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Special Topics Issue: Lessons from Rehabilitating Oiled Wildlife

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Features

Cover by George Kimble.

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Editorial . . .

Lessons of the Exxon Valdez Oil Spill

In the pages of this Special Edition *Wildlife Journal* you will find a collection of up-to-date articles on oiled wildlife rehabilitation. We have included general articles on avian nutrition, blood parasites in oiled birds, and captive husbandry galore - and some articles specific to programs developed and research advanced through the rehabilitation program following the 1989 Exxon Valdez spill in Alaska's Prince William Sound. Much was done and learned in Alaska during the 1989 oil spill but most people in the lower 48 are only now beginning to see articles detailing the specifics on the wildlife rehabilitation programs. While many articles have appeared in print which superficially outlined the costs and content of the programs, here you will find articles written by the people who designed and operated them -not those reporters who dropped by for an afternoon and passed judgement on what they saw.

The oil spill in Alaska seems to have acquired a life of its own. While the state and federal governments and Exxon will argue for years on the effects it had and what kind of damage occurred, we wildlife rehabilitators were proud to have had an opportunity to serve wildlife in need. While you had to have lived it to truly understand all the agendas of those people and agencies involved, every effort was made by the rehabilitators to try to save the birds and otters that were affected.

The people who were invited to work, either by the US Fish & Wildlife Service, Alyeska, or Exxon, were wildlife rehabilitators from near and far with a wealth of background in the species they tried to save. For example, Marge Gibson is a wildlife rehabilitator who has for the last twenty years rehabilitated Golden Eagles in southern California. Marge worked on the California Condor Capture Team and has published numerous scientific papers and studies. Dr. James Scott, from Anchorage, Alaska, has rehabilitated Bald Eagles for the last two decades. Randall Davis, Ph.D., and Terrie Williams, Ph.D., are researchers from southern California who have studied the potential effects of oil on Sea Otters for the last ten years. Other professionals, too numerous to name here, came to help the otters from the Monterey Bay Aquarium, California Marine Mammal Center, and Sea World-San Diego. Jay Holcomb and Alice Berkner, from the International Bird Rescue Research Center, Berkeley, California, lead the largest remote-response contractor for the rehabilitation of oiled wildlife in the United States, and each have over twenty years of experience in wildlife rehabilitation with a specific emphasis on oiled avian rehabilitation. They brought with them a whole team of experienced responders from the Pacific states.

You might be wondering why I go into such detail on the wildlife personnel involved: It is because I have gathered from many people across the country that they were under the impression that no real thought was given to who should head up or staff this response. Further, mass media and even some industry reporting to date have only superficially and simplistically summarized what was a massive undertaking by how many animals lived and died and how much it cost to round them up and fly them in from the Alaska wilderness. As a description of this rescue effort, nothing could be further from the truth.

The Exxon Valdez response was unique for many reasons, including the remote site and sheer size of the catastrophe. Out of this tragedy has come a deeper and better understanding of the effects of oil in our environment. More research occurred during this one spill than in all others before it. It is now time for all who were involved to make the knowledge obtained available so others can learn from it -- and for all those who may be involved in future spills, as well as the public, to begin to review the lessons of this single event. No one wants an oil spill—but our job as responders is to lessen the impact on affected wildlife, to prevent suffering wherever we can, and to learn as much as possible so that those impacts can be prevented or mitigated, both currently and in the future.

This *Wildlife Journal*, then, is in part a collection of some of the information that was gleaned caring for the affected animals. We hope that you will gain a deeper understanding of both the magnitude of the effort, and the lessons learned, from the material presented here.

-Jan White-

P.S. IWRC is deeply grateful to Exxon for donating the funds to help produce this issue, which is finally making so much knowledge available to the rehabililtation community. The donation had no strings attached and Exxon played no role in what material we selected to print.

Avian Malaria in Oil Contaminated Common Murres (*Uria aalgae*)

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Introduction

In early February of 1986, an oil spill polluted the waters and beaches of the coast of central California and debilitated or killed an estimated 10,577 birds. (Page *et al.*, 1986). The most likely source of the oil was a tank barge carrying San Joaquin Valley crude oil from Martinez to Long Beach; the oil was assumed to have been spilled between January 29-30, 1986.

The abrupt appearance of large numbers of oiled seabirds washing ashore on beaches from Monterey county to San Mateo county on February 1st was the first sign that an oil spill had occurred. By February 3rd, beaches in San Francisco, Marin, and San Mateo counties had been oiled. Rehabilitation centers received a steady stream of oiled birds from the central California coast until mid-March.

A total of 3,858 birds were received by the rehabilitation centers between February 1 and March 31, 1986; 3,364 were estimated to have entered the centers between February 1 and February 8th, the peak recovery period, and 917 on February 3rd, the peak recovery day.

Of the 3,858 birds sent to rehabilitation centers between February 1 and March 31st., 83.2% were Common Murres (*Uria aalgae*). Common murres accounted for at least 73% of the identified birds collected, and 87.7% of the identified birds received by the centers during the peak recovery period. Aerial surveys to measure the number and distribution of birds at risk determined that the greatest concentration of murres occurred off Pescadero near the Farrallon Islands (Page *et al.*, 1986).

Birds were recovered from the beaches by large scale rescue efforts on the part of the government agencies, private organizations, and private citizens. Collection centers were set up near beaches to handle birds which were subsequently transported to rehabilitation centers.

Tallies of birds taken from collection sites to rehabilitation centers were used to estimate the number of live birds coming ashore; however, not all collection centers kept complete records on the birds they received. Many collection sites were overwhelmed, and large numbers of birds were either unidentified or uncounted. Some birds bypassed the collection sites altogether, going directly to rehabilitation centers. Rehabilitation centers usually made an accession record only for each group of birds they received, although some did maintain individual records. Because of the overwhelming number of birds and the disparity in record-keeping, estimates of the numbers of birds received were probably low (Page *et al.*, 1986).

Data recorded on group accessions included some or all of the following information: number of birds of each species and location from which the birds were received. Centers maintaining individual bird records kept information such as: submitter; identification number; cleaning necessary or completed; transfers to other centers; final status (died or released).

Rehabilitation techniques were similar. Some birds were given immediate care at the collection sites; this consisted of cleaning the eyes, nares, and mouth of oil, and sometimes stomach tubing with re-hydrating solution. Birds showing signs of oil toxicity (depression, ataxia, diarrhea) were wrapped in rags in an effort to prevent them from preening and ingesting more oil.

At the rehabilitation centers, the birds were examined to determine the extent of their oiling, whether they were showing signs of oil toxicity, and whether any external injuries were evident. Some centers also recorded weights and temperatures. The birds were then given an oral re-hydrating solution.

Birds showing signs of oil toxicity were cleaned immediately, but the rest were first penned by species, hydrated, and fed. Oil was removed from the plumage of a bird by washing it in a series of detergent baths (Williams *et al.*, 1978). After cleaning, the birds were re-hydrated and provided with heat, food, and water. Those in good condition were put in large pools together, and their ability to maintain buoyancy in water was monitored. When they appeared to have recovered, they were banded and released.

Rehabilitation success varied widely between centers, ranging from highs of 85-90% to lows of 30-35%. Of the 3,858 birds received between February 1 and March 31, 1986, 52% were cleaned and released. Criteria chosen for euthanizing and releasing birds also varied. When banded birds began reappearing on beaches, the centers began using stricter release criteria, usually based on body weight or blood parameters. Some centers began holding birds for long periods to determine if they were "fully" recovered. There were no studies done to determine the survival rate of released birds.

