropsy. Treatment of this condition is limited to supportive care. Diazepam (0.2 mg/kg PO or 0.1 mg/kg IM) may be administered to calm excited or agitated otters that exhibit labored breathing or hyperventilation. Diazepam should never be given to otters that show symptoms of shock. Positive pressure inhalation anesthetics or gases are contraindicated for otters with pulmonary disorders.

*Treatment of bullous and subcutaneous emphysema is limited to supportive care. Diazepam (0.2 mg/kg PO or 0.1 mg/kg IM) may be administered to calm excited or agitated otters exhibiting labored breathing or hyperventilation. Diazepam should never be given to otters that show symptoms of shock.*

### Treatments for Late Phase Sea Otters

Sea otters contaminated during the Late Phase of a spill usually benefit from a twenty-four to thirty-six hour rest period before cleaning and treatment (see Chapter 11). Late Phase otters that have encountered light sheen oil that does not penetrate the underfur or disrupt the insulating air layer do not require cleaning. These otters should be placed in a holding pool for observation. If the otter's fur appears normal and maintains its insulating properties, then the animal should be moved to a prerelease facility as soon as possible after physical examination and blood sampling (see Chapter 12). Sea otters are able to remove small amounts of crude oil from the surface of their fur during normal grooming. However, it will be necessary to clean small patches of oil if it has penetrated the underfur.

It is unlikely that Late Phase otters have ingested oil in sufficient amounts to cause a toxic effect. Unless fecal and blood tests indicate otherwise, activated charcoal adsorbents should not be administered. Likewise, interstitial and subcutaneous emphysema are rarely observed in otters during the Late Phase of a spill. Because this group of animals is less prone to shock and hypothermia, organ congestion and tissue damage associated with circulatory collapse are rare. Treatment protocols should be conservative and based on the results of a physical examination, blood analysis, and behavior.

## SUMMARY

The highest incidence of medical problems in sea otters will occur when oil is most toxic during the first three weeks or Early Phase of a catastrophic spill. The rehabilitation team should be prepared to treat animals with pulmonary distress, hypoglycemia, and thermal instability during this phase. As the oil toxicity declines, fewer medical problems are encountered. During the Late Phase, the team should consider the benefits of stabilization periods for animals arriving at the facility. As the degree of external and internal oiling decreases, preparations for halting capture should be considered, as the stress of captivity will eventually exceed the benefits of rehabilitation.

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# Chapter 5

# Diagnosing and Treating Common Clinical Disorders of Oiled Sea Otters

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Susan Donoghue

The clinical disorders exhibited by oiled sea otters will depend on the type of oil encountered and the degree and duration of exposure. Unfortunately, much of this information is unavailable when otters are captured during an oil spill. The route of exposure and duration of contamination can only be inferred from the date of the spill, the rate of oil weathering, and the movement of the oil into otter habitats. To overcome this problem, Williams et al. in Chapter 4 suggest that oil spills be divided into Early and Late Phases. This division enables veterinarians to plan for the type of clinical problems most often encountered when the oil is concentrated and fresh, or after the oil has dispersed and weathered.

Depending on the rate of weathering, the detrimental effects of oil are greatest during the first two to three weeks or Early Phase of a spill (Neff, 1990). During this period, otters often arrive at the rehabilitation center completely covered with fresh oil and displaying the severest medical problems. These animals require immediate and often long-term care if they are to survive. In contrast, the period of treatment and recovery may be short for otters lightly contaminated with weathered oil during the Late Phase of a spill. Some Late Phase otters may even be healthy enough to bypass the rehabilitation process and be sent directly to a prerelease facility. It is important to remember that the primary objective of any clinical regimen will be the graduation of otters through the successive stages of rehabilitation for the purpose of release.

This chapter describes the etiology, clinical manifestations, and treatment of specific disorders that commonly occur in oiled sea otters. A summary of symptoms and recommended treatments is provided in Table 5.5 beginning on page 84. We divide the chapter into three sections: disorders that occur during the Early Phase of a spill, disorders common to both phases of an oil spill, and long-term treatments. Veterinary clinicians are also referred to Chapter 1 for a discussion of the pathology, toxicology, and clinical history of oiled sea otters during the *Exxon Valdez* oil spill (EVOS) and to Chapter 4 for emergency treatment methods and assessment of oil exposure. Appendix 6 lists the equipment required for treating oiled sea otters.

## DISORDERS COMMON TO THE EARLY PHASE OF OIL SPILLS

Whether the cause is related to oil exposure or stress, six primary medical problems have been identified for Early Phase sea otters (Table 5.1). The majority of sea otters arriving at the rehabilitation center during the Early Phase will be heavily or moderately oiled and require immediate cleaning. Special care should be taken when handling animals exhibiting signs of hypothermia or respiratory distress. Unnecessary movement or agitation may induce cardiac arrhythmias and interstitial emphysema associated with these conditions (see below).

### Hypothermia

*(a) Etiology.* For most mammals, hypothermia is defined as a core temperature less than 35 °C (95 °F) (Knochel, 1985). As body temperature declines, heat production is increased by shivering and heat loss is reduced by decreased peripheral blood flow. If the core temperature drops below 32 °C (90 °F), shivering ceases, muscle tone increases, and the animal may appear in rigor mortis.

*Hypothermia is defined as a core temperature less than 35 °C (95 °F). Clinical manifestations of hypothermia include locomotor incoordination, disorientation, and lethargy.*

Hypothermia is a serious threat to sea otters during an oil spill. Because oil destroys the insulating quality of the otter's fur, contamination can result in a rapid decrease of core temperature, especially if the animal remains in the water or is exposed to wind, rain, and cold air temperatures. Oiled otters often forgo feeding to haul out on shore or spend additional time grooming their contaminated fur. The result is a rapid decline in food intake, which can result in hypoglycemia and dehydration, factors that further predispose the otter to hypothermia.

*(b) Clinical Manifestations and Diagnosis.* The normal rectal temperature of sea otters ranges from 37–39 °C (98.6–102 °F). During the EVOS,

Table 5.1
Primary disorders of oiled sea otters during the Early Phase (less than three weeks) and Late Phase (greater than three weeks) of a spill.

**Disorders Common to the Early Phase**

1. Hypothermia
2. Hyperthermia
3. Petroleum hydrocarbon toxicosis
4. Injuries to the respiratory tract
5. Hypoglycemia
6. Shock/seizures

**Disorders Common to Early and Late Phases**

1. Hepatic dysfunction
2. Renal dysfunction
3. Gastrointestinal disorders
4. Anemia
5. Stress

more than 36% of heavily and moderately oiled sea otters arriving at rehabilitation centers were diagnosed as hypothermic. The lowest core body temperature recorded was 29.4 °C (85 °F) for an otter that arrived cyanotic and unconscious.

*The normal rectal temperature of sea otters ranges from 37-39 °C (98.6-102 °F).*

Clinical manifestations of hypothermia include locomotor incoordination, disorientation, and lethargy. Peripheral vasoconstriction and shivering are frequent physiological manifestations of mild hypothermia as core temperature declines to 32 °C (90 °F). At lower core temperatures, hyporeflexia, stupor, cessation of shivering, and muscle rigidity become evident (Knochel, 1985). Left untreated, the hypothermic animal will become unconscious. Reductions in heart rate, blood pressure, peripheral vascular resistance, cardiac output, and central venous pressure occur during severe hypothermia. These cardiovascular changes have a profound effect on organ function and may lead to long-term cellular damage, particularly in metabolically active tissues such as the liver and brain (see Chapter 1). In view of this, the attending veterinarian must consider the possibility of a previous hypothermic event and consequent organ damage for oiled otters, despite the presentation of a normal body temperature during initial examinations.

One of the greatest dangers associated with hypothermia is cardiac arrhythmias, which can result in ventricular fibrillation and death, particularly at core temperatures below 28 °C (82 °F) (Knochel, 1985). Severe shivering contributes to lactic acid accumulation and resultant metabolic abnormalities. Metabolic acidosis and hyperkalemia may occur if hypothermia is prolonged. The concomitant metabolic imbalance leads to cardiac arrhythmias (Bowen and Bellamy, 1988). Atrial fibrillation and ventricular tachycardia also may occur in cases of severe hypothermia. Physical stimulation predisposes the animal to the development of these arrhythmias. Therefore, handling and physical restraint of the hypothermic otter should be minimized.

Creatine phosphokinase (CPK) increases in the blood during severe hypothermia as a result of cellular damage. We found that serum CPK was elevated in 68% of the oiled otters that died during the EVOS (Appendix 3, Figure F). However, CPK also may increase from handling stress and from cardiac and skeletal muscle damage (capture myopathy syndrome) not associated with a hypothermic event (Bossart and Dierauf, 1990). Therefore, CPK should not be considered a diagnostic indicator of cellular damage resulting exclusively from hypothermia.

*(c) Treatment.* We recommend measuring the core temperature of all sea otters entering the rehabilitation center. Body temperature should also be measured every thirty minutes in anesthetized otters during cleaning. A digital thermometer with a flexible thermocouple probe (Physiotemp, Inc.) should be used. The probe should be inserted at least fifteen cm into the rectum and may be left in place during cleaning and treatment. Glass thermometers are not recommended.

*The core temperature of all sea otters entering the rehabilitation center should be measured.*

Treatment of the hypothermic animal involves internal and external rewarming and will depend on the state of consciousness and degree of oiling. Passive rewarming at a rate of 0.5 °C (1 °F) per hour is optimal (Knochel, 1985). Often the core temperature of mildly hypothermic

*Passive rewarming at a rate of 0.5 °C (1 °F) per hour is optimal for hypothermic otters. The core temperature of mildly hypothermic otters will return to normal without additional rewarming therapy if the animal is placed in a warm (20 °C, 68 °F) room.*

otters will return to normal without additional rewarming therapy if the animal is placed in a warm (20 °C; 68 °F) room. Alert animals may facilitate rewarming by grooming or shivering. The animals should be placed in a dry, well-ventilated cage during this period. If cleaning is delayed, the coat of the otter should be dried with towels or a pet dryer set at room temperature to reduce further heat loss.

Usually, the hypothermic otter is extensively covered with fresh crude oil and is lethargic. In cases of severe hypothermia (core temperature less than 32 °C or 90 °F) or prolonged hypothermia lasting more than twelve hours, active rewarming is recommended (Zenoble, 1980). Laying the hypothermic otter on a recirculating warm water veterinary pad (Aquamatic K Pad, American Hospital Supply) or plastic bags filled with warm water will enhance rewarming. Sedated or lethargic otters thermoregulate poorly and will rapidly gain or lose heat during cleaning (Davis et al., 1988). The veterinarian may use this as an opportunity to slowly rewarm the hypothermic otter by maintaining the wash and rinse water temperatures between 37–40 °C (98.6–104 °F).

Active external rewarming by immersion in warm water is potentially dangerous. External rewarming may cause rewarming shock when lactic acid washed out of previously hypoxic tissues leads to severe metabolic acidosis (Knochel, 1985). Earlier studies also described a paradoxical decrease *(after-drop)* in core temperature due to peripheral vasodilation associated with warm water immersion in chronic cold-stress patients. It was believed that cold blood returning from the periphery cooled the myocardium and increased the likelihood of ventricular fibrillation. However, in more recent investigations, the phenomenon of after-drop in body temperature has been difficult to document. There are insufficient stores of blood in vasoconstricted peripheral areas to cause a decrease in myocardial temperature (Lloyd, 1986). Rather than an after-drop in core temperature, the balance between the size of the vascular bed and the circulating blood volume (both of which depend on vasomotor tone and state of hydration) was identified as a critical factor for the survival of humans during rewarming. Rewarming by warm water immersion is currently considered beneficial if cardiovascular and respiratory functions are monitored. Thus, there is growing belief that rewarming by warm water immersion is a fast, effective way of treating hypothermia when the patient is closely monitored. This method is recommended for severely hypothermic animals when core temperature is below 32 °C (90 °F). Water temperature should be 37–40 °C (98.6–104 °F) and the animal's vital signs, especially heart rate, must be monitored throughout rewarming.

Several methods of internal rewarming are possible (e.g. high colonic irrigation, peritoneal dialysis, hemodialysis, intragastric lavage). Most of these techniques are impractical in rehabilitation centers or may cause additional medical complications for animals that are already severely stressed. Rewarming by the administration of warm fluids is the safest and preferred method of treatment. Fluid replacement provides additional benefits by improving peripheral circulation and the cardiac output of a hypothermic animal. The fluids should be prewarmed to 37–39 °C (98.6–102 °F) by passage though a hot water bath or by a bacteriologic incubator. The fluids may be administered subcutaneously or intravenously through the jugular vein or popliteal vein. If the animal is unconscious or sedated, large bore jugular catheters can be used effectively. Lactate-free and potassium-free fluids such as normal saline or a 1-to-1 mixture of 5% dextrose and normal saline (20 ml/kg SQ or IV) are preferred because of the electrolyte and metabolite imbalance of hypothermic patients. A solution containing 10–20% dextrose (10–20 ml/kg IV) is recommended for otters that are hypoglycemic as well as hypothermic. Plasma pH and electrolyte concentrations should be monitored hourly until core temperature returns to 37–39 °C (98.6–102 °F).

During rewarming, sodium-potassium exchange accelerates. As a result, hypokalemia may occur, which can cause cardiac arrhythmias. If cardiac failure occurs, the heart of a hypothermic animal may be unresponsive to lidocaine injections. Cardiopulmonary resuscitation (CPR) and the administration of oxygen should be initiated and continued while core temperature is being raised (Zenoble, 1980). CPR, oxygen administration, intravenous glucose, and warm water immersion were effective in reviving an unconscious, severely hypothermic otter during the EVOS.

Complications following rewarming can include pneumonia, gastric erosions, intravascular erosions, and acute renal tubular necrosis, with pneumonitis the most common problem in human patients (Bowen and Bellamy, 1988). Antibiotic therapy following rewarming along with corticosteroids to combat shock are recommended. Note that the delayed metabolism of drugs in hypothermic animals predisposes them to over medication.

In summary, all animals should be monitored closely during rewarming procedures. Passive rewarming at a rate of 0.5 °C (1 °F) per hour in a room at 20 °C (68 °F) is the preferred treatment for mildly or moderately hypothermic otters. Severe hypothermia (core temperature less than 32 °C or 90 °F) should be treated by intravenous or subcutaneous administration of warm, normal saline or a 1-to-1 mixture of normal saline and 5% dextrose. External rewarming by immersion in warm water also is recommended, but the veterinarian or animal care specialist must closely monitor the animal's vital signs.

***Severe hypothermia (core temperature less than 32 °C) should be treated by the intravenous or subcutaneous administration of warm, normal saline or a 1-to-1 mixture of normal saline and 5% dextrose. External rewarming by immersion in warm water is also recommended, but the veterinarian or animal care specialist must closely monitor the animal's vital signs.***

### Hyperthermia

Panting, dry mucous membranes, lethargy, hind flippers that are warm to the touch, and a core temperature exceeding 39 °C (102 °F) are manifestations of hyperthermia in sea otters. This condition can occur during transport, anesthesia, or whenever caged otters are placed in a poorly ventilated area warmer than 20 °C (68 °F) without access to water or ice. Despite the decrease in insulation resulting from oily fur, sea otters easily overheat when out of water. Excessive grooming, inadequate ventilation in transport cages, and hyperactivity associated with handling exacerbate the problem.

***Hyperthermia is easily prevented by keeping caged sea otters in well ventilated areas at temperatures below 15 °C (60 °F) and by placing chipped ice in the cages.***

Hyperthermia in sea otters is easily prevented by placing the animals in seawater at normal seasonal ocean temperatures. Otters in dry cages should be kept in well ventilated areas at temperatures near 15 °C

*Hyperthermic otters (core temperature greater than 40 °C) should be cooled by wetting the fur, placing ice packs on the hind flippers, and by adjusting the rinse water temperature during washing.*

(60 °F). The grated bottom of transport cages or critical care cages should be partially covered with chipped ice to enable the otter to cool itself. The otter may also eat the ice which provides additional cooling and helps to prevent dehydration. In extreme cases, where the animal's core temperature exceeds 40 °C (104 °F), the hind flippers should be sprayed with water and packed in ice for short periods. Because the flippers are well vascularized, cooling them will provide an immediate, short-term benefit to the overheated otter. Care should be taken to avoid localized vasoconstriction of the flippers due to prolonged contact with ice packs.

### Petroleum Hydrocarbon Ingestion and Absorption

*(a) Etiology.* There is considerable confusion concerning the detrimental effects of petroleum hydrocarbon ingestion and absorption. Much of the confusion undoubtedly originates from the fact that oil is a complex mixture of aromatic and aliphatic petroleum hydrocarbons and inorganic compounds, each varying in toxicity. The situation is further complicated by the fact that the chemical composition of oil, and hence its toxicity, changes as it weathers and dissipates. Thus, marine mammals may be exposed to different concentrations of potentially harmful petroleum hydrocarbons during the course of a spill.

*The probability of systemic hydrocarbon exposure is greatest during the first weeks of a spill when the oil is fresh and the concentration of aromatic hydrocarbons is highest. As a group, the polycyclic aromatic hydrocarbons (PAHs) are the most toxic.*

Each oil spill will be different, and the effects on wildlife will depend on the type of petroleum hydrocarbons encountered, the degree of weathering, and the duration of exposure. As discussed in Chapter 4, the level of toxicity and the probability of systemic hydrocarbon exposure are greatest during the first weeks of a spill when the oil is fresh and the concentration of aromatic hydrocarbons is highest. In the case of chronic spills, as may occur at marine oil terminals and in harbors, the period of toxicity may be prolonged. Ambient air and water temperatures, weather conditions, and sea state will greatly affect the rate of oil weathering.

Individual petroleum hydrocarbons may be cardiotoxic, hemotoxic, neurotoxic, or hepatotoxic and may induce central nervous system depression (Amdur et al., 1991). As a group, the polycyclic aromatic hydrocarbons (PAHs) are the most toxic. The inhalation of high concentrations of petroleum hydrocarbon vapors can cause excitement, depression, unconsciousness, and death; ingestion can cause severe diarrhea, cardiovascular collapse and organ degeneration (Coppock et al., 1986). The effects of benzene, an aromatic compound commonly found in crude oil, have been examined in studies using laboratory mammals. Exposure to benzene may lead to dose-dependent changes in hematological parameters and lesions in the thymus, bone marrow, spleen, and testes (Ward et al., 1982).

Damage to individual organ systems may occur by direct exposure to petroleum hydrocarbons or secondarily from toxic, metabolic by-products. The lungs, kidneys, and liver are target organs for many toxicants (Klaassen and Rozman, 1991). Petroleum hydrocarbons of high vapor pressure are eliminated through the lungs. The lungs also may reduce hydrocarbons into secondarily toxic metabolites. Because the liver is the site of detoxification and elimination of many compounds, it too is considered vulnerable to the effects of petroleum hydrocarbon absorption. The kidneys are susceptible to damage by toxicants because they receive a large portion (approximately 20%) of the cardiac output, and because tubular secretion and reabsorption may concentrate toxicants within cells. The immune and hematopoietic systems also may be affected.

*(b) Clinical Manifestations and Diagnosis.* The clinical manifestations of petroleum hydrocarbon toxicosis are difficult to distinguish from other medical problems exhibited by oiled otters. Information about the type of oil and date of the spill will aid the veterinarian in estimating the maximum duration of exposure and the relative toxicity of the contaminant. The degree of external and internal contamination may be assessed by visual examination of the pelt and by blood tests, as described in Chapter 4. Many heavily contaminated otters will spontaneously pass cestodes and acanthocephalids in their feces, providing another indicator of internal oil exposure.

***The clinical manifestations of petroleum hydrocarbon toxicosis are difficult to distinguish from other medical problems exhibited by oiled otters. Oiled otters may appear normal or display a range of clinical signs including excitability, seizures, CNS depression, lethargy, ataxia, emesis, diarrhea, respiratory distress and cardiac arrhythmias.***

Otters exposed to petroleum hydrocarbons may appear normal during initial examination or display a range of clinical signs including excitability, seizures, CNS depression, lethargy, ataxia, emesis, diarrhea, respiratory distress, and cardiac arrhythmias. The detection of oil in the feces will confirm ingestion. A simple test is to suspend and shake fecal material in water; petroleum products will separate and float to the surface. Hepatocellular enzymes may be elevated (Appendix 3, Figure E). Crude oil can be irritating to mucous membranes; corneal ulceration and photophobia may be apparent.

Aspiration pneumonia is a common and serious clinical disorder which can develop in cattle, cats, and dogs exposed to a variety of petroleum products (Hatch, 1988). However, this condition was never observed in sea otters during the EVOS.

*(c) Treatment.* To prevent further absorption or ingestion of crude oil, sea otters should be moved from the spill area and cleaned with detergent (see Chapter 6). Treatments should focus on delaying absorption and promoting the elimination of ingested oil. The induction of emesis for eliminating ingested petroleum compounds is not recommended due to its limited value when treatment is delayed more than two hours after oil ingestion and the high risk of inhalation pneumonia. Likewise, gastric lavage is not recommended. The oral administration of mineral oil (1 ml/kg) has been used to treat accidental kerosene poisoning in mammals, and may mitigate the absorption of ingested petroleum compounds (Bailey, 1980; Coppock et al., 1986). However, this technique has not been tried on oiled sea otters and it risks aspiration pneumonia associated with vomiting.

Adsorbents such as activated charcoal are often effective in reducing absorption of many ingested toxicants. Several products are available. Toxiban™ (6 ml/kg; approximately 120 ml/dose) was administered orally to heavily and moderately oiled sea otters during the EVOS. A slurry of activated charcoal and water is administered to sedated sea otters via a syringe connected to a stomach tube, (see section on hypoglycemia for details of tube placement). To reduce stress associated with handling and sedating the otter, we do not recommend a multiple treatment program. Other promising treatments include compounds, such as Questran™, that bind bile acids in the

***Adsorbents such as activated charcoal may reduce absorption of many ingested toxicants. Toxiban™ (6 ml/kg; approximately 120 ml/dose) was administered orally to heavily and moderately oiled sea otters during the EVOS.***

gastrointestinal tract, thereby preventing hepatic recycling of toxicants. To date, this product has not been used on oiled sea otters.

Oral treatments are less effective against dermal absorption and inhalation of petroleum hydrocarbons. Absorbed compounds may be sequestered in fat or removed by the liver, kidneys, and lungs. The elimination process of some toxicants may be expedited by diuretics, peritoneal dialysis, or manipulation of urinary pH (Bailey, 1980). However, we do not recommend these procedures for oiled sea otters. Immunosuppression, metabolic imbalance, impaired renal and hepatic function, and cardiac arrhythmias directly or indirectly associated with the absorption of petroleum hydrocarbons may complicate these procedures. Most treatments for petroleum hydrocarbon exposure will be limited to supportive care and the mitigation of its effect on individual organ systems.

### Injuries to the Respiratory Tract

*(a) Etiology.* Exposure of the respiratory tract to air borne or blood borne petroleum hydrocarbons may lead to pulmonary damage and decreased gas exchange across the alveoli. The specific injury will depend on the route of exposure and can involve the upper and lower respiratory tract. Damage to the gas exchange surfaces will increase the work of breathing.

Injuries to the respiratory tract commonly occurred in oiled otters during the first three weeks of the EVOS. Over 75% of oiled sea otters brought to rehabilitation centers during this period showed respiratory distress and interstitial emphysema (Figure 5.1; Williams and Davis, 1990). The incidence of emphysema during the Early Phase suggests that exposure to volatile petroleum hydrocarbons was a significant contributing factor. Depending on environmental conditions, aromatic hydrocarbons (e.g. benzene, toluene, xylene) will evaporate within days of an oil spill. These are considered the most toxic compounds in crude oil and are known to cause damage to the lungs and mucous membranes of the bronchial airways (Geraci and St. Aubin, 1990).

*(b) Clinical Manifestations and Diagnosis.* The inhalation or aspiration of toxic compounds produces many pathologic changes in respiratory tissues including: 1) bronchospasm, 2) impaired mucociliary clearance, 3) mucosal sloughing, 4) atelectasis, and 5) pulmonary edema (Farrow, 1980). Tachypnea, congestion, and the use of accessory respiratory muscles for ventilation are typical clinical manifestations of a respiratory tract injury. The respiratory rate may be accelerated above twenty breaths/minute in oiled sea otters. In other mammals, long-term health problems following exposure to a variety of petroleum hydrocarbons can include aspiration and postinhalation pneumonia. However, histologic examination indicated that pneumonia did not occur in sea otters that died during the EVOS (Chapter 1).

***Tachypnea, congestion, and the use of accessory respiratory muscles for ventilation are typical clinical manifestations of a respiratory tract injury.***

Respiratory tissue injury in oiled otters ranges in severity from irritation of the nasopharyngeal membranes and rhinitis to interstitial and subcutaneous emphysema. Rhinitis and sinusitis can be persistent problems in oiled sea otters. Clinical manifestations are epistaxis and purulent nasal discharge. During the EVOS, cultures and sensitivity tests revealed the presence of pathogenic *E. coli* and *Proteus*. Oral and

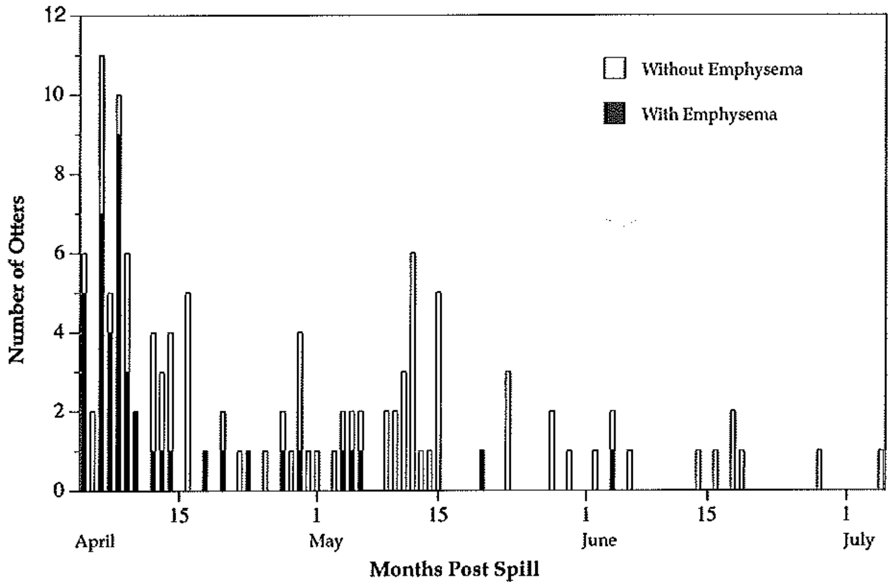



Figure 5.1
The incidence of interstitial and subcutaneous emphysema in relation to time following the EVOS. Height of the bars represent the total number of otters with (dark bars) and without (open bars) evidence of emphysema upon necropsy.

pharyngeal cavities should be examined for edema and swelling. Discharges should be examined microscopically for cellular debris, red blood cells, neutrophils, and bacteria.

The emphysema observed in oiled sea otters may range in severity and location. The condition is classified as: 1) severe (bullous emphysema in the lungs and interstitial areas), 2) moderate (bullous emphysema throughout the lungs), 3) mild (focal areas of lung damage), and 4) none (no evidence of interstitial or subcutaneous emphysema). Subcutaneous emphysema is characterized by pockets of air below the skin. Small bubbles may be felt subcutaneously in the axillary region of the otters. In severe cases, air pockets can be felt or seen beneath the skin along both sides of the neck, thorax, and along the spine. Postmortem examination of otters that died with this condition during the EVOS revealed that the subcutaneous emphysema arose from ruptured membranes in the lungs. Air escaping from the lungs moved along the mediastinum, through the thoracic inlet and accumulated in subcutaneous tissues. To assess the presence of subcutaneous emphysema, the axillary and chest region of the animal should be palpated during the initial physical examination. Gas bullae may be felt as distortions below the skin and can be heard "popping" (crepitation) when pressed lightly. Roentgenographic examination can confirm this condition, but is of little practical use and subjects the animal to additional stress.

*To assess the presence of subcutaneous emphysema, the axillary and chest region of the animal should be palpated during the initial physical examination. Gas bullae may be felt as distortions below the skin and can be heard "popping" (crepitation) when pressed lightly.*

The development of interstitial and subcutaneous emphysema in oiled sea otters is not completely understood. One possible explanation is that chemical irritation of the airways from breathing petroleum hydrocarbon vapors leads to bronchial or laryngeal constriction. Nasal passages may become congested due to inflammation of the mucous membranes. When accompanied by labored breathing, alveolar rupture and bullae formation may ensue. Consequently, the handling of animals with suspected emphysema (i.e. heavily and moderately oiled otters captured during the first weeks of a spill) should be minimized.

*Diazepam (0.2 mg/kg PO or 0.1 mg/kg IM) may be administered to prevent hyperventilation and to reduce the animal's activity level and metabolic rate.*

*(c) Treatment.* The treatment of respiratory injuries is limited and based on methods for mitigating human injuries due to inhalation of toxic substances (Farrow, 1980). Further exposure should be prevented by removing the animal from the spill area and by cleaning contaminated fur. The correlation between the severity of emphysema and presence of volatile components of fresh crude (see Chapter 4) indicates that these measures should occur as soon as possible during the Early Phase of a spill. If the animal is agitated, diazepam (0.2 mg/kg PO or 0.1 mg/kg IM) may be administered to prevent hyperventilation and to reduce the animal's activity level and metabolic rate.

*Rhinitis and sinusitis should be treated with enrofloxacin (2.5 mg/kg bid IM or PO) for mature otters.*

Rhinitis and sinusitis, as determined from cultures and sensitivity tests, should be treated with antibiotics. Initially the otters may be placed on enrofloxacin (2.5 mg/kg bid IM or PO) for mature otters and amoxicillin (12 mg/kg bid IM) for immature otters. Although antibiotics may decrease the frequency of epistaxis and nasal discharge, full recovery may take as long as three months. Respiratory parasites such as nasal mites should be controlled with Ivermectin (50 ug/kg as a single dose SQ or PO).

*The treatment of interstitial and subcutaneous emphysema is limited to supportive care.*

The treatment of interstitial and subcutaneous emphysema is limited to supportive care. In clinical settings, supplemental oxygen has been used to help alleviate respiratory distress. However, its large-scale use for oiled sea otters is impractical. Positive pressure ventilation systems may aggravate this condition by inducing the formation of bullae in alveolar membranes weakened by exposure to petroleum hydrocarbons; positive pressure delivery of oxygen is not recommended. Positive pressure and inhalation anesthetics during cleaning procedures also are contraindicated for otters showing signs of emphysema. Aminophylline (10 mg/kg bid PO, slow release form), a bronchodilator, is recommended for any otter exhibiting respiratory distress. However, aminophylline is a diuretic and can cause cardiac arrhythmias. Therefore, this treatment is not recommended for animals exhibiting renal insufficiency or hypothermia.

## Hypoglycemia

*The high metabolic rate of oiled sea otters predisposes these animals to hypoglycemia when food is withheld for several hours.*

*(a) Etiology.* Hypoglycemia (plasma glucose less than 60 mg/dl) in oiled sea otters may result from: 1) inability to feed prior to capture and a reduction in glycogen stores, 2) fasting during capture and transport, 3) impaired hepatic function or intestinal absorption, or 4) stress and shock. The high metabolic rate of sea otters in general (Costa and Kooyman, 1982), and oiled sea otters in particular (Davis et al., 1988), predisposes these animals to hypoglycemia when food is withheld for several hours. Other factors such as anorexia, hypothermia, and fever also may predispose them to hypoglycemia. Following the EVOS, 40% (n = 27) of the otters that died were hypoglycemic (Appendix 3, Figure A).

*(b) Clinical Manifestations and Diagnosis.* Symptoms of hypoglycemia include pulmonary edema, hypothermia, and central nervous system dysfunction (i.e. depression, seizures, muscular weakness, and loco-

motor incoordination). In severe cases, the animal may become unconscious, and prompt treatment is critical. Plasma glucose concentration should be measured during the initial physical examination of all oiled otters. Reagent strips (Gluco-Stix™, Ames Laboratories) provide a rapid, qualitative measure of blood glucose concentration. This allows the veterinarian to verify the hypoglycemia and initiate emergency treatments. We recommend a subsequent quantitative measurement of plasma glucose as soon as possible. Desktop blood chemistry analyzers (Eastman Kodak, Inc.; Abbot Laboratories) or small digital analyzers for routine blood glucose monitoring in diabetics provide rapid results from small quantities of blood.

(c) *Treatment.* Hypoglycemia is treated by increasing the otter's intake of dextrose (glucose) as soon as possible. The voluntary ingestion of dextrose can be achieved by offering chipped ice balls containing a 50% dextrose solution. If the animal is lethargic or semiconscious, administer 10–20% dextrose (10–20 ml/kg IV to effect). The oral administration of 50% dextrose (1 ml/kg) through a stomach tube will provide an immediate but temporary increase in the plasma glucose concentration. In general, the otter will respond to treatment within thirty minutes of fluid administration, but relapses may occur if the underlying dietary, hepatic, or gastrointestinal problems are not resolved. Following initial treatment, hypoglycemic otters should be fed frequently (at least every hour) until stable. If seizures occur after blood glucose is stabilized, diazepam (0.1 mg/kg IM) should be administered.

*Hypoglycemia is treated by increasing the otter's intake of dextrose (glucose). If the animal is lethargic or semiconscious, administer 10–20% dextrose (10–20 ml/kg IV to effect) or 50% dextrose (1 ml/kg) through a stomach tube.*

Insulin resistance may limit the effectiveness of prolonged glucose administration and carbohydrate feeding to supplement calories in animals that refuse to eat. If an otter can not be encouraged to eat voluntarily, enteral feeding (stomach tube feeding) may be necessary. Animals that will not eat utilize stored fat and tissue protein for metabolic energy. The primary objective of enteral feeding is to prevent the loss of tissue protein by providing nutrients that can be readily digested and absorbed.

During enteral feeding, the otter should be chemically restrained (see Chapter 3), although severely debilitated otters may be physically restrained by experienced handlers. A plastic or wooden dowel should be placed between the premolars, and a stomach tube inserted into the esophagus to a premeasured length (about twenty cm in adult otters). The tube can usually be seen or felt to pass on the left side of the trachea. Proper placement of the tube in the stomach should be tested by listening for bubbling sounds when air is blown into the tube. The enteral diet is injected into the feeding tube with a syringe. After feeding, the tube is sealed while it is withdrawn to prevent leakage of residual fluids into the pharynx.

Enteral diets are slurries of common food items blended with a diluent of either liquid enteral (e.g. Pedialyte™) or water. Carnivores require more fat and protein than the enterals manufactured for humans. An example of a slurry suitable for sea otters is shown in Table 5.2. Resting adult sea otters require about 75 kcal/kg/day in their diet in order to maintain their body weight (Davis et al., 1988); additional food energy would be required for an otter to gain weight. Because of stress caused by orogastric intubation, enteral meals are given only three times daily. Thus, meal size is relatively large. An otter weighing 40 kg requires 3.0 kg (1.0 kg per meal x 3) of the high-energy diet shown in Table 5.2 daily.

Calories and nutrients given parenterally consist of solutions of glucose, amino acids, and lipid emulsions administered intravenously (Table 5.3). For carnivores, dextrose (25 or 50% solutions), amino acids (3.5–10% solutions), and lipids (10 or 20% emulsions) are combined to provide about 35–45% of calories from carbohydrates, 20–25% of calories from amino acids, and 35–45% of calories from fat. Solutions of vitamins, trace minerals, and electrolytes should be provided as well. Parenteral nutrition is expensive, labor intensive, and risks sepsis. For sea otters, it should be used only for critically ill animals, and the switch to enteral or normal feeding should be made as soon as possible.

## Shock

*The symptoms of shock must be recognized and treated quickly.*

*(a) Etiology.* All forms of shock are characterized by acute circulatory insufficiency and inadequate capillary perfusion. Hypovolemic shock due to severe blood loss is rare in oiled sea otters, but should be considered in cases of gastrointestinal hemorrhage (see below). Oiled otters that are hypothermic or stressed may also experience shock due to reduced cardiac output or peripheral vasodilatation. A consequence of the reduction in tissue perfusion is localized hypoxic ischemia and impaired cellular function. To compensate for the general reduction in tissue circulation, the body may respond by readjusting blood flow to vital organs such as the heart and brain. At the cellular level, poor tissue perfusion will result in cellular swelling, intracellular acidosis (as a result of elevated lactic acid production), and extracellular

Table 5.2
Formula for the enteral feeding of sea otters. Metabolizable energy (ME) is from an analysis of gross energy contents of the food items.

| Item | Quantity (grams) | ME (Kcal) | Protein | Fat | CHO |
|---|---|---|---|---|---|
| | | | (% Kcal ME) | | |
| Squid (*Loligo* sp) | 100 | 76 | 82 | 10 | 8 |
| Clams (*Spisula solidissima*) | 100 | 87 | 78 | 22 | 0 |
| Pacific Mackerel (*Scomberomorus japonicus*) | 100 | 195 | 42 | 58 | 0 |
| Clinical Care Feline Liquid Diet, one can | 355 | 327 | 30 | 45 | 25 |
| TOTAL | 655 | 685<br>Approx. 1.0 Kcal/g | 45 | 42 | 13 |

Table 5.3
Examples of parenterals used in nutritional support.

| Product | Nutrient | Manufacturer |
|---|---|---|
| Aminosyn | Amino acids, in 5 concentrations from 3.5-10% | Abbot Laboratories North Chicago, IL 60064 |
| Aminosyn-PF | Amino acids, pediatric formula | Abbott Laboratories |
| ProcalAmine | Amino acids (3%), glycerin (3%), electrolytes | Kendall McGaw Lab, Inc. Irvine, CA 92714-5895 |
| TrophAmine | Amino acids, 6 and 10% solutions | Kendall McGaw Lab, Inc. |
| Liposyn | Fatty acids, in 10 and 20% emulsions | Abbott Laboratories |
| Many products | Micronutrients | LymphoMed Inc. Melrose Park, IL 60160 |

acidemia. The onset of these conditions will depend on the animal's body temperature.

*(b) Clinical Manifestations and Diagnosis.* It is critical that symptoms of shock be recognized and treated quickly. Primary signs of shock in otters are tachycardia, hyperventilation, depression, muscular weakness, cold hind flippers, and hypotension (poor capillary refill, reduced pulse pressure). Poor peripheral perfusion can be detected by the palpation of cold extremities and observing capillary refill times of mucous membranes. Refill times exceeding two seconds indicate inadequate peripheral perfusion.

***Primary signs of shock in otters are tachycardia, hyperventilation, depression, muscular weakness, cold hind flippers, hypotension, poor capillary refill, and reduced pulse pressure.***

*(c) Treatment.* Treatments for shock will be specific for the individual otter and depend on underlying causes. Detailed treatments are complex and are described in detail elsewhere (see for example, Veterinary Pharmacology and Therapeutics, Iowa State University Press; Current Veterinary Therapy, W. B. Saunders Company). For most oiled sea otters, the veterinarian should initiate fluid volume expansion to reestablish adequate tissue perfusion as soon as possible. Administration of normal saline or a 1-to-1 mixture of normal saline and 5% dextrose (20 ml/kg IV) is recommended. Sodium bicarbonate (1 mEq/kg IV or 50 mg/kg PO) or supplemental dextrose (1 ml/kg of a 50% dextrose solution by stomach tube) may be indicated, if the animal is acidotic or hypoglycemic, respectively. Finally, dexamethasone (1–2 mg/kg/day IM) or methylprednisolone (0.06 mg/kg /day IM or IV) should be administered.

### Seizures

*(a) Etiology.* Seizures in oiled sea otters may be caused by:

1) hypoglycemia,
2) hypothermia or hyperthermia,
3) hepatic encephalopathy,

4) electrolyte imbalances,
5) dehydration,
6) sepsis,
7) exposure to petroleum hydrocarbons, or
8) adverse reaction to anesthetics (i.e. fentanyl).

Periodic seizures in some animals may persist for weeks to months, slowly reducing in frequency and intensity over time.

*(b) Clinical Manifestations and Diagnosis.* Depending on the cause, seizures or convulsions are characterized by one or all of the following signs: unconsciousness, loss of (flaccid) or excess (clonus to rigidity) muscle tone, changes in the autonomic nervous system (urination, salivation, defecation, vomiting), and behavioral abnormalities (vocalization, pacing) (Parker, 1980).

*(c) Treatment.* As with shock, the treatment of seizures will depend on the underlying cause(s). For repeated or prolonged seizures, anticonvulsant drugs may be warranted (diazepam, 0.2 mg/kg PO or 0.1 mg/kg IM). In cases of hypoglycemic seizures, anticonvulsants are not necessary; these animals will respond rapidly to glucose administration (see previous section on Hypoglycemia). Seizures associated with hepatoencephalopathy may be reduced by the oral administration of antibiotics to reduce the number of ammonia-producing bacteria in the bowel (see Hepatic Dysfunction below).

## DISORDERS COMMON TO BOTH PHASES OR THE LATE PHASE OF OIL SPILLS

Sea otters arriving at the rehabilitation center three weeks or more after a spill will usually have light or patchy oil on their fur. Because the oil has weathered and the more toxic components have evaporated or dissipated in the water, fewer medical disorders are found in these animals. Nevertheless, each otter should receive a medical examination and the prophylactic treatments described under Stabilization in Chapter 4. These animals usually are alert and will require sedation if cleaning is necessary. Blood and fecal samples should be taken at this time. Five primary disorders have been identified for sea otters contaminated during the Late Phase of an oil spill (Table 5.1).

### Hepatic Dysfunction

*Hypothermia may lead to hepatic congestion and lipidosis with consequent regional hypoxia and cellular damage.*

*(a) Etiology.* The liver plays a central role in many essential physiological processes, including the biotransformation and detoxification of a wide variety of endogenous and exogenous substances. During the process of detoxifying petroleum hydrocarbons, the liver plays a protective role and bears the brunt of potential adverse effects from toxins. Consequently, of the four tissues examined, the liver showed the highest concentration of petroleum hydrocarbons in oiled sea otters (see Chapter 1).

Histopathologic examination of liver samples from sea otters that died during the EVOS showed that both cardiovascular insufficiency and toxicosis were factors contributing to cellular damage in this organ (Chapter 1; Lipscomb et al., 1993, 1994). Cardiovascular congestion may have resulted from shock caused by hypothermia, sepsis, or stress. Hypothermia, in particular, may lead to hepatic congestion and lipidosis with consequent regional hypoxia and cellular damage. These studies showed that the effects of a hypothermic event on the liver may persist long after the core body temperature and tissue perfusion have returned to normal levels in oiled sea otters.

*(b) Clinical Manifestations and Diagnosis.* The clinical manifestations of liver dysfunction are varied and, even when advanced, may consist of nonspecific signs including fatigue, malaise, fever, anorexia, weight loss, nausea, and vomiting (Ockner, 1985). Most of these signs were evident in heavily oiled sea otters during the first two weeks of the EVOS. Although none of these signs are specific for hepatic dysfunction, veterinarians in the rehabilitation center should recognize that oiled sea otters may experience liver damage. Elevations in the serum concentration of alanine aminotransferase (ALT) and aspartate aminotransferase (AST) are good indicators of hepatocellular damage. Fifty-four percent (n = 34) of the sea otters that died following the EVOS had elevated concentrations of ALT, and 61% (n = 41) had elevated concentrations of AST (Appendix 3, Figure E). Because the enzyme ALT is found primarily in the liver, an increase in the serum concentration is considered specific for hepatocellular damage in many mammals (Kerr, 1989). The enzyme AST is found in cardiac and skeletal muscle, liver, brain, and other tissues. Thus, an increase in serum AST indicates nonspecific tissue damage. Handling stress may also increase this enzyme in pinnipeds (Medway and Geraci, 1986). Nevertheless, an increase in AST in conjunction with ALT (Figure 5.2) reinforces the diagnosis of hepatic damage. Other clinical indicators of liver damage include an increase in serum bilirubin and alkaline phosphatase, hypoalbuminemia, increased prothrombin time (clotting time), and hypertriglyceridemia.

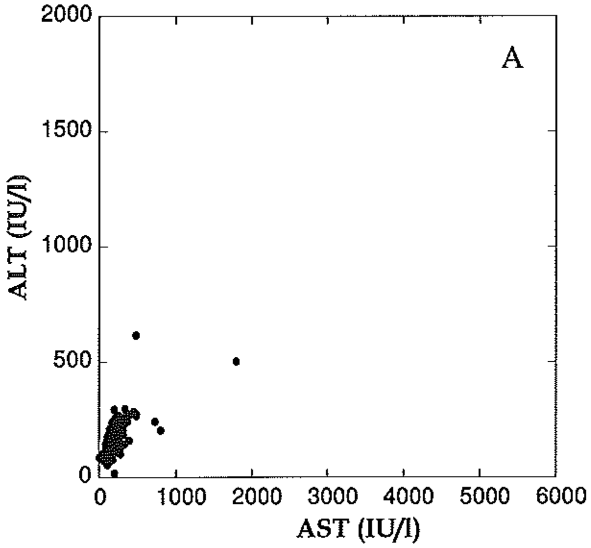
*The clinical manifestations of liver dysfunction may consist of nonspecific signs including fatigue, malaise, fever, anorexia, weight loss, nausea, and vomiting.*

Of the otters necropsied following the EVOS, 30% (n = 41) showed macroscopic evidence of liver damage (friable, discolored, hemorrhagic tissue). Histological examination of the livers showed tissue necrosis, fatty degeneration, hemorrhage, and pericholangitis (inflammation of the tissues that surround the bile ducts). Rather than resulting solely from petroleum hydrocarbon absorption, liver damage in oiled otters has been attributed to several factors, including cardiovascular collapse, hypothermia, shock, renal insufficiency, and sepsis (Lipscomb et al., 1993, 1994).

*Rather than resulting solely from petroleum hydrocarbon absorption, liver damage in oiled otters has been attributed to several factors, including cardiovascular collapse, hypothermia, shock, renal insufficiency, and sepsis.*

Hepatic encephalopathy syndrome can be a serious consequence of liver damage. Subjects with this syndrome show abnormal neurological symptoms including myoclonus (shock-like contractions of muscles), hyperactive muscle stretch reflexes, convulsions, facial grimacing, and blinking (Scharschmidt, 1985). Evidence of these neurological abnormalities were observed during the Early Phase of the EVOS. Although the pathogenesis of hepatic encephalopathy is unclear, it may result from toxic materials that are derived from the metabolism of nitrogenous substrate in the gut (Scharschmidt, 1985). Factors that may precipitate hepatic encephalopathy include azotemia

*Animals with hepatic encephalopathy show abnormal neurological symptoms including myoclonus, hyperactive muscle stretch reflexes, convulsions, facial grimacing, and blinking.*



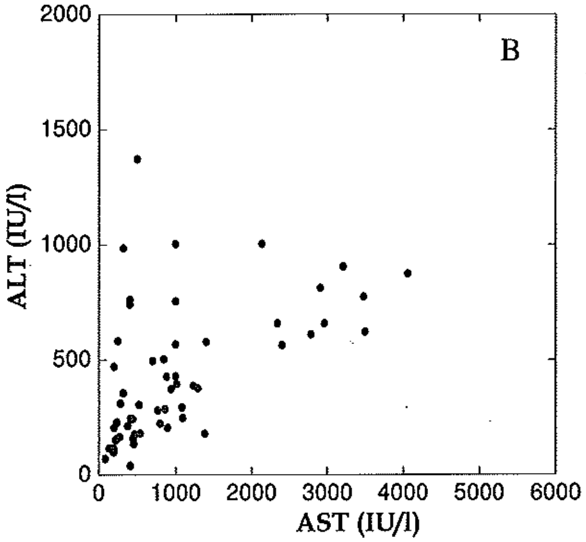




Figure 5.2
Serum ALT concentration in relation to AST concentration for sea otters that were released (A) or died (B) following capture and rehabilitation during the EVOS. The shaded area represents the normal range for healthy, adult sea otters.

(increased BUN), gastrointestinal hemorrhage, infection, a high protein diet, and tissue hypoxia as a result of hypothermia or shock. All of these factors could be present in heavily and moderately oiled sea otters.

*The management of sea otters with liver damage is limited to supportive care. Because sedatives and anesthetics are potentially hepatotoxic, physical restraint should be used for cleaning heavily oiled otters.*

*(c) Treatment.* There is no clinically established way of initiating hepatic regeneration or improving hepatic function; the management of animals with liver damage is largely supportive (Scharschmidt, 1985). Because sedatives and anesthetics are potentially hepatotoxic, physical restraint should be used for cleaning heavily oiled otters. Once the otter is cleaned and clinically stable, all nonessential drugs should be stopped, especially sedatives and potentially hepatotoxic agents.

It is generally recommended that animals with signs of hepatic encephalopathy syndrome be placed on a low protein diet to help reduce the concentration of urea nitrogen in the blood (BUN). Because sea otters normally eat a high protein diet of shellfish, substituting a low protein diet is virtually impossible, unless enteral feeding is considered. The administration of low protein, artificial diets by orogastric intubation may be beneficial for animals with a severely elevated BUN and pronounced signs of hepatic encephalopathy syndrome. Frequent monitoring of blood glucose is necessary, and the administration of a 50% dextrose solution by stomach tube is recommended if the otter becomes hypoglycemic.

Complications associated with liver damage include gastrointestinal bleeding and bacteremia. During the EVOS, oiled sea otters often showed signs of gastrointestinal bleeding throughout the rehabilitation process. Bacteremia generally results from *Staphylococcus aureus* and *E. coli* in humans (Scharschmidt, 1985). Prophylactic antibiotic therapy is recommended for otters that are heavily or moderately oiled (see Chapter 4).

***Complications associated with liver damage include gastrointestinal bleeding and bacteremia. Prophylactic antibiotic therapy is recommended for otters that are heavily or moderately oiled.***

### Renal Dysfunction

*(a) Etiology.* Renal dysfunction may be classified as a prerenal or a primary renal failure. Prerenal dysfunction is associated with decreased renal perfusion as occurs in hypothermic animals. Primary renal failure has many causes including infection, ischemia, and toxemia. Toxic insults, in particular, are a common cause of acute renal dysfunction, usually resulting in irreversible damage to the proximal tubules. However, histopathologic evidence suggests that prerenal failure predominated in oiled otters during the EVOS (see Chapter 1; Lipscomb et al., 1993, 1994).

Acute renal failure (ARF) will result from an abrupt decline in renal function and is characterized by impaired regulation of water and solute balance in the animal. The hallmark of ARF is a decrease in glomerular filtration rate, but the resulting azotemia (increased BUN) may not be evident until severe (75%) renal tubular damage has occurred. Urine volume may be normal or decreased.

No information is available on the susceptibility of sea otters to ARF. However, many of the factors that predispose cats and dogs to ARF are generally present in sea otters during an oil spill. These factors and their probable causes (in parentheses) include:

1) dehydration (inability to feed or anorexia),
2) decreased cardiac output and renal hypoxia (hypothermia and shock),
3) liver damage (hypothermia or toxicant-induced liver damage),
4) sepsis and fever (toxicant-induced immunosuppression and stress), or
5) concurrent use of potentially nephrotoxic drugs (e.g. antibiotics to treat infection).

***The hallmark of ARF is a decrease in glomerular filtration rate, but the resulting azotemia (increased plasma BUN) may not be evident until severe (75%) renal tubular damage has occurred. Urine volume may be normal or decreased.***

*(b) Clinical Manifestations and Diagnosis.* The type and severity of clinical signs for ARF will depend on the kidney's ability to compensate

*Clinical manifestations of ARF may include vomiting, diarrhea, depression, anorexia, oliguria, hypothermia, bradycardia or increase in packed cell volume and total plasma protein concentration.*

for the decreased blood flow. Clinical manifestations may include vomiting, diarrhea, depression, anorexia, oliguria, hypothermia, and bradycardia (Thornhill, 1980). Dehydration, electrolyte abnormalities, and acid-base imbalance are primary indicators of renal dysfunction. Dehydration occurs when fluid loss (from vomiting, diarrhea, and diuresis) exceeds fluid intake. Decreased food intake will also contribute to the fluid deficit. Loss of skin elasticity, dry mucous membranes, and sunken globes indicate dehydration. In severe cases, tachycardia may occur. An increase in packed cell volume and total plasma protein concentration associated with dehydration are also important diagnostic indicators.

*Serum potassium concentrations approaching or exceeding 7 mEq/l should be regarded as an emergency; this concentration of extracellular fluid potassium is liable to induce cardiac arrest.*

Electrolyte abnormalities associated with renal insufficiency have been observed in oiled sea otters, including elevations in serum concentrations of potassium (hyperkalemia), phosphorus (hyperphosphatemia), and chloride (hyperchloremia). Of the adult sea otters that died following the EVOS, 51% (n = 32) had an elevated potassium concentration, 30% (n = 19) had an elevated phosphorus concentration, and 19% (n = 12) had an elevated chloride concentration (Appendix 3, Figures B-D). Serum potassium concentrations approaching or exceeding 7 mEq/l should be regarded as an emergency; this concentration of extracellular fluid potassium is liable to induce cardiac arrest. Only 5% of the otters that died in the rehabilitation center during the EVOS showed a decrease in serum sodium concentration (hyponatremia). Serum calcium concentrations were normal for surviving oiled otters, as well as those that died (Appendix 3, Figure C).

The acid-base balance of oiled otters may be disrupted by impaired renal function or by hypothermia. Although changes in ventilation can compensate for reduced serum bicarbonate during metabolic acidosis, this may not be an option for oiled animals showing poor respiratory function. Decreases in blood pH below 7.0 will cause depression, coma, and hyperkalemia, which in turn can cause cardiac arrhythmias.

In cases of renal insufficiency, there is a decrease in urea excretion and a consequent elevation in serum urea concentration. Blood urea nitrogen (BUN) levels provide an indication of renal function and may be elevated in oiled animals as a result of dehydration, reduced renal perfusion, or primary renal failure. Because a variety of pathological conditions may result in increased serum urea concentrations, elevated BUN should not be used as the only prognostic indicator for renal failure (Kerr, 1989). Following the EVOS, 66% (n = 45) of the oiled otters that died had an elevated serum BUN concentration (Appendix 3, Figure D). This often coincided with an increase in serum potassium (Figure 5.3) and phosphorus (Figure 5.4). Elevated BUN levels usually cause gastrointestinal inflammation and ulceration, which further interferes with feeding and fluid intake in uremic animals.

*The primary goal in treating renal insufficiency is to restore normal hydration and electrolyte balance. A positive response to therapy is indicated by increased urine production and a decrease in plasma BUN, potassium, and phosphate.*

*(c) Treatment.* The primary goal in treating renal failure is to restore normal hydration and electrolyte balance until renal blood flow and glomerular filtration are reestablished. A positive response to therapy is indicated by increased urine production and a decrease in serum

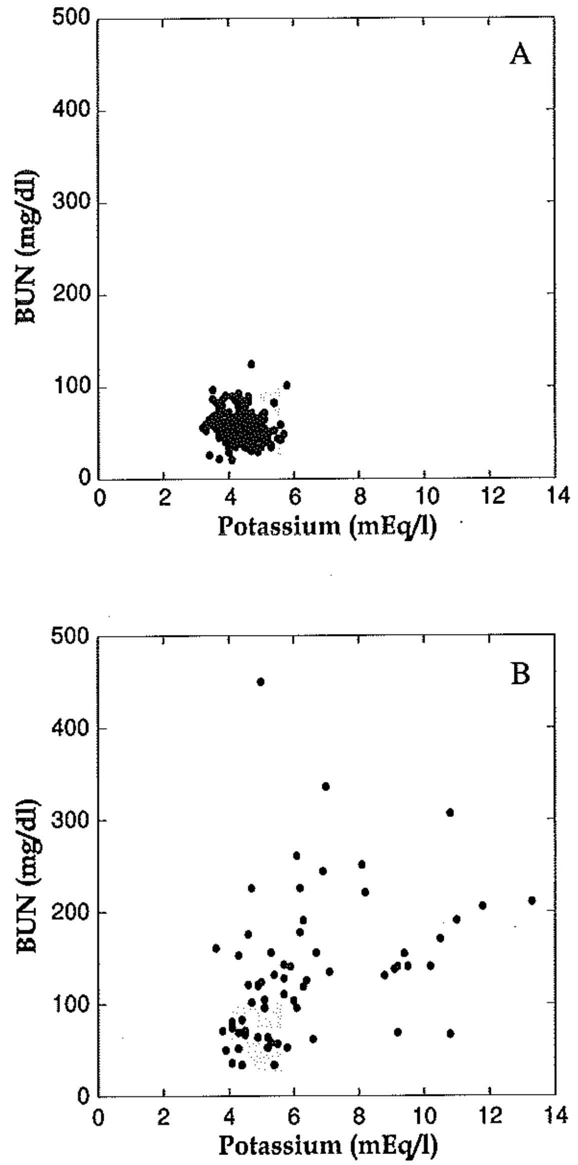



Figure 5.3
Serum BUN level in relation to potassium for sea otters that were released (A) or died (B) following capture and rehabilitation during the EVOS. The shaded area represents the normal range for healthy, adult sea otters.

BUN, potassium, and phosphorus. Because renal failure may occur during the rehabilitation of oiled sea otters, potentially nephrotoxic drugs should be avoided.

To prevent further renal ischemia, dehydration must be treated quickly. Isotonic fluids (normal saline or a 1-to-1 mixture of normal saline and 5% dextrose, 20 ml/kg SQ or IV) should be administered subcutaneously. An intravenous or intraosseous route should be used in cases of severe dehydration in which peripheral perfusion is reduced (Black and Williams, 1993). Although urine production should be measured to properly assess maintenance fluid requirements, this is usually impractical with sea otters. Qualitative indications of urine

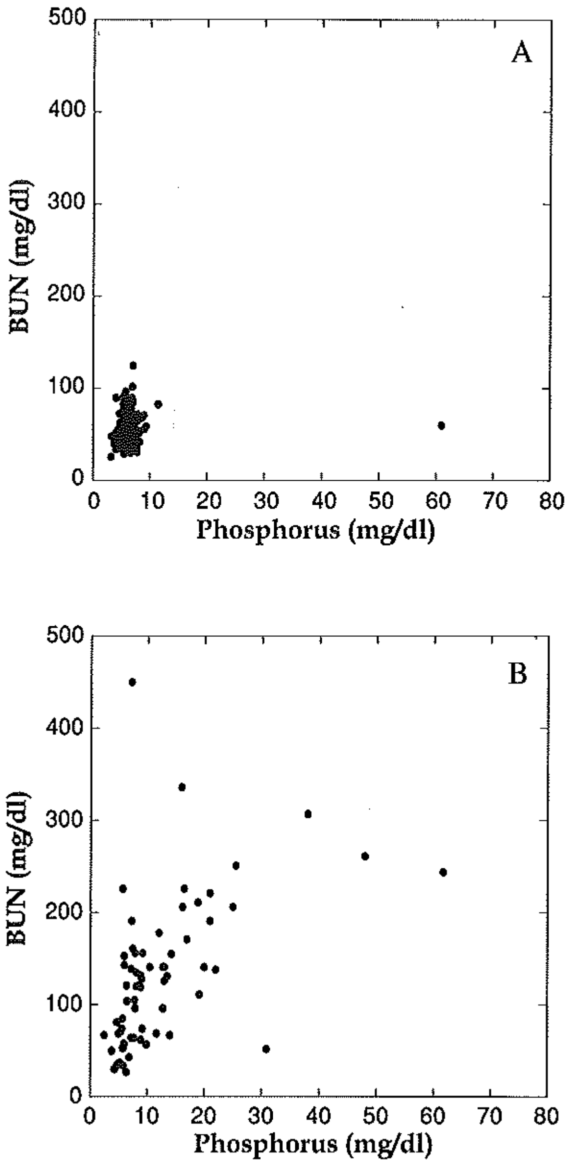



Figure 5.4
Serum BUN concentration in relation to phosphorus for sea otters that were released (A) or died (B) following capture and rehabilitation during the EVOS. The shaded area represents the normal range for healthy, adult sea otters.