During February, 1986, veterinary students from the University of California at Davis, collected duplicate blood samples from the 632 birds at the time of admission to the rehabilitation centers. The packed cell volume (PCV) and plasma protein (P.P.) concentration of each bird was also recorded. One set of slides was used by the author to determine the prevalence of avian malaria in the oil-exposed birds. The information generated, together with that available for PCV and P.P. concentrations, was statistically analyzed in order to determine the effect of exposure to oil on avian malaria infections.

Materials and Methods

Blood smears were air dried and fixed in 95% methanol, then stained with a 2% Giesma stain. The stain was made by using 2 ml of undiluted Azure B Type Giesma stain (Fisher Scientific) and 98 ml of phosphate buffered (pH 7.0) distilled water. The phosphate buffer was prepared as described by Paik and Suggs in *Manual of Clinical Microbiology* (1978). Fresh stain was made daily. The slides were covered with the stain for 30 minutes, and then rinsed with buffered (pH 7.0) distilled water and air dried.

Each smear was examined under oil immersion (1000x) objective until a total of 60,000 red blood cells were counted. The number of fields counted varied with the number of cells/field. Parasites were recorded as the number of malaria parasites/60,000 RBC's. This count was later converted to a standard red blood cell (STDRBC) value, which is the percent of red blood cells (RBCs) parasitized, reported as a decimal.

Malaria parasites were identified with the aid of illustrations provided in *Bird Malaria* (Hewitt, 1940) and *Malaria Parasites and Other Haemosporida* (Garnham and Swinehart, 1966). An attempt was also made to visually determine the species of malaria.

A total of 347 slides were examined. Twenty-one were duplicates, and 36 were of too poor quality to be examined, leaving a total of 290 smears. Of these, 256 or 88.3%, were from Common Murres *(Uria aalgae)*. Other species represented were: loons (unknown species), 18; Red-throated loon (*Gavia stellata*), 1; grebes (unknown species), 5; Western Grebe (*Aechmophorus occidentalis*), 10.

Since common murres comprised both the majority of birds entering the rehabilitation centers, and species from whom slides were read, analyses were performed only on murre data.

The murres were divided into groups by malaria status (positive or negative) and by the date that they entered the rehabilitation centers and were bled. All birds bled between February 8 (the earliest entry) and February 12 were considered to be "early" samples, while those bled between February 13 and February 16 (the latest entry) were designated "late" samples. This labeling refers to the time elapsed from the oil spill to the time at which the birds were sampled, or more specifically, the length of exposure to oil. Since the birds in the "early" category were actually sampled on either February 8 or 9, and those in the "late" category on February 15 or 16, February 12 was chosen as an arbitrary cut point for the analysis.

A chi-square was used to test whether there was a significant difference in infection rates by date. A two-way analysis of variance (ANOVA) (Zar, 1984) was conducted to determine whether either packed cell volume or plasma protein concentrations were affected by malarial parasitism (group), length of exposure to oil (date), or an interaction of the two.

The effect of the level of infection (STDRBC) on the red blood cell count (PCV) and plasma protein concentrations (P.P.) was evaluated using correlation analysis. Analysis of variance was also used to test whether there was an effect of length of exposure to oil (date) on the level of infection (STDRBC) noted in the birds. Effects were considered statistically significant with $P < .05$.

Results

Of the 256 common murre slides examined, 22 (8.59%) were positive for malaria. Nine (8.57%) of the 105 "early" birds were infected. There was no significant difference (P=.992) in infection rates by date. Due to the age and thickness of the smears, and the lack of multiple smears, and the lack of multiple smears which might have shown a greater variety of life stages, definitive speciation of the parasites was impossible. Dr. Charles Van Riper, Department of Wildlife and Fisheries, University of California, Davis was kind enough to review a few of the slides and made a tentative identification of *Plasmodium circumflexum.*

In the malaria-positive birds, the mean level of parasitemia (mean STDRBC) was .00177, or .18%. No significant correlation was found between PCV and STDRBC (r= -0.175; P= .450) or P.P. and STDRBC (r= -0.048; P= .840). No significant difference (P= .305) between dates was found for parasitemia levels (STDRBC).

The mean packed cell volume (PCV) for the common murres in this study was 37.54%. Infected murres (Group 1) had a mean PCV of 37.32%, while that of non-infected birds (Group 2) was 37.56%. No significant difference (ANOVA, P= .999) between groups was found for PCV. The mean PCV of murres (both positive and negative) arriving earlier (February 8-12) was slightly lower (37.00%) than the PCV of those arriving later (February 12-16; 37.92%), but the difference in PCV by date was not significant (P= .932). There was also no significant (ANOVA, P= .543) interaction between date and group for PCV.

The mean plasma protein (P.P.) concentration for all murres was 4.76 gm/dl. The mean plasma protein concentrations of infected birds was 4.42 gm/dl, and that of non-infected birds was 4.79 gm/dl; this difference was not significant (P= .081). The mean P.P. concentration of "early" murres was 3.83 gm/dl, while that of "late" murres was 5.46 gm/dl; this difference was significant (P=.0001). There was no significant interaction (p=.553) between the group and date effects for the plasma protein concentration data.

Discussion

Historical studies of malarial infections in seabirds are based on single blood film surveys. The present study utilized the same method of detection, due to the limited number of slides available from the murres. Because of the cyclical presence of the malarial parasite in the blood, a single blood smear survey can miss many infected birds. Herman *et al.* (1954) determined from a time course analysis of blood smears prepared at periodic intervals after malarial infection that parasites were often evident in the peripheral circulation for only about 24 hours. Herman (1968) also reported that subinoculation of blood from wild birds into susceptible captive hosts has revealed a prevalence of greater than 60% for *Plasmodium* in situations where microscopic examination of single peripheral blood smears yielded less than 1%. Thus, comparison of estimates of prevalence derived from single blood film surveys is risky. We would have a better idea of the true prevalence of avian malaria infections if slides were sequentially collected, or, better still, if a subinoculation technique was utilized.

The average parasitemia level (.18%) of malaria in the murres is comparable to that reported for malaria in sparrows (<1.0%) by Gongolein and Freier (1986), and for that found in selected Hawaiian bird species (.023%) by Van Riper *et al.* (1986). Both studies also used single blood film surveys. The level of parasitemia did not vary by date, suggesting either that length of exposure does not affect the ultimate level of the parasitemia that develops, or that the difference in exposure levels in these birds was too short to affect parasitemia levels.

The mean packed cell volume (37.54%) for the common murres in this study is considered a moderate reduction from the normal PCV of 50-55% listed by Bradley and Threlfall (1974). Fry (pers. comm., 1987) reported that the PCV's of 5 non-oiled murres from the Farallons ranged from 42-50%, but cautioned that the samples were collected at the end of the breeding season and the values might have been affected by recent reproductive efforts.

Ingestion of crude oil is known to cause red blood cell hemolysis. Fry and Addiego (1987) reported that common murres involved in the 1986 and a previous (1984) oil spill had mild to severe anemias. The average PCV of the 1986 oil-exposed murres was 37.7%, or 25-30% below normal. Red blood cells from both groups of birds contained

Heinz bodies which were very similar to petroleum-induced Heinz bodies seen in other species of marine birds (Leighton *et al.*, 1983; Leighton, 1985). Data suggests that ingested oil causes toxic oxidative changes in red blood cells, resulting in a hemolytic crisis and precipitates of hemoglobin oxidized in the protein moiety (Heinz bodies) (Leighton *et al.*, 1983; Leighton, 1985; Leighton, 1986; Fry and Lowenstine, 1985).

Fry and Addiego (1987) reported that oiled birds remained anemic until the rehabilitation centers were able to wash off all the oil. Two local veterinarians (Drs. Gary Blake, Crossroads Veterinary Clinic, and Michael Murray, Coast Veterinary Hospital), with the cooperation of the Monterey SPCA, monitored the progress of 9 common murres rescued during the 1986 oil spill. Four of the birds were severely anemic (PCV < 30%) at admission; they required more than 30 days to reach normal PCVs.

The slow regenerative response to the anemia caused the birds to be held for longer periods of time before being released as preliminary data indicated that birds released with PCVs less than 40% came back to the beaches soon after release. The minimum packed cell volume necessary to support these birds in the wild is not known. Since they are diving birds, they are especially sensitive to the oxygen- carrying capacity of the blood. Unfortunately, prolonged stays at rehabilitation centers increased the chances that the birds would come down with secondary infections. Because the PCV of the murres in this study was not influenced by the presence (or level) of infection with malaria, length of exposure, and/or interaction of the two, it appears that the anemia is predominantly a result of oil toxicity, and not exposure to, or infection by, malaria.

Of the 9 murres monitored by Drs. Blake and Murray, plasma protein concentrations were initially greater than 5.0 gm/dl and remained so for more than 4 weeks of captivity. Although little data is available concerning the normal P.P. concentrations of common murres, Fry (pers. comm., 1987) reported that the average P.P. concentration of 5 non-oiled murres from the Farallons was 3.4 gm/dl. This would suggest that the P.P. concentrations in the oiled murres was elevated.

Increases in P.P. concentration in the 9 murres monitored by Drs. Blake and Murray were originally thought to be due to dehydration, but hydration did not alter the P.P. levels. Quantitative changes in plasma protein synthesis in response to inflammation or infection might also elevate P.P. concentrations (Schreiber, 1987). Initial elevation in P.P.s could be due to inflammation, and the sustained elevation due to the development of secondary infections acquired while in captivity. Aspergillosis and bacterial infections of the epidermis and joint areas of the legs and feet were common in murres kept for prolonged periods in captivity (Fry and Addiego, 1987). Plasma protein analysis indicated that oiled murres lacked a prealbumin region, and had variable, marked elevations of alpha, beta, and gamma globulin proteins compared to un-oiled murres.

In this study the P.P. concentrations did not vary with malaria infection status, but with the length of exposure. The P.P. concentrations of "early" (3.83 gm/dl) murres was significantly lower than that of "late" (5.46 gm/dl) murres. "Early" murres had P.P. concentrations similar to those of non-oiled murres reported by Fry (pers. comm., 1987). If birds entering the rehabilitation centers later had elevated P.P. concentrations, it might be attributed to the development of an inflammatory or immune response; however, without more data on normal hematological parameters, one can only speculate.

The prevalence of avian malaria in the murres in this study (8.3%) is comparable to prevalences found in surveys of other California or West Coast bird species. Van Riper *et al.* (1986) reported the prevalence of avian malaria in selected Hawaiian bird species to be 7.8%; Rock (1984), in a limited survey of various avian species admitted to a wildlife center in Solano County, California, found the overall prevalence of malarial infection to be 7.8%. Herman *et al.* (1954) found that infection rates of house sparrows *(Passer domesticus)* in Kern County, California, varied by year and by habitat. House sparrows from rural areas had infection rates as high as 40%, while birds from urban areas averaged 2-3%.

From what little information is available concerning the prevalence of avian malaria in common murres, this level of infection seems high. Many of the California and West Coast birds live in areas with excellent breeding habitat for the mosquito vector. The murres, however, live and breed on rocky islets and seagirt cliffs, and only recently have extended their distributional range inland. Bennett (pers. comm., 1987) found that seabirds do not usually have blood parasites; examination of blood smears from 500 alcids and 150 sea-going ducks inhabiting northeastern North America and Scotland revealed no blood parasites. Even shorebirds tend to have very low prevalences, often between 2-5%, of blood parasites (Bennett *et al.*, 1982).

Greiner *et al.* (1975) in a comprehensive survey of blood parasites of North American birds, also found that sea and shore birds were nearly hematozoan free. Literature reports compiled on hematozoan infections in a total of 116 common murres revealed none of the birds was infected; indeed, none of the species in the family *Alcidae* harbored hematozoa.

If the level of infection in these murres is indeed high, it may result from one or more of the complications associated with the oil spill, i.e. increased exposure to the vector while beached, increased susceptibility to disease through starvation or dehydration, or perhaps a more specific action of oil on the permeability of the red blood cell membrane itself, increasing the parasite's ability to invade. Pre-existing latent infections being activated by exposure to oil is also possible. Previous research indicates that the length of time the birds were exposed to the vector is adequate for infection to be established. In canaries, the incubation period for *Plasmodium circumflexum* is approximately 7-8 days. The acute clinical infection, and its associated cyclical parasitemia, can last up to 7-8 days (Manwell, 1934).

Ingestion of crude oil is known to cause stress-related lesions. The stress-related lesions include lymphocytic depletion in the primary lymphoid tissues, an increase in the heterophil: lymphocyte ratio in the peripheral blood, lipid depletion and necrosis in adrenal steroidogenic cells, and an increased prevalence and severity of virus-associated lesions in the Bursa of Fabricius (Leighton, 1986). Petroleum-oiled birds show significantly elevated levels of hepatic mixed-function oxidase (MFO) activity, a group of enzymes known to metabolize xenobiotic as well as endogenous steroid hormones (Ratner *et al.*, 1984). Rocke *et al.* (1984) found that mallards ingesting crude oil, had a significant decrease in resistance to *Pasteurella multocida* which appeared to be due to changes in cell mediated responses. These oil induced changes may also affect susceptibility to malarial invasion by altering the host's immune response to the organisms.

Experimental work also suggests that exposure to oil may increase the potential for invasion by its direct effects on the red blood cell membrane. Breuer (1985) reported that gradual, mild hemolysis by dialysis against hypotonic media that contains Mg_2^+ and ATP results in fully invadeable red blood cells. Increased numbers of immature RBCs seen with a response to hemolytic blood loss would also increase the opportunity for malarial invasion as malaria is known to preferentially attack young cells. (Hegner and Eskridge, 1938; Hewitt, 1940; Laird and Lari, 1958). Once established, the malarial infection could exacerbate or prolong the anemia seen in oiled birds.

Other effects of oil include hepatocellular dissociation and hemosiderosis, and renal tubular necrosis (Fry and Lowenstine, 1985). Such damage may be compounded by the effects of malarial infection, which can also cause hepatic lesions and hemosiderosis (Garnham and Swinehart, 1966).

Conclusion

The prevalence of avian malaria in the oiled murres in this study is higher than that reported by other authors. What caused this apparent increase is unknown. Possible explanations include increased exposure to the vector while the birds were beached, increased susceptibility to disease through starvation or dehydration, and direct actions of oil on the permeability of the red blood cell membrane. It is also possible that the birds had pre-existing infections which became active at the time of exposure to oil.