*Severe hyperkalemia (serum concentration greater than 7 mEq/1) should be promptly treated with crystalline insulin (2 units/ kg/day SQ). Alternatively, slow intravenous administration of 1-2 mEq/kg of either sodium bicarbonate or a solution of 5% dextrose is helpful.*

volume and frequency should be noted on the animal's record (Appendix 2, Form I). Serum electrolyte concentrations, PCV/total solutes, and body weight should be monitored closely to avoid over hydration.

Hyperkalemia can cause cardiac conduction abnormalities and is the most life-threatening electrolyte imbalance that occurs in renal dysfunction. Severe hyperkalemia (serum concentration greater than 7 mEq/l) should be promptly treated with crystalline insulin (2 units/kg/day SQ). Alternatively, slow intravenous administration of 1–2 mEq/kg of either sodium bicarbonate or a solution of 5% dextrose is helpful. The former has the added benefit of managing acidosis. The administration of fluids is also important for animals with elevated phosphorus levels. In all cases, treatments for electrolyte or acid-base imbalances should be monitored closely.

When fluid therapy fails to induce diuresis (urine formation), either 10% dextrose (20 ml/kg administered as a slow IV infusion), mannitol (1-2 gm/kg as a 25% solution administered in a slow IV bolus) or furosemide (2 mg/kg IM) is recommended (Grauer, 1986). These treatments require experienced management and constant monitoring. Whether or not diuresis occurs, qualitative urine formation and serum electrolyte concentrations should be monitored as long as the animal receives maintenance fluids.

Providing daily caloric requirements is an important aspect of managing animals with renal dysfunction. Energy requirements have a higher priority than do protein requirements, although supplementation of essential amino acids will reduce body protein breakdown and reduce urea nitrogen formation. Sea otters may be given cimetidine (5-10 mg/kg tid IM or PO) or sucralfate (0.5-1.0 gm tid PO) to combat gastrointestinal inflammation. However, the use of metoclopramide is contraindicated (T. D. Williams, personal communication). Enrofloxacin (2.5 mg/kg bid IM or PO) for mature otters and amoxicillin (12 mg/kg bid IM) for immature otters should be given to prevent or treat sepsis. Dexamethasone (1-2 mg/kg/day IM) may be given to counter the symptoms of shock which may accompany renal insufficiency.

*Give cimetidine (5-10 mg/kg tid IM or PO) or sucralfate (0.5-1.0 gm tid PO) to combat gastrointestinal inflammation. Enrofloxacin (2.5 mg/kg bid IM or PO) for mature otters and amoxicillin (12 mg/kg bid IM) for immature otters should be given to prevent or treat sepsis. Dexamethasone (1-2 mg/kg/day IM) may be given to counter the symptoms of shock.*

### Gastrointestinal Disorders

*(a) Etiology.* Sea otters in the rehabilitation center often exhibit gastrointestinal disorders. These conditions may range in severity from intestinal irritation to life-threatening hemorrhagic gastroenteritis. Possible causes include dietary changes, stress, parasites, uremia, and the ingestion of petroleum hydrocarbons.

*(b) Clinical Manifestations and Diagnosis.* The clinical signs of gastrointestinal disorders will depend on the location of the condition (stomach, large or small intestines). Vomiting suggests gastric problems. Rectal tenesmus, anal prolapse, and diarrhea indicate colonic and rectal disorders (Palminteri and Ryan, 1981). Oiled sea otters may also exhibit dehydration, oral or rectal bleeding, dyspnea, and abdominal tympany, which are associated with nonspecific gastrointestinal problems.

Melena (dark, tarry stools) is often observed in oiled sea otters during the first weeks of rehabilitation. Unfortunately, oil, blood, squid ink (from ingested squid), and activated charcoal administered to adsorb petroleum hydrocarbons all cause darkened stools. Hemocult™ tests are useful for detecting the presence of blood but false positives may result from dietary items containing blood (i.e. whole fish). The presence of oil in fecal material should be determined as described in the preceding section, Petroleum Hydrocarbon Ingestion and Absorption.

*(c) Treatment.* A treatment regimen will depend on the origin and severity of the gastrointestinal problem. Hemorrhagic enteritis may be fatal within twenty-four hours and requires immediate attention. Treatments include subcutaneous, intravenous and intraosseous

administration of fluids and electrolytes to maintain hydration state and acid-base balance. Dexamethasone (1-2 mg/kg/day IM) or methylprednisolone (0.06 mg/kg/day IM or IV) are recommended (Palminteri and Ryan, 1981). These should be supplemented with broad spectrum antibiotics, Vitamin B-complex, and gastrointestinal motility modifiers (diphenoxylate at 0.1-0.2 mg/kg bid PO or aminopentamide sulfate at 0.1–0.4 mg/kg bid IM, SQ or PO). Successful treatment will result in the cessation of diarrhea and a normal packed cell volume (PCV).

*Gastric and intestinal ulcers commonly occur in oiled sea otters and may result from the ingestion of oil, hypothermia, stress, and parasite infestation.*

Gastric and intestinal ulcers commonly occur in oiled sea otters undergoing rehabilitation (Chapter 1). The recommended treatment is to reduce stress (excessive handling, noise, and human contact) and to administer cimetidine (5-10 mg/kg tid PO or 10 mg/kg qid IV or IM). However, cimetidine binds cytochrome p450, which may interfere with the hepatic detoxification of petroleum hydrocarbons. Ranitidine (1–4 mg/kg tid PO) or sucralfate (0.5-1.0 gm tid PO), which do not bind cytochrome p450, may be substituted for cimetidine.

A variety of parasites (nematodes, cestodes, and acanthocephalids) commonly occur in wild sea otters. A qualitative assessment of infestation can be obtained by observing parasites in the stools of otters that have ingested oil, or by the microscopic examination of fecal samples for parasite ova. Although not usually lethal in healthy otters, a large parasite load may compromise the recovery of sea otters exposed to oil. Cestodes also may cause vitamin B deficiency. We recommend prophylactic treatment for gastrointestinal parasites in ambulatory otters. Praziquantel (6 mg/kg as a single dose SQ or PO) should be used to treat cestode infestations, and Ivermectin (50 ug/kg as a single dose SQ or PO) should be used for the treatment of nematodes. Supplemental vitamin B is recommended for sea otters during the treatment for parasites.

### Anemia

*(a) Etiology.* Anemia (inadequate circulating red cell mass) in oiled sea otters may result from renal and hepatic dysfunction, inflammation, hemorrhage and petroleum hydrocarbon toxicosis. Because the etiology may vary, oiled sea otters can display both regenerative and nonregenerative types of anemia. Hemolytic anemia, chronic hemorrhage and iron deficiency anemia, and hypoplastic anemia have been reported for oiled wildlife (Williams and Davis, 1990; White, 1991). Chemical toxin-induced anemias may be associated with marrow aplasia, maturational defects, and hemolysis by both direct or immune meditated mechanisms (Keitt, 1985). All forms of anemia decrease tissue oxygenation. To compensate for the reduction in oxygen delivery to tissues, heart rate and cardiac output may increase.

*Common manifestations of anemia are a packed cell volume less than 33%, poor tolerance to activity, pale mucous membranes, depression, weakness, lethargy, anorexia and tachycardia.*

*(b) Clinical Manifestations and Diagnosis.* Packed cell volume less than 33% (also hemoglobin concentration less than 22.9 g/dl and a red blood cell count less than 6.5 x $10^6$/ml), poor tolerance to activity, pale mucous membranes, and tachycardia are common manifestations of anemia. Animals with anemia routinely exhibit depression, weakness, lethargy, and anorexia. Cardiomegaly, resulting from the increased work of the heart in chronically anemic animals, is a common radio-

graphic finding. The anemias are differentiated based on packed cell volume, plasma protein concentration, erythrocyte size and shape, blood hemoglobin concentration, and careful examination of blood smears (Keitt, 1985). Heinz body formation, evidence of erythrocyte abnormalities or damage, and regenerative erythrocyte response are typical hematological findings for oiled mammals and birds. However, Heinz bodies were rare in blood samples from sea otters during the EVOS.

The anemic condition often develops over time and may not be apparent in animals on admission to the rehabilitation center. Heavily oiled otters that die quickly often show normal and even elevated packed cell volumes, red blood cell concentrations and hemoglobin concentration (Appendix 3, Figure G and H) due to dehydration. A reduction in circulating red blood cells may develop one to two weeks after capture, especially in heavily oiled sea otters (Figure 5.5). Williams (1990) found that anemia can persist for three to four months following exposure to crude oil.

***The anemic condition often develops over time and may not be apparent in animals on admission to the rehabilitation center.***

*(c) Treatment.* The direct treatment of anemia is of little value until the underlying cause is corrected. For oiled otters, an improvement in hepatic and renal function, elimination of infections and hemorrhages, hepatic detoxification of systemic petroleum hydrocarbons, and a balanced diet will promote recovery from anemia. Supportive care to ensure adequate caloric and fluid intake, antibiotic therapy to control

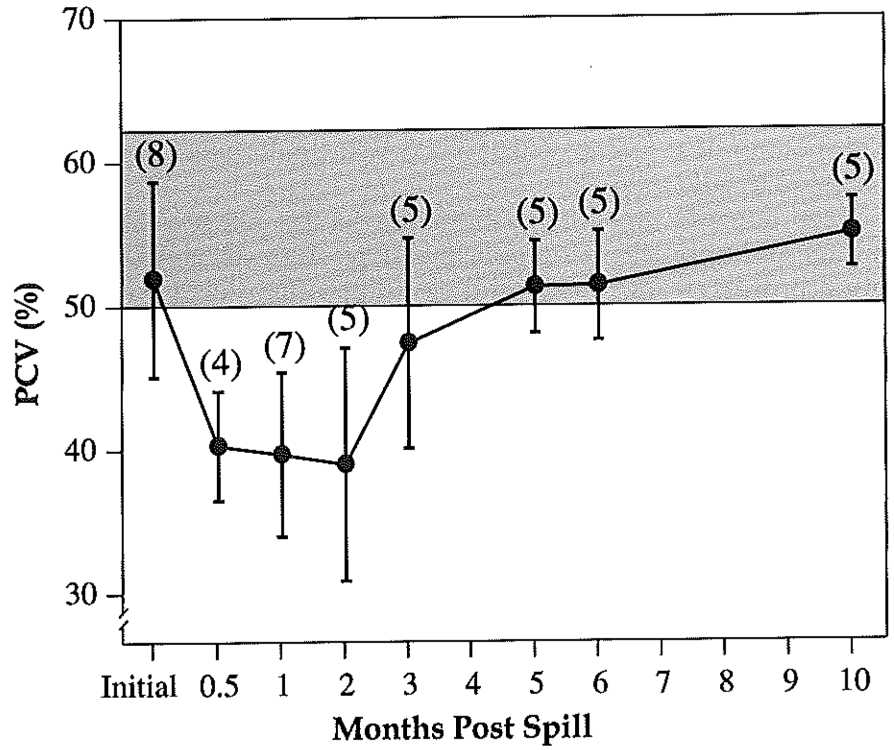



Figure 5.5
Changes in packed cell volume in relation to time following the EVOS for oiled sea otters. Means $\pm$ 1 SD are shown for eight adult otters. Numbers in parentheses represent the total number of otters in each sample period. The range of values for healthy sea otters is shown by the shaded area.

infections, and vitamin and mineral supplementation are recommended. Vitamin B-complex should be given to promote erythrocyte maturation. Because iron is readily taken up by macrophages and sequestered in monocyte-macrophage pools during chronic inflammation, serum iron may be low in anemic animals. Supplemental iron preparations (ferrous sulfate at 0.2 g/day PO for at least two weeks) are beneficial as long as infections are controlled. Androgenic-anabolic steroids (stanozolol, 10–25 mg/otter per week IM) stimulate red blood cell production and may be useful in treating various forms of anemia. However, it may take weeks or months for the hematopoietic effect of steroid treatment to become apparent and it is contraindicated for gravid females. Weekly blood samples should be taken to monitor packed cell volume.

In severe cases of anemia, blood transfusions may be considered. During the EVOS, this treatment was effective in correcting anemia in oiled birds (White, 1991). Blood transfusions assume an appropriate clinical setting and an adequate donor, two factors that are difficult to achieve for sea otters involved in an oil spill. Therefore, it is unlikely that transfusions will be a viable treatment for anemia in large numbers of oiled sea otters.

**Stress**

*(a) Etiology.* Stress is a term used to describe the psychoendocrine response of an animal to environmental and psychological stimuli that cause physical or mental tension. The hallmark of stress is activation of the pituitary-adrenal system, which may eventually result in adrenal hypertrophy, thymicolymphatic involution, gastric ulceration, and suppression of testicular and ovarian function (Levine, 1985). Although the complexity of the stress response makes it difficult to diagnose and monitor, it is apparent that stress will hinder recovery from oil exposure in wild animals.

Oiled otters brought to rehabilitation centers are subject to many strange and unfamiliar situations that may cause stress. The rehabilitation process, from capture and cleaning to treatment and release, can be stressful for wild otters. Manifestations of stress often can not be differentiated from the detrimental effects of oil exposure. However, 25% of the lightly oiled and unoiled otters brought to rehabilitation centers during the EVOS died (Chapter 1). Stress associated with the rehabilitation process may have contributed to this mortality. Also, stress associated with capture and rehabilitation may reduce an animal's resistance to diseases which occur naturally in the wild population (Harris et al., 1990).

Stress-induced immunosuppression in captive sea otters may result in prolonged wound healing and abnormal inflammatory responses to abrasions, cuts, and injections. White blood cell counts (WBC) vary widely for oiled sea otters (Appendix 3, Figure H). Because their immune system may be compromised, we recommend the prophylactic administration of antibiotics on admission to rehabilitation centers (see Chapter 4). Elective surgical procedures should be delayed until leukograms and serum chemistry panels return to normal.

*(b) Clinical Manifestations and Diagnosis.* Stressed sea otters may vocalize continuously, lack locomotor coordination, become anorectic, and exhibit stereotypic behaviors such as prolonged grooming and fur chewing. Plasma catecholamines and corticosteroids may increase initially, then diminish as the otters habituate to the rehabilitation process. However, some otters are less adaptable and may never habituate to captivity. Many of the otters that died in the rehabilitation centers during the EVOS had gastric ulcers and adrenal abnormalities suggestive of stress (Chapter 1; Lipscomb et al., 1993, 1994).

Erythrocyte sedimentation rate (ESR) and serum iron are useful indicators of some types of stress (Table 5.4). The red blood cell sedimentation rate increases for animals with infections and inflammation. Blood samples from clinically ill otters during the EVOS had sedimentation rates seven times the normal rate. Serum iron decreased in response to bacterial infection and was lower in unhealthy otters.

The accumulation of lactic acid in the muscles of otters that are captured with dip nets has been associated with cases of capture myopathy syndrome (Williams and VanBlaricom, 1989). During prolonged chases, increased muscle lactic acid concentration can cause serious damage to muscle fibers. Elevations in both creatine phosphokinase (CPK greater than 490 IU/l) and lactate dehydrogenase (LDH greater than 419 IU/l) indicate skeletal muscle damage and were apparent for oiled otters (Appendix 3, Figure F).

*(c) Treatment.* Stress in sea otters at rehabilitation centers may be prevented by creating a predictable environment that reduces novelty. Good nutrition, access to seawater and haulout space, good sanitation and disease prevention, a tolerable thermal environment, a sense of safety, and opportunities to socialize with other otters are important environmental elements. Most of these requirements can be achieved with properly designed facilities, good husbandry and veterinary care, and by minimizing physical contact between the staff and otters (see Chapter 7 and Chapter 12).

Diazepam (0.2 mg/kg PO or 0.1 mg/kg IM) may alleviate destructive behavioral responses to stress such as excessive grooming, fur and skin biting, and anorexia. Treatment with diazepam allows the animal to slowly regain normal patterns of behavior that facilitate

***Diazepam (0.2 mg/kg PO or 0.1 mg/kg IM) may alleviate destructive behavioral responses to stress such as excessive grooming, fur and skin biting, and anorexia.***

Table 5.4
Sixty minute erythrocyte sedimentation rate and serum iron concentration for healthy and unhealthy sea otters. All samples were obtained from animals placed in rehabilitation centers following the EVOS. (Wilson et al., 1990.)

| | Erythrocyte Sedimentation Rate (mm/hr) | Serum Iron (ug/dl) |
|---|---|---|
| Receiving Medication (n) | $56.0 \pm 10.0$ (8) | $123.0 \pm 38.0$ (8) |
| Healthy (n) | $7.5 \pm 7.0$ (59) | $173.7 \pm 73.0$ (211) |

***Note behavioral signs of stress such as chewing on the cage, screaming, or destructive behavior such as pacing or excessive grooming. Decrease stress by: a) offering the otter ice to chew on, b) minimizing visual and acoustic disturbance, and c) housing the otters in pairs or larger compatible groups.***

Table 5.5
Symptoms and treatments for common clinical disorders in oiled sea otters.

| Problem | | Symptoms |
|---|---|---|
| Hypothermia | Mild | (core temperature 35–36 °C or 95–97 °F)<br>• shivering<br>• locomotor incoordination<br>• disorientation<br>• lethargy |
| | Severe | (core temperature less than 35 °C or 95 °F)<br>• hyporeflexia, muscle rigidity<br>• stupor or unconsciousness<br>• cessation of shivering<br>• decreased heart rate<br>• cardiac arrhythmias<br>• increase in serum CPK<br>• acidosis, hyperkalemia |
| Hyperthermia | Mild | (core temperature greater than 39–40 °C or 102–104 °F)<br>• panting<br>• warm hind flippers<br>• dry mucous membranes<br>• lethargy/agitation |
| | Severe | (core temperature greater than 40 °C or 104 °F)<br>• unconsciousness or stupor<br>• hyperemic mucous membranes |
| Petroleum hydrocarbon ingestion and absorption | | • excitability, seizures<br>• CNS depression, lethargy<br>• ataxia<br>• vomiting<br>• diarrhea<br>• respiratory distress<br>• cardiac arrhythmias |
| Respiratory tract injuries | | • tachypnea<br>• use of accessory respiratory muscles, bronchospasm<br>• rhinitis, sinusitis, purulent nasal discharge<br>• epistaxis, mucosal sloughing<br>• impaired mucociliary clearance<br>• atelectasis<br>• pulmonary edema<br>• interstitial and subcutaneous emphysema |

**Treatment**

1. Place otter in a dry, well-ventilated cage.
2. Monitor rectal temperature.
3. Dry the fur with towels or pet dryer set at room temperature.
4. Passively rewarm at 0.5 °C (1 °F) per hour at a room temperature of 20 °C (68 °F).

1. Monitor rectal temperature, heart rate, respiratory rate, blood glucose, and serum electrolytes.
2. Place otter on a recirculating warm water 40–45 °C (104–113 °F) pad or plastic bags of warm water.
3. Administer warm 37–39 °C (98.6–102 °F) normal saline or a 1-to-1 mixture of normal saline and 5% dextrose SQ or IV.
4. Immerse in water at 37–40 °C (98–104 °F). Caution: this procedure may induce cardiac arrhythmias.
5. Provide general supportive care to prevent hypoglycemia, shock, and infections.

1. Place chipped ice in the bottom of the cage.
2. Move cage to an area with an air temperature of 15 °C (60 °F) or less, good air circulation, and out of direct sunlight.
3. Place otter in a pool of cool (10 °C or 50 °F) seawater.

1. Monitor rectal temperature, heart rate, respiratory rate and blood chemistry.
2. Move otter to a room with an air temperature of 15 °C (60 °F) or cooler.
3. Pack ice around the otter's body and wet the fur, especially the hind flippers, neck and head.
4. Administer normal saline or 1-to-1 mixture of normal saline and 5% dextrose (20–40 ml/kg SQ) to treat dehydration.

1. Remove otter from contact with petroleum hydrocarbons. Clean oiled fur.
2. For heavily and moderately oiled otters, administer a single dose of Toxiban™ (6 ml/kg, up to 120 ml/dose PO).
3. Treat seizures as indicated (see below).

1. Remove otter from volatile petroleum hydrocarbons.
2. Administer diazepam (0.2 mg/kg PO or 0.1 mg/kg IM) to prevent hyperventilation and alleviate stress.
3. Administer enrofloxacin (2.5 mg/kg bid IM or PO) for mature animals and amoxicillin (12 mg/kg bid IM) for immature otters.
4. Administer aminophylline (slow release form, 10 mg/kg bid PO) as a bronchodilator.
5. Control respiratory parasites (i.e. nasal mites) with Ivermectin (50 ug/kg SQ or PO).
6. Do not use inhalation anesthetics or positive pressure $O_2$ delivery.
7. Provide general supportive care to prevent dehydration, shock and weight loss.

Table 5.5
*(Continued)*

| Problem | Symptoms |
|---|---|
| Hypoglycemia | (blood glucose concentration less than 60 mg/dl)<br>• depression, unconsciousness<br>• muscular weakness, locomotor incoordination<br>• hypothermia<br>• seizures |
| Shock | • tachycardia<br>• hyperventilation<br>• depression<br>• muscular weakness<br>• cold hind flippers<br>• hypotension<br>• slow (> 2 sec) capillary refill time in mucous membranes |
| Seizures | • unconsciousness<br>• abnormal muscle tone (flaccid to rigid)<br>• altered autonomic nervous system (urination, salivation, defecation, vomiting)<br>• behavioral abnormalities (vocalization, pacing) |
| Hepatic dysfunction | • fatigue, malaise<br>• fever<br>• anorexia, weight loss<br>• nausea, vomiting<br>• elevated serum ALT, AST, bilirubin, and alkaline phosphatase.<br>• hypoalbuminemia<br>• increased prothrombin time<br>• gastrointestinal bleeding<br>• bacteremia<br>• hypertriglyceridemia<br>• hepatic encephalopathy (myoclonus, hyperactive muscle stretch reflexes, convulsions, facial grimacing, and blinking) |

### Treatment

1. Monitor blood glucose concentration hourly until stable.
2. Administer 10-20% dextrose (10-20 ml/kg IV to effect).
3. Administer 50% dextrose (1 ml/kg) by stomach tube.
4. Offer food immediately and hourly until stable. Begin enteral feeding if otter refuses food.
5. Administer dexamethasone (1-2 mg/kg/day IM).
6. Administer diazepam (0.1 mg/kg IM) if necessary to control seizures.
7. Provide general supportive care to prevent dehydration and hypothermia.

1. Diagnose and treat cause.
2. Administer normal saline or 1-to-1 mixture of normal saline and 5% dextrose (20 ml/kg IV).
3. Administer sodium bicarbonate (1 mEq/kg IV or 50 mg/kg PO) to correct acidosis.
4. Administer dexamethasone (1-2 mg/kg/day IM) or methylprednisolone (0.06 mg/kg/day IM or IV).
5. Monitor serum chemistry.
6. Provide general supportive care to prevent hypothermia and hypoglycemia.

1. Diagnose cause.
2. Monitor serum glucose and chemistry.
3. Administer diazepam (0.2 mg/kg PO or 0.1 mg/kg IM).
4. Treat for hypoglycemic shock as indicated.
5. Treat for hypothermia or hyperthermia as indicated.

1. Administration dexamethasone (1-2 mg/kg/day IM) or methylprednisolone (0.06 mg/kg/day IM or IV).
2. Avoid use of hepatotoxic drugs and anesthetics.
3. Administer enrofloxacin (2.5 mg/kg bid IM or PO) for mature animals and amoxicillin (12 mg/kg/ bid IM) for immature otters.
4. Administer neomycin (1 g every six hours PO) for hepatic encephalopathy.
5. Administer vitamin B-complex (SQ or PO) or as multivitamin (SeaTabs™) PO.
6. Administer vitamin K (1 mg/kg/day SQ or PO).
7. Provide general supportive care to prevent dehydration, hypoglycemia, and hypothermia.
8. Ensure adequate nutritional support with enteral feeding if necessary.

Table 5.5
*(Continued)*

| Problem | Symptoms |
| --- | --- |
| Renal dysfunction | • dehydration resulting in increased PCV and total serum protein<br>• azotemia and electrolyte imbalance (i.e. hyperkalemia, hyperphosphatemia, hyperchloridemia).<br>• plasma acid-base imbalance (metabolic acidosis)<br>• oliguria<br>• loss of skin elasticity, dry mucous membranes and elevated PCV due to dehydration<br>• vomiting, diarrhea, anorexia<br>• depression<br>• hypothermia<br>• bradycardia (or tachycardia in severe cases) |
| Gastro-intestinal disorders | • vomiting<br>• diarrhea<br>• dehydration<br>• melena<br>• rectal bleeding<br>• abdominal tympany<br>• rectal tenesmus<br>• anal prolapse |
| Anemia | (PCV less than 33%)<br>• weakness and lethargy<br>• pale mucous membranes<br>• anorexia<br>• tachycardia<br>• cardiomegaly<br>• possible Heinz body formation |

### Treatment

1. Monitor serum chemistry and acid-base balance.
2. Administer normal saline or a 1-to-1 mixture of normal saline and 5% dextrose (20 ml/kg/day SQ or IV) to maintain hydration.
3. For acute renal failure with hyperkalemia, administer crystalline insulin (2 units/kg/day SQ) and a solution of 5% dextrose (20 ml/kg/day SQ). If blood pH < 7.2, give a slow IV infusion of 1 to 2 mEq/kg sodium bicarbonate.
4. Administer either 10% dextrose (20 ml/kg slow IV infusion), mannitol (1-2 gm/kg 25% solution in slow IV bolus) or furosemide (2 mg/kg IM) if fluid therapy fails to induce diuresis.
5. Avoid the use of nephrotoxic drugs.
6. Administer cimetidine (5-10 mg/kg tid IM or PO).
7. Administer enrofloxacin (2.5 mg/kg bid IM or PO) for mature animals, amoxicillin (12 mg/kg bid IM) for immature otters.
8. Administer dexamethasone (1-2 mg/kg/day IM) or methylprednisolone (0.06 mg/kg/day IM or IV).
9. Provide general supportive care to prevent hypothermia, hypoglycemia, or weight loss.

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1. Monitor serum chemistry and acid-base balance.
2. Administer normal saline (20 ml/kg/day SQ or IV) for dehydration.
3. Administer dexamethasone (1-2 mg/kg/day IM) or methylprednisolone (0.06 mg/kg/day IM or IV) for endotoxic shock.
4. Administer cimetidine (5-10 mg/kg tid PO or 10 mg/kg qid IV or IM) or Ranitidine (1-4 mg/kg tid PO) for gastric ulcers and melena.
5. Administer enrofloxacin (2.5 mg/kg bid IM or PO) for mature animals, amoxicillin (12 mg/kg bid IM) for immature otters.
6. Administer Praziquantel (6 mg/kg single dose SQ or PO) for cestode infestation and Ivermectin (50 ug/kg single dose SQ or PO) for nematodes. Fenbendazole (11 mg/kg/day PO x 3 days) may also be used for nematodes.
7. Administer vitamin B-complex (SQ or IM) or as multivitamin (SeaTabs™) PO.
8. Administer motility modifier diphenoxylate (0.1-0.2 mg/kg bid PO) or aminopentamide sulfate (0.1-0.4 mg/kg bid IM, SQ or PO). Caution: may potentiate the effects of sedatives.
9. Administer vitamin K (1 mg/kg/day SQ or PO).
10. Provide general supportive care to prevent hypoglycemia.
11. Provide increased roughage in the form of whole prey items (i.e. crab carapace).

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1. Monitor PCV, red blood cell morphology and serum chemistry weekly.
2. Administer vitamin B-complex (PO, SQ or IM) or as multivitamin (SeaTabs™) PO.
3. Administer supplemental iron (ferrous sulfate at 0.2 g/day PO for at least 2 weeks). Note: May be contraindicated in presence of severe bacterial infection.
4. Administer androgenic-anabolic steroids (stanozolol, 10-25 mg/otter per week IM). Caution: stanozolol is contraindicated for gravid females.
5. Provide general supportive care to prevent infection, dehydration, hypoglycemia, and weight loss.
6. Administer Praziquantel, Ivermectin, Fenbendazole (as above) to control parasites.

Table 5.5
*(Continued)*

| Problem | Symptoms |
|---|---|
| Stress | • continuous vocalization<br>• locomotor incoordination<br>• anorexia<br>• stereotypic behaviors (pacing, excessive grooming, fur chewing<br>• elevated serum catecholamines and corticosteroids<br>• elevated serum CPK, LDH<br>• elevated erythrocyte sedimentation rate<br>• decrease serum iron |

*Prolonged chases can cause serious elevations in tissue lactic acid concentration and consequent muscle damage. For otters with suspected capture myopathy syndrome, supplemental vitamin E (400 IU/day PO) and selenium (Seletoc™, 0.1 ml/kg as a single dose IM or SQ in two sites) are recommended.*

recovery. Also, low dosages of diazepam may stimulate the otter's appetite, which will promote recovery.

Prevention is the key to managing capture myopathy syndrome. Any sea otter that eludes easy capture with a dip net is probably not suffering from the detrimental effects of oil exposure. Prolonged chases can cause serious elevations in tissue lactic acid concentration and consequent muscle damage. An alternative form of capture, such as a tangle net or Wilson trap, should be used for these otters. Throughout the capture and rehabilitation process, physical stress should be minimized. For otters with suspected capture myopathy syndrome, supplemental vitamin E (400 IU/day PO) and selenium (Seletoc™, 0.1 ml/kg as a single dose IM or SQ in two sites) are recommended.

## LONG-TERM TREATMENT OF OILED SEA OTTERS

The treatment program for each otter should be reevaluated daily. The clinical history of oiled otters during the EVOS showed that anemia, hepatic dysfunction, renal dysfunction, and gastrointestinal disorders may develop two to three weeks after admission to the rehabilitation center (Chapter 1). Sea otters from the Early Phase of the spill showed the highest incidence of these conditions. Weekly serum chemistry panels and hematological analyses are useful for identifying many of these disorders in otters that do not appear to be recovering normally. Most otters with these conditions will benefit from prophylactic fluid and antibiotic therapy.

The rehabilitation of some otters may require several weeks to several months of captivity. Medical problems requiring long-term care generally result from: 1) inability of an otter to maintain a normal core temperature in water because the fur has not regained water repellency, 2) residual tissue and organ damage that may prevent normal physiological function and result in secondary infections, and 3) the stress of captivity which may cause a variety of medical disorders including gastric ulcers, a spastic colon, and depression. Long-term holding also introduces the potential for exposure to infectious diseases and accidental injuries.

**Treatment**

1. Reduce noise and disturbance in environment.
2. Reduce unnecessary handling and contact between staff and otters.
3. Administer diazepam (0.2 mg/kg PO or 0.1 mg/kg IM) to alleviate destructive behaviors and stimulate appetite.
4. Administer vitamin E (400 IU/day), vitamin B-complex (PO or IM), and selenium (Seletoc™, 0.1 ml/kg single dose IM or SQ in two sites). These vitamins and minerals also administered as a multivitamin PO (SeaTabs™).

Captive sea otters may develop abrasions or pressure sores from resting on hard surfaces in haulout areas. These conditions usually occur in otters that have not restored the water repellency of their fur and must remain out of the water for prolonged periods. Perianal (urogenital) areas and the hind flippers are the primary sites affected. Dermatitis, characterized by erythematous regions and abrasions, was observed in many otters during the EVOS. Localized abrasions should be sprayed with Betadine™ solution. In severe cases where the bone is exposed, surgical intervention may be necessary. Antibiotics (enrofloxacin, amoxicillin) should be administered to prevent or control infection. In most cases, placing the otters in seawater as soon as their fur is water repellent will eliminate skin disorders.

*Captive sea otters may develop abrasions or pressure sores from resting on hard surfaces in haulout areas. Localized abrasions should be sprayed with Betadine™ solution. Antibiotics (enrofloxacin, amoxicillin) should be administered to prevent or control infection. Placing the otters in seawater as soon as their fur is water repellent will eliminate skin disorders.*

Long-term supportive care will eventually enable most otters to restore the insulation of their fur and regain the normal physiological function of their organ systems. However, the veterinarian should be aware that the functional capacity of these organ systems may be reduced, and they may fail to respond normally when physiologically challenged or stressed. In view of this, the regimen of care and clinical treatment should anticipate primary and secondary stress-induced disorders. For any medical or husbandry procedure, the veterinarian should consider the procedure's benefits versus the additional stress that will be caused by handling the animal. Limiting the duration and total number of treatment periods will reduce stress.

## SUMMARY

Medical disorders of oiled sea otters may be caused by: primary and secondary effects of exposure to petroleum hydrocarbons, stress associated with capture and captivity, and preexisting health problems in the general sea otter population. Because many of the health problems have no specific treatment, prevention and supportive care are often the only recourse for the attending veterinarian. Broad spectrum antibiotics, fluid therapy, corticosteroids, and supplemental vitamins and minerals should be given to otters upon admission and as needed throughout the rehabilitation process. Treatments specific for individual medical problems should be initiated as soon as possible. This may include regimens for preventing further absorption or ingestion of petroleum hydrocarbons and for mitigating respiratory injury, hypoglycemia, and shock. Long-term care will involve stabilizing organ function, preventing additional stress, and providing adequate nutritional support during rehabilitation.

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Chapter 6

# Cleaning and Restoring the Fur

Randall W. Davis
Lee Hunter

The most immediate and detrimental effect of an oil spill on sea otters is fur contamination. The insulating properties of the pelage result primarily from the layer of air trapped between the hairs. Oil penetrates the fur, eliminates the air layer, and reduces the insulation of the pelage by 70% (Williams et al., 1988). To offset the increased heat loss and maintain a normal core body temperature, oiled otters must further increase their normally high metabolic rate to prevent hypothermia. Alternatively, they can reduce heat loss by leaving the water. However, hauling out on shore prevents the sea otter from foraging, and starvation occurs rapidly. In this chapter, we describe: 1) the physical properties that make sea otter fur an effective insulator in water, 2) the detrimental thermoregulatory effects of oiling, and 3) methods to restore the insulating quality of the fur through proper cleaning and care.

## STRUCTURE AND FUNCTION OF SEA OTTER FUR

Sea otters typically live in water temperatures that are 21–38 °C (70–100 °F) below their core body temperature. Because of this large thermal gradient and the high heat conductivity of water, which is more than twenty-five times that of air, sea otters need good thermal insulation to prevent rapid and excessive heat loss. Unlike cetaceans and most species of pinnipeds, sea otters lack a subcutaneous layer of blubber and depend on air trapped within their dense fur for insulation. The amount of air trapped between the hairs is related to both hair length and to the number of hairs per unit area (hair density) (Tregear, 1965). Most of the heat loss through the pelt is due to conductive and convective heat transfer from the air layer in the fur to the ambient air or water at the tips of the hairs.

Sea otter fur is the densest of any mammal and is composed of stout overhairs (guard hairs) and shorter, finer underhairs (Tarasoff, 1974). Hair density ranges from 26,413 to 164,662 per $cm^2$, with highest densities on the forearms (164,662), sides (157,264), rump (118,691), stomach (82,251), and back (77,526) (Williams et al., 1992). The lowest densities

*Sea otter fur is the densest of any mammal and is composed of stout overhairs (guard hairs) and shorter, finer underhairs.*

are found on the chest (34,639), legs (30,761), and feet (26,413). Each hair bundle contains one guard hair and a variable number of underhairs (range = 12 underhairs per bundle on the legs to 108 underhairs per bundle in the midlateral areas). The length of the guard hairs (2.6–31.5 mm) and underhairs (1.5–26.3 mm) also varies with location on the body, with the shortest hairs on the legs and feet. The guard hairs are oval to round in cross section and have a diameter that ranges from 44–106 microns (mean diameter = 70 microns) (Williams et al., 1992). Underhairs, which are irregularly shaped due to cuticular scales, are wavy and have a mean diameter of 10.3 microns. Sea otters appear to replace their hair throughout the year and do not have a seasonal molt.

The structure of sea otter skin and hair follicles is similar to that described for other carnivores (Williams et al., 1992). The epidermis is thin and consists of only one or two cell layers and the keratinized stratum corneum. The dermis is 2.25–3.25 mm thick and is composed of collagenous connective tissue, smooth muscle, blood vessels, nerves, and apopilosebaceous complexes. The hair follicle is essentially a tubular invagination of the epidermis which encloses a small spike of dermis at its base (Ebling and Hale, 1983). Noticeably absent are arrector pili muscles. Each follicle has a thin, tubular shaped sebaceous gland and an apocrine sweat gland (Williams et al., 1992). The sebum of sea otters is primarily squalene (Davis et al., 1988; Williams et al., 1992). The apocrine gland secretions mix with sebum at the skin surface and are distributed over the fur by the otter's grooming behavior. The total lipid content of the fur ranges from 7.4–27.7 mg/g fur (Williams et al., 1988; Williams et al., 1992). The sebum keeps the skin soft and pliable and may contribute to the fur's water repellency.

Each hair is composed of a cortex, an outer cuticle, and a central medulla. The main structural component of hair is hard, alpha-keratin, which consists of microfibrils embedded in a nonfilamentous matrix (Gillespie, 1983). Most of the keratin occurs in spindle-shaped cells located in the cortex. The cortex is covered by a cuticle of sheet-like cells that overlay each other from the root to the tip of the hair. The medulla consists of air-filled cells located in the center of the cortex. Guard hairs are typically medullated, but underhairs are medullated only at their base.

The cuticle of sea otter hair is of special interest in relation to *felting* and the entrapment of air (Swift, 1977). The cuticular cells create a scaly, ratchet-like surface on the hair and give it a differential coefficient of friction according to whether the impinging surface moves along the fiber from root to tip (i.e. in the direction of the overlapping scales) or from tip to root (i.e. against the direction of the scales). The differential friction effect causes individual fibers within the mat to move preferentially in one direction, thereby becoming locked within the fiber mat. When sea otters groom themselves, they vigorously rub their fur with their forepaws and hind flippers. This activity is essential for maintaining the interlocking underhairs. The amount of air trapped within the felt-like mat is enhanced by the waviness and density of the underhair. The interstices (i.e. intervening spaces) between the hairs are small, yet the void space is still large (i.e. over 80% of the pelt volume). The small interstices and hydrophobic surface of the cuticle prevent the penetration of water (because of the liquid surface tension) and allow air to be trapped between the hairs.

When sea otters encounter an oil spill, the oil penetrates their fur, disrupts the interlocking arrangement of the underhairs, and displaces the air layer (Figure 6.1). The hydrophobic surface of the cuticle and the large surface area of the fur trap the oil and make it impossible for the otter to clean itself. As a result, the oily, clumped fur loses most of its insulation, and the otter is subject to lethal hypothermia.

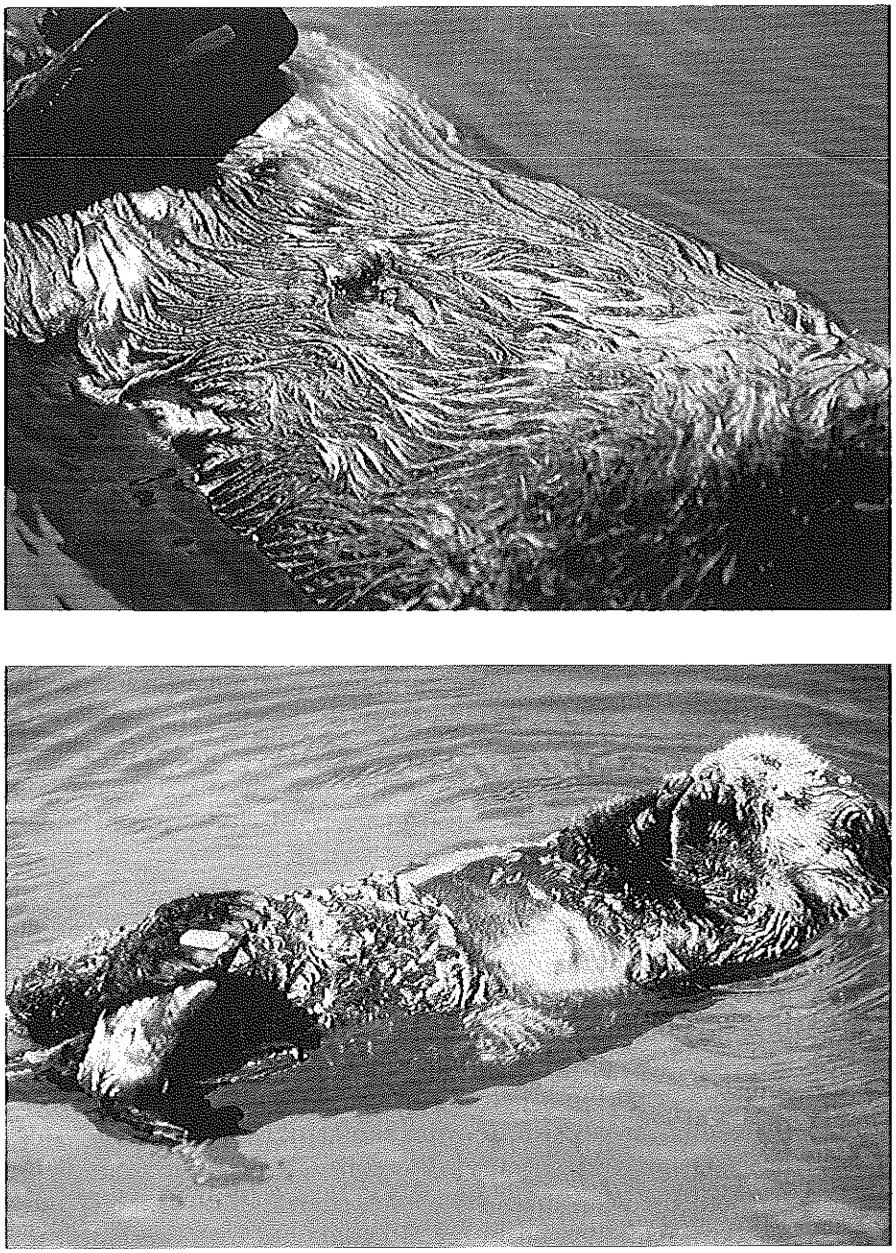

Figure 6.1
The pelage of normal (top) and oiled (bottom) sea otters. Note the striated appearance of normal, water repellant fur. This contrasts with the matted or slick characteristics of fur that is saturated with oil or water.

## CLEANING OILED SEA OTTER FUR

*Heavily oiled sea otters should be washed as soon as possible to prevent further petroleum hydrocarbon exposure. Those with light or patchy oil on their fur can be fed and held in cages for twenty-four hours before cleaning.*

Before cleaning, oiled sea otters should be examined by a veterinarian to determine whether they are healthy enough to tolerate the three-to-four-hour cleaning procedure. (See Chapter 4 for details about stabilization before cleaning.) Alert and active otters should be chemically restrained during cleaning. In general, heavily oiled sea otters should be washed as soon as possible to prevent further petroleum hydrocarbon exposure by dermal absorption or ingestion during grooming. Sea otters with light or patchy oil on their fur may benefit from a period of stabilization before washing (Chapter 11).

The cleaning process can be divided into six phases: 1) chemical restraint, 2) washing, 3) rinsing, 4) drying, 5) application of conditioners, and 6) recovery from sedation.

### Chemical Restraint

*For hypothermic or very lethargic animals, chemical restraint is not recommended; mild physical restraint should be adequate.*

*Before cleaning an oiled otter, an ophthalmic ointment should be applied to its eyes to protect them from detergent.*

Chemical restraint for sea otters during cleaning is described in Chapter 3. After light sedation, the otter is placed on a specially designed cleaning table (Figure 6.2) in the cleaning room and physically restrained by a trained animal handler. For hypothermic or very lethargic animals, chemical restraint is not recommended and mild physical restraint should be adequate. The handler grasps the otter's skin behind the shoulder blades and maintains control over head movements. An ophthalmic ointment should be applied to the otter's eyes to protect them from detergent and oil. During this time, a blood sample should be taken by a veterinarian or technician for hematology and blood chemistry analysis (see Chapter 4, Figure 4.1).

### Washing

*Three persons are required to restrain and wash an oiled sea otter. One person lightly restrains the sedated animal. The other two wash the fur with multiple applications of a solution of Dawn™ dish washing detergent (diluted 1:16 in water).*

At least two people are needed to apply detergent and wash the oiled fur. Multiple applications of a solution of Dawn™ dish washing detergent (diluted 1:16 in water) are used. The detergent is gently massaged into the oiled fur and then rinsed off with fresh water under moderate pressure (30–40 psi; 1 psi = 6.89 kPa) with a spray nozzle. Avoid getting detergent in the otter's eyes, nose, mouth, and ears. Four to eight liters of the detergent solution are normally required. Washing should continue for at least forty minutes or until there is no indication of oil in the rinse water and no odor of petroleum on the fur. Heavy oiling, weathered oil, or the presence of tar balls on the fur may prolong the process. A final forty minute rinse with a spray nozzle is essential to thoroughly remove the detergent and help restore the fur's water repellency (Williams et al., 1988). Water with a high calcium concentration (hard water) should be demineralized with a commercial water softener before rinsing. As the detergent is rinsed out, the fur will become visibly water repellent (Figure 6.1).

*The otter should be washed for at least forty minutes or until there is no indication of oil in the rinse water and no odor of petroleum on the fur. A final forty-minute rinse with a spray nozzle is necessary to thoroughly remove the detergent.*

During sedation and cleaning, the core temperature of the otter should be monitored continuously using a digital, electronic thermometer with the flexible probe inserted fifteen cm into the rectum. A decrease in core temperature may occur during cleaning and may be corrected by adjusting the temperature of the rinse water (normal range 28–32 °C or 82–90 °F). The ambient air temperature in the cleaning room should be 15–20 °C (60–68 °F). If the otter begins to overheat,

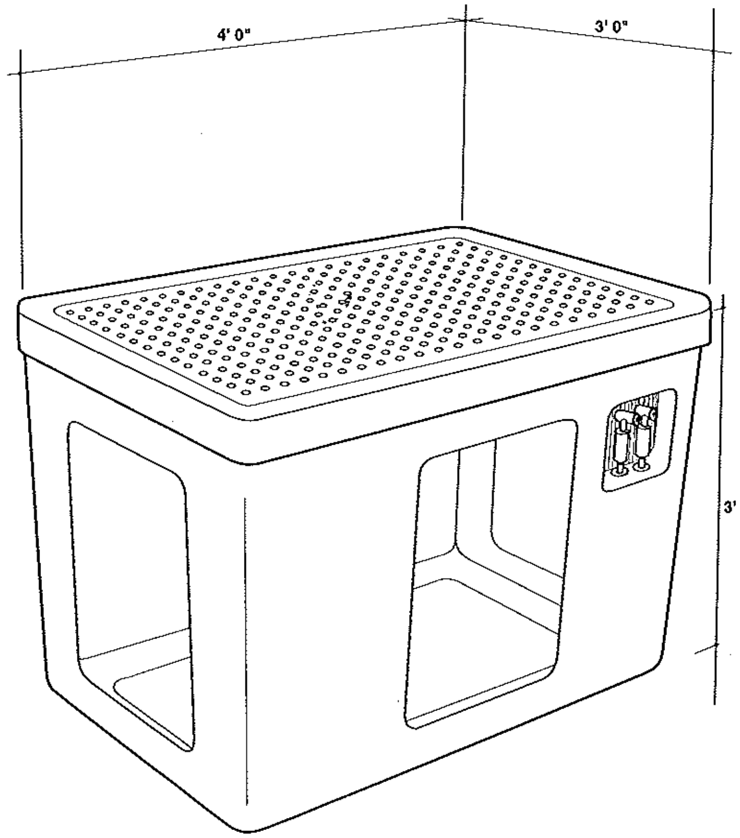


Figure 6.2
Fiberglass table specially designed to wash oiled sea otters. The smooth, tapered surface is perforated with beveled holes (0.4 inch diameter) which collect the rinse water and empty into the sewer. A small alcove on each side of the table contains a retractable, freshwater spray nozzle and a retractable soap dispenser connected to a 20-liter reservoir of a detergent solution.

decrease the temperature of the rinse water or place bags of crushed ice on the otter's hind flippers.

*During sedation and cleaning, the core temperature of the otter should be monitored continuously. Hypothermia and hyperthermia should be corrected immediately by adjusting the temperature of the rinse water.*

## Drying

After the otter's fur is thoroughly cleaned and rinsed, it should be dried in a dehumidified room. Drying will help restore the insulating air layer within the fur. Because the otter's fur acts like a sponge, drying a newly cleaned sea otter can be difficult. Absorbent paper towels or clean, cotton towels work best initially. As the towels become moist, they should be replaced with clean, dry ones. When the bulk of the water has been absorbed, the hair should be dried with commercial pet blow dryers set at room temperature or 20 °C (68 °F).

*Dry the fur using absorbent paper towels or clean, cotton towels.*

## Application of Conditioners

Detergent not only removes petroleum hydrocarbons from the otter's fur, it also removes most of the natural sebum from the skin and sebaceous glands (Williams et al., 1988). As a result, the rate of sebaceous secretion and the concentration of sebum (primarily squalene) in the fur may not return to normal for more than one week (Davis et al., 1988). The importance of sebum in maintaining water repellency and the insulating quality of the fur is uncertain. However, the application of squalene in a volatile silicon and ethanol carrier may accelerate the restoration of the fur. A squalene formula developed by one of the authors (L. H.) and the Hair Care Laboratory at Redkin Laboratories (Canoga Park, CA) contains the following ingredients:

| Ingredient | % v/v |
|---|---|
| squalene | 2.0 |
| glycerol oleate | 0.1 |
| super sterol ester (Croda) | 0.1 |
| cymethicone (Dow Corning 245 fluid) | 57.8 |
| alcohol SDA-40 (200 proof) | 40.0 |

Up to 50 ml of the squalene formula is sprayed evenly onto the otter during drying and massaged into the fur by hand. The ethanol is soluble in water and penetrates the wetted fur. Both solvents are at least as volatile as water and, therefore, facilitate complete drying while coating the fur with squalene. The use of conditioners is still experimental and an optional step in the cleaning process.

### Recovery from Sedation

*After cleaning, drying, and conditioning the fur, the otter should be placed in a cage in the critical care room and allowed to recover from sedation. Once the otter exhibits a stable core temperature, is eating, and shows signs of normal grooming behavior, it should be moved to a larger pen with a small seawater pool.*

After cleaning, drying, and conditioning the fur, the otter should be placed in a cage in the critical care room (see Chapter 12) and allowed to recover from sedation. During this time, the otter's core temperature should be monitored. Hypothermia or hyperthermia should be treated immediately, as described in Chapter 5. After recovery from the sedative, the otter should be offered small blocks of ice to eat. Chewing on ice appears to relieve stress and will prevent dehydration. Food should also be offered. Once the otter exhibits a stable core temperature, is eating, and shows signs of normal grooming behavior, it should be moved to a larger pen with a small seawater pool (Chapter 7).

## POST-CLEANING RESTORATION OF THE FUR

After cleaning with detergent, the sea otter's fur may not immediately regain its water repellent quality, even after conditioning with squalene. This may result from:

1) incomplete restoration of normal concentrations of squalene in the fur and skin,
2) absorption of detergent by the keratin in the cuticle and cortex of the hair which makes the surface of the hair hydrophilic (water absorbent) and lowers the effective surface tension, or
3) mechanical disruption of the underhairs so that they no longer form a tight, interlocking network that traps air.

*The otter's normal grooming behavior in water usually results in full restoration of the fur in seven to ten days.*

Normal grooming behavior by the otter and the gradual reintroduction to water usually results in full restoration of the fur in seven to ten days. Allowing the otter to groom in water is essential for full recovery. However, it may become chilled and should be monitored closely by the husbandry staff. If the otter begins to shiver or becomes lethargic, it should be removed from the water immediately and dried with a commercial pet dryer.

Grooming aligns the underhairs so that they trap air and probably stimulates the production of sebum, which may restore the water repellency of the hair cuticle. Otters usually groom their head and chest first, then proceed to their back and abdomen. Grooming behavior includes rubbing the fur with the forepaws and hind flippers, tumbling and rolling in the water, and blowing air into the fur with the nose. Occasionally, otters will groom each other. As the underhairs become interlocked and the air layer is restored, the fur will become noticeably water repellent and will regain its normal appearance. The percentage of the otter's fur that has regained its normal water repellency should be visually estimated and recorded daily in the husbandry record (Appendix 2, Form J). Otters that fail to groom properly because of poor health or aberrant behavior associated with the stress of captivity will not restore their fur to normal. Consequently, they will need veterinary care and a low-stress environment to resume normal grooming behavior in the rehabilitation center.

## SUMMARY

Sea otters have a very dense fur that traps air and provides thermal insulation in water. This insulation is lost when an otter comes into contact with oil. To restore the fur's insulating air layer, it must be cleaned thoroughly, rinsed well to remove residual detergent, and dried. Finally, the otter must groom itself to restore the fur's full water repellency, a process which may take several weeks. The application of conditioners may accelerate this process, but further research is needed to determine the effectiveness of this procedure.

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# Chapter 7

# HUSBANDRY AND NUTRITION

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Susan Donoghue
Jill M. Otten-Stanger

Specific requirements have been established under the Animal Welfare Act (AWA) by the United States Department of Agriculture (USDA, 1992) for the care of captive sea otters and other marine mammals. These regulations pertain to the long-term captivity of animals in aquaria and zoos. Marine mammals taken into custody for treatment of oil contamination are not considered captive animals under the AWA, because they are being held for veterinary treatment and eventual release to their natural habitat (USDA Regulatory Enforcement and Animal Care Memorandum No. 210). Despite this exemption, the USDA standards should be used when planning rehabilitation facilities and caring for oiled sea otters.

The purpose of this chapter is to describe husbandry techniques that will minimize stress and achieve the highest levels of sea otter well-being in the rehabilitation center. Good husbandry is accomplished by providing for the animal's physiological needs, safety, and behavioral needs. Physiological needs include proper nutrition, an appropriate thermal environment, good sanitation, and disease control. Providing for the otter's safety and behavioral needs involves proper techniques of handling and transport, the placement of animals in compatible social groups, and appropriately designed cages, pens and pools.

## CAGES, PENS, AND POOLS

Sea otters may be housed in portable cages, pens, pools, or floating pens, depending on their health and the condition of their fur. The rehabilitation process can be divided into three phases, each with its particular type of housing: critical care, recuperation, and rehabilitated and awaiting release.

### Critical Care

Portable cages with top and side-mounted, sliding doors (Figure 7.1) should be used to hold sea otters during triage, while they recover from sedation, and when they are seriously ill and require

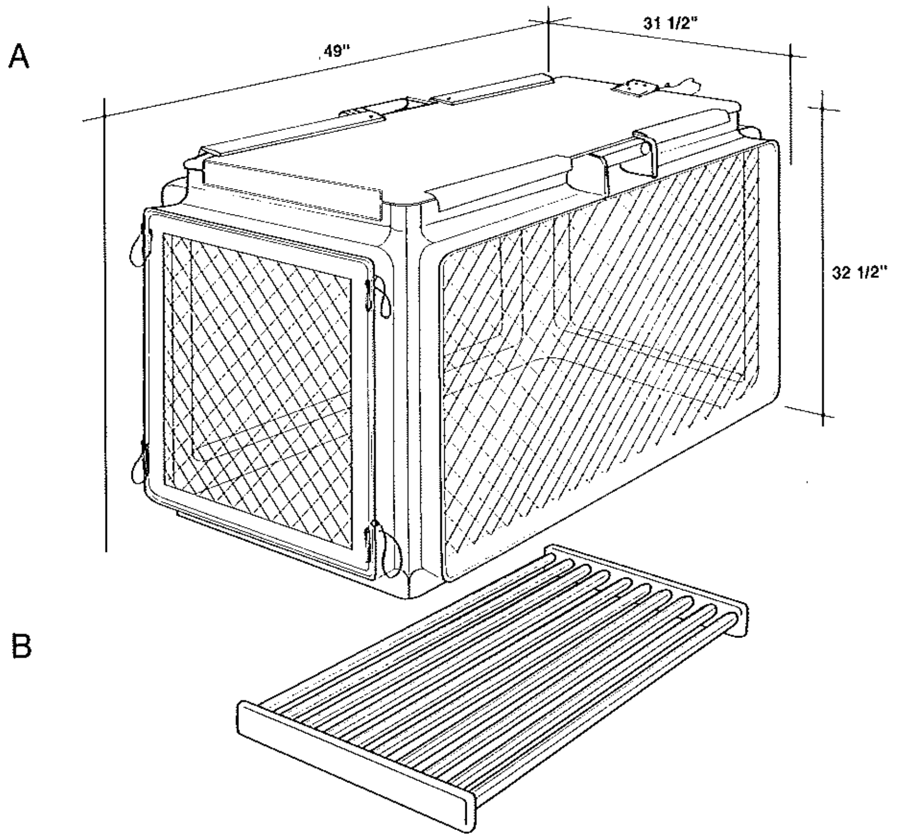


Figure 7.1
Fiberglass critical care cage with top-sliding door and hinged front door (A). The windows are covered with four-inch stretch mesh net. B shows removable rack that is placed on the floor of the cage, preventing the otter from lying in meltwater, feces or urine.

*Critical care cages with open-net sides and top-mounted, sliding doors should be used to hold sea otters before and after cleaning, during recovery from sedation, and for animals with serious health problems that require frequent veterinary care.*

frequent veterinary care. These cages are normally used in the triage room and critical care room of the rehabilitation facility (see Chapter 12) and may be used to transport sea otters over long distances. The cages should be made of smooth fiberglass and have a removable rack that allows the passage of water, feces, and urine into the cage bottom. The interior surfaces of the cages should be rounded to prevent the sea otters from damaging the cage or breaking their canine teeth. The windows should be covered with four-inch, stretch mesh net (0.12 inch braided nylon cord). Each cage should be equipped with handles at the corners (placed away from the windows) to allow the staff to safely carry the caged otter to various areas in the facility.

The critical care room should be well ventilated to reduce humidity and odors, and climate controlled to maintain a temperature of 15 °C (60 °F). When weather permits, sea otters recovering in critical care cages can be placed outdoors with appropriate provisions for shade and windbreaks.