Infection with malaria did not appear to affect the plasma protein concentrations, but length of exposure after oiling did. Birds entering the rehabilitation centers later had elevated P.P. concentrations, which may be associated with the development of an inflammatory or immune response.

Although the murres were anemic, it appears from this study that for at least a few weeks after oiling, the anemia was predominantly a result of oil toxicity, and not infection by malaria. Whether the malaria infections would have posed a greater problem as the birds began to recuperate from the effects of oiling is uncertain. If infection with malaria prolongs the regeneration of the red blood cell mass, or exacerbates other effects of oiling, then birds would have to be kept longer. This increases the chances they will develop aspergillosis or secondary physical lesions, which are reported to be the greatest impediments to successful long-term rehabilitation and release. Hemoprotozoal infections are known to lengthen rehabilitation time and increase mortality rates of raptors (Olsen and Gaunt, 1985). Unfortunately, there is no data to indicate whether infection with avian malaria prolonged or prevented recovery of these murres, or was associated with any post-release mortality.

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Rehabilitation Notes:

Sea Otter Pups (*Enhydra lutris*)

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Introduction

Sea otters are the largest Mustelid (related to the skunk, ferret and river otter) and the smallest marine mammal in North America. Once hunted to near extinction in the late 1800's for their dense pelts, they have been protected since 1911 by the North Pacific Fur Seal Convention and have successfully recovered to repopulate large areas of the coast of Alaska and the Soviet Union and some of their former habitat along the California shore. Sea otters are naturally gregarious animals and may occasionally be seen in large "rafts" of up to one hundred or more animals floating offshore or feeding in kelp beds. They appear intelligent and curious, using rocks as tools to break large shells while feeding. Sea otters are not as shy as their cousins, the river otters, and often will freely approach boats and entertain fisherman and sightseers with their playful antics.

Sea otters have few natural enemies other than man but their populations are constantly stressed by weather, wind and sea conditions, and, in some areas, by intense competition for food. Juveniles and aged otters frequently have dental problems which result in difficulty foraging. Injuries from fighting, parasites, and secondary infections also cause natural mortality. Encounters with man occur when fishermen compete with wild otter populations for shellfish such as abalone, crab and sea urchins or when marine oil spills foul the otter's fur and contaminate its food. Young otters may become separated from their mothers and be found "beached" after severe storms or when the female has been injured or otherwise unable to care for her pup.

Description

• Adult

Males may reach lengths (tip of nose to end of tail) of 145 cm and weights of up to 45 kg (100lb), while females can measure up to 139 cm and 32.5 kg (72 lb) (and occasionally more with full term pregnancy).

The body is somewhat cigar-shaped and covered with dense dark to light brown fur; the face and neck become grey with age. They have loose skin, very little body fat, and no scent glands. The forepaws are heavily padded and extremely dexterous, with short thick claws for digging and capturing prey. Rear toes are elongated and fully webbed to form flippers efficient for swimming below and on the surface of the water. The thick, flattened tail serves for propulsion and as a rudder. A loose fold of skin in axilla ("arm pits") forms a pouch for carrying food and rocks used

Alaskan Sea Otter Pup at Sea World's Animal Care Facility Photo: Jerry Roberts in eating. Flattened ears. Well developed sense of hearing and smell with eyes adapted for keen vision in and out of water (TD Williams, 1990). High metabolic rate requires food intake of 20 to 35% of body weight daily (Kenyon,1969; Costa, 1978). Normal body temperature is 36.7 to 38.1° C (99 to 101°F).

•*Pelage*--Tapering guard hair surrounded by fine underfur with extreme density (ave. 140,000 hairs per sq. cm). Density of fur plus constant grooming results in a pelt with a waterproof air layer held against the skin. This "dry suit" insulates the otter from its frigid aquatic environment and is essential for the otter's survival. Soiling with fecal or food material, or pollutants such as crude oil causes the fur to matt and lose up to 70% of its insulating properties (Davis *et al*, 1988).

•*Life Cycle*--Breeding and pupping year round with increased seasonal activity. Gestation 4 to 7 months (delayed implantation of fertilized embryo tends to concentrate delivery of pups in late spring and early summer in most areas). Single pup completely dependent on mother until 6 to 8 months of age. Slowly maturing with successful reproduction often delayed until 4 (female) to 6 (male) years of age. Life expectancy up to 20 years in captivity. High mortality in first 1 to 1 1/2 years of life in natural habitat.

•*Social Structure*--Frequently seen foraging singly or in mother/pup pairs. Females and pups tend to congregate ("raft") in favorable feeding areas. Juvenile males form loose groups in separate areas. Breeding males establish territories adjacent to females and bond for short periods of courtship and mating (1 to 4 days). Individual otters may travel up to 50 km or more a day to new areas.

•*Habitat*--Coastal areas along the northern Pacific Ocean, especially shallow water (less than 50 fathoms) where various prey species abound and in offshore kelp beds. May be seen resting on beaches, sandbars and shore rocks ("hauled out").

Natural Diet

•Wide variety of bivalves, invertebrates and fishes (Table 1) depending on location and season (Calkins, 1978; Estes, 1981). Smaller prey are eaten along with their exoskeleton but larger clam shells are broken by pounding against a flat rock balanced on the otter's chest while it feeds. Otters will dive for up to 2 minutes gathering food in their underarm pouches, then surface to float on their backs while they wash, sort and ingest their catch.

•Teeth are adapted for crushing and cleaning shellfish with heavy flat molars and rounded canines also capable of inflicting severe bites when threatened. Sea water taken in with food, preformed water in food, and metabolic water are principal sources of fluids but otters will drink from fresh water sources and chew up blocks of ice when available.

•Dental formula — I 2/3 C 1/1 PM 3/3 M 1/2.

Birth and Care of Young

•Newborn sea otters weigh 4 to 5 1/2 lbs. and are almost completely helpless. They are born with their eyes open and deciduous canine teeth fully erupted but are unable to groom or swim for their first 3 to 4 weeks. Pups frequently die of drowning or hypothermia when lost or inadequately cared for. They suckle milk from two nipples located on the lower abdomen of the female otter and eventually feed (as their deciduous teeth continue to develop) on small bits of food offered by the mother.

•The female floats on her back grooming the pup and allowing it to feed and sleep on her upturned chest and abdomen. Periodically, she allows the pup to float on the water surface or places it in a safe haulout area while she forages and grooms her own fur, then returns to retrieve the pup and begins the cycle of grooming, sleeping, and feeding over again. Pups over 8 weeks of age spend increasing periods of time floating or swimming in the water near their mothers, but continue to remain completely dependent on them for protection and for the majority of their food and grooming until they are 6 to 8 months of age. Juvenile otters frequently remain with their mothers until they are over one year old.

Rehabilitation Considerations

•Orphaned sea otter pups may be encountered when separated from their mothers by illness or accident, after violent storms or due to lack of maternal experience or interference from males attempting to breed. Pups may also be left on the beach or in kelp beds while the mother feeds. Careful observation should be made from a distance for several hours before assuming a pup has been abandoned.

•All sea otters are protected by the Marine Mammal Protection Act of 1972 and they are listed as an endangered species in California. Approval and appropriate permits must be obtained from the United States Fish and Wildlife Service (USFWS) and (where applicable) from the California Department of Fish and Game *prior* to any attempt to capture or handle *any* sea otter. Violations may be prosecuted and are punishable by fines of up to $20,000.00 and imprisonment for 6-12 months in cases of criminal intent and by fines of up to $10,000.00 in civil penalties.

•Sea Otters have very specific and essential requirements (Marine Mammal Regulations, 1979) for food and housing and they are extremely labor-intensive and expensive to rehabilitate. Pups and dependent juveniles which are raised by humans can lack skills to survive in the wild and must be placed in a specialized rehabilitation program or permanently placed in one of a handful of adequately equipped seaquaria under the direction of the USFWS. In the author's experience, even adult sea otters are at risk after release because of difficulties establishing resident territories and locating food, and because of their learned association of man with food.

Sea Otter Pup Nursery

Techniques for raising sea otter pups were originally developed by Julie Hymer and Tom Williams at Monterey Bay Aquarium. These procedures were modified in the nurseries at the Sea Otter Rehabilitation Centers in Alaska in the summer of 1989.

•Upon arrival, pups should be given a brief examination to determine body temperature, weight and general condition including an estimate of age, nutritional state, hydration and evidence of disease or injury. Pups are then stabilized as necessary and special attention given to the following priorities (in order of importance).

•*Body temperature*--Otter pups are extremely thermolabile and their body temperature may rapidly move above or below the normal limits (99-101°F). The otter nursery should be well ventilated and room temperature kept at approximately 65°F. Body temperatures should be closely monitored, as the pups may easily become hypo- or hyperthermic.

Conversely, chilling occurs when the pup's fur becomes waterlogged due to poor grooming or when starvation or illness severely debilitate young otters. Pups with temperatures below 98°F must be gradually rewarmed and dried by rubbing with towels. Hand-held hair dryers set at room temperature may be used with caution. In severe cases, warmed intravenous fluids may be given or pups may be placed on slightly warmed (103-104°F) water bottles.

Physical activity combined with the insulation of their dense fur and their high metabolic rate can result in overheating, especially if pups are "cuddled" or held for more than a few minutes. An unheated waterbed, plastic bag filled with chipped ice or snow, or even slightly chilled IV fluid bags can be used to provide a cool, pliable bed on which the pups can play and sleep.

Extremely high body emperatures (greater than 104°F) should be treated immediately by immersing the pup in cool water (60 to 65°F) or by applying ice to the neck and flippers.

•*Hydration*— Sea Otter pups require large volumes of fluid intake. Oral supplementation with a balanced electrolyte solution (Pedialyte™ or Lactated Ringer's Solution (LRS) — 10 ml/lb.) may be given initially and then alternated with formula feedings every two hours. LRS may be administered subcutaneously or intraperitoneally by qualified personnel two or three times daily. These supplements may need to be continued for pups up to 3 to 4 weeks of age. Older pups will drink fresh water running from a hose or faucet. Ice cubes and "snowcones" (crushed ice mixed with clam juice or glucose solutions) are often accepted as additional oral fluid when needed.

•*Nutrition*—Pups are fed a high quality seafood-based diet designed to provide 25 to 35% of their body weight daily in divided feedings. Newborns and pups up to 8 lb. (3 to 4 weeks of age) are given formula (Table 2) every 2 hours around the clock via stomach tube or feeding from the end of a 6 cc plastic syringe. By 5 to 6 weeks of age, most pups will begin eating small pieces of clam or other soft seafood. The amount of solid food is gradually increased while formula feedings continue at a reduced rate (every 3-4 hours depending on the pup's weight gain and activity). Most pups can be weaned to a completely solid food diet by 4 months of age (approximately 12 to 15 lbs.) although they still may have difficulty removing hard shells from crabs and clams. Formula supplementation should be continued if weight gain is not adequate.

•*Grooming*—The Sea Otter pup does not master instinctive grooming skills until it has "practiced" for 4 to 6 months. Nursery attendants must spend several hours each day grooming the pup's fur to maintain the natural loft and waterproof quality. The pup must be frequently rinsed in clean sea water to remove food particles, urine and fecal remnants. After each bath or after swimming, the coat must be thoroughly dried using towels and soft combs to blot and fluff the fur. This process requires up to 1 1/2 hours before, during and after each feeding to insure that the pup remains waterproof and does not chill during sleep.

Nursery Routine

Otter pups generally require a minimum of two attendants working in overlapping 12 1/2 to 13 hour shifts. The "ideal" schedule should include:

1. Prepare and refrigerate formula for next 12 hours.

2. Exchange information

with previous attendant regarding current status, activities or problems.

3. Warm individual feedings in warm water bath (microwave may inadvertently overheat meals, causing burns).

4. Check rectal temperature of young or debilitated pups prior to each feeding. Stable pups over 6 weeks may be checked at beginning of each shift.

5. Weigh pup at least once daily, preferably with scale accurate to one gram. Compare with previous weights, and adjust food and fluid amounts (feed more or more often if pup is not gaining steadily).

6. When pup wakes for next feeding, it should first be bathed in clean water at room temperature (60-65°F). Bathing usually stimulates urination and bowel movement, which can then be rinsed away.

7. Towel dry by rubbing and blotting fur.

8. Feed, keeping pup on its stomach in natural position. Older pups are offered bits of solid food first until it is refused, then formula is fed to achieve total required intake:

Body weight x 30%/divided by the number of feedings daily = amount (in g. or oz.) per feeding.

9. Rinse again to remove food debris. Pups should be allowed to float or swim in clean sea water for short periods but should be removed from water if they become tired or start to wet through to the skin.

10. Thoroughly dry and groom, starting with towel drying (above),then comb and separate hairs until all dampness is removed. A small hair dryer or fan set at low speed with no heat may spreed this process. Avoid overheating the pup with warm air or by holding it for more than a few minutes.

11. Play period (on unheated waterbed). At 3-4 weeks the pup will begin to manipulate shells, rocks and toys, and rub the fur on its chest in early grooming behavior.

12. Sleep period on waterbed or similar cool, pliable surface padded with clean dry towels to absorb additional urine or feces.

Depending on the age of the pups and the proportions of play and sleep time, this cycle is repeated every 2 to 4 hours around the clock until the pup reaches the juvenile stage (3 to 4 months of age). Pups may then take larger feedings during the day and an overnight rest period is provided from late evening until the following morning.

Skill Development

Newborn pups will float in water on their backs for short periods as long as their fur remains waterproofed. They may cry frequently, apparently in an attempt to maintain contact with their mother who would normally remain feeding nearby. At 3 to 5 weeks of age, pups will begin swimming attempts and should be introduced to a small pool filled with clean sea water up to 6 to 12" deep (a child's plastic wading pool works well). Shells, rocks and other toys placed in the bottom of the pool will encourage pups to dive and instinctive foraging behaviors can be reinforced. Toys and ice cubes should also be provided during play periods on the waterbed as soon as pups show any interest in them.

Interaction with other pups (bonding) appears beneficial in learning normal behavior when two or more pups are in the nursery at the same time. However, very young pups may attempt to suckle each other. This should be discouraged as the fur can become damaged when constantly damp from such behavior.

Juvenile pups (3 to 6 months of age) can be allowed to swim for long periods in outdoor pools equipped with accessible haul-out platforms. These pools should be at least 2 feet deep and provided with a continuous flow of clean sea water. Food should be placed in the bottom of the pools to teach pups to dive and carry food to the surface to eat. Adult pelage is usually developed by 13 weeks of age. At this stage, pups should be observed and assisted as necessary while they perfect grooming skills. Body weight should continue to be monitored closely. Once juveniles are able to maintain their own coat in good condition, and when body weight gain is adequate, they may be moved to a permanent care facility.