**Recuperation**

Sea otters should be moved to pens with seawater pools (Figures 7.2 and 7.3) as soon as they are eating, can maintain a stable core tem-

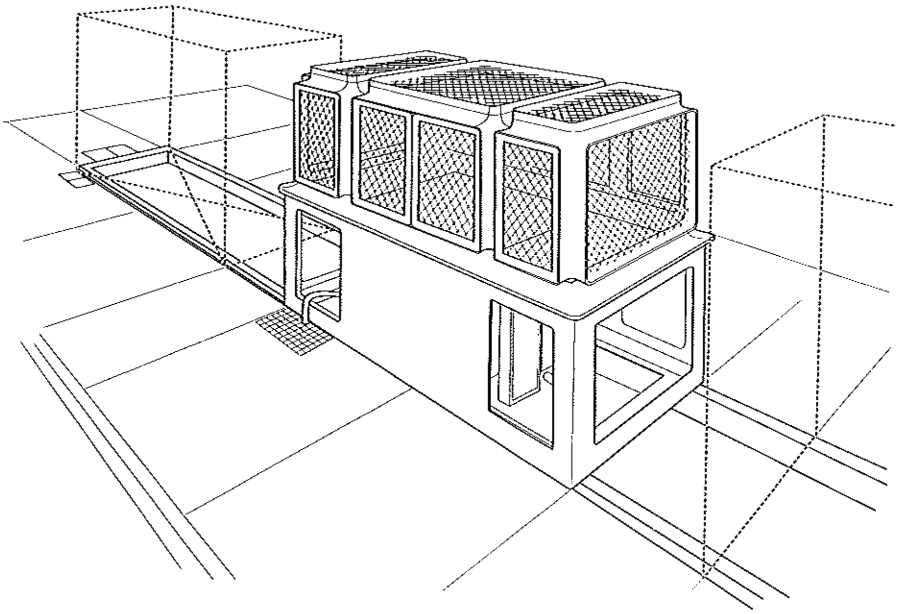

Figure 7.2
Fiberglass pen with a small pool and two haulout platforms designed for two adult sea otters. The four front doors allow easy access to the otters by husbandry personnel. The windows and doors are covered with four-inch stretch mesh net. Seawater flows into the pool through a side-mounted, quick-disconnect hose. Overflow water from the skimmer drains falls into an open raceway and is recirculated or returned to the sea. The pool also can be drained through a bottom-mounted valve. (U.S. Patent #5,315,965.)

perature, and have no other serious clinical disorders. These pens, which can hold two adult sea otters, are made of fiberglass and have four doors so that husbandry personnel can quickly net an animal when clinical care or relocation is required. As with the critical care cages, the interior surfaces should be rounded to prevent broken teeth. The large windows and doors, which are covered with four-inch stretch mesh net (0.12 inch braided nylon cord), provide good ventilation. The pliable net also prevents the otters from damaging their teeth and gums if they bite it.

The pens should be located outdoors in an area with low visual and acoustic disturbance. In Alaska, or where air temperatures drop below freezing, pens may be placed in a climate-controlled indoor area and used for otters that are unable to maintain a normal stable core body temperature.

The seawater pool in each pen should be large enough (3 feet square and 2 feet deep) to allow the otters to perform normal grooming behaviors such as rolling and tumbling. This behavior is essential for the restoration of the fur (see Chapter 6). Because otters defecate frequently, the seawater flow into the pools should result in one complete turnover every thirty minutes (i.e. about 5 gallons per minute in a 150 gallon pool) to prevent fouling the fur and high concentrations of coliform bacteria. The pool should have surface-skimming drains to eliminate floating debris. Clean seawater should be used in the pens and pools to promote the optimum recovery of the fur. If the seawater supply to the pens and pools is recirculated, it must be filtered and

***Because otters defecate frequently, the seawater flow into pens and pools should have a turnover rate of once every thirty minutes. Coliform bacteria concentrations in every pool should never exceed 1000 colonies per 100 ml of water.***

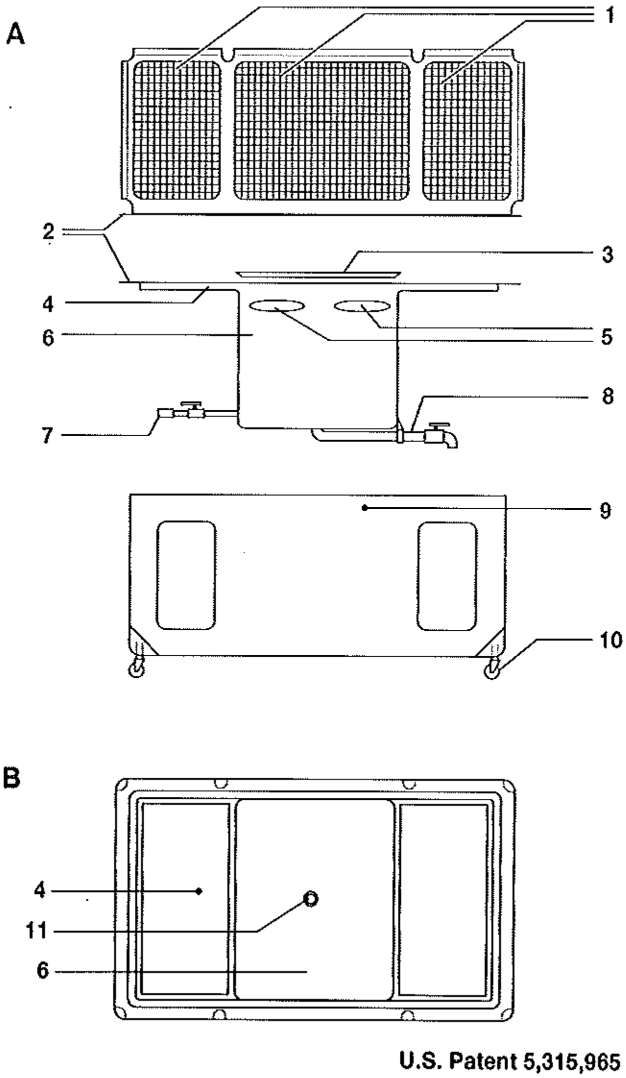


Figure 7.3
Expanded side (A) and overhead (B) views of the molded, fiberglass pen in Figure 7.2 showing the design of the pool, haulout platforms, water supply, drains and cage section. The pen separates into three pieces that stack for easy storage. 1) Nylon net windows, 2) flanges used to bolt upper cage to haulout platforms and pool section, 3) pool cover, 4) haulout platform, 5) skimmer drains, 6) pool, 7) water supply for pool, 8) bottom drain pipe and valve, 9) base section, 10) castor, and 11) bottom pool drain. (U.S. Patent #5,315,965.)

*If the seawater supply to the pens and pools is recirculated, it must be filtered and sterilized by chlorination or ozonation. Because chlorine will damage the otter's fur, the water must be dechlorinated before it is returned to the pens and pools.*

sterilized by chlorination or ozonation (see Chapter 12). Because chlorine will damage the otter's fur, the water must be dechlorinated before it is returned to the pens and pools. Non-chlorinated fresh water can be used for several days if seawater is unavailable, but the long-term effects of holding sea otters in fresh water are unknown.

The pool seawater temperature should be similar to ocean temperatures representative of the season and the sea otter's geographical home range. However, severely debilitated otters that have lost the thermal insulation of their fur will chill rapidly in cold water. Warming the pool water to 20 °C (68 °F) with a heat exchanger may allow otters with damaged fur to groom for longer periods before they begin to chill. In theory, this could decrease the rehabilitation time. As the otters restore the water repellency of their fur, the water temperature should be lowered gradually to the normal ocean temperature for that region. Most facilities are unable to regulate seawater temperature, so the potential benefits of warming seawater in the pens remain untested.

The haulout platforms in the pen should be made of fiberglass that is smooth and has beveled holes (0.4 inches in diameter spaced every 3 inches) for water drainage. The haulout area should be large enough (1.7 feet wide by 3.5 feet long) for an adult otter to move about comfortably and continue grooming after emerging from the water. A removable lid of smooth fiberglass should be placed over the pool to prevent the otter from reentering the water if it becomes chilled or when the air temperature is excessively cold.

Recuperating otters may spend much of their time on the haulout platforms and are prone to abrasions and decubital sores, especially on the flippers and rear legs. A smooth, perforated surface lessens the incidence of these lesions. Materials such as wire mesh, plywood, rigid plastic grate, and indoor-outdoor carpeting are unsatisfactory. Once sores appear, they usually persist until the otters are able to spend the majority of their time in the water.

Otters that are eating well, show normal grooming behavior, are able to thermoregulate in seawater at ambient temperatures, and have no other health problems should be moved to larger outdoor pools (Figures 7.4 and 7.5). The larger area allows the otters to swim, dive, groom, and socialize more actively than in the smaller pen pools. These outdoor pools are circular (14 feet in diameter and 4 feet deep) and

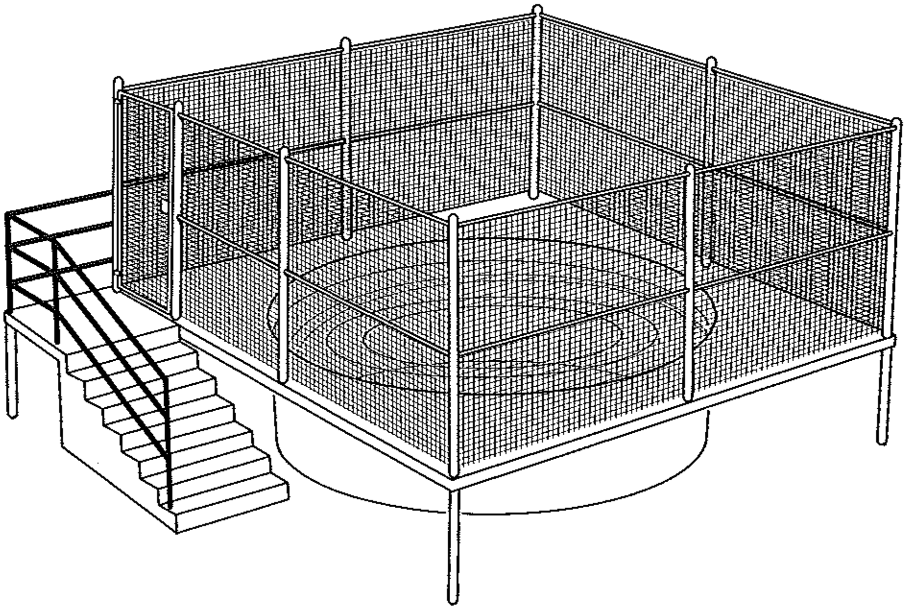

Figure 7.4
Circular pools for holding sea otters. Each pool, which can hold up to six adult otters, is fourteen feet in diameter, four feet deep, and has a six-foot-high fence barrier.

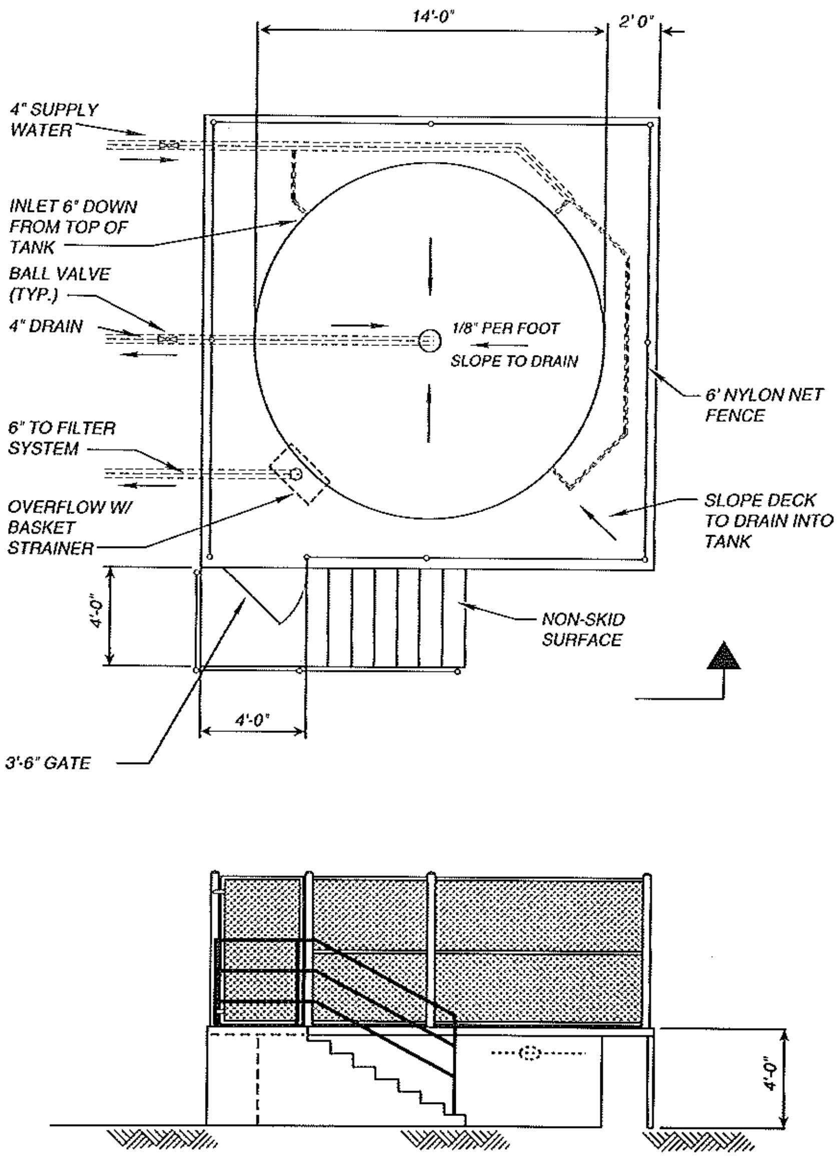


Figure 7.5
Schematic design of the circular holding pool shown in Figure 7.4.

*Sea otters should be moved to outdoor pens with seawater pools as soon as they are eating, can maintain a stable body temperature at ambient air and water temperatures, and have no other serious clinical disorders.*

can hold up to six adult otters. Smooth haulout areas (3 feet wide) should be provided around the perimeter of the pools. The design should allow the husbandry staff to net an otter easily if clinical treatment is required. The seawater supply should result in one complete turnover every thirty minutes to prevent high concentrations of food, fecal debris, or coliform bacteria.

Sea otters that have been cleaned of oil may successfully restore the water repellency of their fur in one to two weeks (see Chapter 6). Normal grooming behavior is an essential part of the rehabilitation process. Not surprisingly, otters that have been heavily oiled or have other serious health problems may not groom effectively and will require additional time to restore their fur. Improper sanitation or inadequate seawater turnover also will delay recovery.

**Rehabilitated and Awaiting Release**

As soon as oiled sea otters have regained their health and the water repellency of their fur, they should be moved to a prerelease facility. The prerelease facility consists of large, floating pens (see Chapter 12) located in a clean bay or lagoon with good seawater circulation. Each floating pen should be sufficiently large (at least 18 feet long, 10 feet wide and 5 feet deep) for the otters to actively swim and dive to regain their stamina, muscle tone, and respiratory capacity. On average, each otter should have at least thirty square feet of surface area in the floating pen and six square feet of haulout space.

**Animal Care**

The otters should be monitored twenty-four hours a day by qualified personnel who are familiar with normal sea otter behavior and can recognize clinical signs of distress. Monitors should be assigned to specific animals or pens (one to four otters in critical care or up to ten animals in the pools and pens). They are responsible for feeding, record keeping (Appendix 2, Forms J-Q), maintaining cleanliness, and ensuring that the otters are able to groom effectively. Abnormal behaviors should be noted and corrective action taken immediately (Table 7.1).

Animals should be handled by trained personnel and only when necessary for transport, treatments, or sanitation. The physical and chemical restraint of sea otters is described in Chapter 3. During routine husbandry procedures that require moving an otter from one cage or pen to another, the staff should use a large dip net fitted with a soft mesh net (4.5-inch stretch mesh). Otters should be weighed during these transfers by suspending the net from the hook of a hanging spring scale. Alternatively, the otter can be placed in a cage and weighed on a platform scale. An otter's weight may vary by several pounds, depending on whether the coat is wet or dry. Weighing an otter only when dry or noting a "wet weight" will avoid confusion in the animal's record.

The husbandry staff should avoid loud talking or socializing near the pens and should observe the otters from a distance or behind a blind to reduce stress on the animals. At the same time, adequate access to the pens is needed for monitors to feed and assist debilitated animals.

It is imperative that the fur remain clean and free from contamination by food or excrement. If an otter in the critical care cages becomes soiled, it should be rinsed in the cage with fresh water or seawater from a low pressure hose. Haulout platforms also should be rinsed of food or feces, and all nets, gloves, and transport cages thoroughly cleaned between use.

*If an otter becomes soiled with food or feces, it should be rinsed immediately with fresh water or seawater from a low pressure hose.*

Hyperthermia is a potentially fatal complication when otters are held out of water (see Chapter 5). In the critical care cages, as soon as otters are dry and no longer at risk of hypothermia, about one-third of the cage floor should be covered with several inches of clean, chipped ice to prevent overheating. Ice helps to prevent pressure sores and keeps the otter's fur clean. Sea otters like to chew on ice, and this behavior also may alleviate stress and dehydration. Cool water sprays

Table 7.1
Solutions to common husbandry problems.

| Problem | Corrective Action |
|---|---|
| Agitated behavior | 1. offer ice or rubber toys to chew on<br>2. place otter in water<br>3. decrease external noise and visual disturbance<br>4. place with compatible otter |
| Diarrhea | |
| a. Normal color | 1. increase dietary roughage<br>2. frequent, smaller feedings |
| b. Bloody or tarry | NOTIFY VETERINARIAN |
| Fighting | 1. reduce crowding<br>2. remove aggressive animals |
| Lethargic | Try to stimulate by handling |
| a. Responsive | 1. offer ice to chew on<br>2. encourage swimming (if possible)<br>3. offer food<br>4. stimulate grooming by drying the fur with pet dryer<br>5. place with compatible otter<br>6. correct over- or under-heating |
| b. Unresponsive | NOTIFY VETERINARIAN |
| Not eating | 1. offer variety of foods<br>2. offer previously favored food<br>3. hand feed with tongs<br>4. offer balls of chipped ice with glucose solution or fish gruel<br>5. identify and eliminate stress<br>6. if longer than six hours, notify veterinarian |
| Seizures | NOTIFY VETERINARIAN |
| Shivering | |
| a. Mild | 1. offer food<br>2. remove from water<br>3. stimulate grooming by drying fur with a pet dryer |
| b. Uncontrolled | 1. move to critical care cage<br>NOTIFY VETERINARIAN |
| Unable to haul out | 1. assist onto haulout platform<br>2. offer food<br>3. allow to groom and rest |

*Sea otters frequently chew on ice. This behavior will help prevent dehydration, hyperthermia, and stress.*

may be used to prevent overheating and shade should be provided when necessary in outdoor areas.

Otters that become chilled in seawater pools or pens, have difficulty hauling out, or experience seizures should be removed from the water with dip nets. If an otter appears hypothermic (begins to shiver violently or becomes lethargic) it should be placed in a critical care cage or confined to a haulout, dried with room temperature air from a pet dryer, offered food, monitored for signs of abnormal behavior, and evaluated by a veterinarian.

Rehabilitated otters awaiting release require only a small husbandry staff (one person for ten otters) to feed and monitor them, maintain sanitation, and provide for security. Under normal circumstances, prerelease otters should be handled only when introducing or removing them from a pen, or for occasional clinical procedures.

### Toys

Grooming behaviors will occupy most of the time spent by sea otters in the rehabilitation facility. However, otters near recovery appear to benefit from access to objects they can chew and manipulate. Blocks of ice, clam shells, kelp, or artificial toys may all serve to occupy them and satisfy their need to manipulate objects in their environment. Artificial objects (pet chew-toys or net buoys) should be large and tough enough to avoid accidental ingestion.

### Social Grouping

When placing sea otters in pens or pools, consideration must be given to social groupings. Otters are naturally gregarious animals that frequently gather into large *rafts* of up to several hundred individuals in favorable feeding or resting locations. Grouping otters within a rehabilitation facility appears to increase grooming activity and appetite, and reduce signs of stress. Even visual contact between sea otters can be beneficial, but housing two or more compatible animals in a pool or pen is preferred.

Adult males and females should be separated to prevent injury to females during copulation. Juveniles of both sexes can be held with mature females. Placement with these older animals often results in bonding, which mimics natural social patterns and may help younger animals learn normal behaviors prior to release. Dominant males may fight if two or more are placed in the same pen or pool with females; however, groups of up to twenty males have been held in large floating pens without problem (Tuomi, 1990). Pregnant females and females with pups need to be housed in smaller groups and observed more closely (see Chapter 8). Once formed, social bonding appears to contribute to the health and well-being of otters in the rehabilitation facility. Movement of otters out of stable groups should be avoided until final release.

*Adult males and females should be separated to prevent injury to females during copulation. Juveniles of both sexes can be held with mature females. Pregnant females and females with pups need to be housed in smaller groups and observed more closely.*

### Transport

During short duration (less than six hours) transport outside of the rehabilitation facility, otters should be placed in kennel cages equipped with a durable, tight fitting rack made of PVC pipe (1.5-inch-diameter spaced one inch apart) in the bottom. The rack should be at least two inches above the floor of the cage to allow water, urine, and feces to fall away from the otter. Chipped or block ice should be placed in the cage to prevent overheating and as a source of fresh water. For long trips (six to forty-eight hours), the otters should be transported in the critical care cages (Figure 7.1). The top-mounted sliding doors allow easy access to the animals by a veterinarian or animal care specialist. Adequate food and ice should be carried in an ice cooler during transport so that the otters can be fed every three hours. Spray bottles of

*During short duration (less than six hours) transport outside of the rehabilitation facility, otters should be placed in kennel cages equipped with a durable, tight fitting rack made of polyvinylchloride (PVC) pipe in the bottom.*

*Chipped or block ice should be placed in the cage to prevent overheating and as a source of fresh water. For long trips (six to forty-eight hours), the otters should be transported in the critical care cages.*

water should be used to flush food, feces, or urine from the fur as needed and to prevent overheating. The air temperature in the vehicle or aircraft should be maintained below 15 °C (60 °F) (Williams, 1990).

## NUTRITION AND FOOD PREPARATION

### Nutritional Requirements

*Wild sea otters normally consume about 25% of their body weight daily in high protein food. A decrease in metabolism may occur during the first twenty-four to forty-eight hours after oil exposure, followed by a period of hypermetabolism which may peak in about four days and last for two to four weeks.*

Sea otters arriving at a rehabilitation center will vary in nutritional condition. Even healthy wild otters have very little body fat and must consume about 25% of their body weight daily in high protein prey items (Table 7.2). This high level of consumption is necessary for the otter to maintain a metabolic rate which is two to three times higher than a terrestrial mammal of the same size. Oil contamination of the fur requires a further increase in metabolism to offset the additional heat loss. This may cause the otter to go into negative caloric balance and to lose weight (Costa and Kooyman, 1982; Davis et al., 1988).

Complicating this scenario, sea otters may be unable to feed normally after an oil spill for several reasons. They may be preoccupied with grooming their contaminated fur and spend less time looking for food. Severe chilling when in the water may prevent normal foraging behavior or force them to go ashore where food is unavailable. Oil contamination of intertidal prey species and oil spill response activities may displace otters from their normal foraging areas (Doroff and Bodkin, 1994). Oil ingestion and stress may cause gastrointestinal inflammation, ulceration, and diarrhea, which interfere with the complete digestion and absorption of food.

Data from hospitalized domestic animals shows that they undergo a series of metabolic adaptations following severe illness or injury (Donoghue, 1989). A lowered metabolic rate occurs during the first twenty-four to forty-eight hours after a life threatening stress, followed by a period of elevated metabolism which peaks in about four days and lasts for two to four weeks. The same metabolic changes appeared to occur in oiled sea otters during the *Exxon Valdez* oil spill (EVOS). Those arriving at the rehabilitation center often showed little interest in food. However, as they began to regain their health and normal appetite, they consumed 30–50% of their body weight in food daily.

When sea otters arrive at the rehabilitation center, their body condition and immediate nutritional needs should be assessed during initial clinical evaluations (see Chapter 4). Serious health problems (hypoglycemia, dehydration, etc.) will occur in animals that have not eaten adequately. These otters will require immediate medical treatment (see Chapter 5). Animals that are not heavily oiled and whose health is stable should be allowed to rest and should be fed for twelve to twenty-four hours prior to sedation and cleaning; this will lessen the stress of capture. During this period, they should be offered familiar food such as clams and crabs. Food should be withheld one to two hours before sedation to prevent vomiting or regurgitation.

### Diet and Food Preparation

Sea otters should be fed a variety of seafoods including shrimp, crabs, clams, fish, squid, mussels, sea urchins, and abalone (Tuomi,

Table 7.2
Representative food items of sea otters reported in Alaska and California (Kenyon, 1969; Williams, 1990; Kvitek et al., 1993). For a comprehensive list of items see Reidman and Estes (1990).

- **Arthropoda**
  - Crab and lobster
    - *Cancer* sp.(Dungeness, rock, red crab)
    - *Telmessus cheiragonus*
    - *Panulirus interruptus* (California spiney lobster)
    - *Pleuroncodes planipes* (pelagic red crab)
    - *Pugettia* sp. (kelp crabs)
    - *Pagurus* sp. (hermit crab)
  - Shrimp
    - *Sclerocrangon boreas*
  - Isopods
- **Annelida**
    - *Nereis* sp. (sand, clam worm)
    - *Arenicola* sp. (lug worm)
    - *Eudistylia polymorpha* (sabellid worm)
- **Mollusca**
  - Gastropoda
    - *Thais, Natica, Buccinium, Astraea, Polinices* sp. (snails)
    - *Haliotis* sp. (abalone)
    - *Tegula* sp. (turban snails)
  - Pelecypoda (Bivalvia)
    - *Modiolus, Mytilus, Musculus* (mussels)
    - *Pododesmus* sp. (oyster)
    - *Siliqua, Tivela, Tresus, Serripes, Macoma, Saxidomus, Protothaca, Mya* sp. (clams), *Clinocardium* sp. (cockle)
    - *Patinopecten* sp.(scallops)
  - Cephalopoda
    - *Loligo opalescens* (market squid)
    - *Octopus* sp. (octopus)
- **Echinodermata**
  - Echinoidea
    - *Strongylocentrotus* sp. (sea urchins)
  - Holothuroidea
    - *Cucumaria* sp. (sea cucumber)
  - Asteroidea
    - *Asterina, Pisaster*
- **Chordata**
  - Pisces
    - *Hemilepidotus hemilepidotus* (Red Irish lord)
    - *Hexagrammos* sp. (greenling)
    - *Cyclopterichthys glaber* (Globefish)
    - *Pleurogrammus monopterygius* (Atka mackerel)
    - Cottidae (sculpins)
    - *Gadus macrocephalus* (Pacific cod)
  - Ascidiacea
    - *Styela* sp. (tunicates)

1990). The caloric value of foods frequently consumed by sea otters during the EVOS are presented in Table 7.3. The percentage of water in these foods is quite high (66–83%). Protein contributes more than 70% of the calories for all items except salmon. By comparison, cat food is typically 25–35% protein and dog food is 18–32%. Only 10–20% of the calories in a sea otter's diet are from fat and almost none from carbohydrates.

*To calculate the required daily food consumption for healthy otters, multiply the animal's body weight (pounds) by 0.25 and then divide this amount into five feedings spaced about three hours apart.*

To estimate the daily food consumption of a healthy otter, multiply its body weight by 0.25 and then divide this amount into five feedings spaced about three hours apart. Food should not be offered late at night, allowing undisturbed rest time. Otters in a hypermetabolic state should be offered as much food as they are willing to consume at each feeding. Once they have regained their health, they should be placed on a normal maintenance diet, about 25% of their body weight daily. However, this should be adjusted for individual animals so that they maintain body weight.

Freezing seafood is thought to reduce the transmission of parasites (Sweeney, 1965) and is convenient for purchase and storage. Fresh seafoods may be used, if the quality can be assured and facilities are available to properly hold and process these foods. Staff should be trained in the proper handling of seafoods (human food sanitation standards) to ensure that food remains nutritious and uncontaminated (Ferrante, 1990).

Table 7.3
Caloric values of foods consumed by sea otters in rehabilitation facilities. Note that the foods are extremely high in protein and contain moderate amounts of fat. Carbohydrate is essentially absent from these foods.

| | PRO[a] | FAT | CHO[b] | PRO[a] | FAT | CHO[b] |
|---|---|---|---|---|---|---|
| FOOD ITEM | (% kcal) | | | (% DM[c]) | | |
| Clams[d] | 78 | 22 | 0 | 62 | 7.7 | 0 |
| Crab[e] | 79 | 19 | 2 | 79 | 8.6 | 2 |
| Pollock[d] | 91 | 9 | 0 | 88 | 4.2 | 0 |
| Mussels[d] | 77 | 23 | 0 | 58 | 7.9 | 0 |
| Scallops[d] | 99 | 1 | 0 | 78 | 0.5 | 0 |
| Shrimp[d] | 85 | 15 | 0 | 84 | 6.5 | 0 |
| Squid[e] | 82 | 10 | 8 | 82 | 4.5 | 8 |

[a] protein
[b] carbohydrate
[c] dry mass
[d] Souci et al., 1989.
[e] Pennington and Church, 1985. Foods referenced in (e) are processed for human consumption; nutrient values are likely to approximate those for the fresh foods offered to sea otters.

*Otter food should be preweighed in one-pound portions, placed in plastic bags, and kept chilled on ice until eaten. Uneaten food should be discarded after six hours.*

The rehabilitation facility should have adequate freezer space to store at least a three-day supply of frozen seafood (Chapter 12). For a facility with 200 adult sea otters, the freezer should be able to hold 9,000 pounds of seafood. Frozen seafood should be thawed in air or cold water and used within several hours to avoid spoilage. Seafood should never be thawed in hot water, as this promotes bacterial growth. The food should be preweighed (one pound portions are convenient), placed in plastic bags, and kept chilled on ice until used. Preweighing the food into bags makes it easier for the animal caretakers to estimate the amount eaten by each otter. Uneaten food should be discarded after six hours.

Vitamin supplementation should be attempted for all captive otters. However, otters are adept at locating vitamin tablets hidden in food, and will often refuse to accept food that has been altered by supplements. Muffins containing krill and vitamins have been used at the Seattle Aquarium (Otten-Stanger, personal observation). SeaTabs™ vitamins are available commercially and tolerated well by most marine mammals.

### Roughage

Even with good sanitation and attention to nutrition, recuperating sea otters often develop diarrhea. The causes are varied and difficult to determine. Sea otter feces is commonly mucoid and poorly formed, especially when the shells or carapace of food items are excluded from the diet. Because defecation usually takes place in the water, detecting true diarrhea can be difficult, especially for observers not accustomed to normal sea otter eliminations. Overfeeding may contribute to diarrhea. The passage of undigested pieces of food, straining during a bowel movement (occasionally resulting in a prolapsed rectum), and bloody or tarry stools should be reported to the veterinarian.

*A varied diet is important for sea otters to remain healthy. The diet should include roughage in the form of shells or carapace from whole food items such as mussels, crabs, and shrimp.*

Increasing roughage in the form of shells or carapace from whole food items such as mussels, crabs, and shrimp produces a more formed stool (Figure 7.6). The indigestible portions act as binders in the feces and may contribute to the mineral nutrition of the otters. This roughage may be removed for animals with gastrointestinal hemorrhaging, but may result in unformed feces that cannot be distinguished from diarrhea.

### Methods of Feeding

Sea otters in critical care cages or fiberglass pens should be hand fed by offering individual pieces of food with long-handled tongs. Food should never be offered to an otter using the bare hands; this may introduce food-borne pathogens, and the otter's sharp claws and strong jaws can inflict serious injury. Food may be placed (in preweighed portions) into stainless steel feeding bowls placed on haulout platforms in the pools and larger pens. Rehabilitated otters in floating pens should be fed by throwing food into the water, or by placing the food in a bucket or basket that is submerged. This will encourage the otters to swim and dive for their food and will reduce the perception of the husbandry staff as a food source.

An accurate record of the type and amount of food eaten by each otter (Appendix 2, Forms K and L) is important for monitoring the animal's recovery. Most otters will readily accept food and rapidly adapt to various feeding routines. A variety of seafood should be consumed to ensure adequate nutritional intake. Some otters develop a preference for certain foods and should be encouraged to eat other

Figure 7.6
Roughage in the form of shells or carapace from whole food items is an important part of the sea otter's diet.

items. Subordinate otters may need additional food offered to them after other animals in the group have finished eating.

*An otter refusing food for more than one feeding or eating less than 10% of it's body weight each day may indicate serious health problems and warrants immediate attention by a veterinarian.*

An otter refusing food for more than one feeding or eating less than 10% of it's body weight each day may indicate serious health problems and warrants immediate attention by a veterinarian. In the large holding pens, it is not possible to determine the exact food consumption of each animal, but husbandry staff should note any animal that does not appear to be eating. An otter that does not feed adequately should be moved to a different pen or to a critical care cage for observation and clinical treatment. Tube feeding may be necessary for severely anorectic sea otters (see Chapter 5).

## WATER QUALITY, CLEANLINESS, AND DISEASE PREVENTION

### Water Quality

*Water flow to the pens and pools should be sufficient so that the entire volume is replaced every thirty minutes. Coliform bacteria concentrations in every pool should be monitored weekly and should not exceed 1,000 colonies per 100 ml of water.*

Water quality is very important for successful rehabilitation. If untreated seawater is used in the facility, it should be obtained from areas that are uncontaminated by chemical or biological waste. Recirculating seawater systems should be professionally engineered and have adequate filtration and sterilization (chlorination followed by dechlorination or ozonation) to keep the water clean and bacteria-free. To further guard against disease transmission, the recirculating seawater systems of pens and pools should be completely separate (see Chapter 12). If other species of animals are held in the same facility, those pools also should have separate seawater systems. Water flow to the pens and pools should be sufficient so that the entire volume is replaced every thirty minutes. Coliform bacteria concentrations in every pool should be monitored weekly and should not exceed 1,000 colonies per 100 ml of water (USDA, 1992). If treated fresh water is used in the pens or pools, it must be dechlorinated.

### Cleanliness

Leftover food, shells, and feces should be removed from pens and cages with small hand-held nets; surfaces should be rinsed with water several times daily. As otters are moved, or at least every three days, enclosures should be drained and washed with detergent, disinfected with dilute chlorine bleach (one part bleach to thirty parts water) to kill bacteria and algae, and then rinsed to remove all residues. Gloves, dip nets, and other equipment should be disinfected by daily soaking in dilute chlorhexidine (Nolvasan™). Food containers and utensils should be washed with detergent, soaked in dilute bleach as above, and then thoroughly rinsed between each feeding. The husbandry staff should wear rubber gloves when handling food, bedding, or waste. This is for their own protection and to prevent contamination.

***To kill bacteria and algae, pens and cages should be rinsed as necessary to remove food and feces and washed with detergent and disinfected with dilute chlorine bleach (one part bleach to thirty parts water) every three days.***

Rehabilitation facility visitors should be restricted and domestic pets excluded at all times. Footbaths containing dilute bleach or chlorhexidine should be used at the facility entrance to prevent the fomite transmission of disease. Coveralls issued within the center should be worn over regular clothing, and street shoes should be exchanged for rubber boots before beginning work. These garments should be cleaned after each shift. Personnel should wash their hands with povidone iodine or chlorhexidine hand soap regularly; this is especially important before and after handling otters or their food, and after cleaning pens. Sinks, showers, and appropriate disinfectants should be provided at strategic locations.

### Disease Prevention

Information on the naturally occurring contagious diseases of all marine mammals is minimal and often incomplete. Clinical signs, routes of transmission, incubation periods, and testing procedures have been partially described for a handful of clinical syndromes such as San Miguel sea lion virus, Erysipelas, Vibriosis, and a few pox viruses. Leptospirosis has been implicated as a cause for chronic renal disease in sea lions along the California coast and for a hemorrhagic perinatal syndrome in Northern fur seals (Dunn, 1990). Other species of mustelids are susceptible to domestic animal diseases including canine distemper, feline panleukopenia, leptospirosis, toxoplasmosis, and rabies (Fowler and Theobald, 1978; Wallach and Boever, 1983). None of these diseases has been documented in sea otters, but the possibility of introducing an infection to an immuno-compromised group of sea otters in the rehabilitation center should be considered. Enhanced serum antibody titers to Salmonella, Vibrio, and Pasteurella bacterial pathogens were detected in sea otters during the EVOS (Wilson et al., 1990), possibly as a result of food contamination during captivity. Harris et al. (1990) have reported finding oral ulcers, associated with an apparent herpes virus, at one of the EVOS rehabilitation centers. These oral ulcers were later found to occur naturally in the sea otter population of Prince William Sound.

*Newly arriving otters should be kept in individual critical care cages and observed for apparent signs of contagious or infectious disease before being placed with other otters.*

When sea otters first arrive at the rehabilitation center, they should be held in individual critical care cages and observed for signs of contagious or infectious disease before being moved into pens with other otters. This procedure should reduce the risk of introducing disease, but it can be difficult to accomplish under emergency conditions. Strict disinfection of transport kennels, cages, pools, food handling utensils, and restraint equipment must be enforced. Animals should be moved as rapidly as possible through the rehabilitation process and constantly monitored for possible signs of contagious disease. Quarantine procedures should be instituted if an infectious or contagious disease is suspected.

Sampling programs such as coliform counts, hematology, serology, bacteriologic, fungal and viral cultures, and the results of necropsy examinations should be utilized to alert staff to potential disease problems. The usefulness of some tests is often quite limited. Specific serologic tests may be inaccurate in species other than those for which the tests were designed. Negative results may create a false sense of security and should not be allowed to justify deviations from disease prevention control protocols and strict quarantine procedures within the rehabilitation facility.

## SUMMARY

The goal of good husbandry is an environment that enables oiled sea otters to regain health and restore their fur so they can be released as soon as possible. However, the stress of captivity can be as debilitating and life threatening as the effects of oil. Husbandry protocols should minimize this stress by providing:

1) properly designed housing with access to clean seawater,
2) appropriate ventilation and temperature control,
3) good nutrition,
4) minimal visual and acoustic disturbance,
5) socialization with other otters,
6) a sanitary and disease-free environment, and
7) minimal handling by husbandry personnel.

Husbandry personnel should recognize abnormal sea otter behaviors and the clinical signs of distress so that corrective measures can be taken immediately.

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Chapter 8

# Rehabilitation of Pregnant Sea Otters and Females with Newborn Pups

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Routine stress from parasitism, minor injuries, environmental factors, and altered nutritional status have surprisingly little effect on pregnancy, once implantation has occurred and the developing fetus is securely established in the uterus. The exception is severe trauma occurring near the end of gestation, which may induce premature parturition (Moberg, 1985). Pregnant sea otters in a rehabilitation center are at special risk from the potential toxicity, organ damage, and thermoregulatory problems associated with crude oil contamination, and by the combined stress of capture and medical treatment (see Chapter 1). During an oil spill, provisions must be made at the rehabilitation center for the treatment, husbandry, and housing of pregnant marine mammals and newborn pups. This chapter addresses the special needs and problems of these animals, with particular emphasis on the pregnant sea otter.

In the wild, female sea otters often congregate in favorite feeding and resting areas, especially during late gestation and for several weeks after the pups are born. An oil spill that moves through such an area may contaminate large numbers of females and their offspring. This situation occurred during the *Exxon Valdez* oil spill (EVOS) when the spill engulfed Green Island in late March. Because peak pupping occurs in May (Reidman and Estes, 1990) and Green Island (Prince William Sound) is used by many female otters as a pupping area, the rehabilitation center in Valdez received a disproportionate number of heavily oiled, pregnant sea otters (Williams and Davis, 1990).

A similar risk exists for other species of marine mammals. The birth lairs of ice-breeding seals and polar bears are vulnerable to contamination by coastal spills. Other species of phocid seals, sea lions, and fur seals give birth on rookeries during the spring. If a spill occurs near a pupping rookery, large numbers of pregnant females and newborn pups may become oiled. Such an incident occurred in 1991 when the *Sanko Harvest* oil spill contaminated hundreds of fur seal (*Arctocephalus fosteri*) pups in southwest Australia (see Chapter 15).

Many newborn pinnipeds, which rely on lanugo (prenatal fur) and have a high metabolic rate to maintain their core temperature, are especially susceptible to hypothermia if they become oiled. In addition, petroleum hydrocarbons may accumulate in the blubber of pregnant females and be incorporated into the milk during lactation (Engelhardt, 1983). This will result in the ingestion of petroleum hydrocarbons by the pup long after the spill has dissipated.

## PREGNANCY IN SEA OTTERS

Few reports provide comprehensive data concerning the rate of success for delivery and rearing of pups by wild sea otters. It has been estimated that only 30% of pups survive their first year (Jameson and Johnson, 1993; Reidman and Estes, 1990). Immature females are considered less capable than experienced adults in meeting the constant demands imposed by feeding and grooming of newborn pups.

During the wildlife rehabilitation program following the EVOS, nearly 70% of the captured sea otters were female; forty-nine of these were diagnosed as pregnant during admission or at necropsy. In forty (81%) of these females, pregnancy was terminated by: 1) death of the mother (n = 19); 2) abortion of a near term fetus or stillbirth (n = 9); or 3) death of the newborn pup (n = 12). Thirteen newborn pups were transferred to a nursery after their mothers were unable to care for them; all but one of these pups died. Four pregnant females completed the rehabilitation process and were released before delivery. Only five of the pregnant otters were able to deliver and successfully care for live pups in the rehabilitation center (Tuomi et al., 1991).

*Pregnant otters in a rehabilitation center are at special risk to oil toxicity, hypothermia, hepatic lipidosis, stress, and anesthetic agents.*

Mortality in pregnant otters reached 38% and was 4% higher than the overall mortality of captured otters following the EVOS. Pregnant otters admitted during the first three weeks exhibited the greatest degree of oiling and suffered the highest mortality. This was similar to results reported for all sea otters in the rehabilitation program (Williams et al., 1990). Hepatic and renal lipidosis was 2.6 times more common in females than males. Females may have been predisposed to these disorders by the high energy demands of pregnancy and lactation (Lipscomb et al, 1993).

Stillborn pups ranged from 1.2–2.0 kg in body weight; five of these pups showed lesions suggesting death in utero before the onset of labor. Neonatal death (pup survival less than three days) occurred in ten of the liveborn pups; eight of these pups weighed less than 1.4 kg and may have been born prematurely. Samples of tissue from a deceased pup and colostrum from one of the females revealed significant levels of petroleum hydrocarbons (see below). One pup had a large umbilical defect with evisceration and died within a few minutes. Another pup underwent successful surgical repair of an umbilical hernia at two days of age. Uterine torsion was diagnosed postmortem in three females with very large full-term fetuses (fetal weight = 2.0, 2.3, and 2.5 kg).

Nine females brought to rehabilitation centers were accompanied by live pups ranging in age from a few days to several months. Two of the nursing females died and their pups were moved to a nursery along with three more pups from this group whose mothers could not care for them. Two of these five separated pups died.

Eleven other orphaned pups were captured and brought into the centers. Orphan pups from the wild had a lower mortality than pups born in the rehabilitation centers. Ten (91%) of the original eleven wild orphaned pups survived and were transferred to seaquaria.

In comparison to the sea otters from the EVOS, reports from a fifteen-year captive breeding program at the Vancouver Aquarium indicate a 72% success rate with eight pups raised to weaning. One stillbirth, one neonatal death, and one pup lost due to lack of maternal care occurred in this series.

## ANESTHESIA AND PHYSICAL RESTRAINT

Data concerning the physiological changes occurring with gestation and parturition indicate an increased health risk for pregnant mammals during anesthesia (Table 8.1; Benson and Thurmon, 1987). For example, cardiac work is increased during pregnancy, thus creating a decreased cardiac reserve. The increase in plasma volume may be greater than increases in red blood cell mass, resulting in decreased

Table 8.1
Physiologic alterations associated with pregnancy (from Benson and Thurmon, 1987).

| | |
|---|---|
| **Cardiovascular** | |
| Heart rate | Increased |
| Cardiac output | Increased |
| Blood volume | Increased |
| Plasma volume | Increased |
| Packed cell volume, hemoglobin and plasma protein concentration | Decreased |
| Arterial blood pressure | Unchanged |
| Central venous pressure | Unchanged but increases during labor |
| **Respiratory** | |
| Minute volume of ventilation | Increased |
| Oxygen consumption | Increased |
| Arterial oxygen tension and pH | Unchanged |
| Arterial carbon dioxide tension | Decreased |
| Total lung capacity and vital capacity | Unchanged |
| Functional residual capacity | Unchanged |
| **Gastrointestinal** | |
| Gastric emptying time and intragastric pressure | Increased |
| Gastric motility and pH of gastric secretions | Decreased |
| Gastric enzyme concentration | Increased |
| **Other Organ Systems** | |
| SGOT, LDH | Increased |
| Plasma cholinesterase concentration | Decreased |
| Renal plasma flow and glomerular filtration rate | Increased |
| BUN and creatinine | Decreased |
| Na+ and water balance | Unchanged |

hemoglobin concentration and packed cell volume (PCV) in the pregnant animal. If these changes are exacerbated by Heinz body formation associated with petroleum hydrocarbon toxicosis, the pregnant female may become anemic. Struggling during restraint or anesthetic induction could result in pulmonary congestion and heart failure in pregnant animals. The functional residual capacity of the lungs is decreased by pressure on the diaphragm and abdominal organs by the gravid uterus. The pressure of the enlarged uterus on the diaphragm and major abdominal vessels can alter oxygenation and return blood flow especially in marine mammals whose natural buoyancy probably minimizes these effects in the aquatic environment. Hypoxemia and hypercapnia may occur if the animal does not breathe properly. The fetus may be adversely affected by abnormal maternal acid/base balance or by decreases in maternal blood pressure which may reduce blood flow to the placenta and cause fetal hypoxia. Vomiting and aspiration are also more likely to occur in the pregnant animal during anesthesia. Complications include asphyxiation and pneumonitis.

*Vomiting and aspiration during anesthesia are more likely to occur in the pregnant animal.*

In view of the above complicating factors, there is no ideal anesthetic for pregnant sea otters. Primary consideration should be given to minimizing the time from induction to recovery, and minimizing the effects of depression on the cardiopulmonary and respiratory systems of the mother (Benson and Thurmon, 1987).

*The choice of chemical restraint must be based on the safety of the mother and the fetus.*

The narcotic, fentanyl, was the most commonly used anesthetic at sea otter rehabilitation centers during the EVOS. It was usually combined with diazepam (to reduce the occurrence of seizures) and a tranquilizer such as azaperone or acetylpromazine (see Chapter 3). This protocol had the advantage of rapid and reliable induction after intramuscular injection. In addition, naloxone could be used as a reversal agent after completion of washing or treatments. All of these agents can cross the placenta (Briggs et al., 1983).

*There is no ideal anesthetic for pregnant sea otters. Primary consideration should be given to minimizing the time from induction to recovery, and minimizing the effects of depression on the cardiopulmonary and respiratory systems of the mother.*

Opiates can cause fetal depression proportional to the degree of analgesia produced. Fetal elimination of opiates may take up to two to six days in some species. Because opiate antagonists such as naloxone also cross the placenta, initial reversal of this depression will occur. However, naloxone itself can cause mild neonatal depression. Because naloxone has a short duration of action, renarcotization from the fentanyl may occur once the naloxone is metabolized and excreted. All otters, and especially neonates delivered within two days of maternal anesthesia, should be monitored for recurring signs of narcosis. Supplemental naloxone should be administered, if indicated.

Phenothiazine tranquilizers, including acetylpromazine, may promote opiate-induced depression but add little to analgesia. They induce hypotension, respiratory depression, and thermal instability. In contrast to the opiates, the duration of action of these tranquilizers is long (lasting up to eight hours) and cannot be reversed. The use of these tranquilizers in pregnant animals should be limited to markedly apprehensive or excited females. The doses should be minimal to produce a calming effect, but not undue generalized depression.

When administered to pregnant animals, diazepam can produce lethargy, hypothermia, and hypotonus in the newborn. These effects are dose related and do not appear to cause severe problems when minimal doses are used (Benson and Thurmon, 1987). As a cautionary note, fetal deformities have been associated with the use of diazepam in the first trimester in human patients (Briggs et al., 1983).

Inhalation anesthetics such as isoflurane and halothane readily cross the placenta, resulting in rapid fetal and maternal equilibrium. Consequently, a degree of depression is created in the fetus that is proportional to the depth of anesthesia in the mother. Deep levels of maternal anesthesia may cause maternal hypotension, decreased uterine blood flow and fetal acidosis. The same responses are observed in mothers suffering from circulatory collapse due to hypoglycemia, hypothermia, or shock. In view of this, the use of inhalation anesthetic agents in hypotensive pregnant otters should be minimized or avoided.

Sea otters in advanced pregnancy should be placed in lateral recumbency (on their side) during anesthesia to reduce pressure on the diaphragm and major vessels. Anaesthetic times should be kept short. Intravenous or subcutaneous fluids (normal saline or a 1-to-1 mixture of 5% dextrose solution and normal saline; 20 ml/kg/day) should be administered to maintain adequate blood pressure and perfusion. If available, assisted ventilation or supplemental oxygen may be beneficial in severely depressed animals. However, positive pressure delivery systems are not recommended if interstitial or subcutaneous emphysema is suspected. (See Chapter 5.) Constant monitoring of body temperature is vital and methods to warm or cool the animals must be provided. Care must be exercised when moving anesthetized otters in advanced pregnancy to avoid abrupt rotational movements which might induce uterine torsion.

## MEDICAL CONSIDERATIONS

Abortion has been observed in many species as a response to severe physiological stress. Starvation may result in abortion as a protective mechanism to conserve the maternal animal's own body reserves. Stresses associated with transport, close housing, sudden reduction or change in food and water intake, and other debilitating factors will cause abortion in pregnant mares, especially during the middle of pregnancy (Roberts, 1980). Miller (1980) notes that abortion in emaciated cattle may occur, but that abortion or premature delivery in these cases does not preserve the life of the animal. Rather, it heralds a terminal event. The report recommends the induction of parturition at an earlier stage in these animals.

Glucocorticoids administered in repeated doses over several days have been used to stimulate abortion in the last trimester of pregnancy in horses (Roberts, 1980). In contrast, similar treatments have no effect on the termination of pregnancy in many other species. Administration of exogenous adrenocorticotrophin (ACTH) or corticosteroids can disrupt implantation and fetal development in sheep and rats. Currently, it is difficult to predict the concentration of adrenal hormones released during a specific stressful event, and whether the levels would be sufficient to result in abortion (Moberg, 1985).

Several forms of glucocorticoids (dexamethasone, prednisolone, triamcinolone) were routinely used to combat shock in debilitated sea otters during the EVOS. Use of these drugs in females was discontinued after it was suspected that corticosteroids contributed to the high incidence of abortion and stillbirths in the centers. To evaluate this, we compared the outcome of pregnancies for otters receiving and not receiving steroids during rehabilitation (Table 8.2). The total number of otters in this study was relatively small and many other variables influenced the condition of the pregnant animals. In general, survival rates were comparatively better for females receiving corticosteroids at admission. The rates of stillbirths and neonatal deaths were similar for both groups. Based on these results, corticosteroid administration should be considered.

During the EVOS, live pups were taken from twelve females which were unable to care for them during the first few hours after birth. Most of these neonates were never able to nurse and were hypothermic due to the inability of the mother to keep the pup's fur properly groomed. Newborn pups are susceptible to chilling and may drown or be injured if the female is inattentive. Pups which become hypothermic due to poor grooming or immersion in water are very difficult to stabilize. Only one of the pups removed from its mother survived. It was transferred to Point Defiance Zoo and Aquarium where it died at about four months of age. The poor viability of pups born to debilitated otters at the centers is not surprising, but the effect of oil exposure, capture stress, medical treatments, husbandry techniques, and natu-

Table 8.2
Outcome of pregnancies correlated with corticosteroid administration during the EVOS. n = the number of adult females in each study group.

| | Corticosteroids Given (n = 32) | | No Corticosteroids Given (n = 17) | |
|---|---|---|---|---|
| **Outcome** | **No.** | **(%)** | **No.** | **(%)** |
| **Female died** | | | | |
| Before delivery | 9 | (28) | 7 | (41) |
| Stillborn pup | 2 | (6) | 1 | (6) |
| Total females died | 11 | (34) | 8 | (47) |
| **Female lived** | | | | |
| Stillborn pup | 6 | (19) | 3 | (18) |
| Live pup which then died | 8 | (25) | 3 | (18) |
| Live pup which lived to release | 4 | (12) | 3 | (18) |
| Released w/o delivery | 3 | (9) | 0 | (-) |
| Total females lived | 21 | (66) | 9 | (53) |

ral maternal abilities on survival remain uncertain. Although maternal survivorship dramatically improved once the oil weathered, the mortality in the offspring remained high. Viable pups were not delivered in the rehabilitation centers until nine weeks after the oil spill. Fifty percent of the deliveries after this period still resulted in death of the offspring, although no further maternal deaths occurred.

Dystocia (delayed or difficult delivery of a full term fetus) is a potential problem in a rehabilitation center. At least two sea otters treated during the EVOS experienced difficult labor. Oxytocin and calcium injections were administered to one of these females in an effort to strengthen contractions, but the effect was questionable. Both otters eventually delivered very large, stillborn pups following more than twenty-four hours of labor. The untreated female subsequently developed a purulent vaginal discharge and was given antibiotic injections for several days before making a full recovery. A captive sea otter housed for more than two years in a seaquarium had to be assisted with the delivery of a large, stillborn fetus after several hours of unproductive effort. This otter sustained pelvic trauma which resulted in paralysis; death occurred several days later (Vancouver Aquarium Animal Care Department, personal communication). Cesarean section may be performed using fentanyl/diazepam sedation and standard surgical procedures if dystocia is determined to be life threatening.

Uterine torsion has not been reported as a cause of mortality in wild sea otters but has been observed and surgically corrected in an otter housed in a seaquarium (T. D. Williams, Monterey Bay Aquarium; personal communication). The high incidence of uterine torsion observed during the EVOS was a definite concern. The weight of the gravid uterus may not be properly supported when the otter is out of water; transport for prolonged periods in kennel cages while the otter struggles may result in torsion. Excessive rolling and violent activity during capture or while under sedation may also predispose the female to this condition. Female otters in advanced pregnancy should be moved with care and observed closely for signs of abdominal distress. Early surgical intervention is required for correction once torsion has occurred. Prevention or early detection is important.

*To avoid uterine torsion, care must be taken in moving otters in the advanced stages of pregnancy.*

## HUSBANDRY CONSIDERATIONS

Oiled females that have recovered sufficiently to swim and groom normally prior to delivery appear to have the greatest success in raising a pup. Pregnant otters that are unoiled or are captured more than eight weeks following a spill are also more likely to successfully deliver and raise a pup. These otters should be handled as little as possible, housed in large seawater pools, fed, and observed regularly according to standard husbandry protocols (see Chapter 7). The holding pool may house other compatible females, but these animals may have to be removed after delivery if they interfere with the mother in feeding or caring for her pup, or if care of the other otters disturbs the new mother. Pup stealing has been observed frequently in captive sea otters and may create problems if the mother is inexperienced or too debilitated to protect the pup from such interference.

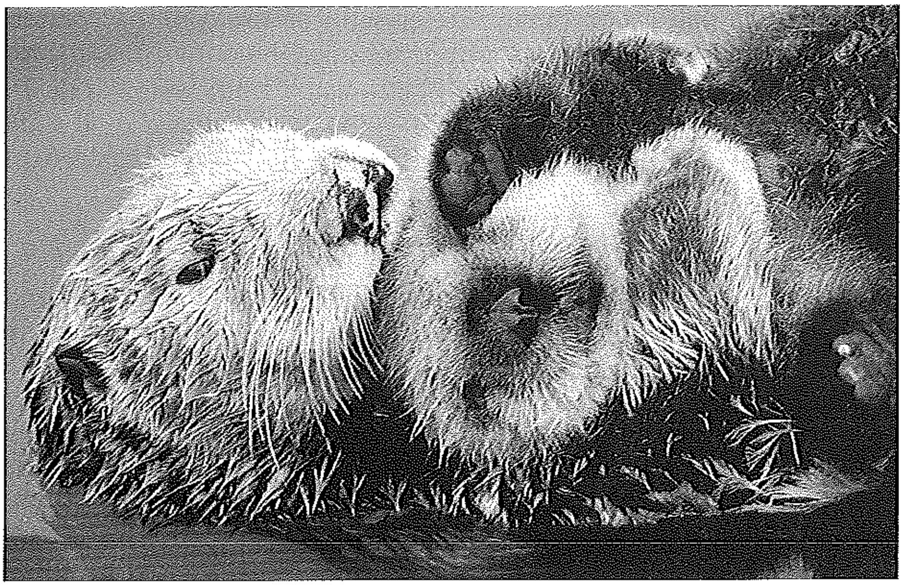

Figure 8.1
Newborn pups are often carried on the female's chest while floating in the water. Note the wooly natal coat of the pup and the rougher texture of the adult's pelage.

*A healthy pup will usually move onto the female's lower abdomen and nurse. The pup must remain nursing and sleeping on its mother's upturned chest and abdomen for the next three to four weeks, except for short periods when she leaves it floating on the surface of the water.*

Most otters deliver after relatively short periods of obvious labor, regardless of whether they are in the water or on a dry surface. Some females with free access to water choose to complete their labor on haul out areas. The onset of labor is frequently signaled by a sudden loss of appetite and increased attention to grooming of the vaginal area. Some females appear to rub their lower abdomen which may assist contractions, and most will alternate periods of straining on the haul out with frequent periods of swimming, including vigorous rolling and grooming behaviors. After delivery, the female usually floats on her back in the water and holds the newborn pup on her chest while she licks and dries its fur (Figure 8.1). The placenta will usually be observed trailing from the vaginal opening for up to two hours after delivery. Eventual passage of these membranes appears to cause the female no distress. A moderate bloody discharge also may be observed during the first post partum day, but is seldom noted after that time.

Once the mother has completed grooming and drying her newborn, a healthy pup will usually move onto the female's lower abdomen and nurse. The pup will remain nursing and sleeping on its mother's upturned chest and abdomen for the next three to four weeks, except for short periods when she places the pup on a haulout or leaves it floating on the surface of the water while she feeds or grooms. A pup will vocalize loudly during these short separations and will gradually start to perform simple swimming movements, beginning with the ability to roll onto its back.

*Housing for female otters with young pups requires haulouts designed to allow the female to crawl out of the water without dragging the pup across a sharp edge, and barriers to prevent pups from becoming entrapped in drains or under platforms.*

Haulouts should be designed to allow females to crawl out of the water without dragging the pup against a sharp edge. Pups can become trapped in overflow outlets or under haulouts unless such structures are adequately enclosed. Pools designed to hold young pups and their mothers should have haul out space which can be gated to separate the animals without undue stress while the pool is cleaned and disinfected. Alternatively, floating maternity pens can be constructed in the prerelease facility. (See Chapter 12 for a description of the different types of enclosures.)

Stillborn pups may be groomed and carried for several hours before the female loses interest. Females may become frantic when handlers attempt to remove weak or dead pups. As a result, a pup may be drowned or crushed if the female will not abandon it. Female otters which are unable to float on the water due to poor coat condition or medical problems can perform pup grooming while in a dry cage. However, they will probably be unable to successfully nurse their offspring.

*Female otters that are unable to float on the water due to poor coat condition or medical problems can perform pup grooming while in a dry cage. However, they will probably be unable to successfully nurse their offspring.*

Once a healthy pup has become bonded to its mother, short separations for purposes of medical treatment or movement within the rehabilitation center cause few problems. When mothers and pups must be separated during transport, it is preferable to place cages so that they may remain in visual contact. In at least one case, a three-month-old pup separated from its mother for medical reasons for more than seven weeks was able to reestablish the maternal bond within twenty-four hours after its return to the mother (J. McBain, Sea World; personal communication).

*Once a healthy pup has become bonded to its mother, short separations for purposes of medical treatment or movement within the rehabilitation center cause few problems. When mothers and pups must be separated during transport, it is preferable to place cages so that they may remain in visual contact.*

The high rate of neonatal death can be extremely distressing to the husbandry staff. This problem should be anticipated and addressed during training with special attention to protocols for handling otters whose pups die. Only one or two people should be allowed in the vicinity of any newborn and its mother. Movement of animals for treatment or pen cleaning should be postponed as long as possible, and then performed efficiently by well-trained handlers. In view of the poor survival rate of pups born to otters early in a rehabilitation program, it may be preferable to allow the female otter to care for its pup with minimal interference. A pup that dies in this circumstance can be removed after the mother abandons it without creating undue stress to the female or the staff.

*Only one or two people should be allowed in the vicinity of any newborn and its mother. Movement of animals for treatment or pen cleaning should be postponed as long as possible, and then performed efficiently by well-trained handlers.*

If a decision is made to remove a pup and care for it in a nursery, it may be preferable to do so before the pup nurses; females exposed to crude oil may transfer petroleum hydrocarbons through the colostrum (see following section). In these cases, the benefits of nursing must be balanced against the potential exposure to petroleum hydrocarbons in the mother's milk. When removing a pup, the mother should be distracted with food or otherwise separated from her pup while a second handler approaches and removes the pup with a net.

Lactating female sea otters have been observed to adopt young pups in a variety of situations (Reidman and Estes, 1990). The successful raising of a pup by a surrogate female in captivity has been reported. This deserves further investigation as an alternative to nursery care for orphaned or abandoned pups.

Lactating females will have a higher nutritional requirement than non-lactating otters (see Chapter 7 for normal dietary requirements). Food should be offered in larger amounts and at more frequent intervals throughout the day (up to 50% body weight per twenty-four hours).

*Lactating females will have a higher nutritional requirement. Food should be offered in larger amounts and at more frequent intervals throughout the day (up to 50% body weight per twenty-four hours).*

## TOXICOLOGICAL CONSIDERATIONS

Toxic substances can pass to a developing fetus through the blood and by simple diffusion across the placental membranes. Currently, it is uncertain whether the placenta can actively prevent the transfer of toxicants from the mother to the fetus. However, the placenta has demonstrated biotransformation properties which could reduce exposure of some substances to the fetus (Klaassen and Rozman, 1991). The effect of an absorbed toxicant will depend on the ability of fetal tissue to concentrate the specific substance. For example, in laboratory mammals the livers of newborns and fetuses will not accumulate some foreign substances and will show much reduced toxicant levels in comparison to maternal liver tissue (Klaassen and Rozman, 1991). Because of a poorly developed blood-brain barrier, the fetal brain may be more susceptible to some toxicants.

In mammals, the effect of a toxicant on the fetus will also depend on the stage of development when exposure occurs (Manson and Wise, 1991). The difference between reversible and irreversible damage often is measured in days. Irreversible effects may be lethal (abortion or stillbirth is induced) or nonlethal (retarded or delayed growth of specific organ systems).

As stated in Chapter 1, it is difficult to verify tissue damage from exposure to crude oil in marine mammals. To date, chlorinated hydrocarbons (DDT, PCBs) have been implicated in reproductive disorders in pinnipeds (St. Aubin, 1990). Little information is available on the direct toxicological effects of petroleum hydrocarbons on the reproductive system, pregnancy, or fetal development. Following the EVOS, petroleum hydrocarbon concentrations were measured in the tissues of a newborn pup from a lightly oiled female sea otter in the rehabilitation center. Polycyclic aromatic hydrocarbons (PAHs) were found in the lungs, liver, and kidneys of the pup. Accumulation was especially marked in the kidney, which showed a mean PAH concentration that was three times the levels in other tissues (T. M. Williams, unpublished data). Although mortality of the pup may have been independent of oil contamination, maternal transfer of petroleum hydrocarbons to the developing fetus appears possible.

In mammals, some toxic agents may be transferred to milk by simple diffusion across blood vessels in the mammary glands. This, in turn, creates a pathway of exposure to the nursing animal. The high lipid content of milk promotes the accumulation of lipid-soluble toxicants including many petroleum hydrocarbon compounds. The problem is exacerbated in marine mammals, which have an exceptionally high concentration of lipids in their milk (Worthy, 1990). Colostrum (the secretion of the mammary glands immediately following parturition) contains an even higher lipid content than milk. Species differences in the excretion of lipid-soluble toxicants through milk will depend on the proportion of milk fat derived from the circulation versus milk synthesis in mammary tissue (Klaassen and Rozman, 1991).

*Maternal transfer of petroleum hydrocarbons across the placenta and through milk may occur and is a concern.*

Although the results are not conclusive, milk transfer of petroleum hydrocarbons has been implicated for both pinnipeds and sea otters. St. Aubin (1990) suggests that the effects of petroleum hydrocarbon exposure through nursing is heightened in immature animals due to their comparatively low levels of detoxifying enzymes. A colostrum sample taken from a heavily oiled sea otter showed high levels of total paraffinic hydrocarbons (941 ppm; T. M. Williams, unpublished data). Ideally, it would be beneficial to analyze the milk of oiled marine mammals before allowing newborns to nurse in rehabilitation centers.

## SUMMARY

The stresses associated with oil contamination and subsequent rehabilitation may be exacerbated in pregnant otters. As a result, the rehabilitation team must be aware of the unique requirements associated with sedating, treating, housing, and feeding this group of animals. Maternal, placental, and fetal compartments are in close communication; thus, oil contamination and the rehabilitation process also may affect the developing fetus. Maternal transfer of petroleum hydrocarbons to the pup may continue after parturition in the form of contaminants transferred through milk.

Rehabilitators must decide whether to separate newborn pups shortly after birth, especially if additional toxic exposure is eminent from nursing. Pups can be successfully raised in nurseries, but are usually unsuited for release back to the wild. Each pup-mother pair must be evaluated individually depending on degree, type and time of oil exposure of the female, the availability of facilities and personnel for rehabilitation, and plans for eventual disposition of rehabilitated animals.

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Chapter 9

# Care of Sea Otter Pups

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Premature separation of a pup from its mother during an oil spill may occur for various reasons: 1) debilitation or death of the female because of oil contamination, 2) pups born at the rehabilitation centers to females unable to adequately care for them, and to a lesser extent, 3) separation resulting from increased boat traffic during spill response operations. Caring for young sea otter pups is time consuming, labor intensive, and requires specialized facilities and expertise. In this chapter, we describe the special needs of sea otter pups placed in rehabilitation facilities and present the protocols for treating and feeding these young animals.

## THE SEA OTTER PUP

Newborn sea otter pups weigh 1–2.3 kg and are totally reliant on maternal care for the first five to eight months of life (Kenyon 1969; Payne and Jameson, 1984; Garshelis et al., 1984; Wendell et al., 1984). Young pups are covered with a woolly natal coat that is so buoyant when properly groomed that the pup floats when temporarily left unattended by the female (see Chapter 8, Fig. 8.1). As with adult sea otters, the pups lack a subcutaneous blubber layer and are totally dependent on their fur for thermal insulation in the cold, marine environment.

To maintain the fur's insulating properties, the female may spend up to 30% of her time grooming the pup while holding it on her chest and abdomen (Payne and Jameson, 1984; Vandevere, 1972). Grooming cleans the fur and may be important in aligning the hairs and stimulating the production of natural oils (sebum) which keep the hair healthy and water resistant (Williams et al., 1988; Davis et al., 1988). Beginning at six weeks of age the natal pelage is gradually molted. At twelve weeks the pup has acquired its adult pelage and is capable of grooming itself (Payne and Jameson, 1984).

The pup receives nourishment exclusively from the mother's milk during the first month after birth. As it grows, the percentage of total food intake represented by milk declines and is replaced with solid food obtained by the mother (Payne and Jameson, 1984). By three months of age, most pups are able to swim and make shallow foraging dives. They are unable to break open hard-shelled prey until five to six months of age. Young sea otters become independent at an age of six to eight months and may weigh 10–20 kg (Payne and Jameson, 1984).

## TRANSPORTATION TO THE REHABILITATION CENTER

When a dependent sea otter pup is orphaned or its fur heavily oiled, personnel on the capture boats or at the rehabilitation center must provide immediate care if it is to survive. Capture and transport should be accomplished calmly, quietly, and rapidly. Young pups are not strong swimmers and can be captured easily with a dip net. Care should be taken to prevent the pup from aspirating water during capture. Juvenile sea otters may elude capture with a dip net if they are healthy and unaffected by the oil (see Chapter 2).

A small pup should be transported by an animal care specialist who can monitor its body temperature and prevent hypothermia or hyperthermia. The hind flippers, which are normally cool, can be palpated for a general indication of hyperthermia; hypothermic pups are often lethargic or comatose. Even young pups are capable of biting and must be handled carefully. A blanket or towel can be used to restrain an active pup, but care must be taken to prevent overheating. Juvenile otters should be transported in kennel cages and monitored by an animal care specialist.

## TRIAGE AND STABILIZATION

If a pup arrives at the rehabilitation center with its mother or is born in the center, it should not be separated from the female unless its health is in jeopardy. Survival may be greatly enhanced if it receives colostrum from a healthy female during the earliest stages of nursing. However, care should be taken to avoid possible petroleum hydrocarbon transfer from an oiled female to her pup through contaminated colostrum. (See Chapter 8.)

*A pup's body weight provides a rough indication of age. Pups weighing 1–7 kg are usually less than three months old. Pups weighing 7–20 kg are usually three to eight months old.*

An initial clinical examination is recommended to assess the pup's body condition and overall health. The following information should be recorded: capture date and location, body weight, standard length, axillary girth, sex, and age. If age is unknown, the body weight provides a rough indication: pups weighing 1–7 kg are usually less than three months old; pups weighing 7–20 kg are usually three to eight months old. For those experienced in handling sea otter pups, dentition, pelage, and behavior can provide additional information to estimate age. A daily record should be maintained on each pup's health status, food consumption, fur condition, and behavior (Appendix 2, Form M).

During the initial examination, behavior should be noted: normal (alert and responsive); depressed (unresponsive to external stimulation but conscious); comatose (unconscious). The fur should be examined to determine whether it is clean or contaminated with oil, feces, or dirt. The presence and location of lacerations or other lesions should be recorded. The sea otter pup's thermoregulatory ability is limited, and body temperature should be carefully monitored with an electronic digital thermometer with a flexible probe inserted 1-3 cm into the rectum. Rectal temperature should be measured during physical examinations and prior to any medical treatments. Normal values range from 37.5-38.1 °C (99.5-100.6 °F) (Williams and Kocher, 1978).

Respiratory rate can be determined by observing movements of the chest wall and is normally 17-20 breaths/minute (Williams and Kocher, 1978). The heart rate is determined by auscultation or palpation of the chest and is normally 144-159 beats/minute. A 6 ml blood sample should be taken from the proximal third of the femoral vein with a 19 gauge, 1-inch needle. Hematology and blood chemistry should be measured and compared with normal values to assess the pup's health (see Appendix 1).

*Newly admitted sea otter pups should be treated with penicillin (20,000 units/kg sid IM), gentamicin (1 mg/kg/day, sid, IM for the first five days), and lactated Ringer's solution (15 ml/kg/day SQ) with vitamin B-complex added (2 ml/L) for the first three weeks or as needed.*

Sea otter pups should be treated prophylactically on admission with penicillin (20,000 units/kg sid IM), gentamicin (1 mg/kg/day sid IM for the first five days), and lactated Ringer's solution (15 ml/kg/day SQ) with vitamin B-complex added (2 ml/L) for the first three weeks or as needed. Medication is usually given subcutaneously between the shoulders or intramuscularly in the rear limb.

## CLEANING AND RESTORING OILED PUP FUR

*Small amounts of crude oil should be removed with a cloth moistened with Dawn™ detergent and water in a 1:16 dilution. Residual detergent should be removed with a moist towel. After cleaning, the fur should blown dry at room temperature and combed to prevent matting.*

Small amounts of crude oil should be removed with a cloth moistened with Dawn™ detergent and water in a 1:16 dilution. When possible, residual detergent should be removed with a moist towel. Heavily oiled pups should be cleaned with water at 38 °C (100 °F) and dilute Dawn™ detergent and then thoroughly rinsed. After cleaning, the fur should be blown dry at room temperature and combed to prevent matting (see Husbandry section below). Rectal temperature should be monitored frequently during the cleaning procedure.

## CLINICAL TREATMENT

### Shock

Shock is often observed when pups arrive at the rehabilitation center. The pups will appear lethargic or comatose and may not have nursed for many hours. This life threatening condition is often caused by dehydration and should be treated with lactated Ringer's solution at a dose of 90 ml/kg for the first day, then decreased to 25 ml/kg/day to cover normal fluid loss by urination and respiratory water loss until the otter's condition stabilizes. The fluids should be warmed to 38 °C (100 °F) and administered subcutaneously.

### Hypothermia and Hyperthermia

The most frequent health problem encountered in sea otter pups is hypothermia (a decrease in core body temperature below 37.5 °C or 99.5 °F). If a pup becomes hypothermic, rub its entire body vigorously with soft, cotton towels until it responds. This procedure stimulates the pup's circulation and rewarms the periphery. Heat lamps can be used for additional heat. Although hair dryers (set on low heat) can be used, the noise may be stressful. A circulating fan is helpful for drying the fur and produces little noise. Do not place the pup on a cool

*Sea otter pups easily become hypothermic or hyperthermic. Rectal temperature should be monitored and should range from 37.5 °C to 38.1 °C.*

waterbed or in water until its core body temperature has stabilized for several hours. If a pup becomes hypothermic while in a pool, simply removing it from the water and towel drying it immediately may correct the problem. (The thermal conductivity of water is twenty-five times greater than that of air, which causes rapid heat loss if the animal is wet.)

Sea otter pups may become hyperthermic (core body temperature above 38.1 °C or 100.6 °F) if they are wrapped in blankets or if the nursery is kept warmer than 15 °C (60 °F). An overheated pup can be cooled by placing it in cool (15 °C or 60 °F) seawater or by placing it on top of ice packs. Also, freshwater ice cubes can be given to the pup to chew. Rectal temperature should be monitored constantly when warming or cooling a pup.

### Aspiration of Water

Pups occasionally suffer respiratory compromise as a result of aspirating water. The clinical signs of aspiration are fever,, lethargy, and dyspnea. If upper airway sounds are heard during auscultation, or if aspiration is suspected, the prophylactic use of broad spectrum antibiotics such as penicillin (20,000 units per kg sid IM), cephalosporin (40 mg/kg bid IM), or sulfatrimethoprim (20 mg/kg bid IM) is recommended.

### Diarrhea

*Diarrhea should be immediately treated with the following combination of medications; cimetidine (5 mg/kg tid IM), atropine sulfate (1 cc/10 kg) and metoclopramide hydrochloride (0.2 mg/kg bid).*

Diarrhea is often a symptom of serious disease. The cause should be determined as soon as possible. The most life threatening diarrhea is caused by hemorrhagic enteritis which results in black tarry feces (Williams, 1990). This clinical condition often occurs within twenty-four hours of a stressful condition, but can also result from too much fat or squid in the formula. The color, frequency, and consistency of the feces is often diagnostic. Diarrhea should be immediately treated with the following combination of medications; cimetidine (5 mg/kg tid IM), atropine sulfate (1 cc/10 kg SQ) and metoclopramide hydrochloride (0.2 mg/kg bid IM) (Williams, 1990).

### Perianal Dermatitis

Feces may soak into the perianal area, mat the fur, and cause perianal dermatitis in sea otter pups. To prevent this condition, the perianal area should be washed vigorously, rinsed with salt water, blown dry at room temperature, and the fur brushed after each urination or defecation. If perianal dermatitis occurs, needle aspirates of the pustules usually yield mixtures of rod and cocci bacteria. This disorder has been treated with limited success with antibiotics (clavamox and cephalexin). Bacterial culture and sensitivity analysis of the aspirates should be performed to determine the optimum antibiotic therapy. Shampooing the affected area daily with benzoyl peroxide helps to control the spread of dermatitis (Styers and McCormick, 1990).

### Hypoglycemia

Both sea otter pups and juvenile sea otters are prone to hypoglycemic seizures after relatively short periods of anorexia, especially when concurrent underlying problems such as sepsis or stress are present.

Hypoglycemic seizures should be treated with 50% dextrose intravenously. If an intravenous route is not available, lactated Ringer's solution and 5% dextrose should be administered intraperitoneally. After the infusion, the pup should receive glucose every two to three hours by stomach tube, orally with a syringe, or saturated in crushed ice until the problem has abated (Williams, 1990).

**Stress**

Infant sea otters experience stress when separated from their mothers. The pup may express this stress by constantly vocalizing or by developing diarrhea, dark colored feces, and by vomiting. Sea otter pups require round-the-clock care (three staff persons working in eight-hour shifts) by experienced animal care specialists. Stress will be minimized if the pups receive good nutrition, have healthy fur, and are kept in a nursery environment that is clean, quiet, well ventilated and climate controlled. Barabash-Nikiforov (1947) found that classical music may soothe sea otter pups. Stress is also alleviated by allowing pups older than two to three months to socialize.

## FEEDING

Sea otter milk is composed of 62% water and 38% solids. On average, the solids are composed of 31% protein, 65% fat, 2.5% carbohydrate, and 1.5% ash (Jenness et al., 1981). Although it is not practical to duplicate the composition of sea otter milk in the rehabilitation center, the following formula has been used successfully to raise sea otter pups at the Monterey Bay Aquarium:

113.5 g (0.25 lbs) white meat of squid (*Loligo spp.*)
113.5 g (0.25 lbs) manila clam meat (*Tapes spp.*)
100 ml (3.33 oz) 5% dextrose
200 ml (6.33 oz) lactated Ringer's solution
2 ml (0.4 tsp) Hi-Vite™ drops
5 ml (1 tsp) cod liver oil
5 ml (1 tsp) D-Ca-Fos™

Blend the ingredients for two to three minutes, then add 200 ml (6.33 oz.) half-and-half (or whipping cream if greater caloric content is needed) and continue blending for one minute; avoid over blending or the mixture will clot. Keep the formula refrigerated and discard unused portions after twenty-four hours. If 5% dextrose and lactated Ringer's solution are unavailable, substitute 300 ml Pedialyte™. Diarrhea can develop in pups placed on a formula diet. During the *Exxon Valdez* oil spill (EVOS), Kellogg's All Bran™ cereal (28.3 gm) was added to the formula to mitigate this problem (Styers and McCormick, 1990). However, the cause of the diarrhea should be investigated before changing the formula. Eliminating stress often can mitigate this problem. Pups may refuse formula if the ingredients are suddenly altered.

Pups less than one month old should be formula fed every two hours and receive 30% of their body weight daily. The formula should be warmed to 38 °C using warm tap water or a double boiler. Pups are sensitive to the temperature of the formula and may reject the bottle if it is too cool. Bottle feeding is relatively new and the preferred method for sea otter pups. Although syringe and tube feeding also work, they do not allow the pup to suckle. The only nipples that have been accepted by sea otter pups are manufactured by Wombaroo Food Products (Brisbane, Australia). Type LD and SD nipples, which are designed for small dogs, cats, and opossums, work best. The nipple is inserted carefully into the pup's mouth and held in place until suckling is initiated. Several days may be necessary to habituate the pup to this method of feeding. If bottle feeding fails, the formula can be gently injected into the pup's mouth with a syringe. Alternatively, pups can be fed through a stomach tube. This method ensures that the pup receives 30% of its body weight per day in formula, and prevents the fur from becoming soiled with formula leaking from the mouth. However, tube feeding can be dangerous if the pup accidentally aspirates formula. Only animal handlers experienced in tube feeding should attempt this method. When used properly, tube feeding is an acceptable alternative to bottle and syringe feeding.

***Pups less than one month old should be formula fed every two hours and receive 30% of their body weight daily.***

Small pieces of local prey items (i.e. rockcod, *Sebastes spp.*; blackcod fillets, *Peprilus spp.*; and geoduck clams, *Panope spp.* for Alaskan sea otters) should be offered after the formula feeding beginning at the age of one month. The amount of solid food should be increased and the amount of formula decreased until the pup is weaned at the age three months. All solid food should be kept chilled and unused portions discarded after each feeding.

After weaning, all hand feeding should be eliminated. Food should be placed in the pen or pool every three hours to ensure that the pup eats 30% of its body weight daily. The diet should include a mixture of one-half whole food items such as rock crabs (*Cancer spp.*), mussels (*Mytilus spp.*), manila clams (*Tapes spp.*), cherry clams (*Venus spp.*), and one-half prepared foods (shells, carapace, and pens removed) such as geoduck clam (*Panope spp.*), squid (*Loligo spp.*), rockcod (*Sebastes spp.*), blackcod (*Peprilus spp.*), shrimp (*Peneaus spp.*), and abalone trimmings (*Haliotis spp.*). Pollock and scallops also have been used. All food debris and particles must be cleaned off the fur by bathing the pup in seawater.

***After weaning, food should be placed in the pen or pool every three hours to ensure that the pup eats 30% of its body weight daily.***

The rate of weight gain in sea otter pups will vary between individuals, but on average, pups gain 0.6 kg every eight days. However, there seems to be a plateau in the 10 kg range when weight gain may slow. For some pups, this plateau may last for a month. Around this age, pups may experience teething problems that cause painful gums and decreased interest in food. Pups should be weighed when they arrive at the rehabilitation center, daily while in the nursery, and weekly when housed in outdoor pools.

## HUSBANDRY

As mentioned earlier, the female sea otter spends up to 30% of her time grooming the pup's fur to keep it clean and water repellent. For orphaned pups in the rehabilitation center, this labor intensive but important activity is provided by nursery personnel who assume the role of surrogate mothers. It is important to remember that each pup may behave differently. The surrogate mother should be aware of the individual needs of each pup and ensure that it receives proper care. After each feeding, urination, and defecation (or at least three times per day), the pup's fur should be cleaned with seawater. The pup's hind flippers can be placed in cool water after a feeding to stimulate urination and defecation. This prevents the pup from fouling its fur while it sleeps. The fur is first dried with clean cotton towels and then brushed with a nylon bristle brush (¾ inch) and a flea comb so that it is free of tangles and has maximum loft. This activity will require about thirty minutes. Pups can be groomed while they sleep, allowing the surrogate mother to thoroughly detangle matted fur. Keeping the fur clean and well brushed is essential, as fur is difficult to restore once it has become severely matted. Cleaning and brushing the fur is especially important around the perianal area to prevent dermatitis. As the pup matures, it will begin grooming itself, thereby relieving the nursery personnel of this responsibility.

Nursery facilities for the care of sea otter pups are described in Chapter 12. Only designated personnel should be allowed in the nursery. The room should be well ventilated, quiet, and maintained at 15 °C (60 °F). A water bed maintained at room temperature is an ideal place for young pups to maintain their body temperature, and it is similar to floating on the surface of the sea. The nursery should also include a shallow saltwater pool (10 feet by 3 feet by 2 feet deep) for young pups to develop swimming skills. The nursery should be visually and acoustically isolated from the activities of the rehabilitation center. Working surfaces should be disinfected twice daily with Nolvosan™ solution (2 tbs/gal). Harsh disinfectants and cleansers should be avoided because of their harmful effects on otter fur. Preventing disease transmission from domestic animals to sea otter pups is a top priority. Personnel should wear clean coveralls in the nursery and disinfect their hands regularly. Shoes should be changed or washed in a disinfectant foot bath before entering the nursery.

Pups should be introduced to outdoor pools as soon as they can swim (age three to four weeks), especially during sunny days. An otter pup can be permanently transferred to an outdoor pool when it is able to groom and feed itself. This usually occurs around the age of three months. However, pups at this age are still dependent on their surrogate mothers and should be closely watched. Pups are ready to be left alone at night at age five to six months. To ensure proper identification, all pups should have identification tags attached to the hind flippers when they are ready to leave the nursery.

## SUMMARY

Sea otter pups require extraordinary care in rehabilitation centers. Along with specialized facilities, orphaned pups demand twenty-four-hour support to meet nutritional, thermoregulatory, and husbandry needs. As the young animals develop, the demands placed on the rehabilitation staff decrease. At age three to four months they will begin to swim, groom, and feed on their own; this marks the beginning of their transition to an independent adult life in captivity. For a review of techniques that will prepare a captive-reared pup for release into the wild, see Hymer (1991) and Williams and Hymer (1992).

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Chapter 10

# Release Strategies for Rehabilitated Sea Otters

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According to the U.S. Fish and Wildlife Services' (USFWS) Response Plan for sea otters (USFWS, in preparation), in the event of an oil spill, *the decision to release sea otters from rehabilitation centers following treatment will be linked to the decision on whether to capture sea otters for treatment.* Assuming a scenario similar to the *Exxon Valdez* oil spill (EVOS), once the decision to capture sea otters is made, the ultimate goal is to return as many sea otters to the wild as possible, *even though the rescue may not be expected to produce results significant at the population level. The decision by the USFWS to proceed with capture, rehabilitation, and release will be made on a case-by-case basis* (USFWS, in preparation). Many factors will influence the decision. Perhaps the most important factors in deciding when and where to release sea otters are the location and availability of suitable release sites and verification that the otters are free of diseases that might be transmitted to the wild population.

Alternative release strategies for sea otters will be contained in the sea otter response portion of the USFWS's oil spill contingency plans for Alaska and California that are being developed as required by the Oil Pollution Act of 1990. Public review of these plans before they are implemented will help to reduce public concern about the survival of rehabilitated otters, their biological effect on the release area, and the potential introduction or spread of diseases into the wild sea otter population.

The objective of this chapter is to review alternative strategies for the disposition of rehabilitated sea otters. Our assumption is that returning as many animals to the wild as possible, whether it be for humanitarian or biological reasons, is the ultimate goal of this effort (Figure 10.1).

## RELEASE ALTERNATIVES

In addition to a no release alternative, there are four alternatives in release of rehabilitated sea otters: 1) release at the site of capture, 2) release in the general vicinity of capture, 3) relocation to an area

Figure 10.1
Releasing a rehabilitated sea otter along the Kenai Peninsula, Alaska. The ultimate goal of a rehabilitation effort is to return the animals to the wild.

already inhabited by sea otters, or 4) relocation to an area uninhabited by sea otters. Each will result in costs and benefits to sea otter conservation.

### No Release

In terms of preventing the possible introduction of any domestic or exotic animal diseases into the wild sea otter population, the most conservative approach would be not to release the animals. If this decision is made, then the only alternatives are placing the animals in zoos, aquaria, or research facilities or to euthanize them. If the number of rehabilitated animals is small (ten or fewer), their placement in such facilities may be feasible. Although several facilities are willing to temporarily care for oiled or young sea otters on an emergency basis, most have little or no need for additional wild-caught sea otters. During the EVOS, thirty-seven sea otters, either because of age or health, required permanent care in captivity. Nine of these heavily oiled otters died in April 1989. Another 197 sea otters were rehabilitated to the point that release was recommended. Placement of that many animals in aquaria was impossible. Given the constraints of existing space, a no release alternative is feasible only if few animals are in need of placement. Clearly, permanently holding large numbers of sea otters would require construction of additional holding space. Euthanasia, although not a preferred option for healthy sea otters, must be considered for unwanted, impaired, or unhealthy animals.

### Release at Capture Site

We assume in this discussion that only sea otters that are oiled will be captured and, therefore, that the capture sites will have been oiled or located adjacent to oiled areas. In many respects, the release of sea otters near their capture sites is preferred because the animals will be familiar with areas normally used for feeding, resting, pupping, and protection from inclement weather. However, release at capture sites could be precluded by contamination of local habitat. Although release at the point of capture may contribute to research objectives, it may not be in the best interest of the released animals. Barring such research, long-term holding of sea otters while the environment cleanses itself may be required if this option is selected.

### Release in General Vicinity of Capture

Releasing sea otters in unoiled areas relatively close to the original capture sites (e.g., within 30-80 km) may minimize the detrimental effects of placing the animals in an unfamiliar area. If the animals are released into familiar habitat, they may remain in the area, thereby enhancing their chances for survival. However, it may be difficult to keep the sea otters from reentering oiled areas. The relative benefits of releasing otters near their original capture sites, which may still suffer from oiling, to minimize relocation effects (see below) cannot be determined at this time. Certainly, the severity and geographical extent of the oil contamination would have to be considered. Assuming that damage to the habitat from oil is not extensive, release close to the original capture area may pose the lowest risk to individual animals.

*Assuming that damage from the habitat from oil is not extensive, release close to the original capture area may pose the lowest risk to individual animals.*

### Relocation to an Area Inhabited by Other Sea Otters

The risks of relocating sea otters into areas inhabited by other sea otters are not known. By relocation, we refer to transporting sea otters to areas outside of their home range. Home ranges of sea otters vary in size and are not known with certainty. However, radio telemetry studies of sea otters suggest that the maximum extent of their home range can be measured in tens of kilometers, as opposed to hundreds or thousands of kilometers. Information on the success of relocations comes largely from programs to reestablish populations in areas where sea otters were historically found (Jameson et al., 1982; Rathbun et al., 1990). Relocation and release into areas already occupied by sea otters may minimize the detrimental effects of relocation and ensure that the area is generally capable of supporting them. However, the risk of disease transmission is higher.

*Relocation and release into areas already occupied by sea otters may minimize the detrimental effects of relocation and ensure that the area is generally capable of supporting them. However, relocated sea otters may not stay in the vicinity of the release site.*

Release into an area already occupied by sea otters does not guarantee a favorable response from the public, especially if commercial, subsistence, or recreational fishing operations are potentially affected (Rappoport et al., 1990). Moreover, relocated sea otters may not stay in the vicinity of the release site. Evidence from Ralls et al. (1992) and Monnett et al. (1990) indicate that some relocated sea otters may travel hundreds of kilometers to return to the vicinity of their capture.

### Relocation to an Area Not Inhabited by Sea Otters

Many efforts have been made to transplant sea otters into uninhabited areas, and although the factors involved are not understood, high rates of mortality and disappearance of those animals are typical (Jameson et al., 1982). The 1989-1991 transplant of southern sea otters to San Nicolas Island in California is a good example. Of the 139 sea otters relocated, only about 12 remained there. At least 10 of the otters died, and a minimum of 31 are known to have returned to the mainland population, a distance of more than 300 km. The remaining sea otters disappeared and are unaccounted for (USFWS, unpublished data). Relocating sea otters, even to areas with abundant food resources, places those animals at increased risk. Within Alaska, because of expansion of natural populations and previous transplant efforts, areas of suitable, unoccupied sea otter habitat are scarce. Release in these areas would likely involve relatively long-distance relocations. Moreover, conflicts with the public may occur if sea otters are released into areas with high shellfish densities which are harvested in commercial, subsistence, and recreational fisheries. Release of sea otters into unoccupied food-rich habitats will likely result in an adverse reaction from some segments of the public.

## GEOGRAPHICAL CONSIDERATIONS

*The severity of a spill and the overall effect of a spill on the sea otter population should be considered when selecting the appropriate release strategy for rehabilitated animals.*

The release strategy selected following an oil spill will depend on the geographic location and severity of the spill. For example, after the EVOS, the western portion of Prince William Sound was so heavily oiled that release of sea otters into this area was not considered. Along the Kenai Peninsula, oiled and unoiled areas formed an irregular mosaic, allowing the release of some sea otters into clean bays relatively close to those in which they were captured. This strategy allowed sea otters to be released into areas presumably familiar to them. However, it did not prevent the otters from reentering contaminated areas. If habitats on the Kenai Peninsula had been more heavily affected by oil, it would have been necessary to release the otters elsewhere, resulting in potentially greater relocation-related stress and detrimental effects.

## TAXONOMIC CONSIDERATIONS

Another factor to consider in release strategies is the overall risk to the population of sea otters from an oil spill. Currently, the population of sea otters in Alaska is considered a subspecies (*Enhydra lutris kenyoni*); one that originally extended southward through British Columbia, Washington, and Oregon (Wilson et al., 1991). Although the EVOS may have killed several thousand sea otters (Doroff et al., 1993; Garrott et al., 1993), it did not place the northern subspecies of sea otter, which numbers more than 100,000 animals (Calkins and Schneider 1985, USFWS unpublished data), at biological risk. Given the low risk to the Alaskan population and the northern subspecies as a whole, more costly and controversial release strategies to safeguard the releasable sea otters, such as long-term holding, were not necessary.

*Rehabilitated sea otters should be released within the subpopulation of their origin. This ensures genetic compatibility and the familiarity of the animal with local habitat and food items.*

If possible, rehabilitated sea otters in Alaska should be released within the subpopulation of their origin, which increases the probability that an individual will be familiar with that area and the food types available in that area. Table 10.1 lists suggested subpopulations of sea otters in Alaska that were identified by the State of Alaska as potential management units when they requested return of management of marine mammals during the late 1970s. These areas were defined in part by the locations of remnant populations, transplant

Table 10.1
Subpopulations of sea otters in Alaska based on locations of remnant populations following commercial exploitation and locations of transplants.

| |
|---|
| Aleutian Islands |
| Near Islands |
| Rat and Delarof Islands |
| Andreanof Islands |
| Islands of Four Mountains |
| Fox and Krenitzin Islands |
| Alaska Peninsula |
| Bristol Bay, North Unimak Island |
| Sanak Islands and Sandman Reefs |
| Shumagin Islands |
| Kujulik Bay, Sutwik Island |
| Kamishak Bay, Katmai |
| Pribilof Islands |
| Kodiak Archipelago |
| Kenai Peninsula |
| Kayak Island, Prince William Sound |
| Southeastern Alaska |

locations, and geographic considerations such as habitat discontinuities.

Sea otter populations in California, Washington, and British Columbia are discontinuous. The population in California also is afforded subspecific status (*E. l. nereis*) based on skull morphology (Wilson et al., 1991). Although the genetic uniqueness of the California population is unclear, preservation of that gene pool is the safest course of action, perhaps justifying more extreme measures for safeguarding rehabilitated animals if an oil spill were to occur there. Whereas rescue efforts following the EVOS had little effect on the overall population in Alaska, similar efforts expended on behalf of the southern sea otter in California could be significant, especially if a large oil spill affected their entire 300-mile range.

The range of *E. l. nereis* presumably extended from Morro Hermoso in Baja California, Mexico (Kenyon, 1969) north to the California-Oregon border (Wilson et al., 1991), leaving a large area of unoccupied habitat suitable for relocation if necessary. However, any attempts to relocate sea otters to northern California will be met with considerable resistance from some segments of the public because of important commercial and recreational shellfish fisheries. An oil spill in the range of the southern sea otter could create a real dilemma for releasing rehabilitated sea otters, perhaps necessitating long-term holding until the habitat is sufficiently recovered.

Sea otter populations in both Washington State and British Columbia resulted from transplants of individuals from Alaska (Jameson et al., 1982); taxonomically they belong to the northern sea otter, *E. l. kenyoni*. Presumably sea otters in those locations are genetically similar to those in Alaska. If at all possible, rehabilitated sea otters from those areas should be released in coastal Washington State or British

Columbia. However, the Alaska origin of those populations increases relocation options, should more extreme measures be needed. If populations in those areas were severely depleted by an oil spill, they presumably could be augmented with sea otters from Alaska. Furthermore, if Washington and British Columbia were severely affected by a large oil spill, perhaps rehabilitated sea otters from those populations could be released in Alaska.

## OTHER CONSIDERATIONS

### Disease

*Consideration must be given to the effect of the release on both the rehabilitated otter and the receiving population.*

The risk of disease transmission from released sea otters to wild populations is an important and legitimate concern. Following the EVOS, some pathologists and the Alaska Department of Fish and Game were opposed to releasing rehabilitated otters because of concern about disease transmission to wild populations (Spraker, 1990). The risks to the wild population from disease potentially originated both from pathogens that existed in localized populations of sea otters prior to capture, and which could be spread more widely following relocation, and from novel pathogens to which the sea otters were exposed during captivity. *It is Fish and Wildlife Service policy in Alaska that whenever release of rehabilitated animals to the wild is contemplated, state-of-the-art measures for disease transmission prevention shall apply* (USFWS, in preparation).

### Duration of Captivity

The length of time sea otters are held in captivity should be minimized. Limiting holding times may reduce the risks of disease transmission and may reduce the risks of captive sea otters becoming dependent on humans for food.

### Composition of Receiving Population

Because sea otters tend to segregate by sex, it may be advantageous to release rehabilitated animals in areas having otters of the same age and sex as those being released (Ralls et al., 1992). This may reduce social stress and may enhance the probability of sea otters remaining in the release area.

### Holding at Release Site

Ralls et al. (1992) suggest that holding relocated sea otters at the release site enhances the probability they will remain in the release area. In their experimental relocation of California sea otters, these investigators held individuals for forty-eight hours. Although Rathbun et al. (1990) did not come to a similar conclusion, it may be prudent to use prerelease holding facilities at the release site until better information on the efficacy of the technique is available.

## SELECTION OF RELEASE SITES

Sharpe (1990) described criteria that were used to evaluate release sites along the Kenai Peninsula for sea otters following the EVOS. These criteria included:

1) amount of habitat of shallow or moderate water depth,
2) amount of kelp,
3) amount of weather-protected habitat,
4) water quality,
5) distance from oiled areas,
6) suitability for post release monitoring,
7) number of sea otters already occupying the area, and
8) suitable transfer sites (helicopter landing zones).

These are reasonable criteria for evaluating specific release sites. Amount of kelp was used by Sharpe (1990) as an indicator of habitat productivity, but in many areas an abundance of kelp does not necessarily equate with abundant food resources for sea otters. Kelp may be uncommon in some coastal areas of Alaska, especially those dominated by soft bottoms in which bivalves make up the predominant foods of sea otters. Moreover, in some rocky areas, abundant kelp is a reliable indicator of heavy and persistent feeding by sea otters (VanBlaricom and Estes, 1988).

Obviously, the presence of other sea otters may be the best indicator that a particular habitat is suitable for sea otters. However, uncertainties associated with disruption of the social organization of otters already in the area may be an important consideration. In addition, placement of sea otters in an unfamiliar area may place them at a competitive disadvantage with local sea otters.

Through predation, sea otters are rapidly able to affect the quantity and size of sessile or slow-moving shellfish. Therefore, the only way to assure that food is not limiting to rehabilitated sea otters is to release them in unoccupied or recently occupied areas. However, as discussed above, this strategy will likely be met with considerable resistance by commercial, subsistence, and recreational fishermen who use the same resources as sea otters.

Prerelease intertidal and subtidal surveys in occupied habitats can reveal on a gross scale the relative abundance of prey in an area. However, because of the patchy nature of their food resources and the ability of healthy sea otters to thrive in areas of long-standing occupation where food appears limited, surveys undertaken to assess the abundance of food resources at potential release sites may be difficult to interpret. Given the resolution of most habitat studies, it is unlikely that pre- and postrelease habitat surveys will be able to document any effects of the released animals on the abundance of sea otter prey.

Recent studies suggest that individual sea otters specialize in certain kinds of prey within a given habitat (M. Riedman, Monterey Bay Aquarium, personal communication; K. Lyons, University of California, personal communication). Therefore, it may be advisable to release sea otters in areas that contain populations of prey comparable to those from where they were captured.

The effect of releasing rehabilitated sea otters on the wild population is not known. Sea otters are gregarious animals with a complex social organization (Garshelis et al., 1984; Riedman and Estes, 1990).

Although their social organization has been described in general terms, little is known about the importance of the social bonding that exists outside of mating and between mothers and pups. Capture, treatment, and temporary holding of sea otters undoubtedly are very disruptive to their social organization. Release of those sea otters may also cause stress depending on the release strategy. Relocating sea otters to an already inhabited area may disrupt both the rehabilitated animals and the receiving population.

## MONITORING RELEASED SEA OTTERS

*All released otters should be marked with uniquely numbered tags, transponder chips, or radio transmitters.*

Several marking methods are available that will facilitate monitoring rehabilitated sea otters after release. Sea otters are routinely marked by securing colored flipper tags to the hind flippers (Jameson, 1989; DeGange and Williams, 1990). Tag colors should be conspicuous and different from colors already in use on free-ranging sea otters in the release area. Because tag loss is known to occur, sea otters are also routinely marked with a small transponder chip for permanent identification (Thomas et al., 1987; DeGange and Williams, 1990). Transponder chips are usually injected beneath the skin in the groin area.

Abdominally implanted radio transmitters (Garshelis and Siniff, 1983; Ralls et al., 1989) provide the most dependable means of marking sea otters for studies requiring frequent observations of individuals. It may be important that some of the released sea otters carry such transmitters as part of a natural resource damage assessment to monitor their movements following release and to estimate survivorship and reproduction (Bayha and Kormendy, 1990). The radio-tagged animals should be released together with the majority of the rehabilitated sea otters, thereby assuring adequate sampling of the released population. Ideally, follow-up studies should be designed to evaluate stresses associated with implant surgery, capture, treatment, and long-term holding. Although it can be argued that the results of follow-up studies will not affect whether or not oiled sea otters are rehabilitated and released, an indication of postrelease survival and movements is important to guide future release efforts.

## SUMMARY AND RECOMMENDATIONS

Ultimately, the USFWS release strategy for sea otters following an oil spill will depend upon the geographic location of the spill, the geographic extent of oiled habitat, the severity of habitat damage, the biological risk to the affected sea otter stock, and the number of affected animals. Consequently, release strategies need to be tailored to each situation where sea otters are captured. To that end we offer the following general recommendations:

1) Rehabilitated sea otters should be used to fill any demand from aquaria before release to the wild is considered.
2) Holding time should be minimized for rehabilitated sea otters that are to be released.

3) In those situations where the extent and severity of habitat damage is limited, releasing sea otters in the general vicinity of the point of capture should give rehabilitated sea otters the best chance for survival. This strategy will also result in the least amount of risk to wild sea otters from disease transmission.
4) In those situations where the capture location and surrounding habitat are severely contaminated and may remain so for many years, sea otters should be relocated, preferably to areas already occupied by sea otters.
5) New techniques should be developed and tested to enhance the probability that relocated animals will remain in the release area.
6) Sea otters from different subspecies should not be mixed.
7) Because of potential management conflicts, rehabilitated otters should not be used to expand the existing range of sea otters, except perhaps in California, Washington State, or British Columbia, where no other alternatives may be available.
8) At a minimum, released sea otters should be individually marked with brightly colored hind flipper tags and a uniquely coded transponder chip.

It is presently difficult to recommend a specific distance to relocate sea otters. Relocated sea otters have traveled hundreds of kilometers to return to areas where they were captured (Monnet et al., 1990; Rathbun et al., 1990; Ralls et al., 1992; USFWS). Thus, it is conceivable that some relocated sea otters will find their way back to contaminated habitat. The advantages of relocating sea otters at distances great enough to discourage homing may be offset by the higher risks associated with relocating sea otters to unfamiliar places.

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# Logistical Considerations for Large Oil Spills

# Chapter 11

# Wildlife Triage

Terrie M. Williams

During an oil spill, large numbers of sea otters may arrive simultaneously at rehabilitation centers. Because facilities and veterinary personnel often are not equipped to handle more than five oiled animals at one time, it becomes necessary to develop a quick, straightforward system for evaluating animals and establishing priorities for treatment. This chapter presents criteria for evaluating large numbers of animals and for developing a triage program during a large scale emergency. Two types of large spills are considered, a short-term event such a tanker spill and a long-term event as occurs with an oil platform blowout.

*A triage system should be established by the rehabilitation team during the initial stages of an oil spill response.*

## TRIAGE FOR OILED WILDLIFE

A triage program allows the rehabilitation team to classify and treat contaminated wildlife in a systematic manner. If all members of the team are familiar with the criteria or priorities, it provides the basis for providing the best care for the largest number of animals. Some animals may require immediate lifesaving procedures, while others may benefit from a period of stabilization. Critically ill animals with little chance of survival may create an unreasonable demand on veterinary resources. In these cases, euthanasia should be considered.

It is the responsibility of the rehabilitation team to assign treatment priorities for the different categories of contaminated wildlife. The triage system described here was developed for subadult and adult animals. Because sea otter pups require specialized care, they should be directed to nursery areas for immediate, full-time attention (see Chapter 9). The criteria used for ranking adult animals in different triage categories are based on: 1) toxicity of the oil encountered, 2) degree of external oiling, 3) stability of the animal, and 4) general medical condition.

*Triage categories take into account the degree of oiling, medical condition, and stability of the animal.*

Factors for determining these criteria are presented in Chapter 4 and Chapter 5. The condition of each otter arriving at rehabilitation centers depends on many unknown factors, such as the duration of oil exposure and the animals' general health before the spill. However, triage criteria necessarily are limited to physiological and behavioral assessments of the animal once it arrives at the center.

For evaluating adult otters, we recommend the five-category triage rating system established for the treatment of war casualties (Bowen and Bellamy, 1988): 1) urgent, 2) immediate, 3) delayed, 4) minimal, or 5) expectant.

### Urgent

Animals in this category require urgent intervention to prevent continued contamination or death. Their survival will depend on quick and efficient treatment. Heavily oiled otters contaminated early in the spill are placed in this category. The primary goal is to remove oil quickly and to avoid systemic contamination due to dermal absorption, inhalation, or ingestion during grooming. Fresh crude oil often irritates the otters' sensitive membranes; excessive biting and scratching can lead to permanent damage of the cornea and interdigital webbing of the flippers. Animals displaying hypoglycemic shock and hypothermia fall within this category regardless of the spill phase. Treatments include washing (Chapter 6) and immediate medical attention (Chapter 5). Rewarming hypothermic animals, cooling hyperthermic ones, and administering fluids are indicated when appropriate. If presented with several animals in this category, animals displaying emergency medical conditions should be treated first.

### Immediate

This group requires immediate washing and treatment of minor medical problems. Usually, survivorship is high if treatment is quick. Heavily oiled animals contaminated late in a spill and showing few medical abnormalities fall into this category. Also, moderately oiled animals captured during all phases of the spill, and animals showing moderate respiratory distress, mild hypoglycemia, or hypothermia require immediate attention. These animals are temporarily stable and tolerate short waiting periods as long as they are supervised. They should await treatment in thermal environments that allow them to maintain normal body temperatures and do not induce panting or shivering. Because of complications associated with anesthetic agents (Chapter 3), they should not be fed unless treatment is delayed for more than three hours.

### Delayed

These animals can tolerate and will probably benefit from a period of rest before treatment. Moderately oiled otters contaminated late in the spill and showing no clinical or behavioral signs of distress should be placed in the delayed category. Other animals in this category include lightly oiled or unoiled otters with minor clinical signs (periodic agitation or shivering, etc.). These animals often will accept food; food, water, and rest are recommended while they await treatment. The period of stabilization can range from twelve to twenty-four hours with little adverse effect. These animals are treated after Urgent and Immediate Care animals are handled.

### Minimal

Animals in this category require minimal or no cleaning and often only require a general physical examination. A stabilization period of twenty-four to thirty-six hours is recommended. Food and water should be offered to alert animals every three hours throughout this period. The animals must be supervised during stabilization. Tests may be necessary to determine if the fur is oiled; treatment and washing will be based on the results of these tests. If the results for oiling are negative and the veterinary staff has determined that the animal is healthy, then we recommend moving these animals quickly to long-term holding areas. Lightly oiled and unoiled otters showing no clinical signs of distress comprise this category.

### Expectant

This category includes all animals that behaviorally and clinically have little expected chance of survival. They should be made comfortable during a brief period of observation. The primary criteria for placement in this category is severe subcutaneous emphysema as determined by palpation. Usually the condition is irreversible and is associated with other severe medical conditions. During the *Exxon Valdez* oil spill (EVOS), otters with subcutaneous emphysema that displayed diaphragmatic and agonal breathing rarely survived twenty-four hours in the rehabilitation center. A veterinarian should be consulted to determine if euthanasia is the most humane alternative for animals in this category.

## SHORT-TERM VERSUS LONG-TERM SPILLS

The assignment of animals to one of the five triage categories will change with the phase and type of spill. In a catastrophic spill, oil is released in a single event and degrades relatively uniformly with time. As a result, the degree of contamination and the associated medical problems of wildlife decline with time and subsequent weathering of the oil. This was observed for sea otters following the EVOS (Table 11.1). The highest percentage of urgent care animals arrived during the first three weeks of the spill. Later in the spill, a greater proportion of animals required only minimal care.

Table 11.1
Distribution of sea otters from the EVOS within the five triage categories. Note the difference in distribution during Early and Late Phases of the spill. Percentages (shown in parentheses) are based on total number of otters received at rehabilitation centers during each phase.

| SPILL PHASE | TRIAGE CATEGORY | | | | |
|---|---|---|---|---|---|
| | Urgent | Immediate | Delayed | Minimal | Expectant |
| Early | 49 (46.2%) | 28 (26.4%) | 20 (18.9%) | 5 (4.7%) | 4 (3.8%) |
| Late | 5 (3.3%) | 21 (14.0%) | 6 (4.0%) | 103 (68.7%) | 15 (10.0%) |

Chronic spills, such as oil platform blowouts and incidents like the Persian Gulf spill, involve the long-term release of fresh oil into the environment. A consequence of chronic spills is prolonged contamination of wildlife by oil containing the highest concentrations of aromatic compounds. Because these compounds are considered the most toxic components of oil, a chronic spill may lead to a prolonged, high incidence of medical problems. Triage will be more difficult during a chronic spill because most animals will require urgent or immediate care until the release of oil is stopped.

## SUMMARY

A triage program provides a systematic approach for sorting large numbers of contaminated wildlife for medical care. This program depends on the phase and type of oil spill. During spills of short duration, Early (less than three weeks post spill) and Late (more than three weeks post spill) Phases are easily distinguished. In contrast, the distinction between phases of a chronic spill will be more nebulous and will depend on several factors including the duration of oil release. For either type of spill, the greatest number of urgent care animals arrive during the Early Phase. The Late Phase is characterized by increased numbers of animals requiring minimal care.

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Chapter 12

# Facilities for Oiled Sea Otters

Randall W. Davis
Charles W. Davis

To care for more than fifty oiled sea otters at one time, a treatment and rehabilitation facility should be designed for moving animals efficiently through the various rehabilitation stages. Depending on the exposure level, rehabilitation of an oiled otter may require a few days to several months. Once the otters have recovered their health and coat condition, they should be moved immediately to a prerelease facility for regaining muscular strength and stamina prior to release. A rehabilitation facility designed as a flow-through system can treat many more otters during an oil spill than the holding capacity of its pens and pools.

*Facilities should be designed to permit the graduation of otters through successive recovery stages.*

Each type of facility and each stage of rehabilitation has specific requirements for indoor space, pens, pools, equipment, and amenities. (See Appendix 6 for a description of the equipment required for rehabilitating oiled sea otters.) Also, the facility should provide space for support functions such as food preparation, veterinary care, administration, security, and maintenance. To ensure good hygiene and prevent disease transmission, the animal care staff needs adequate lavatories, an area to change into sanitary clothing before beginning work, and a cafeteria.

This chapter describes essential design elements for regional rehabilitation and prerelease facilities for fifty or more sea otters. Many of the recommendations are based on the design of sea otter rehabilitation centers built in Alaska during the *Exxon Valdez* oil spill (EVOS). For the rehabilitation of less than fifty otters, the facilities of local oceanaria and centers for the care of stranded marine mammals may be sufficient. However, additional space not commonly found in these facilities will be needed for cleaning the oiled otters and holding them in the outdoor, fiberglass pens described in Chapter 7. Veterinary clinics and zoos are not recommended for the rehabilitation of oiled sea otters that are intended for release because of the risk of exposure to domestic and other terrestrial animal diseases.

## REGIONAL REHABILITATION FACILITY

*The most effective method of caring for large numbers of oiled otters is to establish regional rehabilitation centers. These should be strategically located within high-risk oil spill zones.*

The most efficient and cost effective way of caring for large numbers of oiled sea otters is to concentrate resources and expertise in regional rehabilitation centers. *These regional centers should be strategically located in areas where sea otters are abundant and at risk from an oil spill.* By using a helicopter to transport oiled otters from the capture boats to the rehabilitation facility, each regional center can service an area within a 500-mile radius (i.e. within a five-hour helicopter flight). This is analogous to using a "Life Flight" helicopter to bring patients to a regional hospital that has specialized facilities and personnel. Beyond the 500-mile radius, trained personnel and mobile facilities may be required to medically stabilize the newly captured otters before they are flown to a regional center.

The site for a regional center should have all-weather access by road and aircraft, good telephone communications, a source of seawater, and easy access to commercial suppliers of frozen seafood, medical supplies, building hardware, electronics, and mechanical appliances. We also recommend that service contracts be established with local vendors and building contractors to maintain and immediately repair any mechanical or structural failures within the facility.

### Conceptual Design

*Because of specialized space and facility requirements for sea otters, the regional rehabilitation facility should be a permanent structure.*

Caring for large numbers of oiled sea otters requires facilities that are properly designed and constructed. Because of the specialized space requirements and the need for large pools and filtered seawater, a regional rehabilitation facility for sea otters should be a permanent structure. Even with detailed construction plans and the pre-identification of sites with essential amenities, it may take several weeks to build even a temporary facility. Because the first two to three weeks of a spill pose the greatest risk to otters (see Chapter 4), rehabilitation facilities should be built and maintained on a permanent basis to enable the prompt capture and care of otters as soon as a spill occurs.

The space requirements and conceptual design of a regional sea otter rehabilitation facility are shown in Table 12.1 and Figure 12.1 (see plate facing page 164), respectively. This facility has a capacity of 200 otters, which is equal to the combined capacity of the two sea otter rehabilitation centers built during the EVOS. The indoor space is 16,294 ft$^2$, and the outdoor space is 40,329 ft$^2$. A facility of this size should be adequate for most moderate-to-large spills in areas with a large sea otter population. As oiled otters are rehabilitated and moved to a prerelease facility, space is made available for new arrivals.

When otters arrive at the regional center, they should be transferred to clean cages before rehabilitation begins. The transport cages are cleaned and sterilized in a dedicated wash room and then returned to the capture boats. The oiled sea otters are then moved in assembly-line fashion through areas for triage and sedation, cleaning and rinsing, drying, recovery and critical care, and short-term holding pens. Finally, otters that have restored the water repellency of their fur and are ready to be moved to a prerelease facility are placed temporarily in large pools. Because orphaned sea otter pups require specialized care, they are kept in a separate nursery area. A well-equipped veterinary clinic and surgical suite provide for essential medical care. Otters that die in the facility should be taken to the necropsy laboratory for a complete postmortem examination. The carcasses should be stored in a morgue freezer until their final disposition by the appropriate federal or state trustee (USFWS in Alaska and Washington State; the Department of Fish and Game in California).

To prevent the exposure of sea otters in the rehabilitation center to domestic animal diseases, the entire animal care area should be quarantined from the service and administrative areas. Staff entering the animal care area should wear clean coveralls and rubber boots. Visitors are prohibited from entering this part of the facility. Pets are prohibited within the entire facility at all times.

*Prevent exposure to domestic animal diseases by quarantining the entire animal care area.*

The administrative suite provides office space for the director, the supervisors, and the administrative staff (Chapter 13). Additional space is provided for plant security, communications, a conference room, photocopying, file storage, and a lunch area. A closed-circuit video system allows each room in the animal care area and the outdoor pen and pool area to be monitored by the director, the operations supervisor, plant security, and to be selectively displayed to visitors and the press in the conference room.

The service area is used for sea otter food storage and preparation, plant security for the service entrance, a carpentry shop, and a dressing room, lavatories, showers, and cafeteria for the animal care staff. Outdoor space is occupied by holding pens and pools for sea otters and pinnipeds, a seawater treatment facility, service yard, and parking. The entire rehabilitation facility requires 1.7 acres of land.

## Detailed Description of Indoor Space Requirements

### *(a) Animal care area (Quarantine area)*

Arrival Dock and Cage Cleaning Room (525 ft$^2$)

When oiled sea otters arrive at the rehabilitation facility, they should be delivered to the arrival dock in kennel cages. Quarantine procedures begin at this location. The kennel cages are cleaned and sterilized in the cage cleaning room (Appendix 4, Figure A) before they are returned to the capture boats. This room is equipped with two stainless steel floor sinks equipped with steam or hot water hoses for cleaning cages, shelves for the storage of kennel cages, and a desk and file cabinet. The room is climate controlled, and the lighting fixtures are humidity resistant. The floor is covered with a nonporous, skid-resistant surface which slopes toward two floor drains. The walls are covered with ceramic tile. The waste water system has an oil trap. Doors lead to the triage room and the central corridor.

*Arriving animals are delivered in kennel cages. Quarantine procedures begin at the arrival dock. Cages are cleaned and sterilized in the cleaning room before they are returned to the capture boats.*

Triage and Sedation Room (483 ft$^2$)

The kennel cages are carried from the loading dock through swinging doors into the triage room (Appendix 4, Figure B). The otters are transferred to critical care cages (Chapter 7, Figure 7.1), and the dirty kennel cages are taken directly to the cage cleaning room through a second set of swinging double doors. The otters are weighed and

*The otters are weighed and examined to determine their priority for medical treatment. After medical stabilization, they are sedated prior to cleaning.*

Table 12.1
Summary of space requirements for a 200 sea otter rehabilitation facility.

| Program Elements | | Square Feet |
|---|---|---|
| **INDOOR SPACES** | | |
| **Animal Care Area** | | |
| Arrival Dock and Cage Cleaning | | 525 |
| Triage and Sedation | | 483 |
| Cleaning | | 609 |
| Drying | | 448 |
| Critical Care | | 840 |
| Veterinary Clinic | | 1,404 |
| Clinical laboratory | 912 | |
| Surgery | 300 | |
| Darkroom | 72 | |
| Microbiological Clean Room | 72 | |
| Storage | 48 | |
| Nursery | | 264 |
| Necropsy | | 684 |
| Hot Water Utility Room | | 270 |
| Restrooms | | 110 |
| Corridors | | 1,146 |
| **Animal Care Area Subtotal** | | **6,783** |
| **Administrative Area** | | |
| Director's Office | | 288 |
| Administrative Supervisor's Offices | | 720 |
| Operations | 120 | |
| Public Relations | 120 | |
| Personnel | 120 | |
| Finance | 120 | |
| Logistics | 120 | |
| Documentation | 120 | |
| General Office Space | | 1,848 |
| Operations—six work stations | 360 | |
| Public Relations—one work station | 83 | |
| Personnel—four work stations | 331 | |
| Financial—three work stations | 248 | |
| Logistics—eight work stations | 661 | |
| Documentation— two work stations | 165 | |
| Documentation Records | | 180 |
| Communications | | 144 |
| Administration and Visitor Security | | 144 |
| Conference Room | | 400 |
| Photocopy Room | | 96 |
| Lunch Room | | 300 |
| Restrooms | | 308 |
| Reception | | 168 |
| Storage | | 72 |
| Janitor's Storage Room | | 48 |
| Corridors | | 448 |
| **Administration Area Subtotal** | | **5,164** |

examined to determine their priority for medical treatment. After medical stabilization, they are sedated (if required) prior to cleaning. This room is equipped with a digital floor scale for weighing otters, work counters with sinks, cabinets, a refrigerator, and a wall-mounted hose

Table 12.1
*(Continued)*

| Program Elements | Square Feet |
|---|---|
| **INDOOR SPACES** | |
| **Service Area** | |
| Service Entrance/Delivery Dock | 240 |
| Security | 120 |
| Laundry and Clothing Dispensary | 231 |
| Carpentry Shop | 300 |
| Dressing Room with Lockers | 308 |
| Women's Restroom and Shower | 249 |
| Men's Restroom and Shower | 236 |
| Lunch Room | 655 |
| Animal Food Preparation | 700 |
| Walk-in Freezer and Loading Dock | 580 |
| Janitor | 60 |
| Corridors | 588 |
| Outdoor Area Restrooms | 80 |
| **Service Area Subtotal** | **4,347** |
| **TOTAL INDOOR SPACE** | **16,294** |
| **OUTDOOR SPACES** | |
| Otter Holding Pens | 5,040 |
| Sea Otter Pools | 2,968 |
| Pinniped Pools and Haulout | 1,536 |
| Seawater Treatment | 4,620 |
| Service Yard | 2,880 |
| Triage Van/Boat Storage | 800 |
| Parking | 20,865 |
| Water Tanks and Underground Waste Water Storage | 1,620 |
| **TOTAL OUTDOOR SPACE** | **40,329** |

reel with hot and cold water for washing the floor. The floor is covered with a nonporous, skid-resistant surface which slopes toward a central floor drain. The room is climate controlled and maintained at a temperature of 20 °C (68 °F). The walls are covered with ceramic tile. The lighting fixtures are humidity resistant. A separate door leads to the central corridor.