Sanitation and Health Monitoring

A clean environment is vital to avoid introduction of illness (Howard, 1983) and to maintain coat condition. Swimming and bathing water should be changed with each use. Sea water obtained from a pollution free source is preferable but fresh water can be used temporarily as long as it is unchlorinated. Tubs, beds, towels, toys and feeding utensils must be cleaned, disinfected with dilute chlorine bleach or chlorhexadine (Nolvasan Solution™), then thoroughly rinsed after each use. Only fresh frozen, good quality seafood should be used and it must be kept cool while thawing. Freezing of food items is thought to reduce possible transmission of parasites (Sweeny, 1965). Prepared formula must be refrigerated until use, and leftovers discarded after 24 hours, to avoid introduction of food-born bacterial infections.

Nursery personnel should wear freshly laundered clothing, wash hands and use disinfectant boot baths or a separate pair of shoes inside the nursery area.

Visitors should be kept to a minimum to prevent additional stress to the pups and to guard against disease transmission.

No information is available on the susceptibility of sea otters to common domestic animal diseases, but other members of the Mustelid family have been infected with canine distemper virus, feline panleukopenia virus, toxoplasmosis, leptospirosis and rabies (Fowler, 1978). Therefore, both direct and indirect contact with dogs and cats should be strictly avoided.

Meticulous record keeping is important. Pup weights, amounts and times of feedings, frequency and consistency of bowel movements, general indications of activity, and specific notations of any problems or medical treatments are necessary to monitor the progress of individual animals and to verify the efficacy of nursery procedures.

Diarrhea is common in Sea Otter pups and may result from rapid changes in diet or other stresses. Severe cases may result in dehydration and death. Low blood sugar may cause seizures in pups with digestive problems or inadequate food intake. Skin rashes and hair loss may be seen with improper bathing. Chilling or overheating are constant risks until pups are old enough to groom themselves and be left with constant access to pool water.

Release

Attempts have been made to train pups raised at the Monterey Bay Aquarium for wild release and to date they have been successful in 7 of 13 releases (Julie Hymer, pers. com.). One additional Sea Otter pup was determined as unsuitable for release and was transferred into permanent care. This particular program is quite extensive and involves surrogate mothering on a 24 hour basis. Pups swim in large tanks and learn foraging behavior from about 1 week after their arrival (once their health is stabilized) until they are about 3 months of age. Then, they are taken outside the aquarium and allowed to swim in tide pools with the surrogate mothers (2 per animal working 12 hour shifts) who watch and attempt to teach foraging behavior from the water or nearby rocks. Sea Otter pups are taught to sleep and feed in the tidal areas. Human contact is reduced as the pup reaches 6 to 8 months of age by allowing the pup to spend several months of swimming time in pools with less and less and finally no human contact. During the last month, only live food is fed. Release follows at the age of 8 or 9 months.

All otters are implanted with telemetry devices (good for about 2 years), flipper tags, and transponder chips and released near the Monterey Aquarium. For the first two weeks following release, animals are tracked and observed intensively. During the next two years, the otters are tracked regularly (i.e., weekly). Tags provide further follow-up capability after the life of the radio transmitters.

Since 1988, 14 young Sea Otters have undergone rehabilitation at Monterey Bay Aquarium. Thirteen were released. Of those, 9 entered the program at the age of 12 weeks or less. From this group three have been tracked post-release and are known to have survived, two are missing, two are known dead, and one was released and recaptured as a failure. In that same period, five juveniles (12 weeks to 52 weeks) were rehabilitated and four of those are known to have survived, with one missing at this time.

There have been several reports of older females adopting dependent pups in captive situations, but these bonds were apparently broken and the pups abandoned in times of stress (Kenyon, 1969; Michaelson, 1990; Monnett, 1990).

Pups generally must be transported from the temporary care facility to either permanent placement or to an on-going rehabilitation program such as the one at Monterey Bay Aquarium. Prior to transport, pups must have normal coat condition, adequate weight gain and no serious health problems. They should travel with a trained attendant who is familiar to the pup, and with sufficient equipment to insure that overheating or chilling will not occur. Beds of chipped or block ice on top of a wire floor inside a standard plastic pet cage will provide cooling without soaking the fur. Ice cubes and toys to chew and manipulate, clean towels, grooming supplies, a cooler filled with ice and prepared food or formula, and spray bottles of water for cleaning the fur and misting the flippers are additional requirements. Veterinary inspection and a health certificate may be required along with copies of appropriate permits from USFWS.

Pups and younger juveniles tend to "bond" strongly with their human caretakers and will seek attention and food from people as they would from their mother and other adult otters in the wild. Breaking this bond is difficult both for the caretaker and for the otter. Proper socialization with other otters is preferable for the development of sea otter pups; therefore movement to a long-term facility should be undertaken as soon as possible after the pup is stabilized.

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TABLE 1 Food Items of Wild Sea Otters

abalone	sea urchins
octopi	gaper clams
annelids	spiny lobsters
pismo clams	horse clams
cockles	squid
rock crabs	kelp crabs
barnacles	turban snails
razor clams	limpets
butter clams	tunicates
rock scallops	mussels
chitons	Washington clams
soft shelled crabs	bottom fishes
Dungeness crab	salmon
sea stars	black cod
littleneck clams	kelp species

(Williams, 1990)

TABLE 2 Sea Otter Pup Formula

4 oz. finely chopped clams (geoduck fillets)
4 oz. squid (skin, cuttle, guts and ink sac removed)
100 ml. dextrose 5% in water.
100 ml. Lactated Ringer's solution
200 ml. whipping cream
2 ml. HiVite
1 tsp. dicalcium phosphate
2 ml. cod liver oil
1 tsp. bran

Blend thoroughly, adding chopped squid and fluids first, then cream and clams. Mix fresh daily and keep refrigerated at all times.

[From Julie Hymer (Monterey Bay Aquarium) as modified at the Seward Otter Rehabilitation Center, 1989.]

New Advances in Captive Housing for Common Murres *(Uria aalgae)*

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Introduction

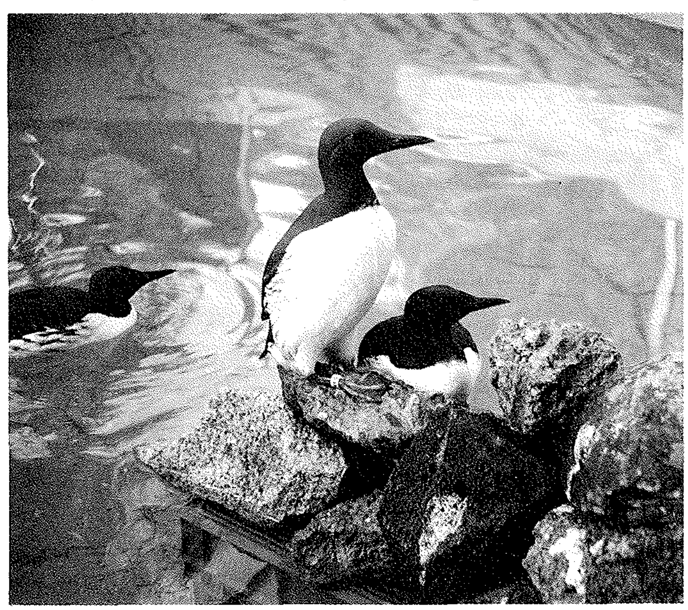
One of the greatest challenges of keeping wild animals in captivity is finding substrate that is conducive to their continuing health. Wild birds that need to be held for long periods of time (i.e., 3 weeks or longer) can succumb to secondary infections and injury as a result of poor housing. Therefore, proper housing can mean the difference between release back to the wild or death in captivity. Reviewing the natural history of the animal is crucial in determining appropriate housing.