## Cleaning Room (609 ft$^2$)

The cleaning room (Appendix 4, Figure B) is designed for washing oiled sea otters with fresh water and detergent. Swinging doors lead from the triage room into the cleaning room. This room is equipped with five cleaning tables individually supplied with hot and cold water and detergent, work counters with sinks, cabinets, and a refrigerator. The specially designed cleaning tables have a perforated plastic surface that supports the sedated otter and allows detergent and water to fall into a basin that drains into a waste water system with an oil trap (see Chapter 6, Figure 6.2). The hot water system has a capacity of ten

***The cleaning room is designed for washing oiled sea otters with fresh water and detergent.***

gallons per minute for each cleaning table. Clean towels are dispensed through a window between the cleaning room and the adjacent laundry room. Dirty towels are returned to the laundry room through a wall-mounted chute. The room is climate controlled and maintained at an air temperature of 20 °C (68 °F). The floor is covered with a nonporous, skid-resistant surface which slopes toward two floor drains. The walls are covered with ceramic tile. The lighting fixtures are humidity resistant. Dual swinging doors lead to the central corridor, and a second door leads to the laundry room.

Drying Room (448 ft$^2$)

After the otters are cleaned, they are taken across the corridor to the drying room (Appendix 4, Figure C). This room has five drying tables, each of which is equipped with two high-speed, overhead, forced air pet dryers. The drying tables have smooth, perforated plastic surfaces that allow air to circulate from below. The room has a work counter with a sink and cabinets. The room is dehumidified and maintained at an air temperature of 20 °C (68 °F). The floor is covered with a nonporous, skid-resistant surface which slopes toward a central floor drain. The walls are covered with ceramic tile. The lighting fixtures are humidity resistant. A swinging door leads to the critical care room. A separate door provides direct access to the outdoor otter pens.

Critical Care (840 ft$^2$)

*Otters that have been cleaned and dried should be allowed to recover from sedation in the critical care room. Also otters that are lightly oiled may be kept in this room for up to thirty-six hours before they are cleaned.*

Otters that have been cleaned and dried should be allowed to recover from sedation in the critical care room (Appendix 4, Figure C). Also, otters that are lightly oiled may be kept in this room for up to thirty-six hours before they are cleaned. Because otters that have been oiled and cleaned may have difficulty thermoregulating at ambient air temperatures, especially during the winter in northern latitudes, they should be kept in the critical care room until they are alert and have begun to groom. The otters are held in specially designed, fiberglass cages (Chapter 7, Figure 7.1) with sliding lids and smooth, slatted bottoms that allow the passage of feces and urine. Up to twenty-eight of these cages sit inside of shallow, stainless steel floor sinks (four feet wide) located along the walls. The floor sinks have a central drain and a hose reel with hot water so that they can be cleaned and sanitized. The center of the room has a work counter with three sinks, cabinets, and a refrigerator. The room is climate controlled and maintained at an air temperature of 15 °C (60 °F). The floor is covered with a nonporous, skid-resistant surface which slopes toward two floor drains. The walls are covered with ceramic tile. Doors lead to the veterinary clinic, the central corridor, and the outdoor otter pens.

Veterinary Clinic (1,404 ft$^2$)

*The veterinary suite is designed for the clinical analysis of blood, fecal and urine samples, storing and dispensing drugs and medical supplies, bacterial culture, and surgical procedures.*

The veterinary suite (Appendix 4, Figure D) is designed for the clinical analysis of blood, fecal, and urine samples, storing and dispensing drugs and medical supplies, bacterial culture, and surgical procedures. Along with the clinical laboratory, the suite has a separate surgery room, a microbiological clean room, a darkroom for developing film, a medical storeroom, and an office area.

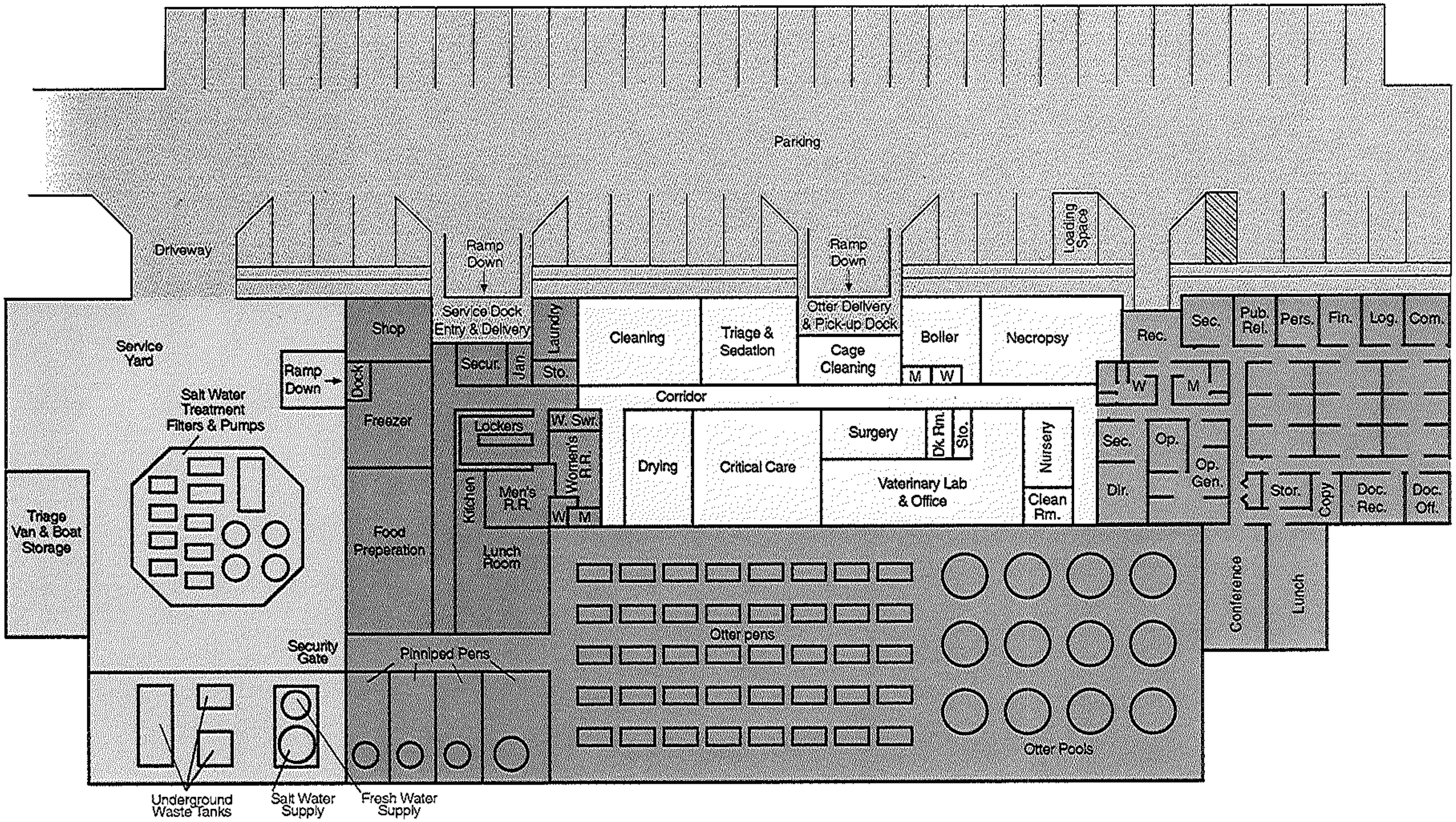


Figure 12.1
Floor plan for a regional rehabilitation center with a capacity of 200 sea otters.

- Clinical Laboratory: Equipped with laboratory benches, sinks, cabinets, shelves, two desks, file cabinets, two refrigerators, and a -70 °C freezer. 912 $ft^2$
- Surgery: Equipped with a surgical table and light, gas anesthesia machine, x-ray machine, work counters with sinks, cabinets, and shelves. The floor is covered with a nonporous, skid-resistant surface which slopes toward a central drain. The walls are covered with ceramic tile. 300 $ft^2$
- Darkroom: Area for an automatic x-ray film processing machine and for conventional film development. 72 $ft^2$
- Microbiological Clean Room: Area equipped with a bacterial hood, shelves, and refrigerator. 72 $ft^2$
- Medical Store Room: Locked room for storing drugs and medical supplies. 48 $ft^2$

Nursery (264 $ft^2$)

The nursery (Appendix 4, Figure D) is designed for the care of captive-born and orphaned sea otter pups. The room provides a quiet environment in close proximity to the veterinary clinic. Amenities include a work counter with two sinks and cabinets, a refrigerator, an unheated waterbed for pups to play and rest on, and a shallow pool (3 ft x 10 ft x 2 ft deep). The floor is covered with a nonporous, skid-resistant surface which slopes toward a central floor drain. The room is climate controlled and maintained at a temperature of 15 °C (60 °F). The walls are covered with ceramic tile. Separate doors provide access to the central corridor and the veterinary clinic.

Necropsy (684 $ft^2$)

The necropsy room (Appendix 4, Figure E) is used for the postmortem examination of sea otters and the preparation of necropsy reports. The room is equipped with work counters and cabinets, three stainless steel sinks, heavy-duty sink-mounted garbage disposal, horizontal exhaust dissection table, fume hood, specimen photographic booth, stainless steel necropsy table with light, walk-in freezer (96 $ft^2$), -70 °C freezer, refrigerator, morgue refrigerator, lavatory with toilet, lockers, shower and dressing area, and a desk and file cabinet. The floor is covered with a nonporous, skid-resistant surface which slopes toward a central drain. The walls are covered with ceramic tile. The room is climate controlled. Direct access is provided to the outside of the facility for waste disposal and for the delivery and removal of dead animals. A second door leads to the central corridor.

Hot Water Utility Room (270 $ft^2$)

This area houses the gas-fired, instantaneous water heaters for sea otter cleaning (Appendix 4, Figure A). For the remainder of the facility, large commercial water heaters should be used. A steam-generating boiler should also be installed for steam cleaning the oily cages in the adjacent cage cleaning room. Direct access is provided to the outside of the facility for maintenance of the heating equipment.

Restrooms (110 $ft^2$)
Men's and women's restrooms in the animal care area.

Corridors (1146 $ft^2$)

*(b) Administrative Area* (Appendix 4, Figure F)
Director's Office (288 $ft^2$)
Office area for the facility director and his secretary. The area can also be used for small conferences with administrative staff and the press. Windows along the exterior wall provide a view of outdoor otter pens and pools.

Administrative Supervisors' Offices (720 $ft^2$)
Offices for following administrative supervisors:
Operations (120 $ft^2$)
Public Relations (120 $ft^2$)
Personnel (120 $ft^2$)
Financial (120 $ft^2$)
Logistics (120 $ft^2$)
Documentation (120 $ft^2$)

General Office Space (1848 $ft^2$)
General office space for the following personnel:
Operations – six work stations (360 $ft^2$)
Public Relations – one work station ( 83 $ft^2$)
Personnel – four work stations (331 $ft^2$)
Financial – three work stations (248 $ft^2$)
Logistics – eight work stations (661 $ft^2$)
Documentation – two work stations (165 $ft^2$)

Documentation Records (180 $ft^2$)
Dedicated room for documentation file storage and computer database management.

Communications Room (144 $ft^2$)
A room for six telephones, radio communications equipment, and telefax machine. This room is essential for good communications during an oil spill.

Administration and Visitor Security (144 $ft^2$)
Area for management of plant security. The room is equipped with the main security system control panel and guard station with desk. A closed-circuit video system enables the security coordinator to monitor entry gates, hallways, all rooms in the animal care area, and the outdoor pens and pools. All persons working in the facility should wear photo-identification badges issued by security.

Conference Room (400 $ft^2$)
This large room is used for general meetings and press conferences. Windows enable visitors to view the outdoor otter pens and pools while maintaining animal quarantine. The closed-circuit video sys-

tem enables visitors to view operations within the facility without entering the quarantine area. The room is equipped with a projection screen and presentation board.

Photocopy Room (96 ft²)
Area for making photocopies and storing supplies.

Lunch Room (300 ft²)
The administrative staff lunch room is equipped with tables, counters, sink, and refrigerator. The capacity of the lunch room is sixteen persons.

Restrooms (308 ft²)
Men's and women's restrooms for administrative offices.

Reception (168 ft²)
Area for visitors to be received and cleared by security.

Storage (72 ft²)
General storage for stationery, computer, and photocopy supplies.

Janitor's Storage Room (48 ft²)
Room for storing of janitor's equipment and supplies.

Corridors (448 ft²)

*(c) Service Area* (Appendix 4, Figures G, H, and I)
Service Entrance/Delivery Dock (240 ft²)
Area for animal care staff to enter the facility and for the delivery of supplies and equipment.

Service Entrance Security (120 ft²)
Animal care staff arriving for work should display their photo-identification badges at the security desk before entering the facility. This room is equipped with a security control panel, guard station, desk, and storage shelves. Windows provide good visual control over the entry and delivery area. Direct access is provided to the main corridor.

Clothing Dispensary and Laundry Room (231 ft²)
Animal care staff should proceed from the security area to the clothing dispensary room to pick up their clean coveralls and rubber boots, and then proceed to the locker room. Soiled coveralls are returned to the clothing dispensary room after the staff complete their shift. Soiled coveralls and towels from the cleaning room are washed in the laundry room (or sent to a commercial laundry company).

Carpentry Shop (300 ft²)
Maintenance and service shop equipped with a full range of power tools and work benches. Direct access is provided through double doors to the service yard and the delivery dock.

Dressing Room with Lockers (308 $ft^2$)

Area for animal care staff to change into clean coveralls and rubber boots and to store articles of personal clothing. This room is equipped with benches and 132 lockers for personal storage. The floor is covered with a nonporous, skid-resistant surface.

Women's Restroom and Shower (249 $ft^2$)

Restroom adjacent to dressing area with three toilets, two lavatories, and two showers.

Men's Restroom and Shower (236 $ft^2$)

Restroom adjacent to dressing area with two toilets, two urinals, two lavatories, and two showers.

Lunch/Observation Room (655 $ft^2$)

Common area for animal care staff to eat meals, socialize, and observe otters in pens and pools. The seating capacity is fifty-four persons. Direct access is provided to the pools and pens, and windows along the two exterior walls provide a good view of the pen area. This room is equipped with kitchen facilities, including tables, catered food service counter, cabinets, sink, and refrigerator.

Animal Food Preparation Room (700 $ft^2$)

The animal food preparation room (Appendix 4, Figure H) is used for thawing frozen seafood and preweighing individual food portions. In a rehabilitation facility with 200 adult otters, the kitchen staff will thaw and prepare 1000 kg of sea food daily. This kitchen is equipped with two stainless steel counters with heavy duty garbage disposals, eight stainless steel thawing sinks (3 ft x 3 ft x 3 ft deep), cabinets, two commercial ice machines, and a commercial refrigerator. An office (50 $ft^2$) with a desk and file cabinet is provided for the food preparation coordinator. The floor is covered with a nonporous, skid-resistant surface and slopes toward two central floor drains. The walls are covered with ceramic tile. Animal care staff pick up buckets of iced seafood at a counter located along the exterior wall. Separate doors provide access to the service yard, central corridor, and outdoor pen and pool area.

Walk-in Freezer and Loading Dock for Animal Food Storage (580 $ft^2$)

This walk-in freezer is large enough to store a ten day supply of frozen seafood. The freezer is located next to the food preparation kitchen and has direct access to the service yard for deliveries of frozen seafood.

Janitor's Storage Room (60 $ft^2$)

Room for storing of janitor's equipment and supplies.

Restrooms for Outdoor Area (80 $ft^2$)

Men's and women's restrooms for outdoor pen and pool area.

Corridors (588 $ft^2$)

## Detailed Description of Outdoor Space Requirements (Figure 12.1)

### Holding Pens (5,040 ft²)

Once sea otters in the critical care area have recovered from sedation, have a stable core temperature, and have begun to feed, they should be moved to outdoor holding pens (Chapter 7, Figure 7.2). This outdoor area is designed for forty fiberglass pens (Figure 12.1) to house eighty sea otters. Each row of pens sits above a shallow concrete trough that catches the seawater overflow from the pens and returns it to the recirculation system. Two-foot-wide covered utility raceways are located between each row of pens to provide for hot (33 °C, 92 °F) and cold seawater connections. The seawater temperature in each pen should be adjustable to meet the needs of individual otters. The seawater turnover rate in each pen should be once every thirty minutes. The pen area is easily accessible from the critical care room, veterinary clinic, and service yard.

### Pools (2,968 ft²)

Once the recuperating otters have restored the water repellency of their fur and are in good health, they should be moved from the outdoor pens to larger pools that enable greater movement. The fiberglass pools are fourteen feet in diameter, four feet deep, and can hold up to six sea otters (Chapter 7, Figure 7.4). The perimeter of each pool has a three-foot-wide haulout area and is surrounded by a plastic-coated chain link fence to prevent the otters from escaping. Exterior stairs provide access to the pools and haulout areas. The seawater turnover rate in the pools is once every thirty minutes.

*The seawater turnover rate in each pen and pool should be once every thirty minutes.*

### Pinniped Pools (1,536 ft²)

This area is designed for holding pinnipeds (seals and sea lions) that have been oiled and cleaned. The rehabilitation process for pinnipeds is similar to that for sea otters (see Chapter 15). The area is paved with concrete, subdivided with chain link fences, and has four round fiberglass pools (three six-foot diameter pools and one eight-foot diameter pool). The seawater turnover rate in the pools is once every sixty minutes.

### Seawater Treatment (4,620 ft²)

This area for seawater filters, ozonation tower, pumps, and heat exchanger is easily accessible from the service yard for equipment maintenance and service. Total seawater recirculation capacity is 2,000 gallons per minute. To prevent the spread of disease, the otter pen area, rectangular pools, and pinniped pools should have separate seawater systems. Each of these three areas has its own seawater filtration system and ozonation tower. Only the sea otter pens have a heated seawater supply.

### Service Yard (2,880 ft²)

Asphalt-surfaced service yard with direct access to seawater treatment area, walk-in freezer, and carpentry shop.

Triage Trailer and Boat Storage (800 $ft^2$)

Asphalt-surfaced storage area surrounded by a chain link fence for the storage of two mobile triage trailers and two skiffs.

Parking (20,865 $ft^2$)

Asphalt-surfaced parking area for fifty automobiles located at the front of the rehabilitation facility.

Freshwater and seawater storage towers and underground waste water tanks (1,620 $ft^2$)

**Prerelease Facilities**

*Rehabilitated otters should be moved from the regional center to seawater pens in a prerelease facility as soon as their fur is water repellent and they have no health disorders.*

Normally about two weeks are required to rehabilitate an oiled sea otter, although the duration may be longer for animals with serious health problems. Rehabilitated otters should be moved from the regional rehabilitation center to seawater pens in a prerelease facility as soon as their fur is water repellent and they are healthy. Because of the many factors that may influence the timing of release (see Chapter 10), prerelease facilities may be needed to hold sea otters for up to six months. As part of prespill contingency planning, possible sites for prerelease facilities should be identified.

Holding pens in the prerelease facility should be large enough for the otters to swim and dive (at least 18 ft long, 10 ft wide, 5 ft deep) and have good seawater circulation. An octagonally shaped floating pen that can hold up to 200 sea otters was used during the EVOS. (Figures 12.2 and 12.3.) The spokes and perimeter of this pen are made of steel pipe (four foot diameter) that form flexible junctures when assembled. This type of construction allows the structure to bend and ride over waves. Each pie-shaped section is draped with netting (four-inch stretch mesh) that is secured four feet above the water line. Floating, wooden platforms provide haulout space for the otters. A small hut in the center provides protection from the weather for the animal monitors.

A less expensive prerelease facility with a 100 otter capacity can be made from a modular, floating dock (JETFLOAT™, Vancouver, B.C.) and twelve floating pens (Figures 12.4, 12.5, and 12.6). The pens (18 ft x 10 ft x 5 ft deep) are made out of aluminum pipe and net (2.0 inch stretch mesh on sides); the pens are secured to cleats on the floating dock. Each pen has a haul out platform (10 ft x 3 ft) made of smooth, plastic slats spaced one inch apart.

Other space requirements for the prerelease facility, but not necessarily located on the floating dock, include a food preparation area, freezers, a small veterinary clinic, administration and records, communications, an area for staff to change into sanitary clothing, and staff accommodations. Depending on the accessibility of the site by road, a helicopter pad and boat dock may be required on shore for the delivery of sea otters, staff, and provisions. Security is essential to prevent visitors and pets from entering the facility. As with the regional rehabilitation center, full quarantine procedures are maintained within the prerelease facility to prevent the introduction of domestic animal diseases.

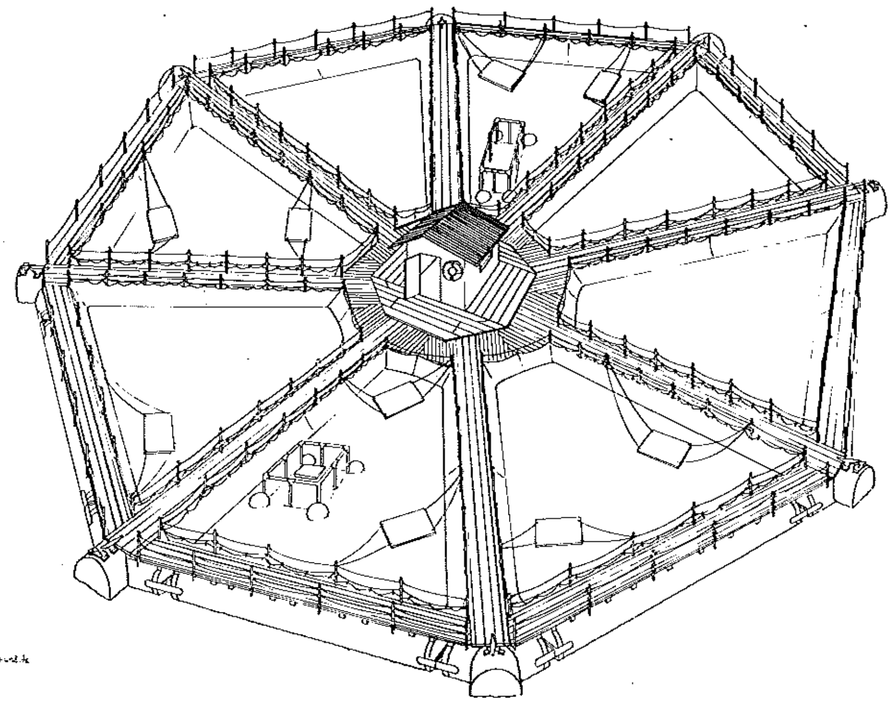

Figure 12.2
Prerelease facility for sea otters consisting of a floating, octagonal pen. Each netted section is about 90 ft. long, 15 ft. deep and can hold twenty-five otters. Maximum diameter is approximately 210 feet. Haul out platforms are placed in each section. Some sections also contain smaller, secondary pens. The small hut is used by the husbandry staff.

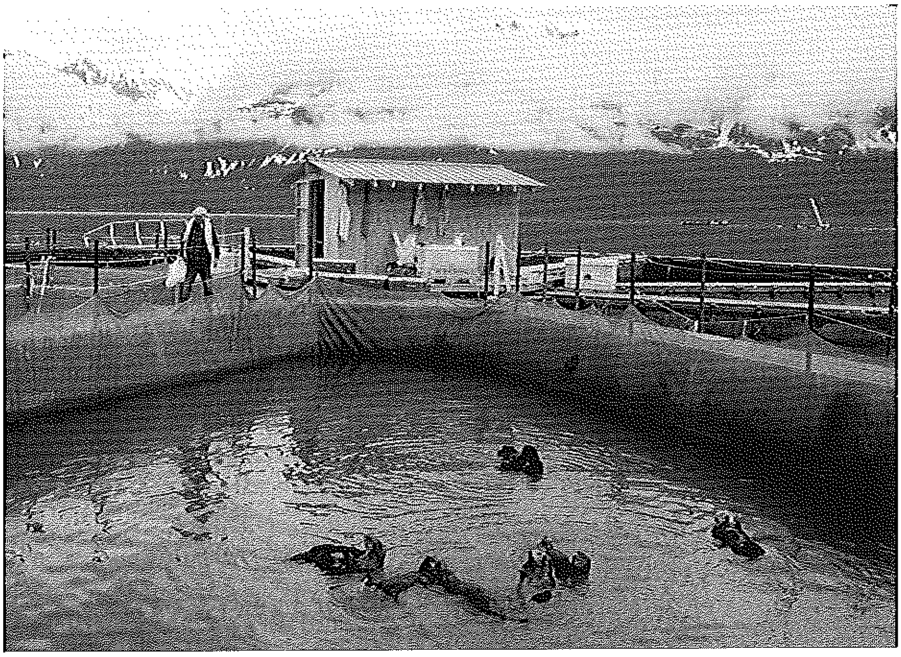

Figure 12.3
Rehabilitated sea otters in one section of a floating, octagon pen in Port Valdez, Alaska.

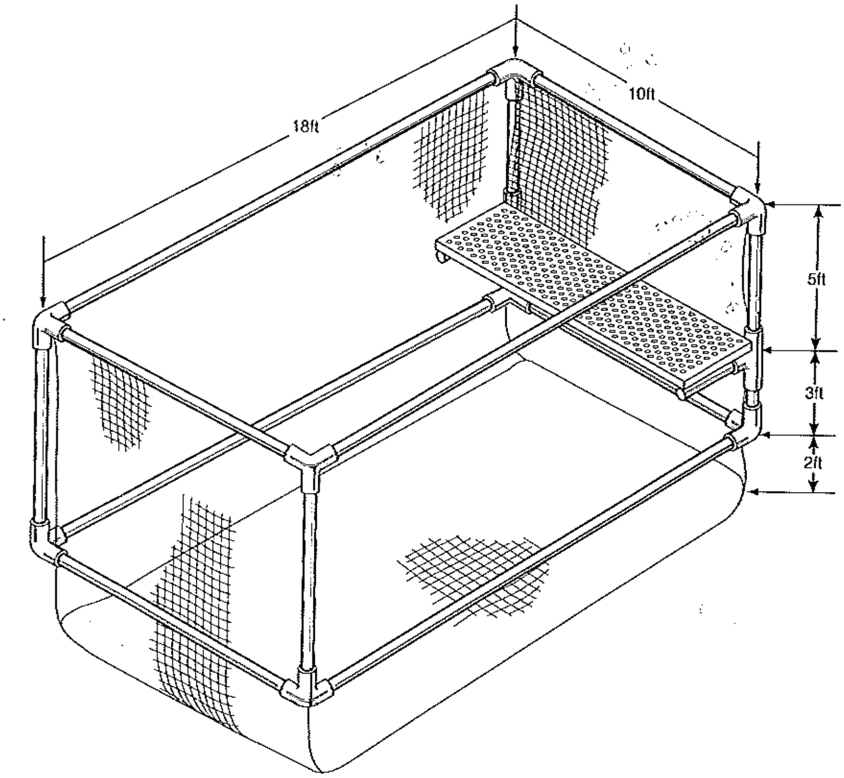


Figure 12.4
Floating sea otter pen for use in the prerelease facility shown in Figure 12.6. Flotation is provided by a modular floating dock. Otters are contained within a net bag that is hung within the aluminum pipe framework.
A haulout platform of smooth, plastic slats is placed at one end of the pen.

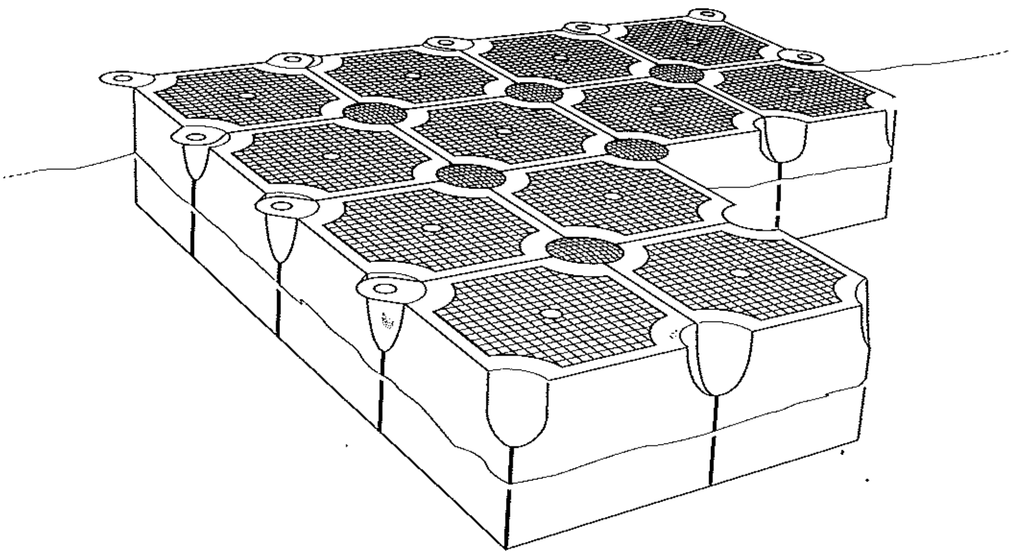

Figure 12.5
Modular, floating dock used in conjunction with the floating sea otter pens illustrated in Figure 12.4.

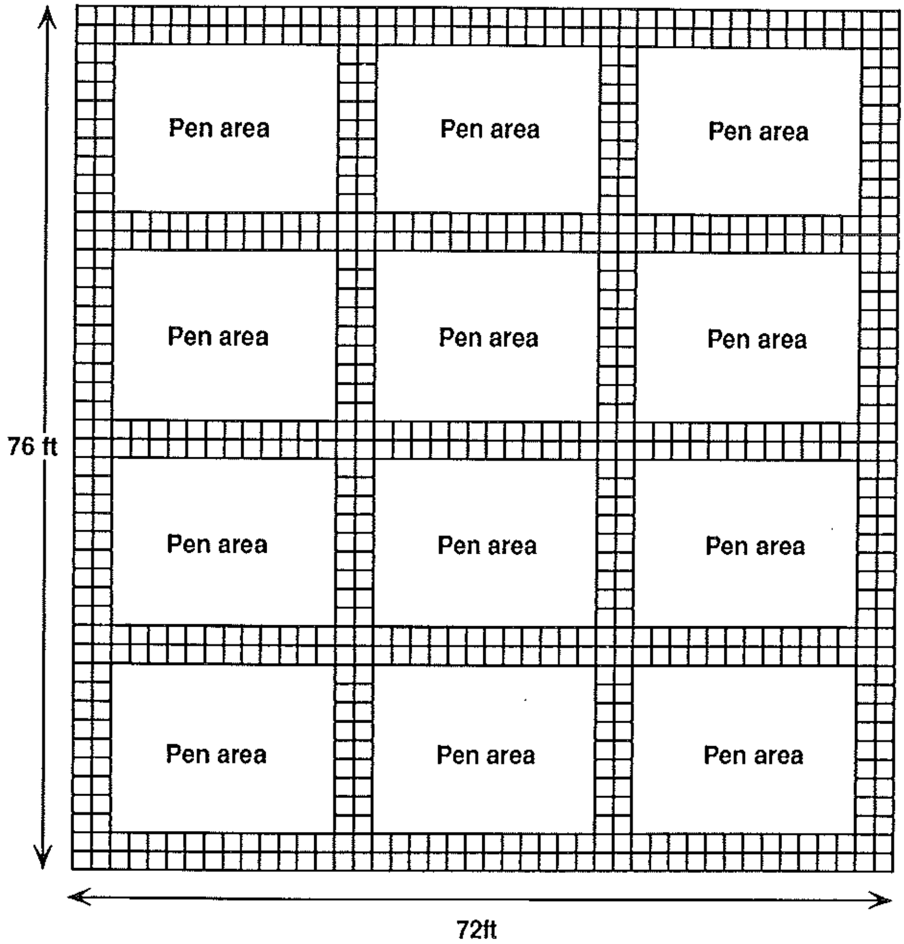


Figure 12.6
Overhead view of a prerelease facility consisting of a floating dock and sea otter pens shown in Figures 12.4 and 12.5.

If a large preemptive capture effort is planned after a spill (see Chapter 2), quick access to seawater pens in a prerelease facility is vital. Modular systems like the ones above will allow staff to quickly assemble the pens when needed. A modular design also enables the addition of new pens as needed, thereby allowing unlimited capacity.

## Remote/Mobile Triage Facilities

Transporting sea otters over long distances is stressful. For otters that have been exposed to oil, this stress can cause death or seriously complicate medical conditions. Mobile triage units are beneficial in certain cases because they allow staff to stabilize the animals medically before they are flown long distances to a regional rehabilitation center. Mortality can be reduced significantly if mobile units are employed when large numbers of otters must be captured more than 500 miles (five-hour helicopter flight) from the regional center.

*Mortality can be reduced significantly if mobile triage units are employed when large numbers of otters must be captured more than 500 miles from the regional center.*

These mobile units, by necessity, are self-contained (including electrical generators and hot water) and transportable by truck, ship, large helicopters, or fixed-wing aircraft (C-130 cargo plane); the latter may

*Mobile units are self-contained (including electrical generators and hot water) and transportable by truck, ship, large helicopters, or fixed-wing aircraft.*

be necessary for areas inaccessible by road such as the Aleutian Islands or southeast Alaska. A mobile facility (Figure 12.7) should consist of a trailer (10 ft wide, 33 ft long) that is divided into three functional sections. The largest section is for triage and can hold up to eight otters in portable cages until they can be flown to the regional center. Otters arriving from the capture boats are examined by a veterinarian or animal care specialist and treated for hypothermia, dehydration, malnourishment, capture stress, or other medical problems. After they are medically stabilized, the otters are placed in critical care cages (Chapter 7, Figure 7.1) and monitored. The cages are placed in a shallow, fiberglass floor sink that collects waste water and drains into the sewer or a storage tank. A hose can be used to rinse the cages and the floor sink. Because heavily oiled otters have lost their ability to thermoregulate at cold temperatures, the room should be maintained at about 15 °C (60 °F). However, the otters should also be checked regularly to ensure that they are not overheating.

The triage area includes space for clinical blood analysis, communication equipment, and a desk. Blood samples from newly arrived otters should be analyzed for metabolites, electrolytes, and hematological variables. This information is vital for veterinarians to diagnose and treat immediate medical problems (see Chapter 4). This area is also used to store clinical supplies and drugs. Hot water is provided by a wall-mounted, propane-fueled instantaneous water heater. Communication equipment should include of a VHF radio and telephone (cellular telephones are very useful in areas with service). Good communication between the mobile facility and capture boats, helicopter, and the regional rehabilitation facility is vital. Administrative and animal health records are also kept in this area.

The other end of the trailer is used for sea otter food preparation. This kitchen is a smaller version of the one at the regional facility, consisting of a stainless steel counter for food preparation, a deep sink with fresh water for thawing frozen seafood, and a chest freezer (25 $ft^3$). This is enough freezer space to store one week of food for ten adult sea otters.

The trailer should be designed with external connections for water, electricity, propane, and sewage. If these amenities are not available at the site, then backup systems are required. These consist of fifty-gallon portable storage tanks for fresh water and a 5kW diesel-electric generator with a fifty-gallon fuel tank. The generator should be housed separately in a noise-insulated, weatherproof container. In remote areas where sewage treatment is unavailable, waste water from the kitchen and sea otter holding area can be drained onto the ground by running a hose several hundred feet from the trailer. The waste water should contain only nontoxic, biodegradable substances such as food and feces. Portable propane tanks should be used for the instantaneous hot water heaters and space heaters. Additional outdoor space for holding sea otters in cages, storing equipment, and for conducting other activities that require shelter can be provided by portable, vinyl enclosures similar to those made by Weatherport Company (Anchorage, Alaska).

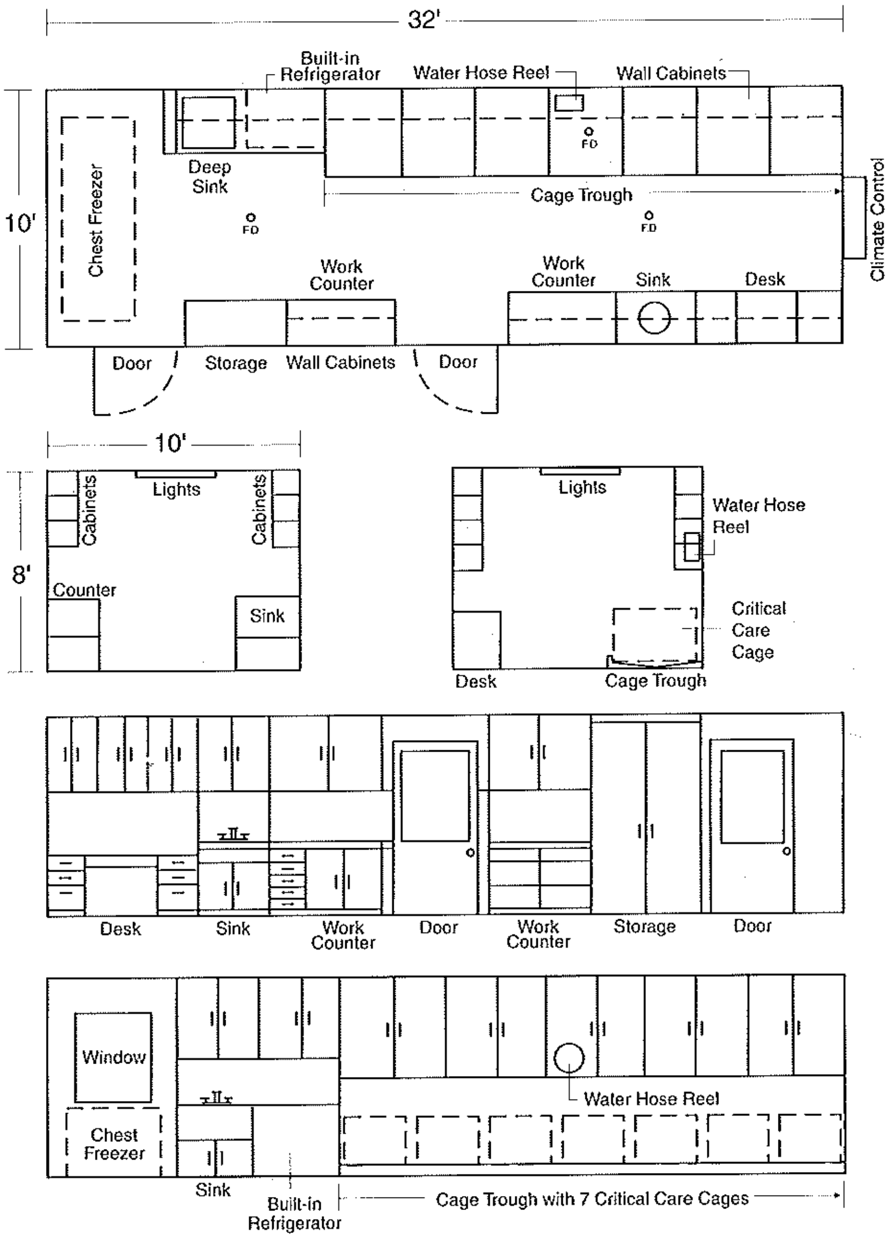


Figure 12.7
A mobile rehabilitation facility for sea otters captured in remote locations.

If the mobile unit is placed in a remote area without access to hotels and restaurants, then a second trailer will be required to provide living accommodations for the staff and a kitchen for their food preparation. If the trailer is placed on the deck of a large ship (i.e. an oil tanker), then fresh water, electricity, and waste water treatment, staff accommodations and meals can be provided on-board. The ship can move with the spill, and oiled sea otters can be transported to the shore-based rehabilitation center by helicopter.

# Chapter 13

# Facility Management and Personnel

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*The role of management is to ensure that the rehabilitation program is properly implemented. Staff members should understand the chain-of-command, rules of employment, and their job responsibilities.*

The role of management is to ensure that the rehabilitation program is properly implemented. The management structure should be organized before an oil spill and executed by experienced professionals. Although the management style should be interactive and encourage the free exchange of information and ideas, staff members should understand the chain-of-command, rules of employment, and their job responsibilities.

This chapter describes the management structure and staff requirements for large rescue and rehabilitation programs involving fifty or more sea otters. For spills involving fewer than fifty otters, the number of personnel can be reduced as appropriate by assigning more than one job to each staff member.

## MANAGEMENT STRUCTURE AND PERSONNEL RESPONSIBILITIES

### Director

*The director should understand the effects of oil on sea otters and, ideally, have experience in every phase of the rescue and rehabilitation process.*

The director is responsible for the overall rescue and rehabilitation program, its facilities, and its staff (Figure 13.1). He or she should understand the effects of oil on sea otters and, ideally, have experience in every phase of the rescue and rehabilitation process. Management experience and good interpersonal skills also are important. The ultimate success of the rehabilitation program will depend on the expertise and experience of the management team the director assembles.

The director is ultimately responsible for operating the rehabilitation program, but is usually occupied with matters other than the daily operations of the facility. He must be responsive to the needs and desires of the spiller (if one is identified) and government officials, including the trustee resource agencies – U.S. Fish and Wildlife Service (USFWS) and the Department of Fish and Game (DFG), the on-scene coordinator, and the regional response team. Other demands on his time will come from special interest groups and the media. The director will have time to deal with these groups professionally and

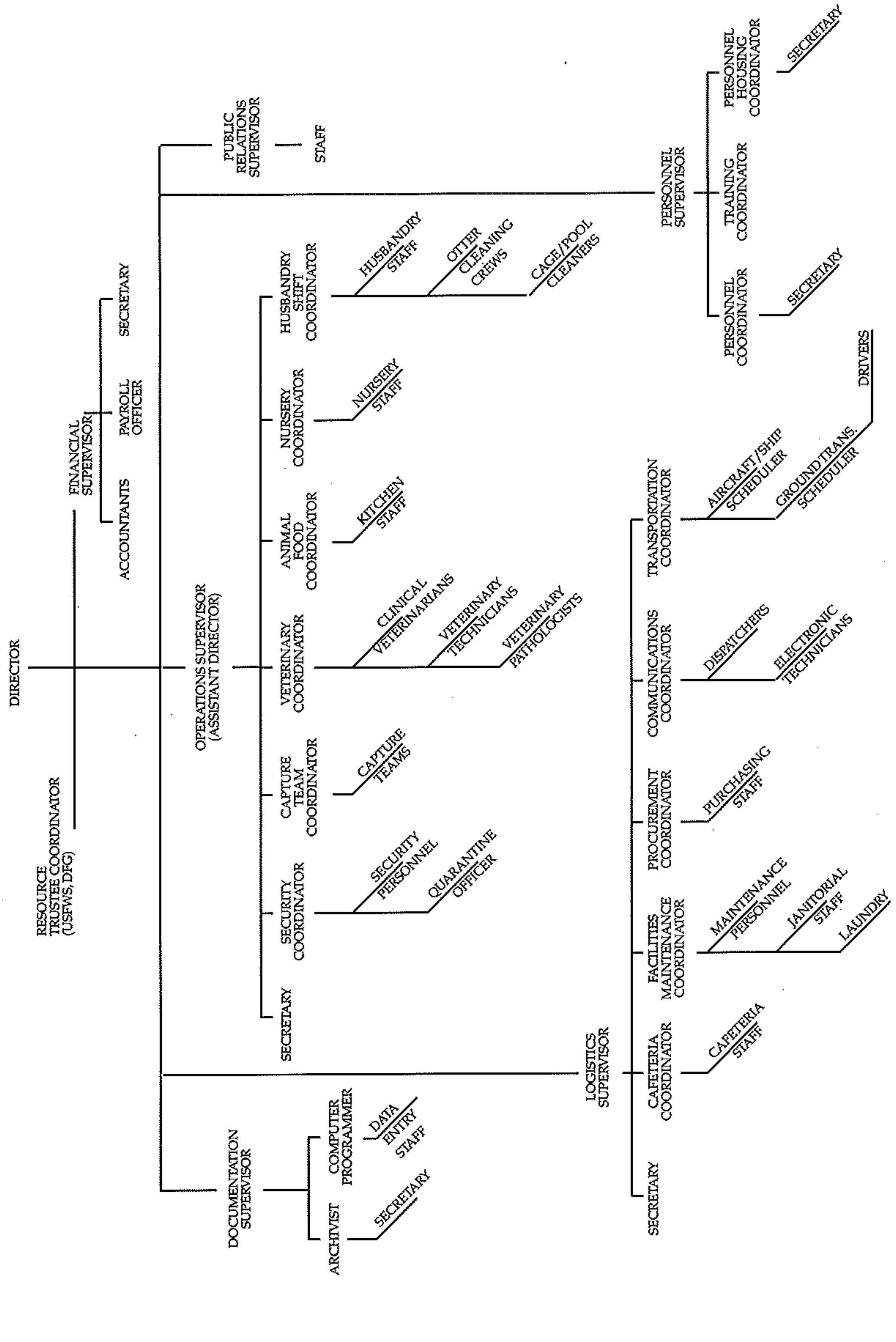


Figure 13.1
Management structure for a large rescue and rehabilitation program involving fifty or more sea otters.

effectively only if he is confident about daily operations; this confidence will come only through good management and a well-trained staff.

Because sea otters are protected under the Marine Mammal Protection Act of 1972, the director must receive authority from the USFWS for their capture, rehabilitation, and release. Under emergency conditions such as an oil spill, provisional authorization can be provided quickly to individuals with recognized expertise and experience. However, to avoid confusion and delays, the director should obtain preauthorization for sea otter rehabilitation from the USFWS.

*The director must receive authority from the USFWS for sea otter capture, rehabilitation and release.*

During an oil spill, a USFWS coordinator may be designated to provide trustee agency oversight of the rescue and rehabilitation program. This coordinator may direct the capture operations through the capture team coordinator (see below), who is a member of the management team and also may be an employee of the trustee agency. Such an arrangement ensures direct communications between the capture teams in the field and the trustee agency on such important issues as the preemptive capture of unoiled otters and when to begin and end the capture operation.

The director may not be involved in the daily operations of the rehabilitation center, but must remain informed about the status of the facility and any problems that require his personal attention. This can be accomplished through daily meetings with the management team, which includes a financial supervisor, operations supervisor, logistics supervisor, personnel supervisor, documentation supervisor, and public relations supervisor. Their feedback is essential to ensure efficient and effective operations. To manage rehabilitation program finances, the director should meet daily with the financial supervisor, review the accounts, and approve all purchase requests. The hire and discharge of any personnel should be reviewed with the operations supervisor and the personnel supervisor. In the director's absence, the operations supervisor should become acting director.

Good media relations are essential during an oil spill. Because many people find sea otters appealing, the press will be very interested in the well-being of otters in the rehabilitation center. The director should meet daily with the spiller, the USFWS, and the public relations supervisor to organize press briefings and interviews. Alternatively, if the spill is under federal control, media relations may be coordinated by the USFWS and the on-scene coordinator.

*Good media relations are essential during an oil spill.*

**Financial Supervisor**

The financial supervisor is responsible for maintaining financial records, preparing payroll, and approving all purchase requests, leases, and contracts. Staff accountants, the payroll officer, and secretarial staff will assist this individual (Figure 13.1). The accountants maintain a current balance on all expenditures. The payroll officer distributes and collects employee time cards from respective supervisors, verifies employee working hours, and prepares the payroll. Purchase requests for supplies and equipment should be submitted through each supervisor to the procurement coordinator, who must receive approval from the financial supervisor or a designated accountant before placing the order. Copies of all purchase vouchers are sent to the accountants.

*The financial supervisor is responsible for maintaining financial records, preparing payroll, and approving all purchase requests, leases, and contracts.*

In some instances, the financial supervisor may be an employee of the responsible party paying for the rescue and rehabilitation program. Under these circumstances, the financial supervisor acts as a liaison between the rehabilitation program and the responsible party's financial office, which must approve all expenditures.

### Operations Supervisor

*The operations supervisor is responsible for the cleaning, husbandry, feeding, and veterinary care of sea otters in the rehabilitation center, as well as for organizing capture teams, ensuring they are properly trained, and coordinating capture efforts with the USFWS.*

The operations supervisor is responsible for the cleaning, husbandry, feeding, and veterinary care of sea otters in the rehabilitation center, as well as for organizing capture teams, ensuring they are properly trained, and coordinating capture efforts with the USFWS. The operations supervisor is also responsible for security and maintaining quarantine conditions at the center. When the director is absent, the operations supervisor should become acting director of the rescue and rehabilitation program. This supervisor relies on the husbandry coordinator, nursery coordinator, animal food coordinator, veterinary coordinator, capture team coordinator, and security coordinator to fulfill these responsibilities (Figure 13.1). Personnel supervised may include husbandry staff, sea otter cleaning crews, cage and pool cleaners, nursery staff, kitchen staff, clinical veterinarians, veterinary pathologists, veterinary technicians, capture teams, security personnel, the quarantine officer, and secretarial staff.

The operations supervisor works with the personnel supervisor to ensure that the animal care staff and capture teams are properly trained and clothed (see Chapter 14). He relies on the husbandry coordinator, nursery coordinator, and animal food coordinator to ensure that proper husbandry protocols (see Chapter 7) and safety procedures (see Chapter 14) are followed.

The husbandry coordinator supervises the husbandry staff who monitor and feed the otters, the sea otter cleaning crews who wash and dry the oiled otters, and the cage and pool cleaning crews. The husbandry coordinator works with the documentation supervisor to ensure that proper records (see Appendix 2 for record forms) are maintained by the husbandry staff and that each otter can be identified by its flipper tag. Three eight-hour shifts are required to provide the otters with continuous care. Depending on the number of oiled otters arriving at the rehabilitation center, up to three eight-hour shifts will be needed for the sea otter cleaning crews. Cage and pool cleaning crews should work only one shift during the day.

The nursery staff coordinator supervises the nursery personnel who care for orphaned sea otter pups. The care of sea otter pups is very labor intensive and requires a well-trained and dedicated staff. Three eight-hour shifts are needed to care for the pups.

The animal food coordinator supervises the kitchen staff who prepare the frozen or fresh seafood for the otters. Only a daytime and evening shift are needed for the kitchen staff, because the otters are not fed between midnight and 7:00 AM.

The veterinary coordinator supervises the veterinary staff to ensure that the otters receive prompt medical care on a twenty-four-hour basis. Three eight-hour shifts are needed for the clinical veterinarians and veterinarian technicians. All otters that die in the center should be necropsied within two hours by a veterinary pathologist and tissue samples taken for toxicological and histopathological analysis (see Chapter 1). The USFWS may provide a veterinarian to conduct or supervise the necropsies and tissue collections. This person may also assist the clinical veterinarians in verifying that rehabilitated otters are healthy, disease-free, and ready for release.

The husbandry coordinator, animal food coordinator, and veterinary coordinator maintain inventories of essential equipment, supplies, and seafood. When shortages are identified, purchase requests are given to the operations supervisor, who forwards them to the procurement coordinator. The animal food coordinator and the veterinary coordinator should institute quality control procedures for all perishable supplies, especially seafood and drugs.

The capture team coordinator directs capture operations and works with the personnel supervisor to ensure that capture teams are properly trained. As mentioned above, this person may be the USFWS coordinator. The capture team coordinator works with the transportation coordinator, communications coordinator, procurement coordinator, and the USFWS coordinator to ensure that capture boats are chartered and that capture efforts are properly coordinated with the aircraft or ship-based transportation of sea otters, personnel, and supplies. Good communication (by radio or cellular telephone) with the capture boats is vital to ensure the prompt transportation of newly captured sea otters to the rehabilitation center.

*Good communication (by radio or cellular telephone) with the capture boats is vital to ensure the prompt transportation of newly captured sea otters to the rehabilitation center.*

The security coordinator controls the movement of personnel into and out of the facility by placing security guards at all entrances and issuing photo-identification badges to all personnel. These security procedures are needed to prevent the accidental introduction of domestic animal diseases into the animal quarantine area by unauthorized visitors. To ensure that the quarantine is maintained, a veterinarian or a trained specialist with expertise in quarantine procedures for domestic animal diseases will, as the quarantine officer, assist the security coordinator.

**Logistics Supervisor**

The logistics supervisor is responsible for chartering capture vessels and crews, transporting personnel and animals, maintaining communications between the rehabilitation center and field operations, procuring equipment and supplies, maintaining the facilities and equipment, and, in remote areas, feeding the staff. This person relies on a transportation coordinator, a communications coordinator, a procurement coordinator for supplies and equipment, a facilities maintenance coordinator, and a cafeteria coordinator (Figure 13.1). Under the logistics supervisor are the aircraft and ship scheduler, the ground transportation scheduler, drivers, radio and cellular telephone dispatchers, electronic technicians, purchasing staff, maintenance personnel, janitorial and laundry staff, cafeteria staff, and secretaries.

*The logistics supervisor is responsible for chartering capture vessels and crews, transporting personnel and animals, maintaining communications between the rehabilitation center and field operations, procuring equipment and supplies, maintaining the facilities and equipment, and in remote areas, feeding the staff.*

The transportation coordinator charters or leases boats, helicopters, fixed-wing aircraft, trucks, vans, and cars. This includes leasing cars or trucks for use by the director, supervisors, and other key personnel. The transportation coordinator relies on the ship and aircraft scheduler to coordinate the aircraft or ship-based transportation of sea otters, personnel and supplies between the capture boats and an airport or harbor. The ground transportation scheduler arranges for the transportation of otters, personnel and supplies by van, truck, or car to and from the rehabilitation center, relying on a team of drivers who maintain radio contact with dispatchers in the communications room.

The communications coordinator should establish a radio and cellular telephone communications network between the capture boats, aircraft, ground transportation, and the rehabilitation center. Supervisors and other key personnel should carry hand-held radios and wear pagers so they can be contacted twenty-four hours a day. A dedicated communications room should be established in the rehabilitation center to coordinate communications with all field operations. The communications coordinator should use dispatchers to transmit and receive information and trained communications technicians to keep the equipment operational. The inability to reliably communicate with the capture boats greatly impeded the sea otter rescue effort during the *Exxon Valdez* oil spill (EVOS).

The procurement coordinator for supplies and equipment is responsible for locating vendors and preparing purchase vouchers for all equipment and supplies. Purchase requests should be received through the appropriate supervisor before a voucher is prepared. The voucher is then approved by the financial supervisor and a copy sent to his office after an order is placed with a vendor.

The facilities maintenance coordinator ensures that the rehabilitation facility and its equipment are in good operating condition. This includes the physical structure, all amenities (lighting, climate control, plumbing, the seawater system, etc.), outdoor pens and pools, and the landscaping. This person works with the operations supervisor and staff to establish maintenance priorities for the facility. Maintenance work can be conducted by in-house staff or independent contractors. If contractors are used, the facilities maintenance coordinator should negotiate maintenance agreements before a spill occurs. This will help ensure prompt service and a more competitive price. All maintenance agreements must be approved by the financial supervisor. The facilities maintenance coordinator also supervises the janitorial and the laundry staff, who keep the facility interior clean and wash the towels and coveralls used by the animal care staff.

In remote areas, the cafeteria coordinator is responsible for feeding personnel at the rehabilitation facility, relying on the cafeteria staff to prepare or cater the meals which should be served in a sanitary room separate from the animal care area (see Chapter 12). The cafeteria coordinator works with the procurement coordinator to purchase food and supplies.

**Personnel Supervisor**

The personnel supervisor is responsible for hiring, discharging, and ensuring that personnel are trained in accordance with Occupational Safety and Health Administration (OSHA) standards (see Chapter 14). For spills in remote areas, this person also is responsible for staff housing. This supervisor relies on the personnel coordinator, training coordinator, personnel housing coordinator, and secretarial staff (Figure 13.1).

*The personnel supervisor is responsible for hiring, discharging, and ensuring that personnel are trained in accordance with Occupational Safety and Health Administration (OSHA) standards.*

The personnel coordinator works with the operations supervisor and logistics supervisor to determine the number and type of personnel needed in the rehabilitation center and on the capture boats. This person actively recruits paid and volunteer staff during an oil spill response (see below), maintains personnel records, and works with the payroll officer to administer payroll.

The training coordinator works with the operations supervisor and capture team coordinator to ensure that all personnel receive specific job training according to OSHA standards before commencing work, and that they understand their employee responsibilities and rights. To avoid labor disputes and possible lawsuits, a personnel handbook should be prepared. The handbook should clearly describe the rules of employment, including job responsibilities, the chain-of-command, proper attire, safety, hygiene, benefits (health and disability insurance), overtime, promotion, and dismissal.

If the spill occurs in a remote area, the personnel housing coordinator is responsible for staff housing. This may be accomplished by arranging for staff to stay in private homes, leasing apartments or condominiums, bringing in trailers, or constructing temporary buildings.

### Documentation Supervisor

The documentation supervisor ensures that: 1) sea otters are properly identified when captured, 2) data forms are completed, filed, and copies sent to the USFWS, and 3) data is entered into a computer database, analyzed, and made available to appropriate staff at the rehabilitation center. To accomplish this, the documentation supervisor relies on an archivist, computer programmer, and data entry personnel.

The documentation supervisor works with the training coordinator to ensure that capture teams, husbandry staff, and veterinarians understand documentation forms used during the capture, rehabilitation, clinical care, necropsy, release, and transfer of sea otters (see Appendix 2). This person also works with the capture team coordinator and husbandry shift coordinator to ensure that each otter is identified with a flipper tag for tracking from capture until release, transfer, or death.

The archivist maintains all records and distributes copies to the USFWS. The computer programmer maintains a computer database, supervises the entry of all data, and prepares daily status reports on the number of otters in the facility, their food consumption, and medical condition. This person also assists supervisors in maintaining computer hardware and software.

### Public Relations Supervisor

*The public relations supervisor works with the director, the spiller, the on-scene coordinator, and the USFWS to coordinate daily press briefings and media interviews.*

The public relations supervisor works with the director, the spiller, the on-scene coordinator, and the USFWS to coordinate daily press briefings and media interviews.

Table 13.1
Estimated peak management and staffing requirements for facilities with 50, 100 and 200 sea otters. The number of personnel is based on three eight-hour shifts.

| **Management or staff position** | **Peak number of personnel for facilities with the following number of sea otters:** | | |
|---|---|---|---|
| | **50 Otters** | **100 Otters** | **200 Otters** |
| **Director** | 1 | 1 | 1 |
| **Financial Supervisor** | 1 | 1 | 1 |
| Accountants | 1 | 1 | 2 |
| Payroll Officer | 1 | 1 | 1 |
| Secretary | 1 | 1 | 1 |
| **Operations Supervisor** | 1 | 1 | 1 |
| Husbandry Shift Coordinator[1] | 3 | 3 | 3 |
| Husbandry Staff[2] | 50 | 100 | 200 |
| Otter Cleaning Crews[3] | (15) | (20) | (25) |
| Cage/Pool Cleaning Crews[4] | 2 | 3 | 4 |
| Nursery Coordinator | 1 | 1 | 1 |
| Nursery Staff[5] | 2 | 5 | 8 |
| Animal Food Coordinator | 1 | 1 | 1 |
| Kitchen Staff[6] | 3 | 5 | 8 |
| Veterinary Coordinator | 1 | 1 | 1 |
| Clinical Veterinarians[5] | 5 | 8 | 8 |
| Veterinary Technicians[7] | 2 | 4 | 4 |
| Veterinary Pathologist[4] | 1 | 1 | 1 |
| Capture Team Coordinator | 1 | 1 | 1 |
| Capture Team Members[8] | 24 | 40 | 80 |
| Security Coordinator | 1 | 1 | 1 |
| Security Personnel[5] | 2 | 2 | 5 |
| Quarantine Officer[9] | (1) | (1) | (1) |
| Secretaries[7] | 2 | 2 | 4 |
| **Logistics Supervisor** | 1 | 1 | 1 |
| Transportation Coordinator | 1 | 1 | 1 |
| Aircraft/Ship Scheduler[6] | 1 | 1 | 1 |
| Ground Transportation Scheduler[10] | (1) | 2 | 2 |
| Drivers[7] | 2 | 2 | 4 |
| Communications Coordinator | 1 | 1 | 2 |
| Dispatchers[6] | 1 | 1 | 2 |
| Electronic Technician[4] | 1 | 1 | 1 |
| Procurement Coordinator | 1 | 1 | 1 |
| Purchasing Staff[4] | 1 | 2 | 2 |
| Facilities Maintenance Coordinator | 1 | 1 | 1 |
| Maintenance Personnel[6] | 3 | 5 | 7 |
| Janitorial Staff[7] | 2 | 4 | 4 |
| Laundry Staff[4] | 1 | 1 | 1 |
| Cafeteria Coordinator | 1 | 1 | 1 |
| Cafeteria Staff[6] | 1 | 3 | 3 |
| Secretaries[7] | 2 | 4 | 4 |

The press will request access to the rehabilitation facility to photograph and videotape the otters and staff. This poses several serious problems. First, the presence of visitors makes it difficult to quarantine animals and increases the risk of exposure to domestic animal diseases. Second, the added commotion is stressful to the otters. Organizing a press pool (a single representative for the entire press group) is one solution. Alternatively, the facility should be designed with viewing areas that are isolated from the animal care area by glass (see

Table 13.1
*(Continued)*

| Management or staff position | Peak number of personnel for facilities with the following number of sea otters: | | |
|---|---|---|---|
| | 50 Otters | 100 Otters | 200 Otters |
| **Personnel Supervisor** | 1 | 1 | 1 |
| Personnel Coordinator | 1 | 1 | 1 |
| Training Coordinator[11] | (1) | 1 | 1 |
| Personnel Housing Coordinator[11] | (1) | 1 | 1 |
| Secretaries[4] | 1 | 1 | 2 |
| **Documentation Supervisor** | 1 | 1 | 1 |
| Archivist[4] | 1 | 1 | 1 |
| Computer Programmer[4] | 1 | 1 | 1 |
| Data Entry Personnel[7] | 2 | 2 | 4 |
| Secretaries[5] | 0 | 1 | 2 |
| **Public Relations Supervisor** | 1 | 1 | 1 |
| Public Relations Staff[4] | 0 | 0 | 1 |
| **Total Personnel** | 137 | 228 | 392 |

[1] This number divided equally into three, eight-hour shifts.
[2] Assumes one Husbandry Staff member per three otters for each of three eight-hour shifts.
[3] Sea Otter Cleaning Crews can be taken from the Husbandry Staff.
[4] Day shift only.
[5] This number plus coordinator divided equally into three, eight-hour shifts.
[6] This number plus coordinator divided equally between day and evening shifts only.
[7] This number divided equally between day and evening shifts only.
[8] This is an estimated number of capture team members assuming four persons per boat.
[9] This position filled by veterinary coordinator.
[10] For a fifty otter facility, the aircraft, ship and ground transportation scheduler is one position. Otherwise, this number divided equally between day and evening shifts.
[11] For a fifty otter facility, the personnel supervisor and personnel coordinator should handle the responsibilities of the training coordinator and the personnel housing coordinator.

Chapter 12). Video cameras may be placed in key locations throughout the facility so that visitors can view the rehabilitation process on video monitors outside of the quarantine area.

## NUMBER OF PERSONNEL REQUIRED

Oiled sea otters require care twenty-four hours a day, so a core professional staff of administrators, veterinarians, veterinary technicians, and animal care specialists is required (Table 13.1). The support staff should be large enough for three eight-hour shifts so that the otters receive continuous care. Some overlap in shifts will allow the exchange of information among staff members, especially the husbandry staff.

*Oiled sea otters require care twenty-four hours a day. The staff should be large enough for three eight-hour shifts so that the otters receive continuous care.*

The appropriate staff size will depend on the number and health of the otters in the facility. At the beginning of a spill when capture teams are in full operation and heavily oiled otters require intensive care (one animal monitor per three otters), the number of personnel will range from 137 to 392 for facilities with capacities of 50 to 200 sea otters, respectively (Table 13.1). After capture operations end and the rehabilitated otters require less care (one animal monitor per ten otters), the staff can be decreased by fifty percent or more. Staff reductions should occur in accordance with efficient management of the facility and husbandry needs of the otters. At the time of their employment, all personnel should be told that the rescue program is temporary, and that their jobs will be terminated as the otters are rehabilitated and released.

## THE ROLE OF VOLUNTEERS

After an oil spill, there is a large response by the volunteer community to help with sea otter rescue and rehabilitation. The availability of experienced veterinarians, animal health technicians, and animal husbandry staff is often inadequate to care for the large number of otters that may become oiled during a major spill. Volunteers can be a valuable supplement to the professional staff, if they are properly trained and supervised (see Chapter 14). They can assist with sea otter husbandry and cleaning, cage and pool cleaning, food preparation, ground transportation, communications, facility maintenance, and secretarial duties. During the EVOS, approximately 200 volunteers were used in the rehabilitation centers. With proper training and supervision, the animals will benefit, and the volunteers will find their time and effort rewarded.

A training program for volunteers with a yearly refresher course should be an integral part of a rehabilitation facility. This ensures that a group of knowledgeable and motivated volunteers are immediately available if an emergency arises. Training programs for volunteers should include instruction on sea otter behavior, the effects of oil on sea otter health (Chapter 1), husbandry (Chapter 7), veterinary procedures in which they may be asked to assist (Chapters 4 and 5), record keeping, quarantine procedures for disease control, and occupational safety and hygiene (Chapter 14).

## SUMMARY

Good management is essential for a successful rescue and rehabilitation program. Because the rehabilitation team must respond quickly, a well-designed management structure should be organized before an oil spill. Personnel requirements will change during the course of a spill and will depend on the number and health of the otters in the rehabilitation facility. If properly trained and supervised, volunteers can be a valuable source of manpower and enthusiasm for the labor intensive task of caring for oiled sea otters.

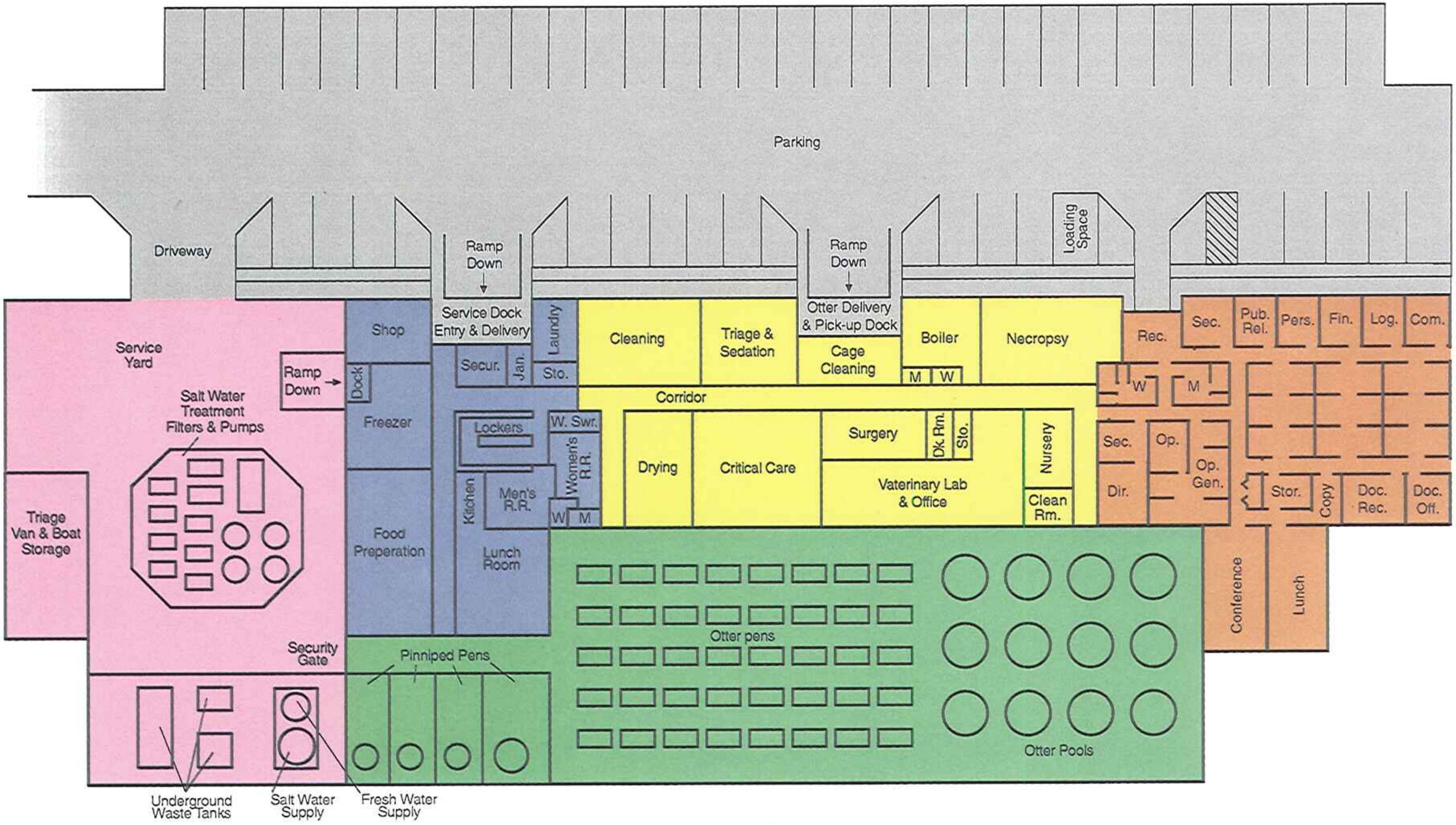


Figure 12.1
Floor plan for a regional rehabilitation center with a capacity of 200 sea otters.

# Chapter 14

# Occupational Safety in the Rehabilitation Center

Patty Chen-Valet
Theodore Camlin

*Health and safety of personnel are always the highest priorities in the rehabilitation center.*

Health and safety of personnel should be the highest priorities during the capture and rehabilitation of oiled sea otters. During a rehabilitation program, workers will be constantly challenged physically and emotionally. Although their primary objective is to save as many animals as possible, they must not neglect their own health. Workers must be reminded that if they become ill or injured, they cannot effectively provide care for animals. Individual safety depends on understanding and practicing four basic principles: 1) maintain safe working conditions and procedures, 2) know occupational health and safety regulations, 3) know the potential hazards of working with oiled wildlife, and 4) wear protective clothing and practice good hygiene.

In this chapter, we describe the protocols necessary for creating a safe working environment, handling oiled wildlife safely, and protecting oneself from injury and illness in the rehabilitation center. We also outline the Occupational Safety and Health Administration (OSHA) regulations that are applicable to oiled wildlife rehabilitation.

## MAINTAINING SAFE WORKING CONDITIONS

### Keep the Work Place Clean and Safe

During an oil spill, the rehabilitation facility will become a place of great activity as staff members endeavor to care for oiled animals. In order to prevent accidents, it is important to keep the facility clean and free from accumulated clutter. When not in use, equipment and supplies should be stored according to the manufacturer's recommendations. Trash should be disposed of immediately in Department of Transportation approved containers, and personal possessions and food stuffs should be kept out of the animal care area. Floors and counters should be cleaned and disinfected regularly. Hallways, aisles, and emergency exits should be kept unobstructed at all times.

### Occupational Safety Regulations

The capture, triage, and rehabilitation of oiled sea otters must comply with various safety regulations established by the OSHA. The

*The capture, triage, and rehabilitation of oiled sea otters must comply with various safety regulations established by the OSHA.*

OSHA regulation most significant to oiled wildlife response is the "Hazardous Waste Operations and Emergency Response" standard (29 CFR 1910.120). Training requirements for emergency response operations are covered under section (q)(6) of the standard and will apply until the emergency response is declared to be in the "post emergency response" stage. This is typically done by the federal on-scene coordinator (FOSC) in concurrence with the regional response team (RRT). Following this, the training requirements for waste site operations (sections b-o) are invoked. Additional regulatory requirements that may apply include (but are not limited to):

1) Hazard Communication, 29 CFR 1910.1200. Written hazard communication plan, Material Data Safety Sheets (MSDS) access at multiple sites.
2) Permissible Exposure Limits, 29 CFR 1910.1000 (and other substance-specific standards). Evaluation and monitoring of possible hazards and the assignment of responsibility for exposure controls.
3) Respiratory Protection, 29 CFR 1910.134. Written plan, respirator selection, and training and maintenance responsibilities.
4) Protective Equipment, 29 CFR 1910 Subpart I. Regulatory and local requirements (as applicable, see Appendix 5 for guidance to regions).
5) Blood-borne Pathogens, 29 CFR 1910.1030. Exposure to blood and other body fluids.

## Chemical Safety

*The hazard communication standard requires that all chemicals be identified, that hazard information be conveyed to employees, and that MSDS on all chemicals be available to employees upon request.*

Chemical exposure may cause or contribute to many serious health effects. Because of the seriousness of these potential health problems, OSHA has issued a rule called the "Hazard Communication" (29 CFR 1910.1200). In general, the duties of paid workers (permanent and temporary staff) in the wildlife rehabilitation centers are covered under this standard.

A basic goal of the hazard communication standard is to ensure that employers and employees are informed about hazardous chemicals in the work place and how to handle them safely. The standard requires that all chemicals be identified, that hazard information be conveyed to employees, and that MSDS on all chemicals be available to employees upon request.

The operations supervisor at the rehabilitation center must provide employees with information and training on the safe use of hazardous chemicals at the time of their initial assignment or whenever a new hazard is introduced into the work place. Employees must be informed of any operation where hazardous chemicals are present and of the location of the MSDS. Employee training should include information regarding: 1) the visual appearance or odor of hazardous chemicals when being used, 2) the physical and health hazards of the chemicals in the work area, 3) the measures employees can take to protect themselves from these hazards, such as appropriate work practices (manufacturer's recommended usage), emergency procedures, and protective clothing, and 4) an explanation of the labeling system and the MSDS.

The following is a list of chemical products commonly used in wildlife rehabilitation facilities:

| Product | Use |
|---|---|
| 1. Bleach | Disinfectant |
| 2. Nolvasan™ | Disinfectant |
| 3. Roccal™ | Disinfectant |
| 4. Benz-all™ | Cold sterilization |
| 5. Povodine™ (Betadine™) | Antiseptic |
| 6. Formalin | Preservative |

Copies of the MSDS for these products should be kept in accessible locations in the animal care area and the administration office. All storage bottles should be labeled with the name of the product, expiration date, concentration, compounds of concern, and any safety warnings. New staff members should consult their supervisor on how to use these products safely and effectively. Safety glasses and gloves should be worn when using bleach and formalin, and skin contact should be avoided.

The OSHA requirements for capture teams in the spill area are covered by the "Hazardous Waste Operations and Emergency Response—HAZWOPER" standard (29 CFR 1910.120). For a discussion of this standard, see Chapter 2.

Most states administer their own occupational safety and health programs and have standards that are at least as stringent as federal OSHA requirements. For additional information on regional standards, contact one of the U.S. Department of Labor Occupational Safety and Health Administration Regional Offices listed in Appendix 5.

### Properties and Potential Hazards of Petroleum Hydrocarbons

Petrochemical products are composed of aromatic and non-aromatic petroleum hydrocarbons. The chemical composition of each product will determine its toxicity to wildlife and personnel working in the rehabilitation center. Crude oil, diesel fuel, gasoline, and various grades of refined oil are the most common petrochemicals that are spilled. Benzene and hydrogen sulfide are the two most common hazardous chemicals found in oil. Usually, the oil on wildlife arriving at the rehabilitation center will be weathered and contain negligible amounts of these volatile components. Nevertheless, the triage and cleaning rooms should have adequate ventilation to prevent the accumulation of petrochemical fumes. Along with wildlife, personnel on capture vessels and at the rehabilitation center may be exposed to petroleum hydrocarbons. The primary routes of exposure are inhalation, absorption, and ingestion.

*Inhalation.* Inhalation of volatile petroleum hydrocarbons can cause respiratory distress, nausea, and dizziness. Persons with these symptoms should notify their supervisor and leave the exposure area. If symptoms persist for more than several hours, the individual should seek medical attention.

*Absorption.* Direct contact with petroleum hydrocarbons can irritate the skin, especially sensitive areas around the eyes, nose, and mouth. Injection as the result of a puncture wound can also provide a route of entry for petroleum hydrocarbons and bacteria. Immediately wash the area of exposure with soap and water. If oil contacts an individual's eye, flush the eye with water for fifteen minutes. Notify the supervisor and seek first aid. Wear appropriate gloves, safety glasses, goggles, or a face shield when handling oiled wildlife to minimize the risk of absorbing petroleum hydrocarbons.

*Ingestion.* Although this mode of exposure is unlikely in the rehabilitation center, ingesting significant quantities of petroleum hydrocarbons may cause nausea, vomiting, and dizziness. Do not induce vomiting. Notify the supervisor and seek immediate medical attention.

## POTENTIAL HAZARDS OF WORKING WITH OILED WILDLIFE

### What Makes Them Dangerous?

Most wild animals are unaccustomed to close contact with humans and may act aggressively when brought into captivity. Usually, they will defend themselves against any act that they interpret as a threat. Such threatening acts include handling, standing too close, cornering, staring, sudden movements, and loud noises. Sea otters will defend themselves by biting, scratching, or simply overpowering you. In addition to direct injury, bites and scratches can cause localized or systemic infections.

Husbandry staff must be properly trained and supervised by animal care experts before handling oiled sea otters or other marine mammals. If staff members do not understand or feel uncomfortable performing a procedure, they should notify their supervisor. Otherwise, they could be placing themselves, the animal, and others in danger. For everyone's safety, it is essential that personnel understand the procedures they have been asked to perform, especially when it involves direct contact with wild animals.

***Ask for assistance with any job you feel uncomfortable performing, especially if it is a new procedure for you.***

### Zoonoses

Zoonoses are diseases transferable from animals to man. Wildlife carry various bacteria, fungi, viruses and parasites, some of which are transmissible to humans. Although there are few diseases known to be transferred from marine mammals to humans, two common diseases are salmonellosis and general bacterial infections due to bites or scratches (i.e. "seal finger"). Salmonellosis may be caused from the accidental ingestion of fecal material from an infected animal and results in abdominal pains followed by severe diarrhea. Bacterial infections of the skin are caused by the exposure of open sores and cuts to bacteria in the animal's fur, feces, saliva, or food. Both medical conditions should be treated immediately under the supervision of a physician.

Blood-borne pathogens are a concern when working with wildlife. These pathogens include salmonellosis and hepatitis. Although direct transmission from marine mammals to humans is very rare, animal caretakers should be aware of the potential danger. The best prevention is to wear gloves when handling the animals, avoid direct contact with animal blood and other fluids, and wash your hands after handling animals. Animal care staff should wash their hands before eating, at the end of their shift, and after contact with animal feces and urine. Practicing good hygiene, using common sense, and staying healthy will minimize the risk of contracting diseases from wildlife. Persons who are ill, pregnant, taking drugs that suppress their resistance to disease, or under eighteen years of age should not work directly with wildlife. For more information on blood-borne pathogens, refer to the references at the end of this chapter.

*Wash hands with soap often, especially before eating or drinking. Wash hands after working with an animal and before leaving the facility.*

*Practicing good hygiene, using common sense, and staying healthy will minimize the risk of contracting diseases from wildlife.*

## PROTECTIVE CLOTHING

Protective clothing is designed to minimize exposure to harmful chemicals and injury and to prevent the transmission of diseases between husbandry staff and the sea otters.

### Work Clothing

The animal care staff should wear clean coveralls over their regular clothes to prevent contamination with animal food, feces and urine. Coveralls also will limit the introduction of domestic animal diseases into the rehabilitation center. Clean coveralls should be issued to each staff member at the beginning of a shift and laundered in the center after each use; they should not be taken home by the staff. Lockers should be provided for storing personal clothing and street shoes before work begins.

*The animal care staff should wear clean coveralls over their regular clothes to prevent contamination with animal food, feces, and urine.*

### Rubber Boots

The animal care staff should wear slip-resistant rubber boots that will keep their feet dry and protect them from injury. The boots should be kept in the rehabilitation center and the soles cleaned with a liquid disinfectant (e.g. Nolvasan™ or bleach) at the end of each shift. Maintaining clean footwear is essential for preventing the introduction of domestic animal diseases into the rehabilitation center.

### Water-resistant Clothing

Water-resistant clothing (rain jackets and trousers) should be worn when cleaning oiled sea otters, moving animals between pens and pools, and during inclement weather. The rain gear will keep coveralls dry and prevent contamination with oil, feces, and urine.

### Gloves

Rubber gloves should be worn when cleaning oiled sea otters, assisting with medical procedures, preparing or handling sea otter food, and whenever hands need protection from contact with oil, dirt, and feces. Wearing rubber gloves is especially important in preventing infection if a person has open sores or cuts on his or her hands. Heavy leather gloves should be worn when handling sea otters to protect hands from scratches and bites. Even though gloves are worn when

*Rubber gloves should be worn when cleaning oiled sea otters, assisting with medical procedures, preparing or handling sea otter food, and whenever hands need protection from contact with oil, dirt, and feces.*

*Keep wounds covered. Seek treatment for bites and other injuries promptly.*

working, hands should be washed at the end of each shift and before eating. Also, avoid touching anyone with gloved hands in case the gloves are contaminated.

### Safety Glasses

Safety glasses should be worn whenever working with hazardous chemicals such as formalin and bleach. They will also protect eyes from detergent and oily water when washing oiled sea otters. Persons wearing contact lenses should also wear safety glasses, especially in the sea otter cleaning and drying rooms.

## PERSONAL CARE

Working in the rehabilitation facility can be physically and mentally demanding, and it is important to avoid becoming overly tired or ill. Here are some suggestions for personnel:

*Do not smoke or eat in animal care areas.*

*If you are not feeling well, DO NOT work directly with the animals. Take care of yourself: drink fluids, eat regular meals, rest periodically, and get plenty of sleep.*

1) Drink plenty of fluids to prevent dehydration.
2) Eat regular meals.
3) Rest if you feel tired.
4) Pace yourself. Individuals will have different tolerance levels to various situations. Respect your personal limitations.
5) Get eight hours of sleep daily. You will be surprised how tired you can become at the end of a shift.
6) Practice good hygiene. Wash your hands frequently. Poor hygiene can transmit diseases to yourself and the otters.
7) Renew your tetanus vaccination every five years.
8) Do not eat or smoke in the animal care area.
9) Pregnant women should not work directly with oiled wildlife because of the potentially harmful effects of petroleum hydrocarbons and zoonoses on the fetus.

## FIRST AID

A first aid kit for routine cuts and abrasions should be located in every room in the rehabilitation center. If someone is injured, their supervisor should be notified immediately. Staff members should be familiar with the emergency exits and the locations of fire extinguishers.

## SUMMARY

Rehabilitating oiled sea otters is a physically and emotionally demanding experience. Personnel should be aware of and respect their personal limitations, practice good hygiene, and use common sense. Remember, safety always comes first.

## SUGGESTED READING

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# Other Marine Mammals

# Chapter 15

# The Effects of Oil Contamination and Rehabilitation on Other Fur-Bearing Marine Mammals

Nicholas J. Gales
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The amphibious life history of pinnipeds and polar bears exposes them to spilled oil under circumstances not faced by sea otters. Their utilization of coastal and pack ice zones (which in many cases coincide with areas of hydrocarbon exploration, handling and transport) and the gregariousness of some pinnipeds, increase the potential for large scale impact. Furthermore, pinnipeds are a highly diverse group of mammals in terms of their global distribution, size, behavior, difficulty and risk of handling, and susceptibility to oil contamination. Any prediction of the impact on this group of animals must consider such variables as the type of oil involved, how much it has weathered, and the environmental conditions at the time. Light oil freshly spilled on a warm day is a threat to those breathing the vapors; heavy, weathered or residual oil in cold water is tenacious enough to restrict physical movement. In view of this, we caution against generalizing the findings of previous investigations. Rather, we encourage a thorough investigative approach to each new case to advance our ability to cope with inevitable future events.

The goal of this chapter is to provide workers with a practical framework for dealing with an oiled pinniped or polar bear. Clearly, the scope of potential scenarios of oil impact among these species is enormous. Our approach is to present a guide that must necessarily be tailored to meet local needs and animals. We assume that workers undertaking any such action will have a thorough knowledge of the life history and ecology of the species involved and the environmental and logistic conditions of the site. For a more detailed treatment of this subject, we refer readers to McLaren (1990) and St. Aubin (1990a) for pinnipeds and Stirling (1990) and St. Aubin (1990b) for polar bears.

We also provide a historical summary of oil spills involving the river otter, a fur-bearing mammal that may frequent coastal habitats. Information concerning the effects of oil contamination on this species is sparse. Therefore, we do not discuss the handling, cleaning, or treatment of oiled river otters. Readers are referred to Chapters 2 through 6 in this volume which address these topics for sea otters.

## A BRIEF HISTORICAL PERSPECTIVE

### Pinnipeds

*Pinnipeds and polar bears are susceptible to contamination by spilled oil. The behavioral, biochemical, and physiological responses of the animal will depend on the type and weathering of the oil encountered.*

The past four decades have seen at least twenty-nine encounters between pinnipeds and oil (St. Aubin, 1990a), although these have resulted in too few quantitative accounts to allow us to accurately predict the impact. Large scale mortality has rarely been observed, but oil has clearly been implicated in some deaths.

Many of the reports have been anecdotal and do not specify the number of animals or species involved. Despite large numbers of seals being affected, such as 10,000–15,000 harp seals in the Gulf of St. Lawrence in 1969 (Warner, 1969) and approximately 650 gray and harbor seals following the *Arrow* oil spill in Chedabucto Bay in 1970 (Anonymous, 1971), little, if any, follow-up work has been done that quantitatively links mortality in marine mammals with exposure to spilled oil. An exception to this is the behavioral, histological, and toxicological study of pinnipeds following the *Exxon Valdez* oil spill (EVOS) (Loughlin, 1994).

Still less is known about the best approach to deal with oiled pinnipeds. Indeed, in one small study conducted on oiled gray seals on the coast of Wales in 1974, the authors concluded that the disturbance caused by cleaning was probably more damaging to the pups' chances of survival than the oil itself (Davis and Anderson, 1976). During the EVOS, eighteen harbor seal pups were brought to rehabilitation centers in Alaska for cleaning. Although covered with crude oil, few medical problems were encountered and the seals were eventually released (Williams and Davis, 1990). In view of this, wildlife experts questioned the relative benefits of placing oiled seal pups in rehabilitation centers when important maternal bonds are broken (Williams et al., 1994).

Laboratory studies on the effects of oil have been conducted only on ringed and harp seals (Smith and Geraci, 1975; Geraci and Smith, 1976). Such experiments are limited by public attitudes that consider them inhumane and unnecessary, and studies have been restricted to small sample sizes. Furthermore, the results of laboratory studies may be biased by stress associated with handling and captivity.

Most species of pinnipeds are sufficiently dispersed and their populations robust enough to preclude devastation by a single oiling event. Yet some, such as the Mediterranean monk seal, could be significantly affected. Their declining population of less than 1000 animals exists as several localized stocks that are highly vulnerable to oil. It is therefore imperative to gain experience while dealing with less threatened species to direct treatment of those that are most at risk.

### Polar bears

The literature offers no information on the fate of bears exposed to oil in their natural environment (St. Aubin, 1990b). No major spill has occurred when bears have been present, and there are only anecdotal accounts of bears biting cans of oil or fuel storage bladders, without obvious immediate effect. Nevertheless, opportunities for contact exist throughout most of the polar bear's range, where petroleum resources are being exploited and oil is transported and stored. Their life history and behavior also conspire to draw polar bears into contact with oil (Stirling, 1990), and it is conceivable that field workers might yet have to deal with a dozen or more bears fouled after encountering a contaminated lead.

### River Otters

*River otters are vulnerable to the direct effects of oil exposure, as well as indirect effects associated with habitat contamination.*

River otters that frequent marine habitats have been involved in several recent oil spills. This species appears vulnerable to the direct effects of oil exposure, as well as indirect effects associated with habitat contamination. The impact of oil on this species may be underestimated because river otters often return to holts following contamination.

In 1978 following a spill of Bunker C fuel from the *Esso Bernicia,* fourteen carcasses and eighteen live oiled otters from a population of European river otters *(Lutra lutra)* in the Shetlands were found (Richardson, 1979). Necropsy examination of five oiled carcasses revealed congested lungs, hemorrhagic gastroenteropathy, and a mixture of oil and blood in the intestines resulting from ingestion of oil during grooming (Baker et al., 1981). In comparison, no river otter deaths could be directly attributed to oil during the 1993 *Braer* spill, which also occurred along the Shetland coastline (J. Conroy, Institute of Terrestrial Ecology, Banchory Research Station, Scotland, personal communication). Long-term studies concerning the chronic effects of this spill are currently being conducted.

Behavioral and physiological effects have been reported for river otters *(Lutra canadensis)* within the spill area of the EVOS. River otters from contaminated sites showed: 1) an increase in plasma haptoglobin (an indicator of physiological stress), 2) a decrease in body mass, 3) larger home ranges, and 4) a more restricted diet than otters living in uncontaminated areas (Bowyer et al., 1993; Duffy et al., 1993). Oil related mortality and population differences between contaminated and noncontaminated sites were considered, but could not be determined due to the relatively small sample size of the studies (W. Testa, University of Alaska, personal communication).

## CATEGORIES OF OIL IMPACT

### Pinnipeds

Most observers of oiled pinnipeds have been unable to correlate the degree of oiling with the type of effect, its consequences, or even associated pathological changes. Nevertheless, we can examine the effects under four broad categories as a background to developing specific action plans. The impacts can be summarized as: a) fur/hair entrapment, b) irritation of eyes, mucous membranes and integument, c) ingestion/inhalation and systemic effects, and d) behavioral disturbances.

*Although external and systemic contamination have been documented, oiled pinnipeds exhibit few pathologic injuries to organ systems. In general, mortality rates following oil exposure have been low for this group of mammals.*

*(a) Fur/Hair Entrapment.* The direct physical effects of oil entrapped in fur or hair may be severe enough to cause difficulty in swimming, plug nasal passages, and lead to suffocation and drowning. The degree of effect will depend on the degree of oiling, the body surface

involved, and the viscosity of the oil (Figure 15.1, see plate facing page 204). Locomotory problems have been observed primarily in young animals such as harp (Warner, 1969) and gray seal pups (Davis and Anderson, 1976) which were so encased that their flippers stuck to the body and the animals drowned. Impaired movements of eyelids and vibrissae may also be damaging (St. Aubin, 1990a). Plugging of respiratory passages with Bunker C oil reportedly killed seal pups at two major spills (Engelhardt, 1985). By contrast, some species, such as the northern elephant seal, can tolerate up to 75% surface fouling with no increase in mortality (Le Boeuf, 1971). In fact, all but one of fifty-eight oil contaminated elephant seal pups were resighted and found to be clean as little as one month later.

Oil fouling of pelage can produce aberrations in thermoregulation. Species that rely primarily on fur rather than blubber for insulation are clearly the most vulnerable. Fur also provides an ideal matrix for oil entrapment. Oil not only subverts the ability of fur to trap an insulating layer of air next to the skin, it also removes the natural oils that contribute to the waterproof quality of the fur (St. Aubin, 1990a).

Thermal demands are greatest for polar and subpolar pinnipeds. However, these species depend primarily on blubber for insulation with the result that external contamination causes little thermoregulatory stress. This distinction applies to adult animals only, as most neonatal pinnipeds initially rely on lanugo for insulation until they develop an effective blubber layer. The degree to which the pelt is compromised might also differ in molting animals, which experience some degree of physiological stress at that time.

Studies that measured changes in heat conductance through pelts have shown up to a 50% decrease in the insulating value of fur seal pelts oiled *in vitro*. A smaller decrease was found in oiled pelts from Weddell seal pups, and virtually no change was reported for the relatively poor insulating pelts of sea lions, bearded seals, and ringed seals (Øritsland 1975; Kooyman et al., 1976, 1977). These findings do not address adaptive responses, such as shivering, alterations in metabolic rate and changes in peripheral circulation that may alter the thermal balance of living animals.

*(b) Eyes, Mucous Membranes, and Integument.* Oil is an irritant and can produce acute changes to the mucous membranes of the eye, oral cavity, respiratory surfaces, and anal and urogenital openings. The extent of damage will depend on the duration of exposure and the volatility of the oil. Most reports of oil-fouled pinnipeds include descriptions of excessive lacrimation, acute conjunctivitis, swollen nictitating membranes, corneal opacity (Figure 15.1), abrasion, and occasionally ulceration (e.g. Lillie, 1954; Spraker et al., 1994; Smith and Geraci, 1975). The latter authors noted that most signs subsided when the animals had access to clean water.

The integument is less sensitive to contact with petroleum hydrocarbons, and pathological changes have rarely been reported in this organ. This may be due to the limited amount of available data. However, it is clear that animals with sparse pelage, and perhaps those during the molt, would be most vulnerable. Johnson (1983) noted that the creviced skin of the walrus may present special problems. The degree to which hydrocarbons can be absorbed across the integument is unknown, but Engelhardt (1985) felt it was unlikely to make a long-term contribution to tissue burdens.

*(c) Ingestion/Inhalation and Systemic Effects.* Ingestion of petroleum hydrocarbons adhering to the body surface is of little concern to pinnipeds, which groom using their flippers rather than their mouth. Thus, pinnipeds are only likely to ingest oil by: 1) accidentally opening their mouths while swimming, 2) sucking from an oil fouled nipple or playing with contaminated debris, and 3) ingesting contaminated prey. The first two routes are unlikely to lead to significant intake, and the third only applies to pinnipeds such as walruses and bearded seals, which consume benthic invertebrates, prey items that are known to accumulate hydrocarbons (McLaren, 1990).

***Ingestion of petroleum hydrocarbons adhering to the body surface is of little concern to pinnipeds, which groom using their flippers rather than their mouth.***

Three limited studies demonstrated that phocid seals fed small quantities of oil were not obviously affected, even though the oil was readily absorbed through the intestine and distributed to body organs (Smith and Geraci, 1975; Geraci and Smith, 1976; Engelhardt, 1982). Conversely, oil in the gut and other organs was considered the cause of death in some gray and harbor seals stranded in France (Babin and Duguy, 1985). A causative relationship was not established in the latter study because of the autolyzed state of the carcasses. Regardless, most data indicate limited ingestion of oil by pinnipeds and an ambiguous clinical expression of metabolic toxicity from the ingested oil.

Hydrocarbons can also be absorbed by inhaling vapors. Experiments have shown that pinnipeds can accumulate petroleum hydrocarbons up to several ppm in blood and tissue after exposure to petroleum vapors (Engelhardt et al., 1977). Following the oil spill from the *Sanko Harvest*, volatile compounds (particularly acetone) in the blood reached levels of between 30–90 ppm in fur seals that encountered the oil within twenty-four hours of the spill. This compares with 10–20 ppm in those animals exposed to the oil after it had weathered for more than seventy-two hours. Presumably, most of the volatile compounds had dissipated by this time. The concentrations of straight chain petroleum hydrocarbons in these same animals were less than 1 ppm (Gales, 1991). Based on these studies, it appears that inhalation or perhaps dermal absorption, rather than ingestion, were the primary routes of exposure in the fur seals. Once again it was not possible to establish a causal relationship between the degree of exposure (as determined from petroleum hydrocarbons levels in the blood) and mortality or tissue pathology (Gales, 1991).

Likewise, harbor seal pups exhibited few pathologic injuries and low mortality despite heavy external oiling following the EVOS (T. M. Williams et al., 1990, 1994). As found for sea otters, total paraffinic hydrocarbon concentrations in the blood were variable for the pups (Figure 15.2). Values ranged from 22 ppm to 260 ppm (mean = 91 $\pm$ 27 SE ppm, n = 9). Although some of the seal pups had blood hydrocarbon levels above the calculated lethal threshold dose for sea otters (Chapter 4), none showed evidence of systemic toxicosis and all survived. The comparatively high survivorship of the seal pups is undoubtedly related to many factors including: 1) age, 2) species-specific differences in the uptake, metabolism, excretion, and storage of

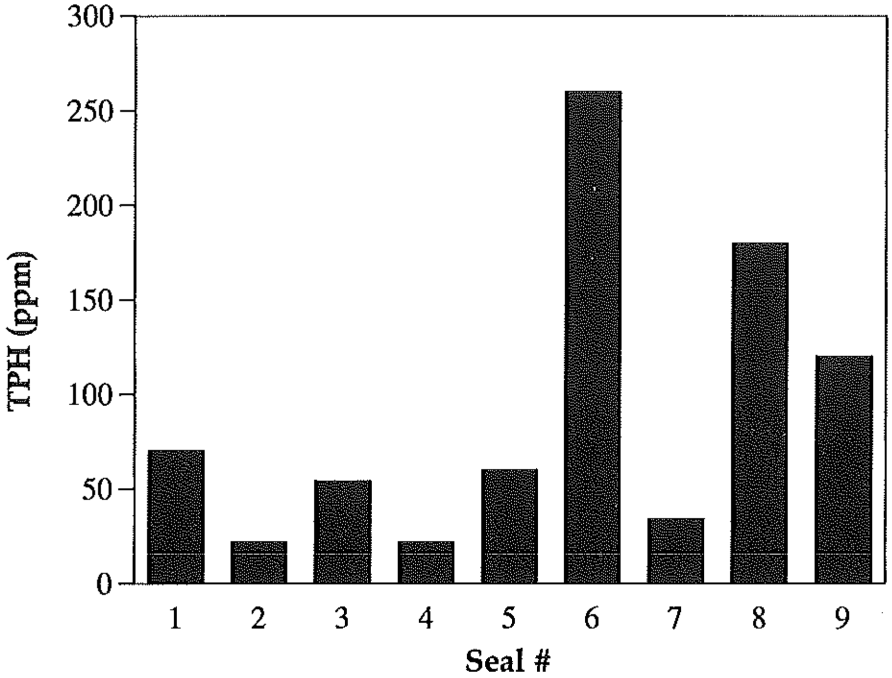


Figure 15.2
Total paraffinic hydrocarbon concentration (ppm) in whole blood samples from heavily oiled harbor seal pups following the EVOS. Height of each bar represents the value for blood samples taken on the day of admission to rehabilitation centers. Note the wide range of values despite the same degree of external oiling. Data from T. M. Williams et al., 1990, 1994.

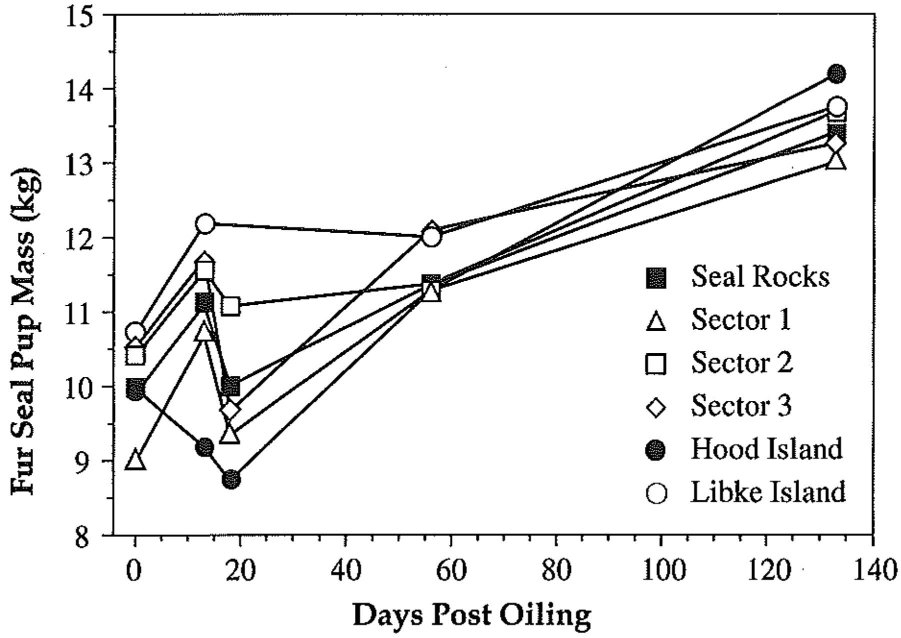


Figure 15.3
The mass of fur seal pups in relation to days post oiling following the *Sanko Harvest* oil spill in Western Australia. Pups from Seal Rocks (Sectors 1 and 2) and Hood Island were oiled. Changes in mass for these animals are compared to unoiled pups from Seal Rocks (Sector 3) and Libke Island. At the time of release, there was no significant difference between the mean mass of pups from these different areas (Gales, 1991).

petroleum hydrocarbons, and 3) oil weathering prior to contact (T. M. Williams et al., 1990).

It is likely that pinnipeds can detoxify absorbed hydrocarbons in a manner similar to other mammals, but may suffer damage to various organs if blood or tissue levels reach critical thresholds (St. Aubin, 1990a). We will discuss pathological and clinical findings in a later section and refer readers to Neff (1990), St. Aubin (1990a), Frost et al. (1994) and Engelhardt (1985) for general details of petroleum hydrocarbon toxicity and clearance in pinnipeds.

*(d) Behavior.* Oil spills can disrupt normal behavior by restricting movements to and from haulout sites. We do not know whether pinnipeds can detect oil, and if they can, whether or not they will avoid it. Although there is no experimental evidence that fouling with oil affects behavior in pinnipeds, there have been several anecdotal observations that infer some disturbances. Uncharacteristic swimming behavior, including vigorous head shaking, and swimming with the neck, head and trunk out of the water, has been noted in fur seals occupying a chronically polluted harbor (Shaughnessy and Chapman, 1984). Further, there is contradictory evidence that the mother-pup bond, for which scent appears to be an important component, may be disrupted. Observations of pup rejection by females has been noted, although the familial relationship between the observed animals was not known. Davis and Anderson (1976) reported that the mother-pup bond in gray seals was not affected by oiling, and noted that interrupting feeding to clean oiled pups may have had a greater impact on eventual mass at weaning than did the oiling itself. Heavily oiled New Zealand fur seal pups were observed nursing from females; there was no significant difference in the preweaning mass of heavily oiled pups and unoiled pups (Figure 15.3; Gales, 1991).

The behavior of different age classes of pinnipeds will determine their chances of encountering oil. For example, fur seal pups often congregate in tidal pools where there is little wave activity and oil can become trapped. The risk of fouling is greater for pups than for adults. Older animals tend to enter and leave the water in areas of higher wave activity where oil is physically repelled from the rocks. This basic difference in behavior explains why, after the sinking of the *Sanko Harvest*, an entire cohort of pups was contaminated, but no adults came into contact with the oil (Gales, 1991). There is clearly a need for quantitative studies to clarify the behavioral impact of oil fouling.

## Polar Bears

A single laboratory study (Øritsland et al., 1981) highlighted the vulnerability of polar bears to oil. Like sea otters and fur seals, polar bears depend on fur for insulation. Fouling of the coat increases heat loss, placing the animals in thermal stress. Polar bears also share the sea otter's compulsion to maintain a clean coat, and will ingest any oil adhering to their fur. In two of three captive bears, the combined effects of metabolic stress and hydrocarbon toxicity had fatal consequences. Liver and kidney failure, anemia, and depressed lymphoid activity were noted. Secondary bacterial and fungal infections, which contributed to the animals' demise, were evidence of stress-related impairment of immune function. It is unknown whether

***Polar bears exhibit injuries to a wide range of organ systems following exposure to crude oil.***

bears exposed in the wild would exhibit the same complications in the absence of the additional stress of captivity.

## ASSESSMENT OF IMPACT AND STRATEGY PLANNING

An oil spill that impacts marine mammals is a major media event, placing considerable pressure on wildlife managers and biologists to act with minimal time for adequate preparation and planning. Yet, the assessment and strategy planning component of any operation will determine the ultimate efficacy of the action taken. It is imperative that the aims of the rescue effort are clearly set. Any marine mammal rescue program must also take into account several important aspects of the species' behavior and life history; these will dictate what can and should be done.

Pinnipeds and polar bears are amphibious animals with haulout patterns that vary seasonally. The threat of oil fouling will differ depending on whether the animals are in the marine or terrestrial phase of their life cycle. During the pelagic phase, the animals may simply abandon the area to avoid the disturbance associated with clean-up activities. At other times of the year, some species of pinnipeds spend several weeks on shore without entering the water thereby also avoiding exposure. The situation is more serious when animals are regularly crossing between land and sea through a transition zone that tends to accumulate oil. Pinnipeds are usually gregarious while on shore; any impact is therefore likely to be localized and involve many animals of all ages. The magnitude of the problem will vary enormously depending on how approachable, tractable, and susceptible to disturbance the affected species is. In cases involving large terrestrial congregations, the rescue operation may cause greater perturbation than the oil itself. Here, the benefits of cleaning animals must be carefully weighed against the potentially negative effects of disturbing the colony. Pressure from public expectation should not be allowed to influence decisions. Unless there is strong evidence that the animals will soon become recontaminated, we believe that it is better to treat and release the animals on site rather than to subject them to the stress of relocation or prolonged confinement in a rehabilitation center.

In establishing a realistic set of goals for the rescue operation, it may be necessary to limit expectations and focus on what is achievable and most beneficial to the affected group or population. If large numbers and multiple-age classes of animals are impacted by oil, it is unlikely that the entire group can be captured for cleaning and treatment. Thus, when a colony of breeding seals is affected, efforts should be directed towards accessible animals such as pups of the year. It may also be appropriate to focus attention on reproductively active females, rather than males, to minimize mortality among the animals most important to the long-term health of a population.

With this approach in mind, the following information is necessary before any action is taken:

1) Approximate number of affected animals, their age, sex, physiological state (e.g. molting, lactating, pregnant), distribution, and degree of mobility between marine and terrestrial habitats.

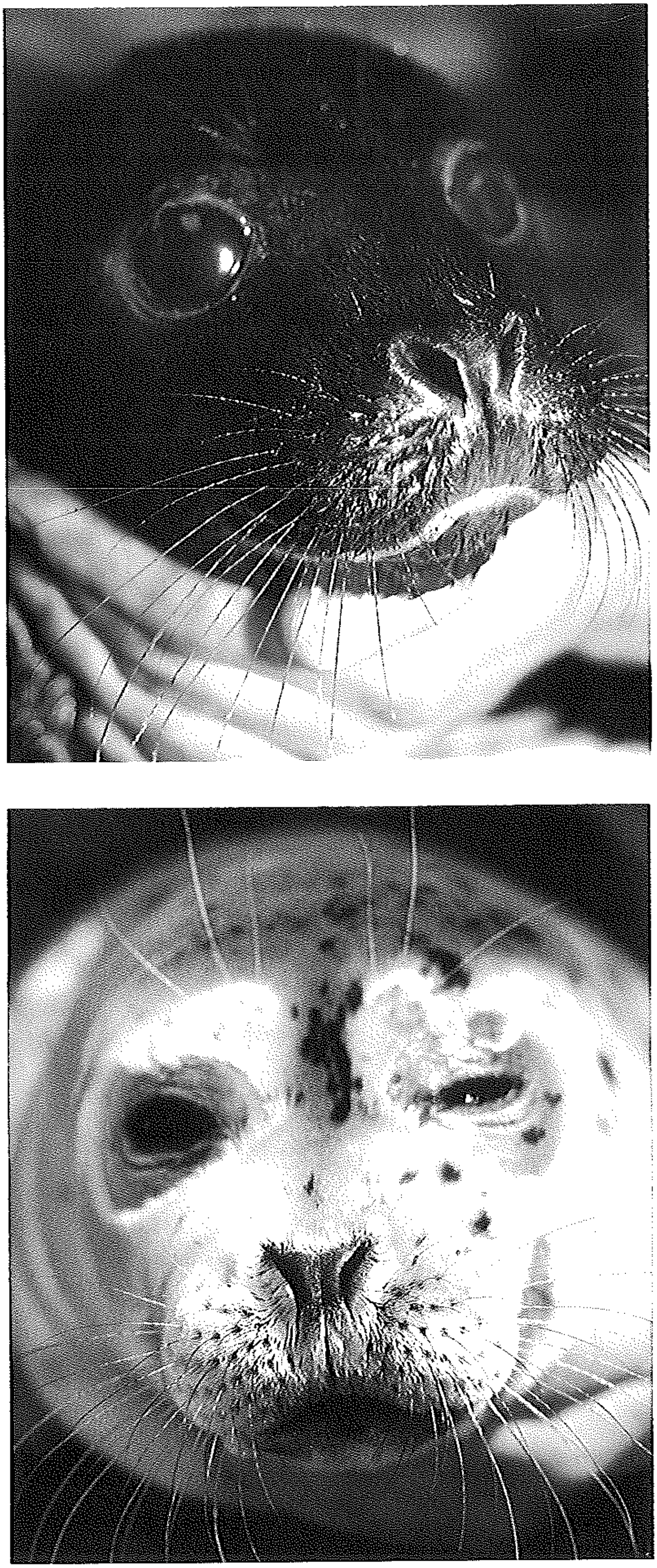

Figure 15.1
Harbor seal pup contaminated during the EVOS. Photographs show the animal immediately before (top) and after (bottom) cleaning with Dawn™ detergent. Light area on the eye in the top photograph shows corneal ulceration.

2) Approximate number of animals at risk.
3) Accessibility of the affected area and the potential to remove the risk of further contamination.
4) Availability of equipment necessary to capture, clean, house (either temporarily or for ensuing transport), and treat the oiled mammals.

*The stress of capture and captivity has a detrimental effect on pinnipeds and polar bears. Consequently, the benefits of cleaning must outweigh the effects of stress before a rehabilitation program for these species is initiated.*

It is assumed that efforts to remove oil from the environment are underway concurrently, and that no attempt will be made to release cleaned and treated animals until the potential for recontamination has been minimized or eliminated.

## CAPTURE AND RESTRAINT

Methods for capturing pinnipeds have been described in the literature (Geraci and Lounsbury, 1993). These techniques are generally restricted to the smaller otariids and phocids. Most methods rely on the use of nets to capture individual animals. Alternatively, mass capture of several animals is possible and has been described for fur seals. Chemical capture and restraint has been extensively reported and recently reviewed for marine mammals (T. D. Williams et al., 1990). Telazol® (8–9 mg/kg) has proven to be reliable and safe for immobilizing polar bears under a variety of field conditions (Stirling et al., 1989).

*Methods for capturing pinnipeds rely on the use of nets to capture individual animals. Telazol® has proven to be reliable and safe for immobilizing polar bears under a variety of field conditions.*

The potential for physically or chemically capturing marine mammals will depend on the number of target animals, the number of nontarget animals, and the terrain. Capture is usually limited to the land or ice as capture techniques at sea are generally considered hazardous. Because of the difficulties, it is important to be realistic when selecting target animals. Adult seals and bears that are fouled with oil and capable of avoiding capture by rapidly entering the sea should probably not be captured. Their condition can be monitored visually, especially if they are marked with projectile paint pellets or another identifiable tag.

We recommend capturing unoiled animals for use as a control group. These animals are especially useful for establishing normal values for body mass, clinical state, and hematological and biochemical constituents. Such controls also enable the researcher or veterinarian to differentiate between anomalies caused by the oiling and those associated with disturbance by the cleaning method. Control animals should be marked for the duration of the study.

Many chemical compounds used for capture or immobilization interfere with thermoregulation, compounding the problems already faced by an oiled fur seal or polar bear. The greatest concern is for animals in polar and subpolar environments. Any type of capture or restraint will impose some form of stress, which must also be considered when handling these animals. Fortunately, pinnipeds and polar bears generally tolerate capture and transportation better than sea otters; they do not appear as susceptible to the capture myopathy or "capture stress syndrome" described for sea otters (Williams and VanBlaricom, 1989).

Once an animal has been captured, it may be necessary to retain it for detailed clinical evaluation, intensive treatment, or simply to await the removal of oil from its environment. In the latter instance, it is preferable to assemble holding pens on location for pinnipeds. Such pens must: 1) be designed for quick and easy construction, 2) have the intrinsic strength to contain the animals, and 3) adequately meet the behavioral and physiological needs of the species and age class to be held. Following the sinking of the *Sanko Harvest*, more than 200 New Zealand fur seal pups were held in five temporary pens constructed on two separate islands. The pens were made from chicken wire and averaged 5 m by 3 m in size, with a fence height of 1.2 m. Shade was provided by tarpaulins. These structures held the animals for up to two and a half days until the oil had been cleaned from the surrounding areas. Overcrowding in one pen led to the death of six pups, but otherwise the pens were adequate (Gales, 1991).

When permanent holding facilities are required (as with polar bears), it may be necessary to transport the animals from the capture site. Such undertakings are logistically challenging, but allow intensive study of the affected animals. A major problem associated with long-term holding of oil-fouled pinnipeds and polar bears is the stress associated with removing an animal from the wild. Even healthy individuals taken into captivity may experience difficulties during acclimation, particularly in learning to accept food. The problems are intensified if the animal is clinically compromised. Furthermore, some species and age groups are more adaptable than others. (See Chapter 1.)

## CLINICAL EXAMINATION AND TREATMENT

An initial clinical examination is required to determine if the animal should be: 1) released untreated, 2) cleaned of oil and released, 3) cleaned of oil, treated, and released, or 4) cleaned of oil and held in captivity for long-term treatment.

All animals should be temporarily marked, preferably with a color coded tag that identifies what level of attention they may need. Flipper tags (e.g. Jumbo rototags; Dalton-supplies, Heneley-on-Thames, England) are effective. Assessment should then address the following general categories, which were found to be useful in dealing with oiled New Zealand fur seals (Gales, 1991).

### Degree of Oiling

An arbitrary scale of 0–5 may be used, where 0 represents no contamination and 5 represents complete coverage with oil.

### Mass

This is used as an approximate index of nutritional status. Unlike sea otters, which have a high metabolic rate and depend on regular caloric intake (Costa and Kooyman, 1982), pinnipeds are physiologically capable of fasting. Thus, acute metabolic dysfunction such as hypoglycemia (Chapter 5) is less likely in pinnipeds. A reduced or zero caloric intake is manifested primarily as a decrease in mass in pinnipeds.

Measurement of mass is probably only practical in small pinnipeds. For larger animals, condition indices such as ultrasonic measurement of blubber thickness can be used. Mass can also be used to quantify recovery. Davis and Anderson (1976) demonstrated a decreased growth rate and a lower average peak mass for oiled gray seal pups compared with unoiled pups. Gales (1991) showed that oiled fur seal pups underwent a marked decrease in mass following the oiling event, but recovered to normal levels in 140 days (Figure 15.3).

*Measurement of body mass is only practical in small pinnipeds. For larger animals, condition indices such as ultrasonic measurement of blubber thickness can be used.*

### Clinical Signs

Hypothermia and/or stress due to toxicosis can be recognized by shivering and a moribund or even comatose state. Core body temperature should be measured with a digital thermometer with a flexible probe. However, it is unlikely that core temperature will be as labile in pinnipeds and polar bears as it is in oiled sea otters. Respiratory injury, such as the interstitial emphysema reported for oiled sea otters (Chapter 5), has not been reported in pinnipeds. This may reflect a lack of sufficient monitoring of oil exposed pinnipeds, or a possible higher tolerance to pulmonary contact with petroleum hydrocarbons. Emphysema was recorded for one polar bear following experimental exposure to oil (Øritsland et al., 1981).

*Hypothermia and/or stress due to toxicosis can be recognized by shivering and a moribund or even comatose state. Core body temperature should be measured with a digital thermometer with a flexible probe.*

Dehydration is commonly observed in oiled wildlife. The degree of dehydration can be roughly assessed using a skin pinch test. In dehydrated seals and polar bears, the skin will remain raised for several seconds after pinching. This test is not definitive and is less appropriate for thick skinned pinnipeds with abundant subcutaneous blubber. Hematology can provide a more accurate measure of fluid balance. The degree to which an animal avoids capture and resists handling is also a good index of clinical state. Surface contact of oil on eyes and mucous membranes should be noted.

*Dehydration can be roughly assessed using a skin pinch test. Hematology can provide a more accurate measure of fluid balance.*

Treatment is initially based on clinical signs, and later on of clinical pathology results (see below). Irrigating eye washes and broad spectrum ophthalmic antibiotics should be used to treat eye injuries. Systemic fluid treatment administered subcutaneously or orally may be used when indicated. Ringer's solution is appropriate for subcutaneous injection. Dextrose administration is only indicated in hypoglycemic animals.

## CLEANING PROCEDURES

The selection of appropriate chemicals for cleaning fur or hair is often constrained by logistics, supply, and local availability. The use of Dawn™ detergent has been recommended for cleaning oiled sea otters (Chapter 6) and is probably appropriate for oiled pinnipeds (Figure 15.1) and polar bears. Another product that has proved effective is CT 18® concentrated cleansing gel (Chemtech Products, Australia). It is a neutral pH, nonionic detergent with a phosphate buffering system that works well in salt water and causes little irritation to skin and mucous membranes. Furthermore, it is a nonsolvent and biodegradable. Two washes with CT 18® removed 90% of the oil from fur seal pups, but left a detergent residue even after rinsing. The animals were subsequently sprayed with Preen Trigger Prewash Spray® (Samual Taylor, Australia), and this powerful degreaser was massaged into the fur before being rinsed off. Preen® contains a low odor aliphatic hydrocarbon solvent and less than 20% by weight of a nonionic

*The use of Dawn™ detergent is appropriate for oiled pinnipeds and polar bears. Another product that has proved effective is CT 18® concentrated cleansing gel.*

degradable surfactant (alcohol ethoxylates). Preen® successfully removed the detergent residue (Gales 1991).

Davis and Anderson (1976) used several detergents on gray seal pups in Wales. They found that Winfield® detergent liquid and BP 1100X® were the most effective, although the latter was less effective against weathered oil.

To effectively clean an animal, the detergent must be thoroughly worked into the fur. This can be accomplished using a stiff bristled hair brush for both the washing and rinsing steps. The number of washes and rinses will depend on the effectiveness of the detergent and how much oil is on the animal. Oiled fur seal pups needed three wash-rinse cycles that took approximately thirty minutes per animal (Gales, 1991). A high volume supply of clean water greatly facilitates the cleaning procedure. In the field this can be achieved through the use of high pressure water pumps. Cleaning stations should be situated far enough from the major seal haul out site to minimize disturbance.

The need to dry the animals will depend on the ambient conditions. It is probably less critical to dry pinnipeds than the more thermally sensitive polar bears or sea otters.

Washing animals should only be attempted when the risk of recontamination has been removed or significantly reduced. Clean-up operations may be able to deal with oil on the shore more easily than on nursing mothers, which readily transfer oil to their pups. Davis and Anderson (1976) discontinued their cleaning efforts partly because of maternal recontamination.

## BLOOD ANALYSIS AND PATHOLOGY

Detailed postmortem examinations will greatly augment current deficiencies in our understanding of the pathophysiological effects of oil. To ensure high standards during specimen collection, all fresh carcasses should be examined under laboratory conditions whenever possible. Macroscopic and microscopic findings should be correlated with the clinical history of the animals. Serial blood samples from oiled and non-oiled animals yield potentially invaluable data that can be used to direct treatments and subsequently to document the nature of the impact.