Captive Housing

The Common Murre (*Uria aalgae*) is a pelagic bird and a good example of a species with very specific housing requirements. This is an animal that spends much of its life in the open ocean (Terres, 1980; Lofgren, 1984). Any time on land is spent on sheer cliffs and rocky ledges, and they even nest in this type of terrain. Their sharp claws and strong legs allow them to perch effortlessly in areas that are totally inaccessible except by wing. These are very social birds who are found in groups, whether nesting or out feeding (Terres, 1980; Bent, 1963).

Unfortunately, Common Murres are frequent victims of oil spills. They travel together on the ocean in groups of hundreds of individuals, all of whom can be impacted by a single patch of oil floating on the water. Murres that come into oiled wildlife rescue centers are housed in small groups to reduce stress, since these animals appear to behave more normally when housed using the "same species cage-mates" rule which approximates their natural history.

Seabirds treated by the International Bird Rescue Research Center (IBRRC) are generally housed on white nylon netting stretched across a frame and placed inside high-walled pens. The netting serves several crucial purposes. First of all, fecal matter excreted by the animals falls through the netting and onto the newspaper below. This prevents soiled and matted feathers and lessens the possibility of fecal contamination, which will quickly rot essential feathers (Thorne, 1986). Secondly, the netting distributes the bird's weight along the length of its body, rather than forcing the animal to sit for long periods of time in one position, with most of its weight on one part of its keel



Common Murres resting on rock perching. Photo: Jan White as happens with other substrates (i.e., rolled newspaper, toweling). This helps prevent the formation of pressure sores along the keel, which can seriously threaten the release of the bird.

In the post-wash stage of rehabilitating oiled murres, the animals must be placed in enclosed outdoor pools in order to test their waterproofing and evaluate other release criteria such as normal behavior and feeding. Blood values (PCV, total proteins) and body weights must also be monitored as they are prepared for release. Also, wild murres feel more at ease in an outdoor pen that is open to the environment and away from the activity of the indoor holding area. The net-bottomed concept, originated by Jay Holcomb, the director of IBRRC, has been adapted to these outdoor pools (Holcomb, 1988). Netting is stretched around the perimeter of the pools so that, if the birds must leave the water, they have no choice but to haul-out onto the netting. This method has worked well for many aquatic and pelagic species held on a short-term basis.

Sometimes, however, medical problems preclude a short stay and necessitate a different approach. In the case of birds contaminated with crude oils, often the hemolytic anemias that can result from ingesting such oil will prevent clean birds from being released right away. As a result, birds must often be held from one to three weeks while their depressed packed cell volumes and total proteins return to normal.

A serious consequence of long-term captivity for murres, even with net bottom caging, has been hock lesions — which can lead to subsequent joint infections. This is a result of the way in which murres act in captivity and the perching substrate provided to them. When under stress, murres huddle close together and even sit on top of each other. They tend to keep their legs flat against the netting and walk on their hocks which distributes their weight abnormally to their hock region. Even in thenet surrounded pools, the murres develop scabs, then open wounds,or hot, swollen infected joints on which they rock back and forth while trying to move about.

During recent oil spill rehabilitation efforts, a new technique was introduced at IBRRC to combat this debilitating condition. Using the natural history as a guide, a pool was set up without netting and rocks were stacked on top of milk crates and placed in the middle of the pool. The feces could fall between the rocks, through the milk crates, and into the pool that was continually flushed out with fresh water. The rocks were also hosed off daily. Waterproofed murres were then placed into the pool.

The end result was that the murres spent a great deal of time in the water and, because the rocks resembled the birds' natural substrate, the animals clung to the rocks in a more normal manner (often hanging by their toes) than they could on the netting, thereby distributing their body weight normally. This alteration in substrate not only prevented hock swelling in unaffected birds, but also helped reverse the swollen, hot hocks in already affected birds.

Conclusion

Working with pelagic seabirds has been a source of consternation to wildlife rehabilitators for years. While much more remains to be learned about seafaring birds, new husbandry methods now make long term care feasible and safe. Using the natural history of a species to develop the best husbandry techniques is a concept that has proven useful. IBRRC's staff is very enthusiastic about this new finding and will use rock perching as standard operating procedures when caring for various species of alcids.

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Nutrition Support of Oil Contaminated Wildlife: Clinical Applications and Research Potentials

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Introduction

Positive responses from nutrition support of the sick and injured are well documented in humans, observed clinically in domestic veterinary patients, and likely to benefit wildlife. Oil contamination presents a unique challenge of large magnitude and complexity for a nutrition support team. Few disturbances have such untoward effects on so many aspects of nutrition - food sources, feeding behavior and abilities, digestion and absorption, and metabolism. Attention to nutrition during oil spills may encompass everything from support of a population in the wild that has lost its food supply to maintenance of an individual captive patient with multiple organ disease.

While a fast of a few days length is rarely metabolically detrimental to healthy animals, it may be clinically important in sick or stressed patients. Oil-contaminated animals may present with a primary diagnosis of starvation, stress, or illness. Treatment procedures may result in anorexia or fasting as patients may be without food during life-saving transport, medical support, diagnostic procedures, and washing.

Patients may undergo metabolic stress due to capture and confinement, or due to diseases such as infection or trauma. Thus, certain patients may be hypermetabolic from stress or disease and others may be hypometabolic from starvation. Primary illnesses may exacerbate metabolic imbalances, and treatment or confinement may alter homeostatic capabilities. Hospitalized patients, irrespective of their primary illness, often have altered calorie (kcal) needs, reproportioned fuel sources, and negative protein balance. Nutrition support should address each condition while providing general supportive nutritional care for all.

Nutrition support of hospitalized patients must integrate clinical knowledge with basic nutrition for healthy animals. It is unlikely to benefit the patient when attempted in the absence of sound clinical and nutritional knowledge. Special management considerations characteristic of oil spills, such as the numbers of animals, unpredictable occurrence of spills, limited budgets, and reliance upon volunteers, will affect the provision of nutrition support and should be considered in the design of a ready-response program.

Goals of Nutrition Support

The practical goals of nutrition support are to provide a formula of fuels and other nutrients in proportions utilized by the patient with maximal efficiency, and to deliver this formula in such a way as to minimize discomfort (Donoghue, 1989). Nutrition support prevents malnutrition while optimizing patient responses to therapies. It is a treatment modality for a small but significant percentage of cases and a treatment adjunct for all other hospitalized animals.

Case Management

Case management for all animals follows several steps (Donoghue, 1989):

1. Assess the patient's nutritional status;

2. Estimate proportions of fuel sources;

3. Calculate approximate calorie needs;

4. Select diet and route of administration;

5. Initiate the support program;

6. Evaluate responses and modify as needed;

7. Plan transition periods from hospital to release and from nutrition support to usual diet.

Successful execution of steps 1, 2, and 3

Table 1. Estimates of likely metabolic groups of patients following oil contamination, and the types of fuel sources that may be beneficial.