Blood should be collected into three types of sterile containers: 1) 15% EDTA anticoagulant for hematology, 2) potassium oxalate anticoagulant for measurement of petroleum hydrocarbons, and 3) no anticoagulant for serum biochemical analysis. A full profile for routine hematology and plasma biochemistry should be run for all samples. Constituents that are sensitive to stress are particularly important. Cortisol, serum iron and erythrocyte sedimentation rate were useful indicators of stress in sea otters (Williams and Davis, 1990). However, individual variation in baseline values may mask some of the stress-related changes. A large sample of control and oiled animals may be needed to establish differences between the groups. In phocid seals, aldosterone and sodium are particularly useful measures (St. Aubin and Geraci, 1986).

Oiled fur seal pups showed a typical stress leukogram. Marked leukocytosis, due to a neutrophilia, with a concomitant lymphopenia and eosinopenia, was noted in pups at the time of oiling; the leukogram returned to normal ranges within two months (Gales, 1991). No other hematological or serum biochemical change signalled systemic toxicosis or organ dysfunction following oil exposure (Gales, 1991). This contrasts markedly with the results for sea otters (see Chapter 5 and Appendix 3).

Petroleum hydrocarbon levels in blood can indicate the degree and route of absorption. Straight chain hydrocarbons are absorbed through the gut, whereas aromatic compounds are absorbed primarily by inhalation, and to a much lesser extent through the skin. For most marine mammals, there is little background data on circulating levels of petroleum hydrocarbons. Interpretation of any findings after oil exposure rests on the assumption that such compounds are normally undetectable. Observations on the dynamics of petroleum hydrocarbon levels in blood will greatly assist future attempts to understand the significance of such data.

## POST-RELEASE MONITORING AND SUMMARY

Monitoring released pinnipeds and polar bears is critical for determining the effectiveness of any clean up operation, as well as the overall impact of the oil on individual animals and the population as a whole. In some instances (e.g. nursing seals), visual recaptures may suffice. However, it is more likely that radio or satellite transmitters will be needed to follow widely ranging pinnipeds or polar bears. Such endeavors are expensive but represent an investment as critical as the original clean up effort, and the costs must be incorporated into the restoration plan from the outset.

Whenever possible, recaptures of previously oiled and nonoiled animals should be included in any follow-up plan. These recaptures can be used to assess the condition of the fur or hair, measure body mass, and collect blood samples for clinical pathology and circulating hydrocarbon levels. Breeding colonies of pinnipeds should be monitored during subsequent pupping seasons to determine the long term effects of oil contamination on reproduction.

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Figure 15.1
Harbor seal pup contaminated during the EVOS. Photographs show the animal immediately before (top) and after (bottom) cleaning with Dawn™ detergent. Light area on the eye in the top photograph shows corneal ulceration.

# Appendix 1

# Average Values for Physiological, Hematological, and Morphological Parameters for Sea Otters, Polar Bears, Northern Fur Seals, and Harbor Seals

Average values for physiological, hematological, and morphological parameters for sea otters, polar bears, northern fur seals, and harbor seals.

| | | SEA OTTER (*Enhydra lutris*) | | POLAR BEAR (*Ursus maritimus*) | | NORTHERN FUR SEAL (*Callorhinus ursinus*) | | HARBOR SEAL (*Phoca vitulina*) | |
|---|---|---|---|---|---|---|---|---|---|
| Variables | Units | Adult | Pup | Adult | Cub | Adult | Pup | Adult | Newborn |
| Average Weight: Male | kg | 27-48 | < 2 mo. 1.1 - 4.4 2-8 mo. 4.5-13.6 | 350-650 | birth wt 0.6-0.8 4-5 mo 8-11 | 180-270 | 5-22.7 (yearling) 18.2-31.8 | 87-170[2] | 11-19[2] (yearling) 60-120 |
| Average Weight: Female | kg | 16-32 | | 175-300 | | 40-50 | | 60-142[2] | |
| Average standard Length: Male | m | 1.35 | n.d. | 2.5-3 | n.d. | 2.1 | n.d. | 1.61-1.86[2] | 0.79-0.98[2] |
| Average standard Length: Female | m | 1.25 | n.d. | 2-2.5 | n.d. | 1.5 | n.d. | 1.48-1.69[2] | 0.79-0.98[2] |
| Normal Heart rate | bpm | 144 to 159 | n.d. | n.d. | n.d. | 80-120 | n.d. | 130-150 | n.d. |
| Normal respiration rate | bpm | 17-20 | n.d. | 15-30 | n.d. | 6 | n.d. | 3-4 | n.d. |
| Normal core body temperature | °C (°F) | 37.5-38.1 (99.5-100.6) | n.d. | 36.5-38.3 (97.6-101) | n.d. | 36.0-37.7 (96.8-99.9) | n.d. | 36.9-38.7 (98.4-101.7) | n.d. |
| RBC | $10^6/mm^3$ | 3.21-6.54[1] | 2.68-4.85[1] | 4.5-8.6[1] | n.d. | 3.84-5.29[1] | n.d. | 3.99-5.61[1] | 5.0-6.3[1] |
| Hb | g/dl | 10.8-22.9[1] | 8.3-17.8[1] | 12-15[1] | n.d. | 12.7-17.8[1] | n.d. | 14.4-24.0[1] | 18.1-22.2[1] |
| PCV | % | 33-70[1] | 25-51[1] | 37-50[1] | n.d. | 34-51[1] | n.d. | 40-60[1] | 50-61[1] |
| MCV | fl | 82-129[1] | 86-110[1] | 50-99[1] | n.d. | 85-105[1] | n.d. | 92-121[1] | 87-108[1] |
| MCH | pg | 27-37[1] | 27-37[1] | 17-31[1] | n.d. | 29-35[1] | n.d. | 33-44[1] | 31-40[1] |
| MCHC | g/dl | 31-38[1] | 31-38[1] | 24-35[1] | n.d. | 32-38[1] | n.d. | 34-38[1] | 34-39[1] |
| WBC | $10^3/MM^3$ | 5.2-21.6[1] | 1.1-11.1[1] | 2.8-11.6[1] | n.d. | 7.0-13.8[1] | n.d. | 7.6-19.4[1] | 5.5-14.6[1] |
| PMN's | % | 37-84[1] | 40-76[1] | n.d. | n.d. | 53-83[1] | n.d. | 46-85[1] | 57-89[1] |
| Bands | % | 0[1] | 0[1] | n.d. | n.d. | 0-2[1] | n.d. | 0-5[1] | 0-9[1] |
| Lymphs | % | 13-61[1] | 21-60[1] | n.d. | n.d. | 11-38[1] | n.d. | 9-45[1] | 9-24[1] |
| Monos | % | 1-7[1] | 1-12[1] | n.d. | n.d. | 0-8[1] | n.d. | 1-17[1] | 5-12[1] |
| Eos | % | 1-6[1] | 1-4[1] | n.d. | n.d. | 0-11[1] | n.d. | 0-9[1] | 0-1[1] |
| Basos | % | 0[1] | 0[1] | n.d. | n.d. | 0[1] | n.d. | 0-2[1] | 0[1] |
| AST | IU/l | 500 max | 500 max | 8-55[1] | n.d. | 56-129[1] | n.d. | 70-241[1] | 198[1] |
| ALT | IU/l | 33-366[1] | 5-357[1] | 0-15[1] | n.d. | 13-76[1] | n.d. | 36-69[1] | n.d. |
| Total bilirubin | mg/dl | n.d. | n.d. | 0.6-0.8[1] | n.d. | 0.0-0.2[1] | n.d. | 0.1-0.5[1] | 3.9[1] |
| CK | IU/l | 490 max | 490 max | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| GGT | IU/L | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| BUN | mg/dl | 25-101[1] | 29-190[1] | 2-23[1] | n.d. | 20-73[1] | n.d. | 25-97[1] | 57.6[1] |
| Creatinine | mg/dl | 0.3-3.9[1] | 0.2-2.0[1] | n.d. | n.d. | 0.2-0.8[1] | n.d. | 0.4-1.4[1] | 1.01[1] |
| AP | IU/l | 27-714[1] | 21-688[1] | 4-30[1] | 8-118[1] | 80-124[1] | n.d. | 30-303[1] | 221[1] |
| LDH | IU/l | 419 max | 419 max | 37-406[1] | n.d. | 620-955[1] | n.d. | 321-1250[1] | n.d. |
| Glucose | mg/dl | 60-237[1] | 27-174[1] | 48-156[1] | n.d. | 84-210[1] | n.d. | 41-164[1] | 108[1] |
| Triglyceride | mg/dl | n.d. | n.d. | n.d. | n.d. | 7-294[1] | n.d. | 22-362[1] | 53[1] |
| Cholesterol | mg/dl | 97-414[1] | 113-885[1] | 153-525[1] | n.d. | 265-317[1] | n.d. | 212-302[1] | 302[1] |
| Lipase | IU/L | 10-228[1] | 15-142[1] | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| Protein, Total | g/dl | 4.3-11.6[1] | 3.2-7.7[1] | 5.9-8.2[1] | n.d. | 6.3-7.8[1] | n.d. | 6.1-9.7[1] | 5.8[1] |
| Albumin | g/dl | 1.2-5.0[1] | 1.2-3.9[1] | n.d. | n.d. | 3.8-4.5[1] | n.d. | 3.1-4.0[1] | 3.8[1] |
| Globulin | g/dl | 3.1-6.6[1] | 2.0-3.8[1] | n.d. | n.d. | 1.8-4.0[1] | n.d. | 1.8-4.0[1] | 2.0[1] |
| Sodium ($Na^+$) | mEq/l | 139-163[1] | 128-180[1] | 123-157[1] | n.d. | 147-157[1] | n.d. | 145-156[1] | 152[1] |
| Potassium ($K^+$) | mEq/l | 4.0-5.6[1] | 3.6-5.6[1] | 2.2-3.9[1] | n.d. | 4.4-5.1[1] | n.d. | 4.0-6.0[1] | 4.5[1] |
| Chloride ($Cl^-$) | mEq/l | 95-120 | 95-120 | 94-108[1] | n.d. | 100-112[1] | n.d. | 97-111[1] | 106[1] |
| Calcium ($Ca^{++}$) | mg/dl | 5.4-14.5[1] | 6.2-12.6[1] | 7.7-9.7[1] | 8.6-10.9[1] | 9.4-9.8[1] | n.d. | 8.8-10.9[1] | 9.0[1] |
| Phosphorus[1] | mg/dl | 3.3-14.4[1] | 3.8-13.2[1] | 3.3-7.9[1] | n.d. | 4.7-7.7[1] | n.d. | 4.3-7.9[1] | n.d. |

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# Appendix 2

# Forms for Documenting Necropsy Results, Capture, Treatments, Observations, and Release Data for Sea Otters Placed in Rehabilitation Facilities

**Shana Loshbaugh**
**Keith Bayha**

Form
- A. Gross Necropsy Report
- B. Tissue Sample Checklist
- C. Sea Otter Capture
- D. Capture Boat Animal List
- E. Animal Transporter's Log
- F. Admission and Washing
- G. Chemical Restraint and Treatments
- H. Physical Examination
- I. Critical Care
- J. Husbandry
- K. Daily Food Consumption for Individual Otters
- L. Daily Food Consumption for Multiple Otter Pens and Pools
- M. Sea Otter Pup Care
- N. Transfer Summery
- O. Daily and Weekly Animal Count
- P. Release
- Q. Admissions and Final Disposition Summary

**Form A**

**GROSS NECROPSY REPORT**

Date ____________ Tag ____________ Pathology ____________

Species ____________________ Common Name ____________

Sex ________ Age ______ Weight ______ kg ________ lbs

Length: Straight __________ cm Curvillinear __________ cm

Girth: Maximum __________ cm Axillary __________ cm

Blubber Thickness: Dorsal ____ cm Lateral ____ cm Ventral ____ cm

Condition ______________________________________

CLINICAL ABSTRACT:

INTEGUMENT:

NUTRITION:

MUSCULOSKELETAL SYSTEM:

FAT DISTRIBUTION:

ABDOMINAL CAVITY:

LIVER

GALLBLADDER

DIGESTIVE SYSTEM:

ESOPHAGUS

SMALL INTESTINE

LARGE INTESTINE

**Form A, GROSS NECROPSY REPORT** *(Continued)*

PANCREAS:

ENDOCRINES:
THYROID

PARATHYROID

HEMOLYMPHATIC SYSTEM:
BONE MARROW

LYMPH NODES

THYMUS

SPLEEN

CARDIOVASCULAR SYSTEM:

RESPIRATORY SYSTEM:
LUNG

TRACHEA

NASAL PASSAGE

URINARY SYSTEM:
TESTES/OVARIES AND UTERUS

NERVOUS SYSTEM:

SPECIAL SENSES:
EYES

EARS

**Form A, GROSS NECROPSY REPORT** *(Continued)*

PARASITISM:

DIFFERENTIAL DIAGNOSIS: (TSWAG)

REMARKS:

TISSUES SAVED FOR HISTO:

TISSUES SAVED FOR TOX:

## Form B
## TISSUE CHECKLIST

### HISTOLOGY

Abdomen:

___ liver
___ gallbladder
___ adrenals
___ kidneys
___ urinary bladder
___ spleen
___ pancreas
___ stomach
___ small intestine
___ large intestine
___ lymph nodes

Thorax:

___ tongue
___ thyroid/parathyroid
___ trachea
___ esophagus
___ thymus
___ heart
___ lung
___ diaphragm

Other:

___ brain
___ eyes
___ spinal cord
___ nasal turbinates
___ parasites
___ muscle
___ blubber/fat
___ skin
___ gonads
___ other ________________

### TOXICOLOGY

___ liver
___ bile
___ lung
___ kidney
___ fat/blubber
___ brain
___ muscle
___ skin
___ stomach contents
___ intestinal contents
___ placenta
___ amniotic fluid
___ ascites
___ cardiac blood
___ thoracic fluid
___ other ________________

### FOOD HABIT

___ stomach
___ intestinal contents

### MEASUREMENTS

___ teeth
___ skull
___ baculum
___ other________________

**Form C**

**SEA OTTER CAPTURE**

Project ______________________________

Date ______________________________

Otter # ______________________________

**Capture Boat Information**

Capture Boat __________________________ Crew Leader __________________________

Boat Log # __________________________ Reported By __________________________

**Otter Capture Information**

Date ____________ Specific Location ______________________________ Map on Back ( )

Time ________ AM ___ PM ___ Reason for Capture ______________________________

______________________________________________________________________

What was the animal doing prior to capture? ______________________________

______________________________________________________________________

Capture Method ______________________ Pursuit Time ______________________

Other Notes ______________________________________________________________

**Otter Description**

Sex: M F Weight ________ lbs or kg Length ______ in or cm

Description ______________________________________________________________

Tag Number ________ Tag Color ________ Tag Location: Left ________

Tag Number ________ Tag Color ________ Tag Location: Right ________

What did the otter do in the boat? ______________________________

______________________________________________________________________

**Otter Disposition**

Date ____________ Time ____________ AM ___ PM ___

( ) Died - Probable Cause ______________________________

( ) Escaped - Because ______________________________

( ) Released - Because ______________________________

**Otter Transport**

Sent To (place) ____________ Date __________ Time ________ AM ___ PM ___ Via ______

Condition at time of transfer ______________________________

Transport Carrier ____________________ Signature ____________________

## Form D

## CAPTURE BOAT ANIMAL LIST

Project ______________________________

Date ________________________________

Boat Name ___________________________

Recorder _____________________________

| Boat Ref# | Date | Location | Species | Notes | Disposition | Date |
|---|---|---|---|---|---|---|
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Page _____ of _____ pages

**Form E**

## ANIMAL TRANSPORTER'S LOG

Project ______________________________

Carrier ______________________________

Recorder ______________________________

| Boat numbers for all animals transported | Picked up from | Date Time | Delivered to | Date Time |
|---|---|---|---|---|
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**Form F**

## ADMISSION AND WASHING

Rehabilitation Center ____________________

Date ____________ Time ________ AM PM

Otter # ________ Tag # ________ Tag Color ________

Capture Location ____________________

Delivered By ____________________

### Animal Description

Sex (circle): M F Pregnant (circle): Yes No

Age (circle): Pup Yearling Juvenile Adult

Weight (kg): Otter and Cage ______ Cage ______ Otter ______

Degree of Oiling (circle): None Light Medium Heavy

Oiled Fur Test Results ____________________

Clinical Condition ____________________

### Animal Cleaning

Washing (circle): Not Washed Incomplete Wash Complete Wash

Begin Washing ______ AM PM End Washing ______ AM PM

| Time | Core Temp. (°C) | Respiration (breaths/min) | Observations |
|---|---|---|---|
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Washing Supervisor's Signature ____________________

Veterinarian's Signature ____________________

## Form G
## CHEMICAL RESTRAINT AND TREATMENTS

Rehabilitation Center ______________________________ Date ____________

Otter # __________ Tag # __________

Reason for Chemical Restraint ______________________________________________

### Type of Chemical Restraint

| Type | Dose | Time | Route |
|---|---|---|---|
| ________ | ________ | ________ | ________ |
| ________ | ________ | ________ | ________ |
| ________ | ________ | ________ | ________ |
| ________ | ________ | ________ | ________ |
| Reversal ____ | ________ | ________ | ________ |

Level of Anesthesia: None Light Moderate Heavy Variable

### Treatments

Antibiotics: Type ______________ Dose ______________

Type ______________ Dose ______________

Steroids: Type ______________ Dose ______________

Vitamins: Type ______________ Dose ______________

Type ______________ Dose ______________

Fluids ______________________________________________

Activated Charcoal ______________ Other ______________

### Clinical Samples

Blood Sample: None SMAC CBC Toxicology Other

Other Samples: None Urine Feces Tissue Biopsy

Notes:______________________________________________

After reversal, animal recovered at __________ (time) and was returned to __________

______________________ (place).

Veterinarian's Signature ______________________________________________

## Form H
## PHYSICAL EXAMINATION

Rehabilitation Center ____________________

Date ________ Otter # ________ Tag # ________

Sex ____ Age ______ Weight ______ Length ______

### Examination

Medical Condition ____________________
____________________

Fur Condition ____________________
____________________

Head ____________________
____________________

Chest ____________________
____________________

Abdomen ____________________
____________________

Forelimbs ____________________
____________________

Hindlimbs ____________________
____________________

Genitalia ____________________
____________________

Wounds and Lesions ____________________
____________________

Other Observations ____________________
____________________

Veterinarian's Signature ____________________

## Form I
## CRITICAL CARE

Rehabilitation Center ______________________________ Date ____________

Otter # __________ Tag # __________ Tag Color ___________

Sex _________ Age _________ Weight _________

Medical Condition ______________________________________________________________

________________________________________________________________________________

### Medical and Behavioral Observations

________________________________________________________________________________

________________________________________________________________________________

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## Form J
## HUSBANDRY

Rehabilitation Center ______________________________

Date ______________ Shift ______________

Tag # ______________ Tag Color ______________

Pen or Pool # ______________

| Time | In Water | Hauled Out | Observations |
|---|---|---|---|
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Notes for Next Shift ______________________________

______________________________

Recorder's Signature ______________________________

## Form K
## DAILY FOOD CONSUMPTION FOR INDIVIDUAL OTTERS

Rehabilitation Center ____________________ Date ______________

Otter # __________ Tag # __________ Tag Color __________

| Feeding Times | | | | | |
|---|---|---|---|---|---|
| Food Types | Food Weights (kg) | | | | |
| | | | | | |
| | | | | | |
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| | | | | | |
| | | | | | |
| Total Per Meal | | | | | |

Total Food Eaten Today __________

Foods Refused ________________________________

Foods Preferred ________________________________

Appetite (circle one): None Poor Fair Good Excellent

Recorder's Signature ________________________________

**Form L**

## DAILY FOOD CONSUMPTION FOR MULTIPLE OTTER PENS AND POOLS

Rehabilitation Center ____________________

Date ____________ Shift ____________

Pen # ____________ Location ____________

### Identification of Otters in Each Pen or Pool

| Otter # | Tag # | Tag Color | Sex | Observations |
|---|---|---|---|---|
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Otters Removed from Pen ____________ Why? ____________

Otters Added to Pen ____________ Why? ____________

### Food Consumption

| Feeding Times | | | | | |
|---|---|---|---|---|---|
| Food Types | Food Weights (kg) | | | | |
| | | | | | |
| | | | | | |
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| | | | | | |
| | | | | | |

Total food placed in the pen or pool today ____________

Notes ____________

Recorder's Signature ____________

**Form M**

## SEA OTTER PUP CARE

Rehabilitation Center ____________________

Date ____________ Shift ____________________

Otter Name __________ Otter # __________ Tag # __________

Weight (kg) __________ and Length (cm) __________ as of today.

### Food Consumption

Method of Feeding: Intubation Syringe Self Combination

| Feeding Times | | | | | |
|---|---|---|---|---|---|
| Food Types | Food Weights (kg) or Volume (ml) | | | | |
| Formula (ml) | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| Total Per Meal | | | | | |

Total food eaten today __________

### Urination and Bowel Movements

| Time | Feces or Urine | Abnormalities Noted |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

Behavioral Observations ____________________

____________________

Medical Observations ____________________

____________________

Nursery Recorder's Signature ____________________

**Form N**

**TRANSFER SUMMARY**

Rehabilitation Center ____________________________________________

| Otter # | Tag#/Color | Sex | Location Collected | Transfer Date | Transfer Location |
|---|---|---|---|---|---|
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**Form O**

## DAILY AND WEEKLY ANIMAL COUNT

Rehabilitation Center ______________________________

**Date**

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |

**Received**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Captured | | | | | | | |
| Transferred | | | | | | | |
| Born | | | | | | | |
| Other | | | | | | | |
| **Total Received** | | | | | | | |

**Departed**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Died | | | | | | | |
| Euthanized | | | | | | | |
| Transferred | | | | | | | |
| Released | | | | | | | |
| Escaped | | | | | | | |
| **Total Departed** | | | | | | | |

**Alive at Center**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Females | | | | | | | |
| Males | | | | | | | |
| Pups | | | | | | | |
| **Total Present** | | | | | | | |

## Form P
## RELEASE

Rehabilitation Center ____________________

Otter # __________ Tag # __________ Tag Color __________

Weight __________ Distinguishing Marks ____________________

Last Blood Test ____________________ Date __________

Original Capture Location ____________________ Date __________

Radio Transmitter (check): yes __________ no __________

Transmitter Number ____________________

### Pre-Release Clinical Treatment

Date __________ Time __________

Vitamins __________ Antibiotics __________

Other ____________________

Comments ____________________

Veterinarian's Signature ____________________

### Release Information

Date __________ Time __________

Departing Location ____________________

Release Location __________ Latitude __________ Longitude__________

Mode of Transportation to Release Site ____________________

Left Flipper Tag # __________ Color __________

Right Flipper Tag # __________ Color __________

Comments ____________________

Supervisor's Signature ____________________

**Form Q**

## ADMISSIONS AND FINAL DISPOSITION SUMMARY

Rehabilitation Center ______________________________

| Otter # | Tag#/Color | Sex | Location Collected | Admit Date | Final Disposition | Final Date |
|---|---|---|---|---|---|---|
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# Appendix 3

# Hematology and Blood Chemistry of Oiled Sea Otters

**Tamela Thomas**

Figure A. Glucose
B. Sodium and Chloride
C. Calcium and Phosphorus
D. Blood Urea Nitrogen and Potassium
E. Alanine Aminotransferase (ALT) and Aspartate Aminotransferase (AST)
F. Creatine phosphokinase and Lactate Dehydrogenase
G. Hemoglobin and Packed Cell Volume
H. Red Blood Cell and White Blood Cell Counts

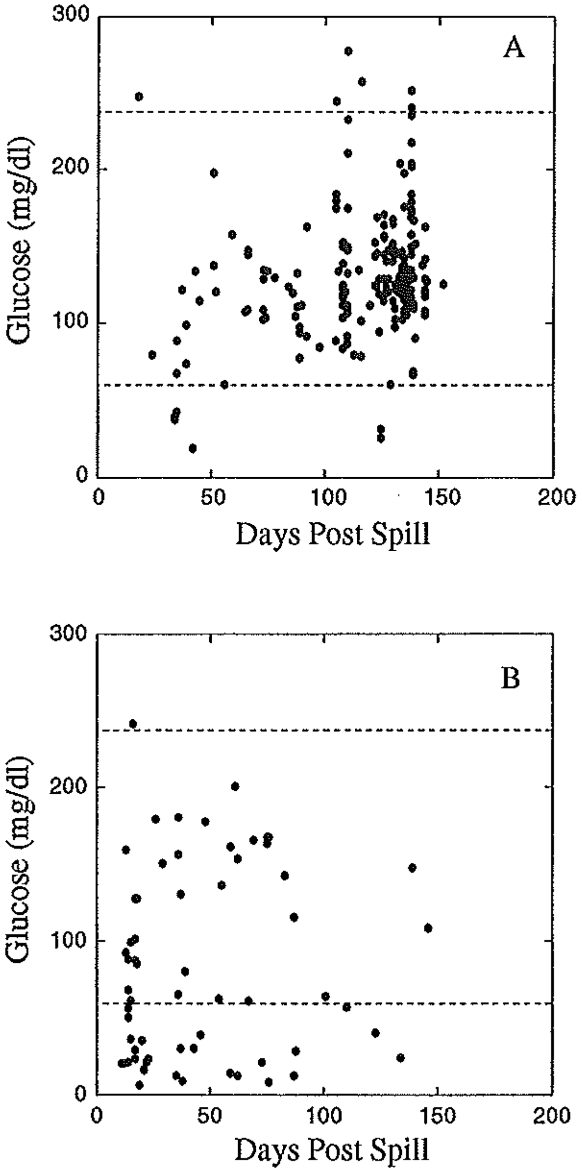



Figure A.
Serum glucose concentrations for sea otters that lived (A) and died (B) relative to the number of days after the spill. These were the final values measured in the rehabilitation centers prior to the otters' release or death. The dashed lines indicate the maximum and minimum range of normal values.

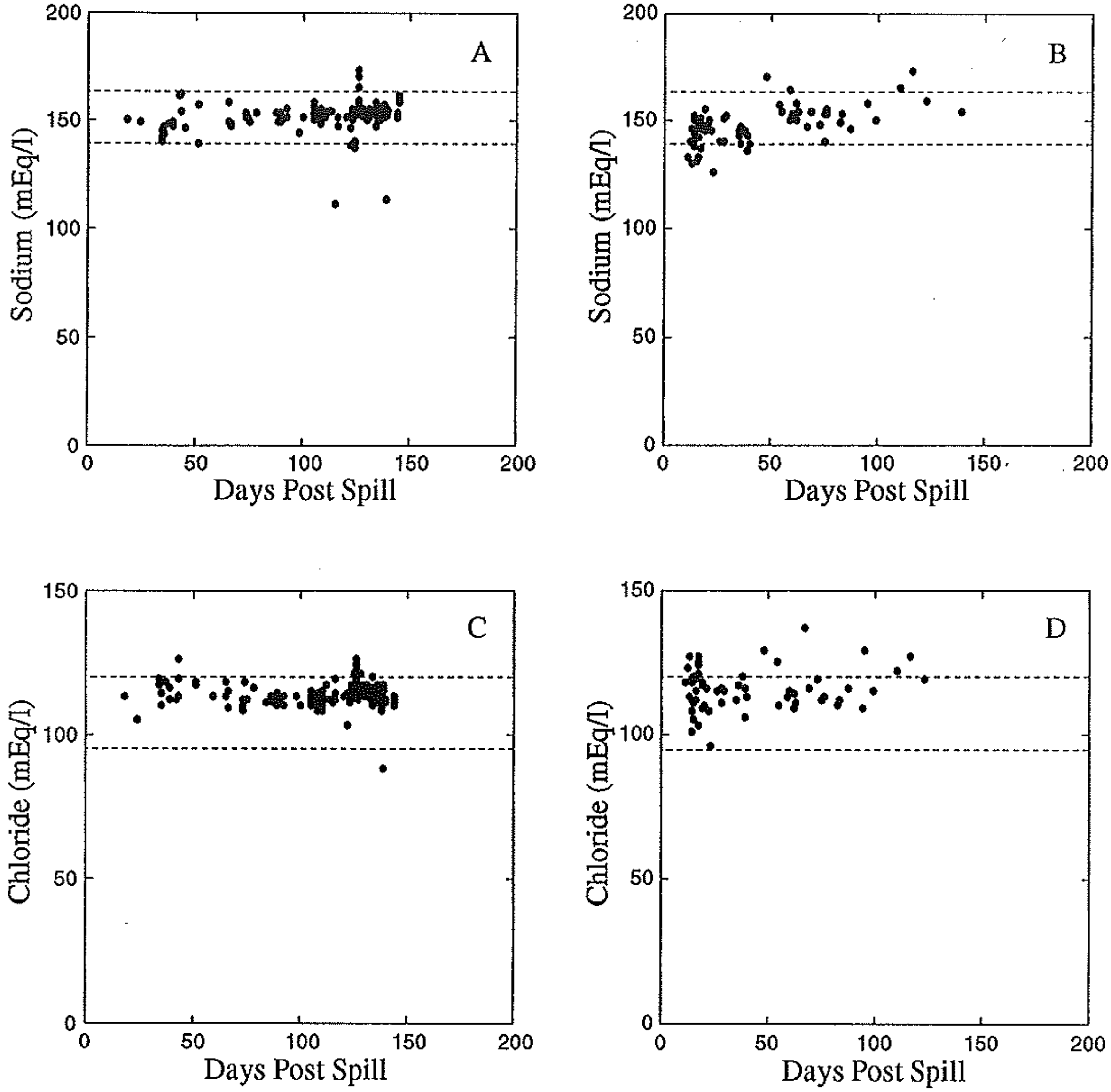



Figure B.
Serum sodium and chloride concentrations for sea otters that lived (A and C) and died (B and D) relative to the number of days after the spill. These were the final values measured in the rehabilitation centers prior to the otters' release or death. The dashed lines indicate the maximum and minimum range of normal values.

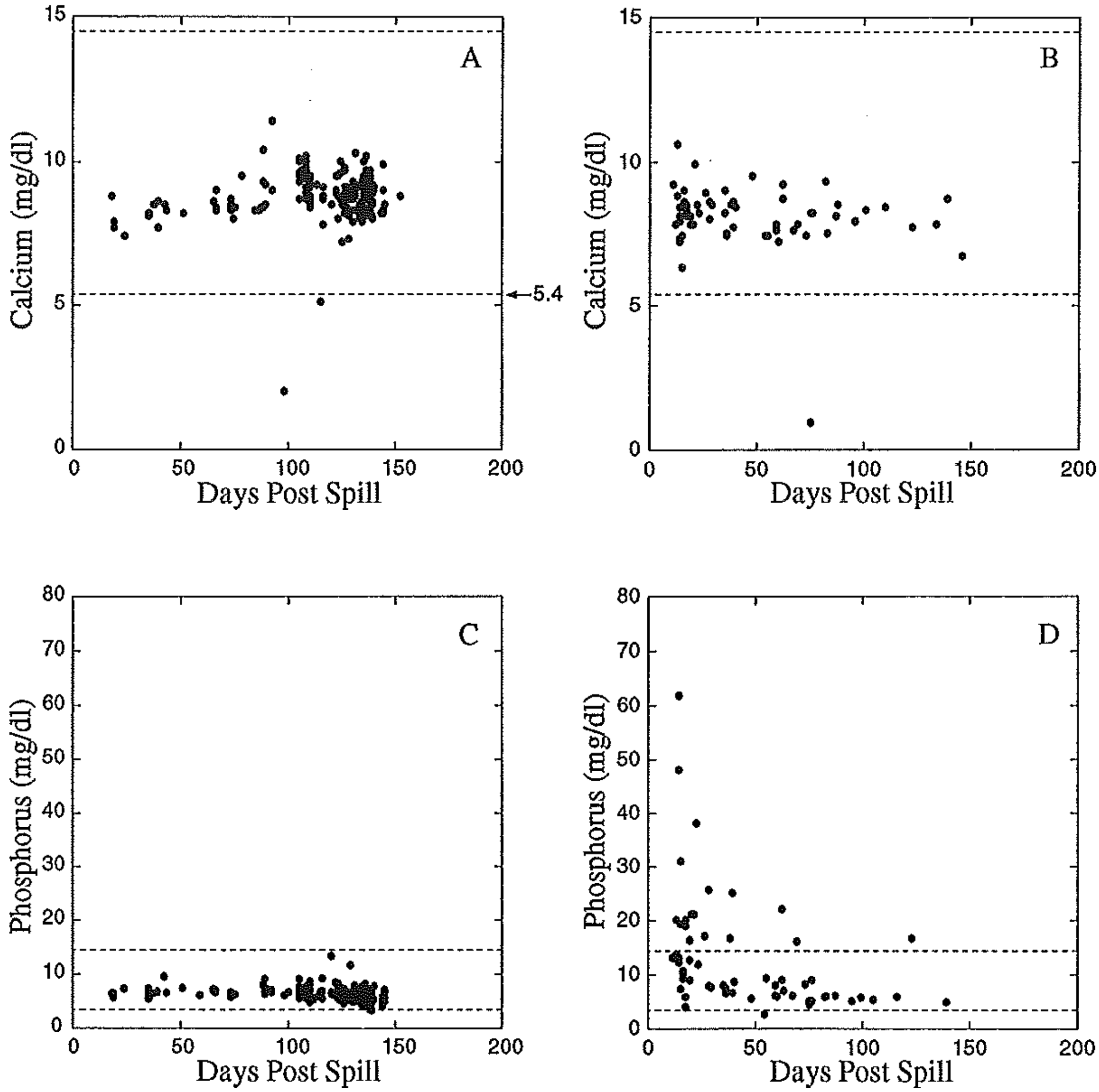



Figure C.
Serum calcium and phosphorus concentrations for sea otters that lived (A and C) and died (B and D) relative to the number of days after the spill. These were the final values measured in the rehabilitation centers prior to the otters' release or death. The dashed lines indicate the maximum and minimum range of normal values.

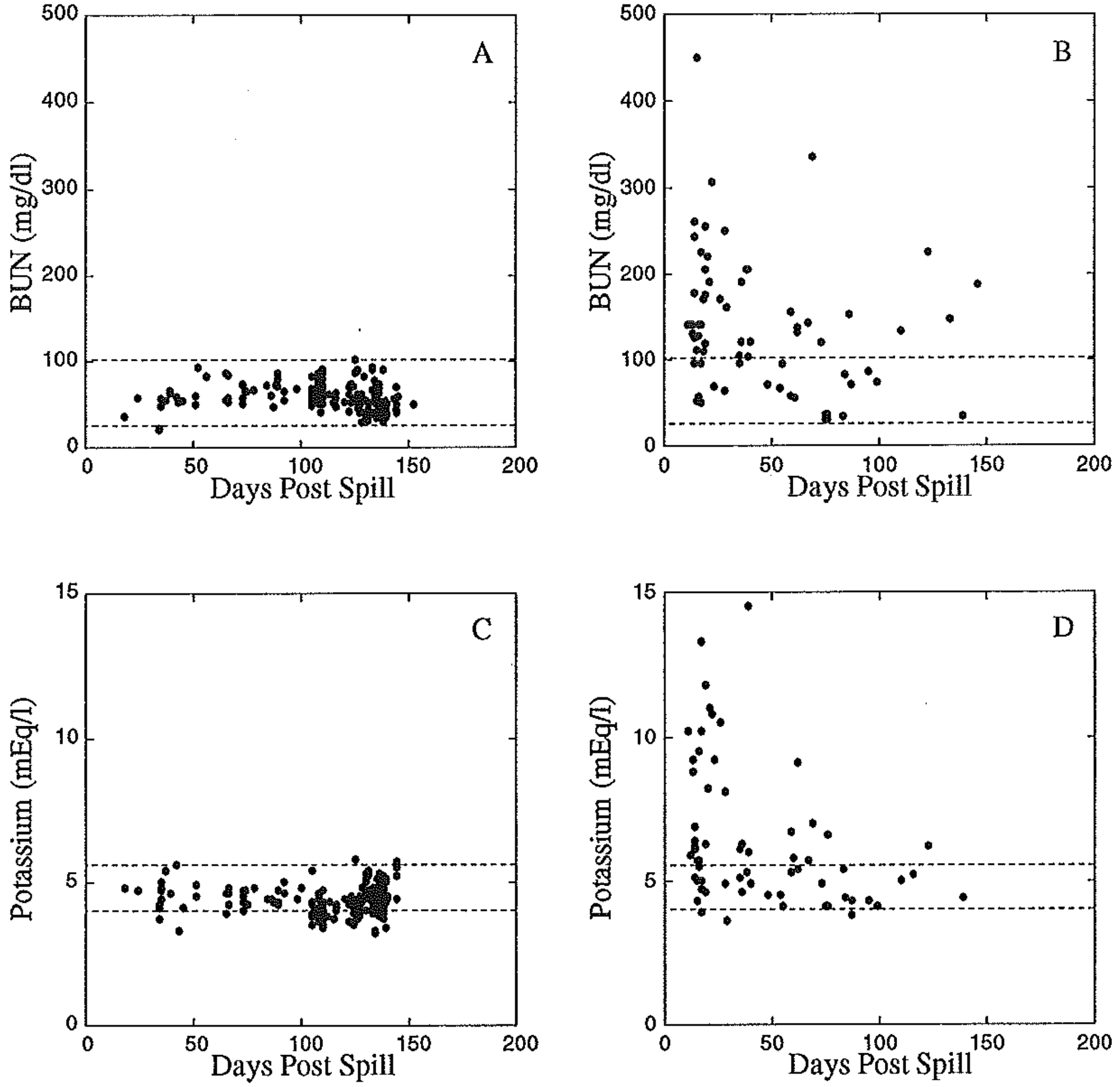



Figure D.
Blood urea nitrogen (BUN) and potassium concentrations for sea otters that lived (A and C) and died (B and D) relative to the number of days after the spill. These were the final values measured in the rehabilitation centers prior to the otters' release or death. The dashed lines indicate the maximum and minimum range of normal values.

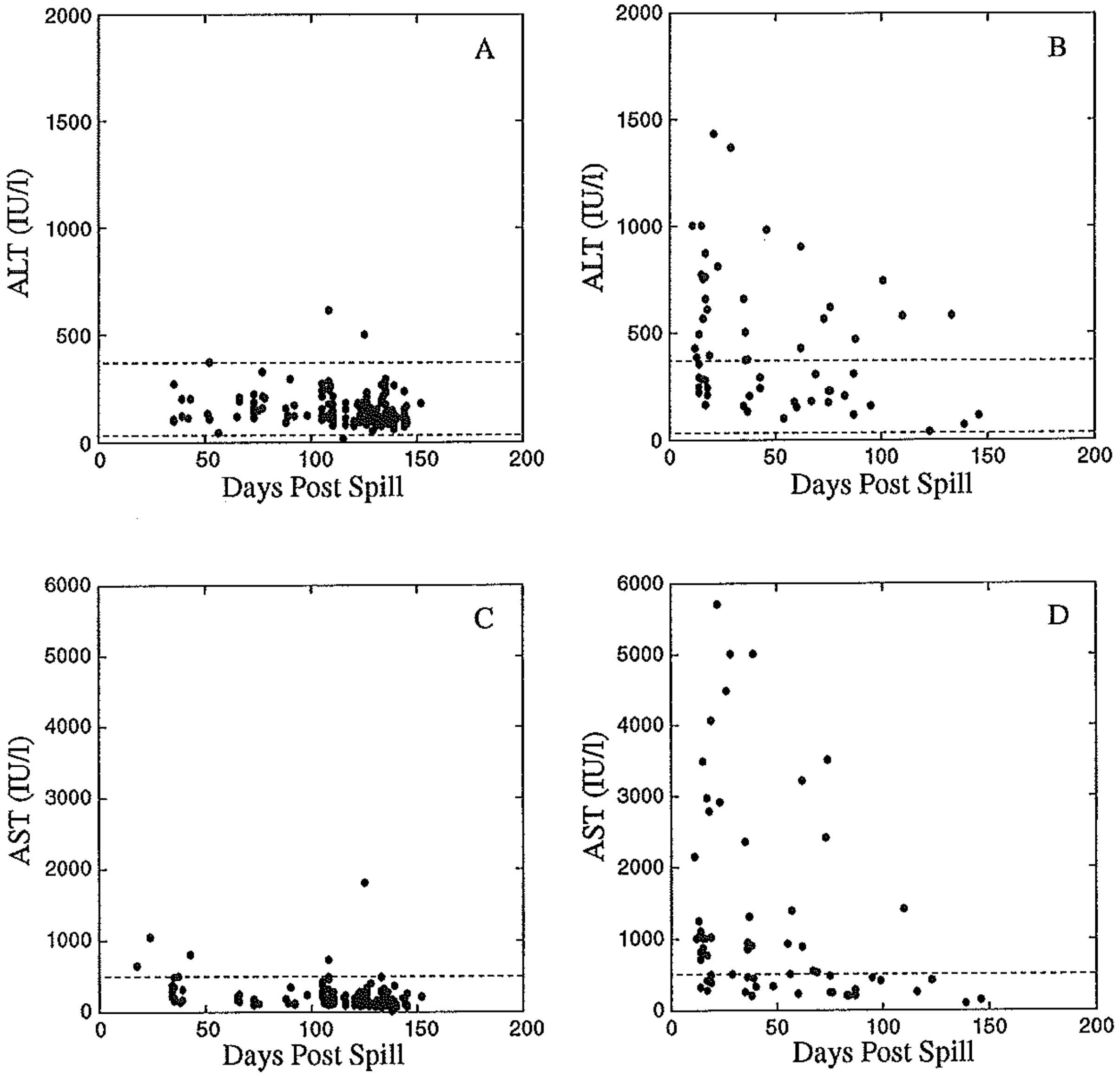



Figure E.
Serum alanine aminotransferase (ALT) and aspartate aminotransferase (AST) activities for sea otters that lived (A and C) and died (B and D) relative to the number of days after the spill. These were the final values measured in the rehabilitation centers prior to the otters' release or death. The dashed lines indicate the maximum and minimum range of normal values.

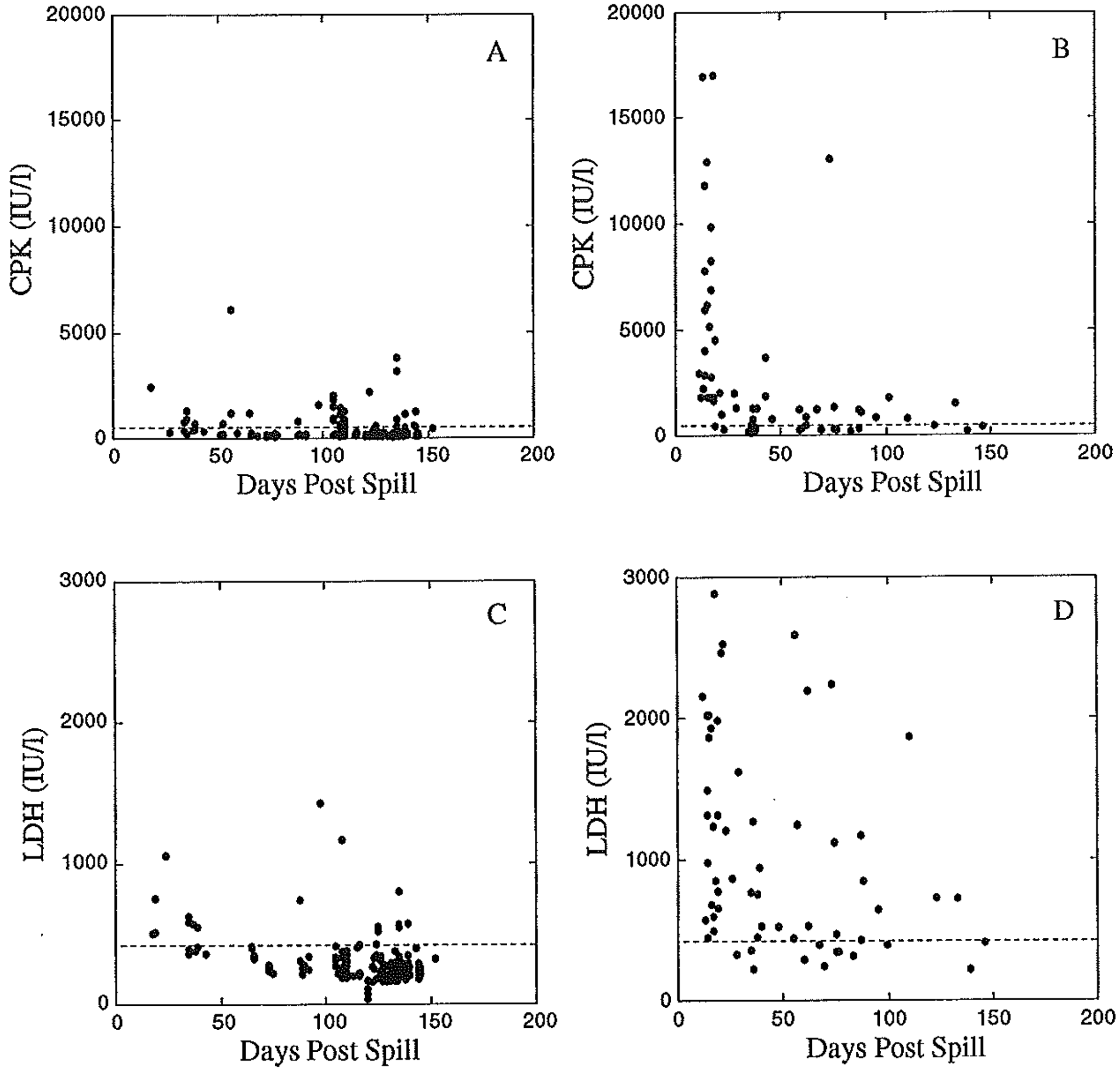



Figure F.
Serum creatine phosphokinase (CPK) and lactate dehydrogenase (LDH) activities for sea otters that lived (A and C) and died (B and D) relative to the number of days after the spill. These were the final values measured in the rehabilitation centers prior to the otters' release or death. The dashed lines indicate the maximum range of normal values.

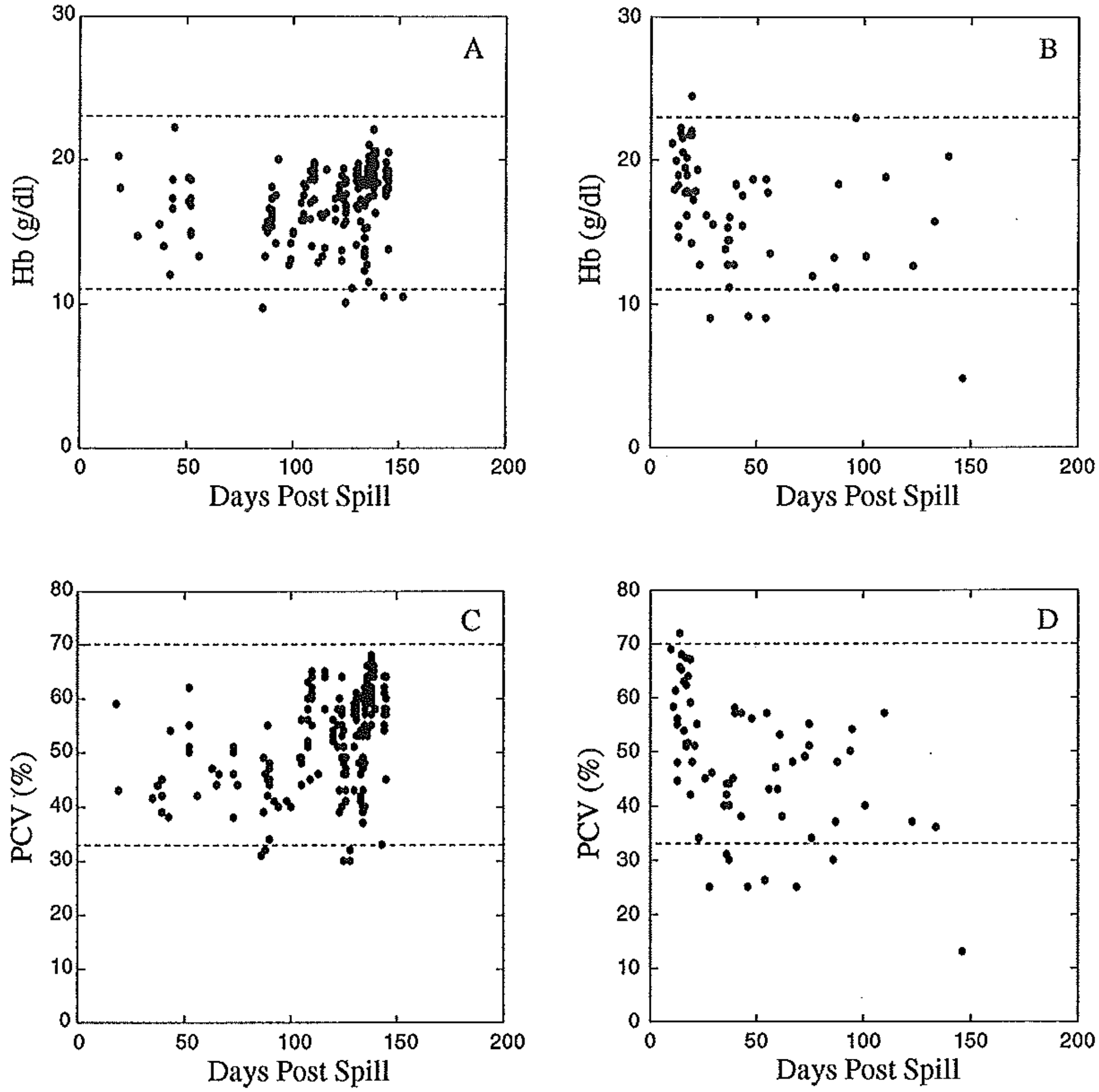



Figure G.
Blood hemoglobin concentrations (Hb) and packed cell volumes (PCV) for sea otters that lived (A and C) and died (B and D) relative to the number of days after the spill. These were the final values measured in the rehabilitation centers prior to the otters' release or death. The dashed lines indicate the maximum and minimum range of normal values.

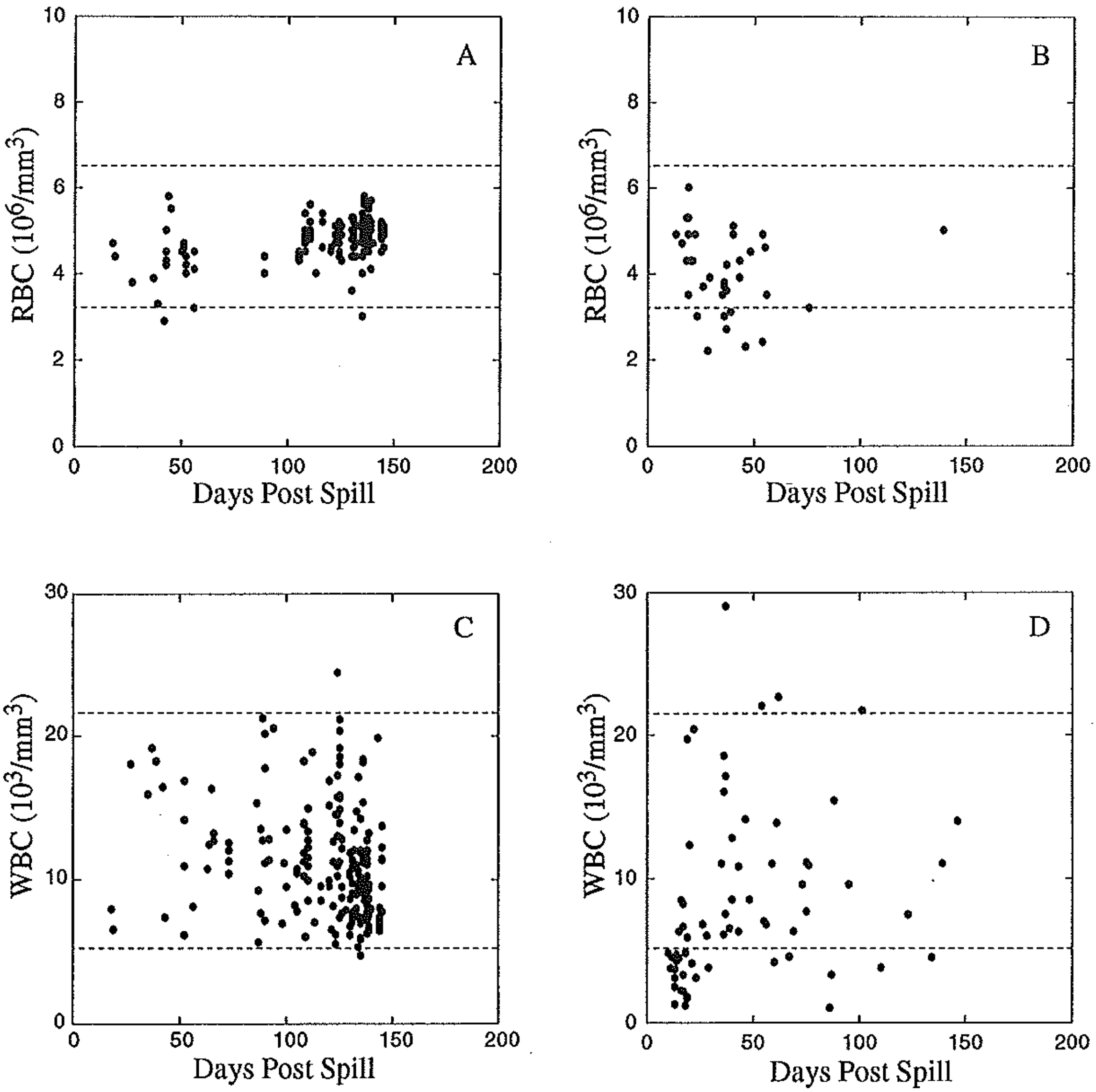



Figure H.
Red blood cell concentrations (RBC) and white blood cell concentrations (WBC) for sea otters that lived (A and C) and died (B and D) relative to the number of days after the spill. These were the final values measured in the rehabilitation centers prior to the otters' release or death. The dashed lines indicate the maximum and minimum range of normal values.

# Appendix 4

# Detailed Floor Plans for a Sea Otter Rehabilitation Center

Charles Davis



**ABBREVIATIONS**

| | | | |
|---|---|---|---|
| Auto | Automatic | LOG | Logistics |
| C | Computer | Off. | Office |
| CH. | Chair | PER | Personnel |
| Dev. | Development | P.R. | Public Relations |
| DOC | Documentation | Prep. | Preparation |
| Equip. | Equipment | Proj. Screen | Projection Screen |
| F.D. | Floor Drain | Ref. | Refrigerator |
| FIN | Finance | S.S. | Stainless Steel |
| Horiz. | Horizontal | Sup. | Supervisor |
| Jan. | Janitorial | VM | Video Monitor |

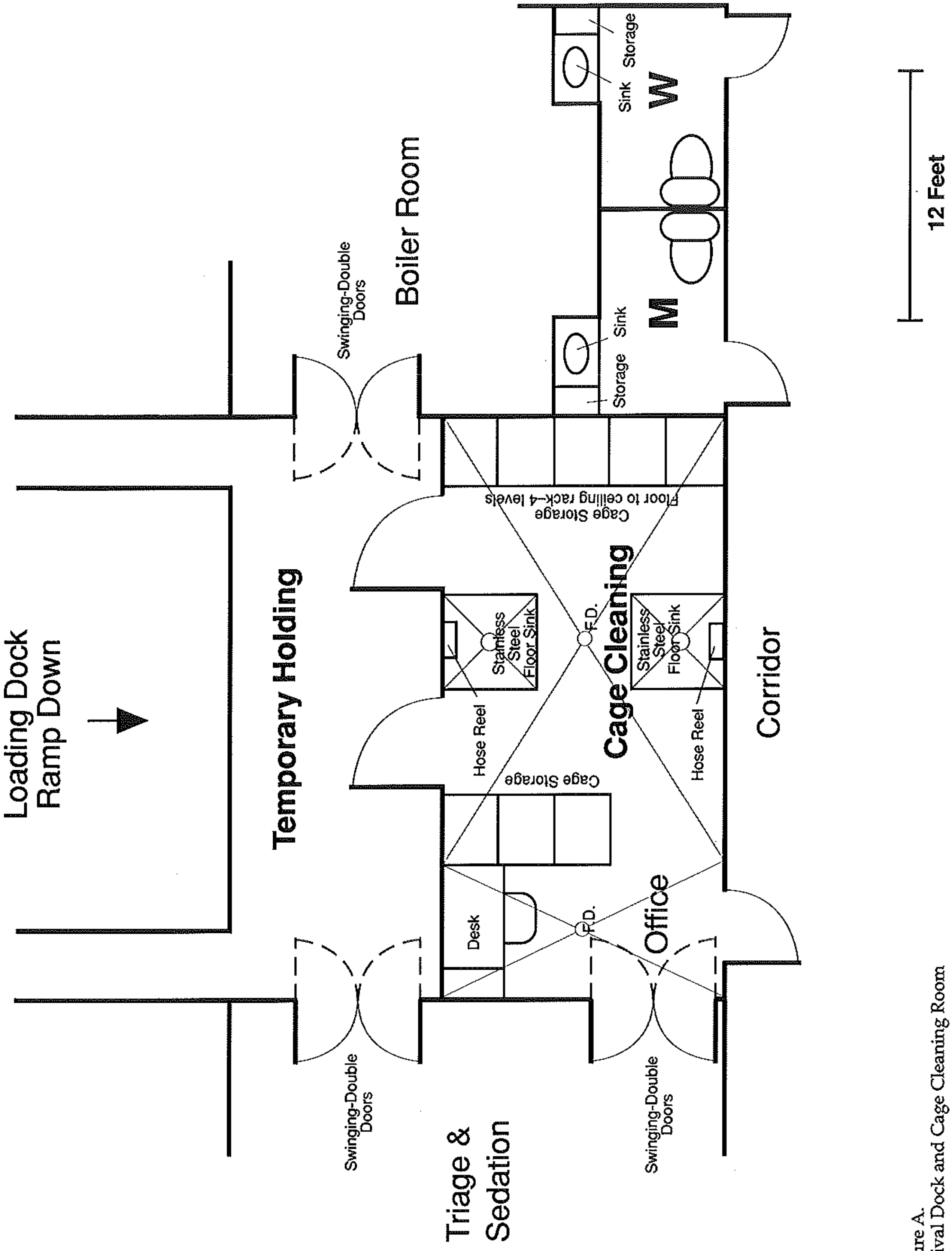



Figure A.
Arrival Dock and Cage Cleaning Room

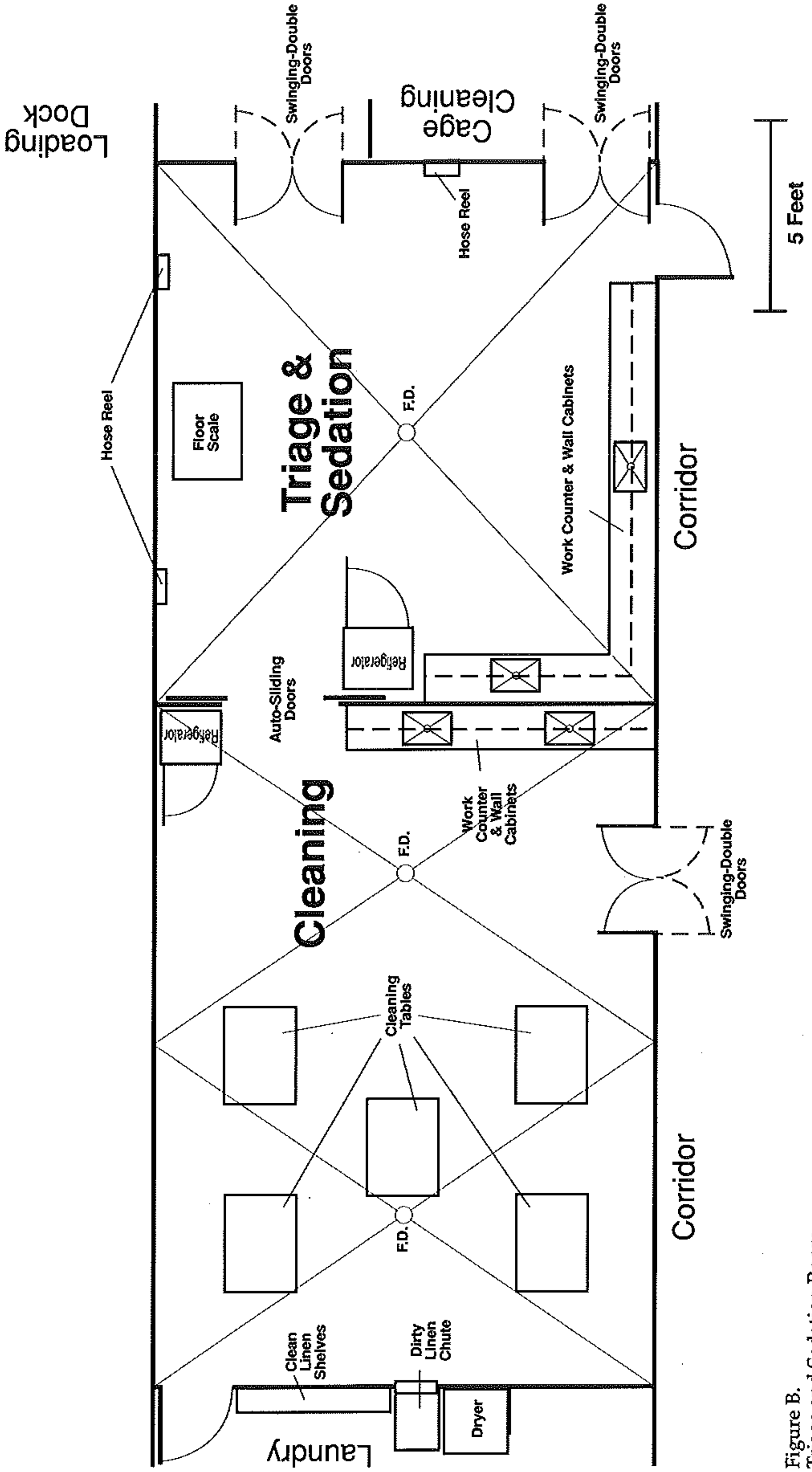



Figure B.
Triage and Sedation Room

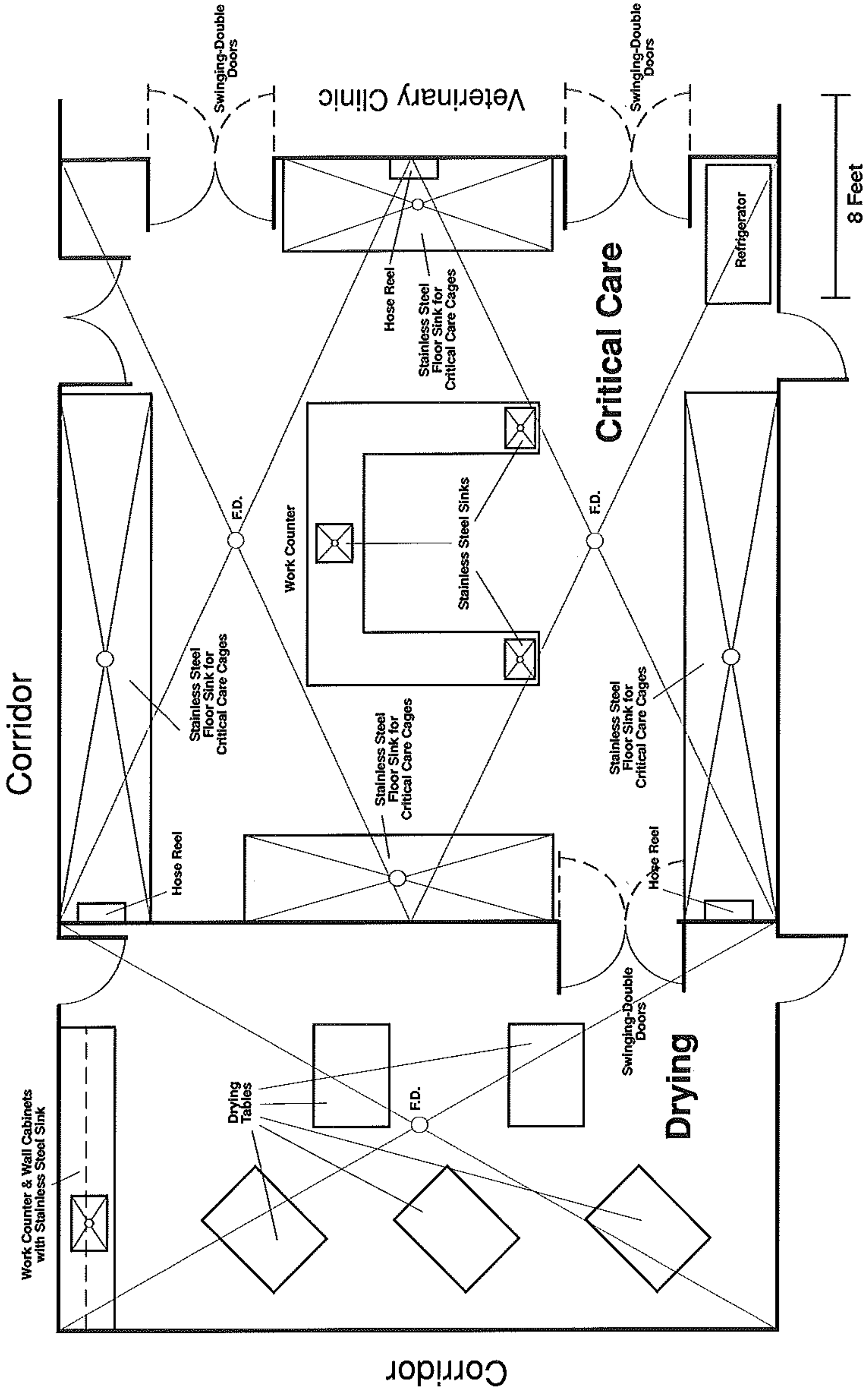



Figure C.
Drying and Critical Care Rooms

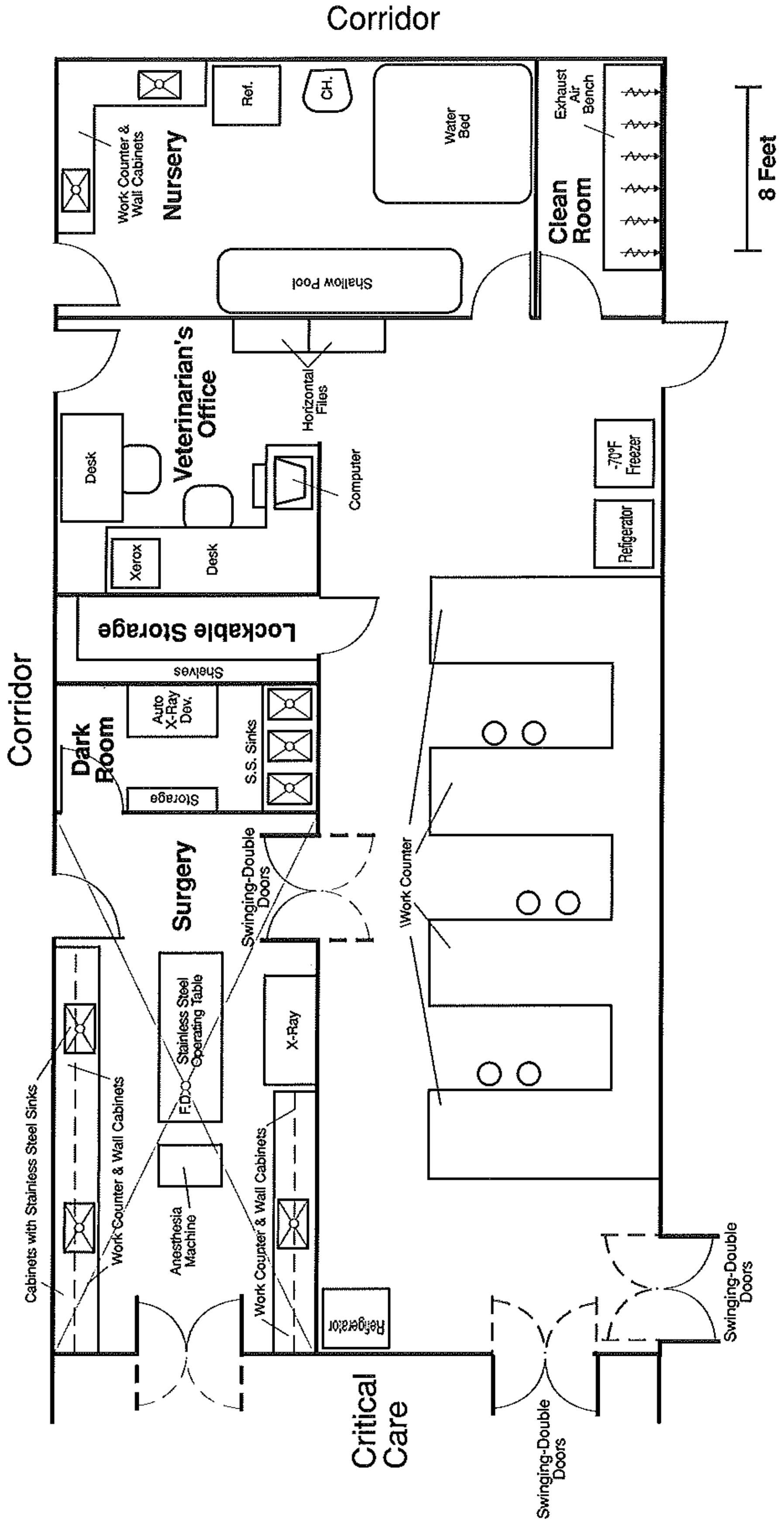



Figure D.
Veterinary Suite and Nursery

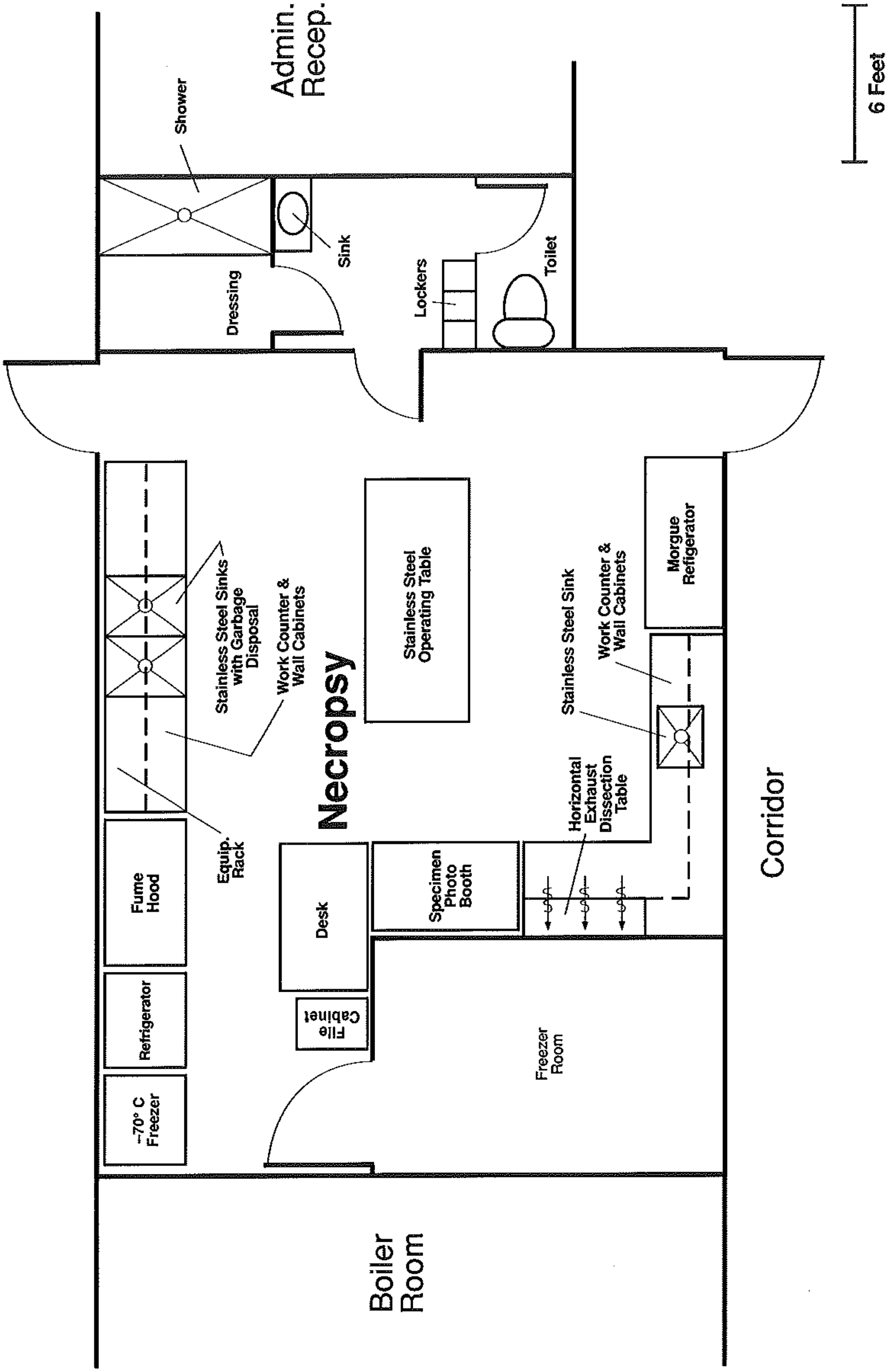



Figure E.
Necropsy Room

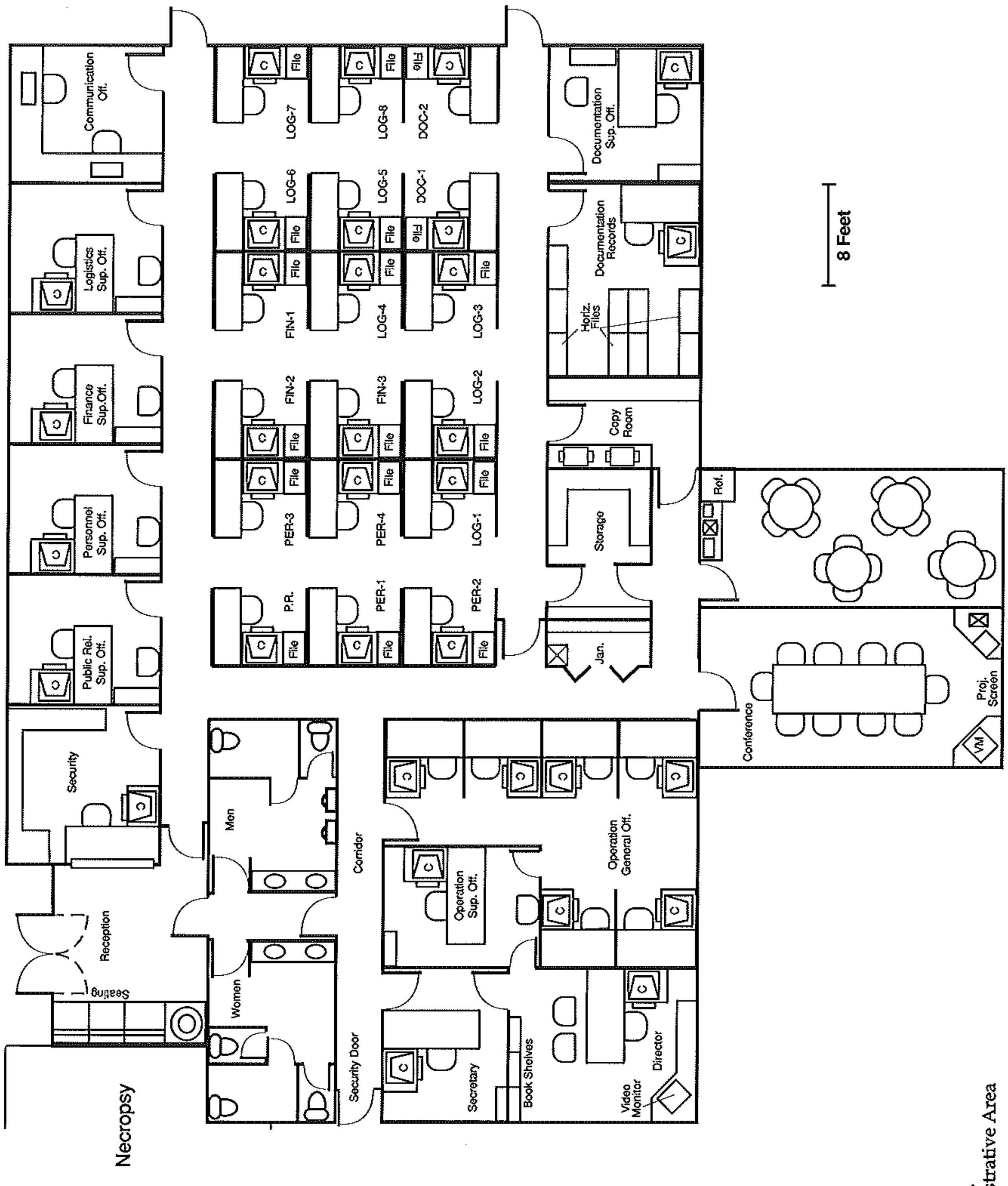



Figure F.
Administrative Area

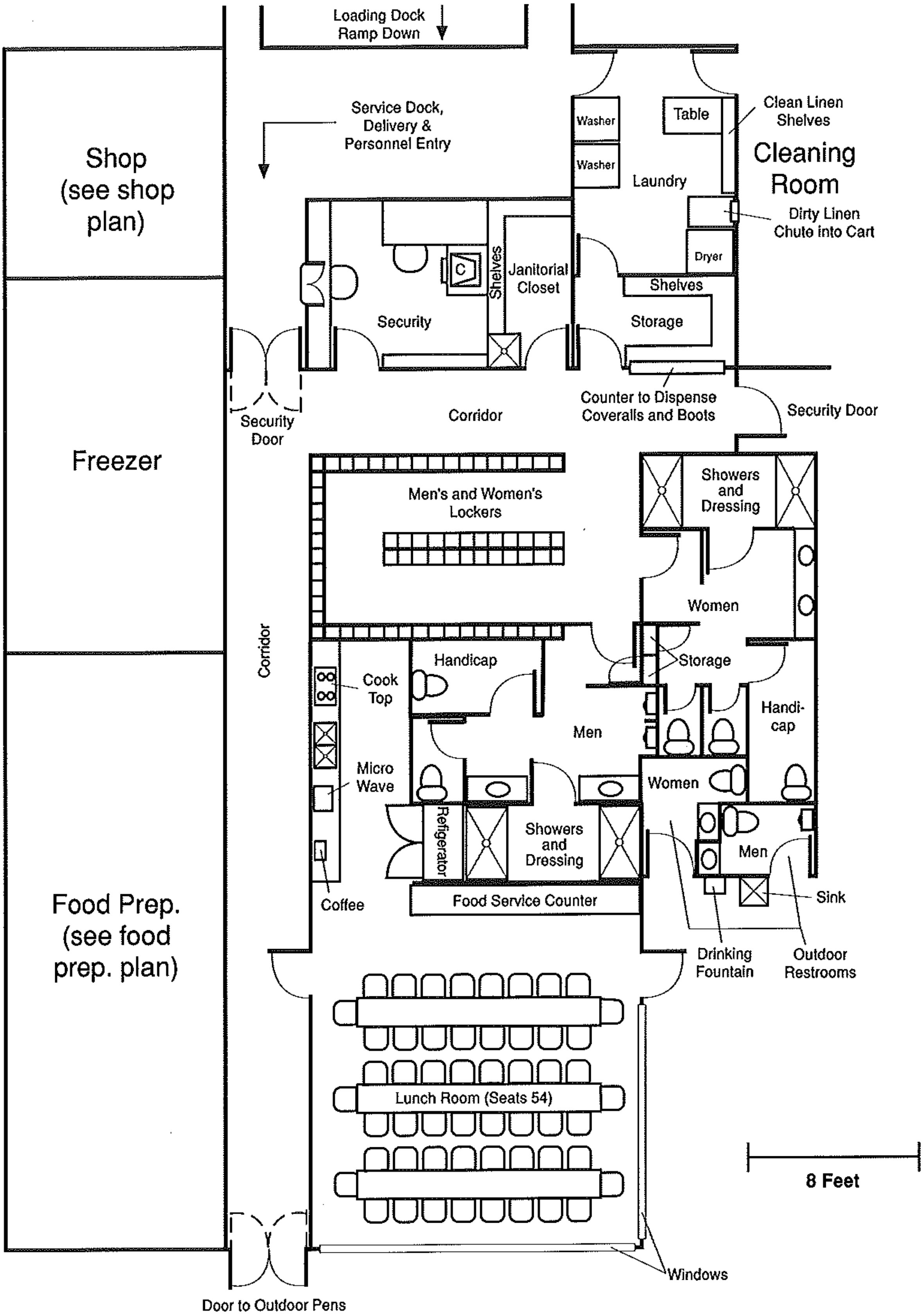



Figure G.
Service Areas

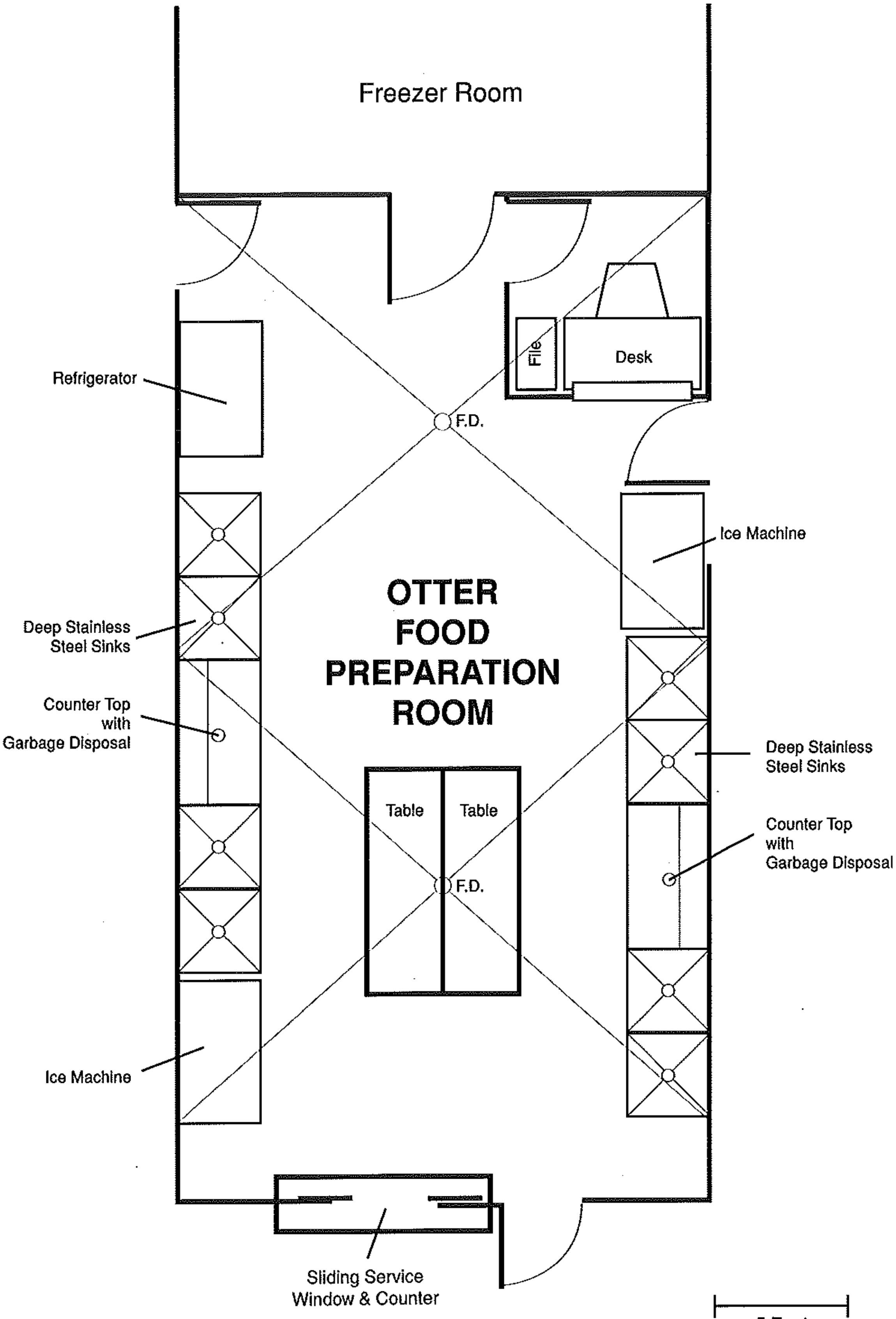



Figure H.
Food Preparation Room


Figure I.
Shop and Service Areas

# Appendix 5

# U.S. Department of Labor Occupational Safety and Health Administration Regional Offices

## U.S. DEPARTMENT OF LABOR OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION REGIONAL OFFICES

**Region I**
(CT*, MA, ME, NH, RI, VT*)
133 Portland Street
1st Floor
Boston, MA 02114
Telephone: (617) 565-7164

**Region II**
(NJ, NY*, PR*, VI*)
201 Varick Street
Room 670
New York, NY 10014
Telephone: (212) 337-2378

**Region III**
(DC, DE, MD*, PA, VA*, WV)
Gateway Building, Suite 2100
3535 Market Street
Philadelphia, PA 19104
Telephone: (215) 596-1201

**Region IV**
(AL, FL, GA, KY*, MS, NC*, SC*, TN*)
1375 Peachtree Street, N.E.
Suite 587
Atlanta, GA 30367
Telephone: (404) 347-3573

**Region V**
(IL, IN*, MI*, MN*, OH, WI)
230 South Dearborn Street
Chicago, IL 60604
Telephone: (312) 353-2220

**Region VI**
(AR, LA, NM*, OK, TX)
525 Griffin Street
Room 602
Dallas, TX 75202
Telephone: (214) 767-4731

**Region VII**
(IA*, KS, MO, NE)
911 Walnut Street
Room 406
Kansas City, MO 64106
Telephone: (816) 426-5861

**Region VIII**
(CO, MT, ND, SD, UT*, WY*)
Federal Building, Room 1576
1961 Stout Street
Denver, CO 80294
Telephone: (303) 844-3061

**Region IX**
(American Samoa, AZ*, CA* Guam, HI*, NV*, Trust Territories of the Pacific)
71 Stevenson Street
Room 415
San Francisco, CA 94105
Telephone: (415) 744-6670

**Region X**
(AK*, ID, OR*, WA*)
1111 Third Avenue
Seattle, WA 98101-3212
Telephone: (206) 442-5930

* These states and territories operate their own OSHA-approved job safety and health plans (Connecticut and New York plans cover public employees only). States with approved plans must have a standard that is identical to, or at least as effective as, the federal standard.

# Appendix 6

# Equipment Used for the Capture, Handling, and Treatment of Oiled Sea Otters

## I. SEA OTTER CAPTURE

Equipment and supplies for one sea otter capture kit. Each capture boat should have one kit. The quantity of each item is shown in parentheses.

1. Kennel cages for transport (10)
2. Long handled dip nets (4)
3. Long handled tongs (5)
4. Plastic totes for thawing frozen food (2)
5. Knives/cutting board (1 board/2 knives)
6. Rubber gloves (25)
7. Ziploc® bags (200)
8. Heavy leather gloves (4)
9. Stuff bag (1)
10. Squeeze box (1)
11. Spray bottles (3)
12. Ice chest (1)
13. Electronic scale (100 kg range) for weighing otters (1)
14. Chlorine bleach (1 gal)
15. Chlorhexidine (1 gal)
16. Scrub brushes (2)
17. Towels (2 dozen)
18. Dawn™ detergent (1 gal)
19. Sponges (2)
20. Record forms multi-sheet, pressure paper (100)
21. Indelible markers (10)
22. Clip boards (2)
23. Flipper tags (100)
24. Flipper tag tool (2)
25. Duct tape (2 rolls)

## I. SEA OTTER CAPTURE *(Continued)*

26. First aid kit (1)
27. Flashlights (3)
28. Hair dryers (2)
29. Digital thermometer with flexible probe (1)
30. Cargo totes with lids for storing the kit (3)
31. Tangle nets (150 ft long, 15 ft deep, 10 in stretch mesh, buoyant rope, 1 in nylon rope instead of a lead line) (2)
32. Anchor lines for tangle nets (A-3 buoy, 150 ft of 3/8 in nylon rope, 14 lb anchor, 5/16 in galvanized shackles, 6 ft galvanized chain) (2)
33. Special note: the capture vessel should have a freezer to store 100 lbs of sea food for the otters.

## II. TRIAGE AND STABILIZATION

Equipment and supplies for a sea otter triage and stabilization kit. The quantity of each item is shown in parentheses.

1. Critical care cages with trays (see Figure 7.1) (10)
2. Chest freezer (200 cubic feet) (1)
3. Kennel cages for transport (series 400) (15)
4. Long handled dip nets (5)
5. Stainless steel bowls (10)
6. Long handled tongs (5)
7. Food scale (1)
8. Small plastic totes for thawing frozen food (10)
9. Knives/cutting board (2)
10. Rubber gloves (50)
11. Ziploc® bags (200)
12. Leather gloves (welding) (5)
13. Stuff bags (2)
14. Squeeze box (1)
15. Spray bottles (5)
16. Small ice chest (2)
17. Electronic scale for weighing otters (1)
18. Chlorine bleach (1 gal)
19. Chlorhexidine (1 gal)
20. Scrub brushes (3)
21. Towels (3 dozen)
22. Dawn™ detergent (1 gal)
23. Hoses (2)
24. Sponges (5)
25. Rain coat/pants (5)
26. Record forms (50)
27. Indelible markers (10)
28. Clip boards (10)

## II. TRIAGE AND STABILIZATION *(Continued)*

29. Flipper tags (50)
30. Cork board (1)
31. Duct tape (5 rolls)
32. First aid kit (1)
33. Flashlights (2)
34. Hair dryers (5)
35. Marine radio (1)
36. Cellular phone (1)
37. Veterinary kit
    - Lactated Ringer's Solution (12 liters)
    - Normal saline (12 liters)
    - 5% Dextrose/Lactated Ringer's (12 liters)
    - 5% Dextrose (12 liters)
    - Sterile water for injection (1 liter)
    - Pedialyte™ (12 liters)
    - Amoxicillin (10 gm)
    - Keflex™ (10 gm)
    - B-complex with B-12 (500 ml)
    - Vitamin E/Se (500 ml)
    - Dexamethasone (500 ml)
    - Cimetidine (30 gm)
    - Carafate™ (100 gm)
    - Opthalmic solution (60 ml)
    - Irrigating eye wash (16 oz)
    - Cotton balls (1 pkg)
    - Isopropyl alcohol (64 oz)
    - Hivite™ drops (30 ml)
    - Cal-De-Phos™ Mineral Supplement
    - Cod liver oil (100 ml)
    - Syringes (1 ml w/o needle) (100)
    - Syringes (3 ml w 20 g x 1.5 in needle) (100)
    - Syringes (12 ml) (100)
    - Syringes (20 ml) (100)
    - Syringes (60 ml) (50)
    - Needles (19 g x 1.5 in) (100)
    - Needles (16 g x 1.5 in) (100)
    - Needles (20 g x 1.5 in) (100)
    - IV administration sets (20)
    - Exam gloves (latex, nonsterile) (100)
    - Thermometers—rectal (6)
    - Nolvosan™ solution (1 gal)
    - Nolvosan™ scrub (1 gal)
    - Betadine™ solution (1 pt)

## II. TRIAGE AND STABILIZATION *(Continued)*

Blender (1)
Red rubber catheter (16 Fr) (6)
Stethoscope (1)
Plastic case (2)
Vacutainers (red top) (100)
Vacutainers (lavender top) (100)
Vacutainers (grey top) (100)
Vacutainers (green top) (100)
Blood glucose reagent strips (1 pkg)
Blood urea nitrogen reagent strips (1 pkg)

## III. VETERINARY LABORATORY

Equipment and supplies for a veterinary laboratory in a regional rehabilitation center.

### Equipment

1. Refrigerator (large capacity)
2. -10 °C freezer
3. -70 °C freezer
4. Microbiological incubator
5. Temperature controlled bath
6. Coulter counter
7. Blood chemistry analyzer (Corning, Kodak)
8. Binocular microscope with 4x, 10x, 40x, oil oculars and camera mount (Nikon)
9. Clinical centrifuge
10. Hematocrit centrifuge
11. Refractometer (temperature compensated)
12. Flame photometer (Na/K analysis)
13. Blood gas analyzer
14. pH meter
15. White blood cell differential counter (6 key tally counter of WBC)
16. WBC counter (single stroke key tally for total WBC)
17. Water purification system (reverse osmosis and deionization)
18. Test tube rocker
19. Glucometer™
20. Pulse oximeter
21. EKG portable (LifePac™)
22. Medical oxygen tank and regulator
23. Warm water circulating pad
24. Blender

## III. VETERINARY LABORATORY *(Continued)*

### Supplies

1. Test tube racks
2. Microscope slide boxes for storage of fixed slides
3. Microscope slide markers (indelible)
4. Microscope slides (frosted end and plain)
5. Microscope slide coverslips
6. Fecalyzer test kit for conducting fecal test
7. Fecal flotation solution
8. Hemacult test kits to test for blood in the feces
9. Isopropyl alcohol (70%)
10. 10% formalin (for fixing tissue)
11. Poly vinyl alcohol (PVA, preservative for giardia, and other parasites)
12. Methyl alcohol
13. Stains for differential blood smears:
    - Wright stains #1, #2 (Eosin), #3 (blue), #4 (clear)
    - methylene blue (1%)
    - methylene blue (1%)
    - Giemsa
    - Sudan 3
14. Gram stain kit for staining bacteria, fungi, and yeast
15. Coplin jars with lids for holding blood stains
16. Novalsan™ solution (disinfectant)
17. Spray fixative for fixing blood smears
18. Parafilm
19. Bunsen burner
20. Transfer pipettes (glass and plastic)
21. Hematocrit tubes (plain and heparinized), tube reader and tube sealant
22. Centrifuge tubes
23. Blood collection tubes
    - Red topped 5 cc
    - Red topped 10 cc
    - Purple topped 2 cc
    - Royal topped 7 cc
    - Grey topped 5 cc
    - Serum separator tubes 10 cc
24. Laboratory notebooks
25. Examination gloves (latex, nonsterile)
26. Office supplies
27. Inoculating loop for making smears for gram staining
28. Unopette WBC/platelet counters for white cell counts

### III. VETERINARY LABORATORY *(Continued)*

29. Tissue forceps
30. Staining rack
31. RBC sedimentation rate tubes and rack
32. Safety goggles
33. Culterettes (aerobic and anaerobic)
34. Blood culture bottles
35. Lens paper
36. Kimwipes™
37. Chlorhexadine scrub
38. Povidone iodine solution
39. Lactated Ringers solution (1 liter bags)
40. Normal saline solution (1 liter bags)
41. 5% dextrose/normal saline (1 liter bags)
42. 5% dextrose (1 liter bottles)
43. Sterile water for injection
44. Pedialyte™ (500 ml bottles)
45. Enrofloxacin (22 mg/ml)
46. Amoxicillin (2 gm bottles)
47. Cephalin injection
48. B-complex with B12 (100 ml bottles)
49. Seletoc™ (Vit E/Se) (100 ml)
50. Dexamethasone (4 mg/ml)
51. Cimetidine (300 mg tablets)
52. Sucralfate™ (1 gram tablets)
53. Ivermectin
54. Praziquantel
55. Stanozolol
56. Mannitol
57. Furosimide
58. Dantrolene
59. Neomycin tablets
60. Theodur SR™ (aminophyllin)
61. Diazepam (5 mg/ml)
62. Lidocaine™ (2%)
63. Propanolol
64. Sodium bicarbonate
65. Opthalmic solution (Bacitracin)
66. Irrigating eye wash (8 oz)
67. Cotton balls
68. Hivite™ drops
69. Cal-De-Phos™ Mineral Supplement
70. Cod liver oil

## II. VETERINARY LABORATORY *(Continued)*

71. Syringes
    - 1 ml (TB) w/o needle (100/box)
    - 3 ml w 20g x 1 1/2" needle (100/box)
    - 12 ml (50/box)
    - 20 ml (50/box)
    - 60 ml (20/box)
72. Needles
    - 19 g x1 1/2" (100/box)
    - 16 g x 1 1/2" (100/box)
    - 20 g x 1" (100/box)
73. IV administration sets
74. Red rubber catheter (16 Fr)
75. Blood glucose reagent strips
76. Blood urea nitrogen reagent strips
77. Necropsy kit
    - Formalin solution (10%)
    - Scalpel handle
    - Scalpel blades
    - Tissue forceps
    - Hemostatic forceps
    - Dissecting scissors
    - Bone saw
    - Specimen jars (assorted sizes)
    - Toxicology specimen vials (2 oz)
    - Xylene
    - Acetone
    - Dichloromethane
    - Aluminum foil (heavy duty)
    - Surgeons gloves

## IV. SEA OTTER HUSBANDRY

General equipment and supplies for husbandry. Numbers of each item will depend on the number of animals to be treated.

**Feeding**

Food freezers
Stainless steel bowls
Long handled tongs
Food scales
Thawing tubs/totes
Knives/cutting boards
Rubber gloves
Chipped ice maker/storage
Food storage bags

**Restraint/transport**

Leather welders' gloves
Large dip nets
Stuff bags
Squeeze cage
Shipping kennels with racks
Slide top cage
Spray bottles
Insulated ice chest
Platform or spring scale

**Sanitation**

Chlorine bleach
Chlorhexidine solution
Pool nets (debris scoop)
Scrub brushes/towels
Foot baths
Rubber gloves/boots
Dawn™ detergent
Hoses
Rain coat/pants

**Recordkeeping**

Record forms
Indelible/waterproof pens
Clipboards
Toe tags
Binoculars
Message/location boards
Waterproof covers
Copy machine
Duct tape (temporary ID)

**Safety**

First aid kit
Life jacket/ring
Flashlights
Two way radio

**Supportive care/other**

Hair dryers/fans
Feeding tubes/mouth gag
Net mending equipment
Rectal thermometer

ATROPINE. An alkaloid in the form of white crystals soluble in alcohol and glycerine; used as an anticholinergic for relaxation of smooth muscles in various organs, to increase heart rate by blocking the vagus nerve, and as a local application to the eye to dilate the pupil and to paralyze ciliary muscle for accommodation.

AUSCULTATION. The act of listening for sounds within the body, chiefly for ascertaining the condition of the lungs, heart, pleura, abdomen and other organs, and for the detection of pregnancy.

AUTOLYSIS. The spontaneous disintegration of tissues or of cells by the action of their own autogenous enzymes, such as occurs after death and in some pathological conditions; the destruction of cells of the body by its own serum.

AUTONOMIC NERVOUS SYSTEM. The portion of the nervous system concerned with regulation of the activity of cardiac muscle, smooth muscle and glands.

AXILLARY. Pertaining to a small pyramidal space between the upper lateral part of the chest and the medial side of the arm, and including, in addition to the armpit, axillary vessels, the bronchial plexus of nerves, a large number of lymph nodes, and fat and loose alveolar tissue. The term often refers to the transverse plan through the chest at the level of the armpits.

BILIRUBINURIA. Presence of a bile pigment in the urine.

BRADYCARDIA. Slowness of the heart beat, as evidenced by slowing of the pulse rate to less than 60 beats per minute.

BRONCHOSPASM. Spasmodic contraction of bronchial muscle in the lungs.

BULLAE. Plural for bulla, a sac.

BULLOUS. Pertaining to or characterized by bullae.

CAPTURE MYOPATHY SYNDROME. Muscle damage caused, in part, by lactic acidosis resulting from extreme exercise or exertion such as occurs when animals are chased or physically restrained during capture.

CARDIAC ARRHYTHMIAS. Any variation from the normal rhythm of the heart beat, including sinus arrhythmia, premature beat, heart block arterial fibrillation, arterial flutter, pulsus alterans, and paroxysmal tachycardia.

CARDIOMEGALY. Cardiac hypertrophy; enlargement of the cardiac muscle.

CATECHOLAMINE. Any of a group of amines that act upon nerve cells as neurotransmitters or hormones. Adrenaline, norepinephrine, and dopamine are catecholamines.

CATHARTIC. An agent that causes evacuation of the bowels by increasing bulk and stimulating peristaltic action.

CEPHALIC. Pertaining to the head or the head end of the body.

CEPHALEXIN. An oral cephalosporin used in the treatment of pneumococcal and Group-A streptococcal respiratory infections and infections of the urinary tract, skin, and soft tissue.

# Glossary

Abdominal tympany. Bloating or gas in the abdomen.

Acanthocephalids. Thorny-headed or spiny-headed parasitic worms of animals from the phylum Acanthocephalia.

Acidosis. A pathologic condition resulting from accumulation of acid in, or loss of base, from the body.

Acidotic. Pertaining to or characterized by acidosis.

Alveolar. Pertaining to an alveolus (a small saclike dilation) in the mammalian lung. The alveolus is the primary gas exchange structure of the lung.

Anorexia. Lack or loss of the appetite for food.

Anaphylaxis. An unusual or exaggerated allergic reaction of an organism to foreign protein or other substances which may produce shock.

Aplasia. Lack of development of an organ or tissue, or of the cellular products from an organ or tissue.

Arrhythmia. Any variation from the normal rhythm of the heart beat.

Arterial fibrillation. Arterial arrhythmia characterized by rapid randomized contractions of the arterial myocardium, causing a totally irregular, often rapid ventricular rate.

Ascites. Effusion and accumulation of serous fluid in the abdominal cavity.

Aspiration. The act of inhaling. The removal of fluids or gases from a cavity by the application of suction.

Ataxia. Failure of muscle coordination; irregularity of muscle action.

Atelectasis. Collapse of the adult lung.

Atrial. A chamber affording entrance to another structure or organ, usually the heart.

CESTODES. Any parasitic tapeworm or platyhelminth of the class Cestoidea, especially those of the subclass Cestoda.

CETACEANS. Any of an order (Cetacea) of marine mammals including whales, dolphins, and porpoises.

CHLORAMPHENICOL. An antibiotic substance originally derived from cultures of *Streptomyces venezuelae,* and later produced synthetically. It occurs as fine, white to grayish or yellowish white, needlelike crystals or elongated plaques, and is used as an antibacterial and antirickettsial.

CLONUS. Alternate muscular contraction and relaxation in rapid succession.

COLONIC IRRIGATION. Flushing of the colon with warm water or fluid to raise body temperature.

CORTICOSTEROIDS. Any of the steroids produced by the adrenal cortex, including cortisol, corticosterone, aldosterone, etc.

CREPITATION. A sound like that made by rubbing the hair between the fingers, or popping.

CYANOSIS. A bluish discoloration, applied especially to such discoloration of skin and mucous membranes due to excessive concentration of reduced hemoglobin in the blood.

DECUBITAL ULCERS. An ulceration caused by prolonged pressure in an animal allowed to lie still on a flat surface for a long period of time.

DEHYDRATION. The removal of water from a substance. The condition that results from excessive loss of body water.

DEXAMETHASONE. A white, odorless crystalline powder used as an anti-inflammatory adrenocortical steroid of the glucogenic type.

DIARRHEA. Abnormal frequency and liquidity of fecal discharges.

DIAZEPAM. An off-white to yellow crystalline powder used as a minor tranquilizer, and also as a skeletal muscle relaxant. This drug is commonly referred to as valium.

DIURESIS. Increased secretion of urine.

DIURETIC. Increasing the secretion of urine, or an agent that promotes urine secretion.

DYSFUNCTION. Disturbance, impairment, or abnormality of an organ's function.

DYSPNEA. Difficult or labored breathing.

EDEMA. The presence of abnormally large amounts of fluid in the body's intercellular tissue spaces; usually applied to demonstrable accumulation of excessive fluid in subcutaneous tissues.

EMACIATION. Excessive leanness; a wasted condition of the body.

EMESIS. The act of vomiting.

EMPHYSEMA. A pathological accumulation of air in tissues or organs; applied especially to such a condition of the lungs.

EPIDERMIS. The protective outer skin layer of vertebrate animals covering the sensitive dermis.

EPISTAXIS. Nosebleed; hemorrhage from the nose.

ERYTHROCYTE. Red blood cell.

ENTERAL. Within, by way of, or pertaining to the small intestine.

EVOS. Abbreviation for the 1989 *Exxon Valdez* oil spill in Prince William Sound, Alaska.

FATIGUE. A state of increased discomfort and decreased efficiency resulting from prolonged or excessive exertion; loss of power or capacity to respond to stimulation.

FECES. The excrement discharged from the intestines, consisting of bacteria, cells exfoliated from the intestines, secretions (chiefly of the liver), and a small amount of food residue.

FELINE PANLEUKOPENIA. A viral disease of cats, characterized by leucopenia and marked by inactivity, refusal of food, diarrhea, and vomiting.

GLUCOCORTICOIDS. Any corticoid substance which increases gluconeogenesis, raising the concentration of liver glycogen and blood sugar.

GLYCOGEN. A polysaccharide, the chief carbohydrate storage material in animals. It is formed by and stored in the liver and to a lesser extent in muscles, being depolymerized to glucose and liberated as needed.

HAIR FOLLICLES. A cavity or sac in the body in which hair is produced.

HEMATOPOIETIC. Pertaining to or affecting the formation of blood cells.

HEMOCULT TEST. Bacteriological culture of the blood.

HEMODIALYSIS. The removal of certain elements from the blood by virtue of the different diffusion rates through a semipermeable membrane.

HEMORRHAGIC GASTROENTERITIS. Bleeding and inflammation of the stomach and intestines.

HEPATOENCEPHALOPATHY. A degenerative disease of the brain, usually occurring secondarily to advanced liver disease but also seen in the course of any severe disease.

HISTIOCYTOSIS. A condition marked by the abnormal appearance of histiocytes in the blood.

HYPERCAPNIA. Excess of carbon dioxide in the blood.

HYPERKALEMIA. Abnormally high potassium concentration in the blood, most often due to defective renal excretion.

HYPERPHOSPHATEMIA. An excessive amount of phosphates in the blood.

HYPERPLASIA. The abnormal multiplication or increase in the number of normal cells in normal arrangement in a tissue.

HYPERTHERMIA. Abnormally high body temperature.

HYPERTRIGLYCERIDEMIA. An excess of triglycerides in the blood.

HYPERVENTILATION. A state in which an increased amount of air entering the pulmonary alveoli (increased alveolar ventilation), results in reduction of carbon dioxide tension and eventually leads to alkalosis; deep and rapid breathing.

HYPOALBUMINEMIA. An abnormally low albumin (a type of plasma protein) content of the blood.

HYPOGLYCEMIA. An abnormally diminished glucose content of the blood, which may lead to tremulousness, cold sweat, piloerection, hypothermia, and headache accompanied by confusion, hallucinations, bizarre behavior, and ultimately, convulsions and coma.

HYPOREFLEXIA. Weakening of the reflexes.

HYPOTHERMIA. An abnormally low core body temperature.

HYPOXIC TISSUES. Low oxygen content or tension; deficiency of oxygen in tissues.

IMMUNOSUPPRESSED. Artificial prevention or diminution of the immune response.

INTERSTITIAL. Occupying the small, narrow spaces or interstices of tissue.

INTRAGASTRIC LAVAGE. The irrigation or washing out of the stomach.

ISCHEMIA. Deficiency of blood supply due to functional constriction or actual obstruction of a blood vessel.

ISOTONIC. Having the same osmotic pressure.

JUGULAR. Pertaining to the neck; a jugular vein.

LARYNGEAL. Pertaining to the larynx.

LAVAGE. The irrigation or washing out of an organ, such as the stomach or bowel.

LEPTOSPIROSIS. Infection by *Leptospira*. The infections are transmitted to man from dogs, swine, and rodents or by contact with contaminated water, as in swamps, canals, or ponds.

LEUKOCYTE. White blood cell.

MEDIASTINUM. The mass of tissues and organs separating the two lungs, between the sternum in front and the vertebral column behind, and from the thoracic inlet above to the diaphragm below.

MELENA. Dark, tarry stools.

METABOLIC ACIDOSIS. A disturbance in which the acid-base status of the body shifts toward the acid side because of loss of base or the retention of noncarbonic, or fixed acids.

MYOCLONUS. Shock-like contraction of a portion of a muscle, an entire muscle, or a group of muscles; restricted to one area of the body or appearing synchronously or asynchronously in several areas.

MYOCARDIUM. The middle and thickest layer of the heart wall composed of cardiac muscle.

MUSTELIDS. Members of the family Mustelidae: weasels, stoats, badgers, otters, polecats, martens.

NARCOTIC. Benumbing, deadening: an agent that produces insensibility or stupor.

NASOPHARYNGEAL MEMBRANES. Membranes of the part of the pharynx which lies above the level of the soft palate.

NAUSEA. An unpleasant sensation, vaguely referred to the epigastrium and abdomen, and often culminating in vomiting.

NECROPSY. Examination of the body after death; autopsy.

NEMATODES. Any of a class or phylum of slender, unsegmented, cylindrical worms, often tapered near the ends. Parasitic forms such as the hookworm, pinworm, and trichina belong to this group. Nematodes are commonly called roundworms.

NEPHROTOXIC. Toxic or destructive to kidney cells.

NEUROLEPTANALGASIA. A state of quiescence, altered awareness, and analgesia produced by the administration of a combination of a narcotic andalgesic and a neuroleptic agent.

OSHA. Abbreviation for the Occupational Safety and Health Administration of the U.S. Government.

OLIGURIA. Excretion of a diminished amount of urine in relation to the amount of water intake.

OPHTHALMIC. Pertaining to the eye.

PAH. Polycyclic aromatic hydrocarbon or petroleum aromatic hydrocarbon.

PALPATE. To examine by the hand; to feel.

PARAFFINIC HYDROCARBON. An organic compound that contains only carbon and hydrogen and is found in petroleum: any of a group of saturated aliphatic hydrocarbons characterized by a straight or branched carbon chains.

PERICHOLANGITIS. Inflammation of the tissues that surround the bile ducts.

PERITONEAL DIALYSIS. Dialysis through the peritoneum.

PHARYNGEAL. Pertaining to the pharynx.

PHC. Petroleum hydrocarbon.

PHOCID. Pertaining to marine mammals of the order Carnivora and family Phocidae; the true seals (i.e. harbor seals).

PHOTOPHOBIA. Abnormal visual intolerance of light.

PINNIPEDS. The group of aquatic mammals including seals, sea lions, and walruses.

PNEUMONITIS. Inflammation of the lungs.

POSTMORTEM. After death.

PROLAPSE OF RECTUM. Protrusion in varying degree of the rectal mucous membrane through the anus.

PROPHYLACTIC. Tending to ward off disease or an agent that tends to ward off disease; administered or performed to prevent disease.

PULMONARY EDEMA. Abnormal, diffuse, extravascular accumulation of fluid in the pulmonary tissues and air spaces due to changes in the hydrostatic forces in the capillaries or to increased capillary permeability.

PURULENT. Consisting or containing pus; associated with the formation of, or caused by, pus.

RADIOGRAPHY. The making of film records of the body by exposure of film specially sensitized to x-rays or gamma rays.

RECTAL TENESMUS. Painful, long-continued, and ineffective straining at stool.

RHINITIS. Inflammation of the mucus membranes of the nose.

SALMONELLOSIS. Infection with certain species of the genus Salmonella, usually caused by the ingestion of food containing the organisms or their products and marked by violent diarrhea attended by cramps and tenesmus and/or paratyphoid fever.

SEIZURES. The sudden attack or recurrence of a disease.

SELENIUM. A poisonous nonmetallic element resembling sulfur. In small amounts, it is an essential element in the diet.

SEPSIS. The presence in the blood or other tissues of pathogenic microorganisms or their toxins; the condition associated with such presence.

SHOCK. A condition of acute peripheral circulatory failure due to derangement of circulatory control or loss of circulating fluid. It is marked by hypotension, coldness of skin, usually tachycardia, and often anxiety.

SINUSITIS. Inflammation of a sinus. The condition may be purulent or nonpurulent, acute or chronic.

SLOUGH. Necrotic tissue in the process of separating from viable portions of the body.

STUPOR. Partial or nearly complete unconsciousness.

SUBCUTANEOUSLY. Under the skin.

SUBCUTANEOUS EMPHYSEMA. The presence of gas or air in the subcutaneous (beneath the skin) tissues of the body.

TACHYPNEA. Excessive rapidity of respiration; a respiratory neurosis marked by quick, shallow breathing.

TENESMUS. Straining, especially ineffectual and painful straining at stool or in urination.

THERMOREGULATORY. Controlling or regulating body temperature.

THORACIC. Pertaining to or affecting the chest.

THYMICOLYMPHATIC INVOLUTION. Degeneration or retrograde change of the thymus and the lymphatic glands.

TOXOPLASMOSIS. A protozoan disease of man caused by *Toxoplasma gondii.* Congenital toxoplasmosis is characterized by lesions of the central nervous system, which may lead to blindness, brain defects, and death.

TRIGLYCERIDES. A compound consisting of three molecules of fatty acid esterified to glycerol; it is a neutral fat synthesized from carbohydrates for storage in animal adipose cells.

ULCERATION. The formation or development of an ulcer.

VASOCONSTRICTION. The diminution of the caliber of vessels, especially constriction of arterioles leading to decreased blood flow to a part.

VENTRICLE. A small cavity, such as one of the several cavities of the brain, or one of the lower chambers of the heart.

VENTRICULAR FIBRILLATION. Arrhythmia characterized by fibrillary contractions of the ventricular muscle due to rapid repetitive excitation of myocardial fibers without coordinated contraction of the ventricle; an expression of randomized circus movement, or of an ectopic focus with a very rapid cycle.

VENTRICULAR TACHYCARDIA. An abnormally rapid ventricular rhythm with aberrant ventricular excitation which is commonly associated with atrioventricular dissociation.

ZOONOSES. A disease of animals that may be transmitted to man.

## BLOOD CHEMISTRY ABBREVIATIONS

ALT. alanine aminotransferase

AP. or ALKPHOS. alkaline phosphatase

AST. aspartate aminotransferase

BANDS. immature segmented neutrophiles

Basos. basophilic leukocyte

BUN. blood urea nitrogen.

$Ca^{++}$. calcium ion

CK. or CPK. creatine phosphokinase

$Cl^{-}$. chloride ion

Eos. eosinophilic leukocyte

GGT. gama glutamyl transferase

Hb. or HGb. hemoglobin

LDH. lactate dehydrogenase

Lymphs. lymphocytes

MCH. mean corpuscular hemoglobin

MCHC. mean corpuscular hemoglobin concentration

MCV. mean corpuscular volume

Mono. monocyte

PCV. packed cell volume

PLT. platelet

PMN. polymorphonuclear neutrophil leukocyte

$K^+$. potassium ion

RBC. red blood cell

$Na^+$. sodium ion

SEGS. segmented neutrophiles

WBC. white blood cell; white blood cell count

## PHARMACOLOGY ABBREVIATIONS

bid. twice a day

IM. intramuscular

IV. intravenous

PO. by mouth

sid. once a day

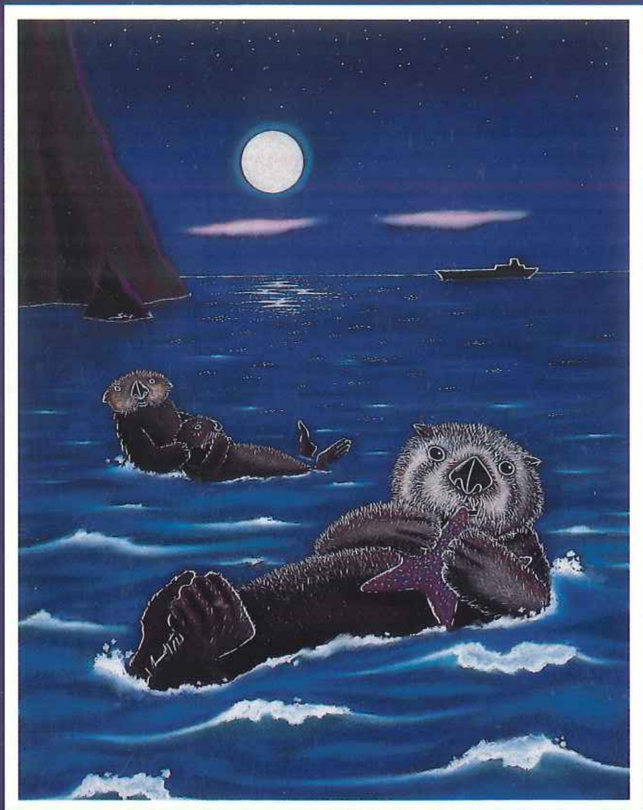
SQ. subcutaneous

## DEFINITION SOURCES:

Barnhart, R. K. 1986. *The American Heritage Dictionary of Science.* Boston: Houghton Mifflin Co.

*Dorland's Illustrated Medical Dictionary.* 1974. Philadelphia: W. B. Saunders Co.

# Index



This book was written by 29 professionals with the often unwilling cooperation of 357 Alaskan sea otters—the most photogenic and probably the most vulnerable of the mammalian victims of the 1989 *Exxon Valdez* oil spill.

Although a handful of earlier studies had shown serious physiological and behavioral changes in otters with oiled fur, researchers and rescuers working with the Prince William Sound sea otters had only a few studies to which to turn. Unfortunately, the sparse existing literature severely underestimated the toxic effects confronting oiled otters and the logistical problems attending attempts at treating them. The workers were unprepared for the variety of medical problems they encountered and for the high death rates among the animals they were trying to save.

Thanks to this book, the next group of workers who will have to deal with marine mammals affected by an oil spill will be better equipped. The book is intended as a practical guide, a compendium of suggestions and experiences to assist future response teams. In fifteen chapters and six appendices, the authors review what previous studies said and what was learned in the aftermath of the spill. Much of the information for both sea otters and harbor seals from the *Exxon Valdez* spill is original data, published here for the first time.

The book covers a broad range of concerns, from how best to capture a sea otter through suggested treatments to considerations governing release of rehabilitated animals. Experts also discuss facility design, volunteer training, and personnel safety issues.

Although its contents are useful for a variety of people from policymakers to veterinarians encountering a single oiled sea mammal in need of care, *Emergency Care and Rehabilitation of Oiled Sea Otters* aims chiefly at helping rehabilitators, representatives of the oil industry, and government agents conduct successful rehabilitation efforts for sea otters.

**About the Editors**

Dr. Terrie M. Williams is currently assistant professor of biology at the University of California, Santa Cruz. She was the director of the Sea Otter Rescue Center and program manager for the sea otter toxicology/histopathology program established in Valdez, Alaska during the aftermath of the *Exxon Valdez* oil spill accident. She is co-director of International Wildlife Research.

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