GROUP	CHARACTERISTICS	FUELS
Debilitated	Low body weight, hypothermic, low heart and respiratory rates.	Low carbohydrate; Occas. elemental
Gastrointestinal	Moderate to severe enteritis, diarrhea, or vomiting.	Low fat; Elemental
Respiratory	Aspiration pneumonia, rapid or labored breathing.	High fat; High protein
Stressed	Signs of hypermetabolism or infection, elevated heart and respiratory rates, elevated body temperature.	High fat; High protein

requires knowledge of the metabolic changes that occur with fasting and diseases or trauma. These metabolic changes differ between herbivores and carnivores, hence the metabolic considerations become more complex with oil contamination because of the potential for a wide representation of affected species with varied food preferences and nutrient needs.

Assessment of Nutritional Status

Assessment of nutritional status is used to estimate the degree of lost adipose (fat) and lean (protein) tissues. Measures of body weight coupled with the body palpation by experienced personnel provide the best estimates of body condition of oil-contaminated birds. In theory, energy stores, nutrient status, and degree of nutritional balance may be assessed through dietary history, physical examination, morphometric measurements and appropriate biochemical analyses. In fact, most of the methods for humans were developed for populations, not individuals, and thus have limited value for predicting the nutritional status of a particular wildlife patient. Methodologies have not yet been applied to the quantitative assessment of nutritional status of captive wild veterinary patients.

The utility of laboratory data is limited for several reasons. Blood concentrations and cell counts may be confounded by fluid shifts. Biochemistries examine one point in time and we must infer the time course of underlying events, such as metabolic turnover. Analyses of metabolites most likely to provide relevant information for veterinary patients are not run by many clinical laboratories for humans. In critical care patients, body weight (BW) changes often reflect water balance rather than ongoing changes in lean body mass (LBM) and adipose.

Weight loss is characteristic of fasting and stress. In humans, all tissues, except brain and bone, lose cell mass to varying degrees in starvation (MacDonald, 1985). Even weight lost by healthy individuals in weight reduction programs consists of 15 to 40% LBM (Shils, 1988). Stressed patients lose clinically important amounts of LBM and much of the effort in nutrition support aims to control this loss, i.e. depletion of tissue protein.

During re-feeding and weight gain, however, LBM makes up only 38 to 64% of BW gains (Shils, 1988). The percentage depends on dietary protein content; low protein diets are inefficient (Shils, 1988). Whether an animal is lean or fat, hospitalization because of illness is not the time for complacency about BW loss.

A body condition score was applied by the author to companion animals (Kronfeld, in press; Donoghue, in press). It is used with dietary history, physical examination, and routine biochemistries to assess nutritional status (Donoghue, 1988). The score is a five-point system, where 1 is equivalent to cachectic and 3 is optimal for the particular species, breed, age, and sex. A score of 5, in companion animals, is equivalent to obesity. Since non-captive wild animals are rarely obese, a five-point scoring system for sick wildlife may range from 1 (cachectic) to 5 (overweight). The score should account for degree of muscle wasting as well as fat loss, and recognize species differences in degrees of subcutaneous fat when body conditions are optimal. In the author's work, hospitalized dogs that receive nutrition support have worse body condition scores than the general hospitalized dog population (Kronfeld, in press; Donoghue, in press).

Several methods are used in humans that may have future application in wildlife nutrition support such as indirect calorimetry, double-labeled water, and electrical impedance (Donoghue, 1988).

For sick humans, an acute loss of 10% of body weight (BW) or a chronic loss of 20% BW signals a need for intensive nutrition support. For oil contaminated birds, findings of increased mortality with decreased body weight (Frink, 1989; Dein, 1986) most likely signal the same need for attention to the provision of fuel sources.

Assessment of oil-contaminated animals suggests four main groups of patients characterized by i) starvation, ii) gastrointestinal disease, iii) pneumonia, or iv) stress, including trauma and infection (Table 1). Each group is likely to benefit from provision of specific fuel sources.

Estimation of Fuel Source Utilization

The body's cells must have a supply of fuel for production of energy (metabolizable energy, ME), usually measured as kcal. The usual dietary energy sources are carbohydrate, fat, and protein. The usual fuel sources for cells are glucose and fatty acids. The proportion of each fuel source contributing to a patient's overall caloric expenditure varies with their relative availabilities to cells, metabolic peculiarities of certain cells, and sensitivity to insulin.

The rehabilitator can control exogenous fuel sources, such as ingested foods or intravenously administered solutions. The difference between overall caloric expenditure and exogenous sources is made up from endogenous sources, such as liver and muscle glycogen, adipose fat and tissue protein. Nutrition support aims to minimize the use of endogenous calories, especially those derived at the expense of tissue protein.

In meat-eaters, the relative importance of exogenous and endogenous sources of fuels follows a cycle (Donoghue, 1989). Exogenous sources predominate during assimilation, and endogenous sources become predominant following assimilation. During assimilation, insulin is released and favors uptake of glucose and fatty acids by liver and adipose tissue. After assimilation of the meal, these responses subside as insulin decreases while glucagon and growth hormone increase. The liver releases glucose, and fat cells release fatty acids. As the interval between meals extends, amino acids may be mobilized to serve as substrates for gluconeogenesis. This pattern is reversed by another meal, as the feeding cycle continues. Or it may intensify, as it develops into the metabolic and hormonal pattern of fasting or starvation (Donoghue, 1989).

During simple starvation, animals use endogenous fuels derived from tissues for energy. The main fuel sources are glucose (from carbohydrate stores of glycogen), fatty acids (from fat stores of adipose), and amino acids from protein.

Glycogen stores are exhausted in just a few days of fasting. Mammalian endotherms utilize about 85% fat (of which about 15% is ketones) and 15% protein (Donoghue, 1989). Carnivores use more protein than do herbivores, but, for both, fat is the primary fuel source. Use of protein is too costly because its catabolism results in losses of function that become life threatening.

During stress from injury or illness, animals also utilize endogenous fuels, and relatively more amino acids are mobilized from tissue pro-

Table 2. Optimal ranges of nutrients, % kcalME, for hospitalized carnivores (Donoghue, 1989). Hospitalized herbivores will require lower protein and lower fat, and additions of fiber.

	HYPOMETABOLIC [1]	NORMOMETABOLIC[2]	HYPERMETABOLIC
PROTEIN	30-48	16[3]-40	40-48
FAT	20-30	30-50	30-50
CARBOHYDRATE	20-40	20-40	10-30
RESTRICTED PROTEIN[4]	6-22	6-22	16-22
RESTRICTED FAT[4]	5-20	5-20	5-20

1 Critically ill patients may present hypometabolic, but become hypermetabolic after initial supportive therapy.
2 Normometabolic hospitalized patients are supported with wide ranges of dietary fuel sources because many require nutrient restriction. Best results are obtained when carbohydrate is kept to minimum levels. For example, fat is increased when patients are protein restricted and protein is increased when fat is restricted.
3 Low protein formulas utilized amino acids or modules such as dehydrated cottage cheese.
4 Degrees of protein and fat restriction were determined partly by the severity of the patient's illness and partly by the patient's metabolic state. In true carnivores, protein is never restricted below 20% kcalME.

tein. This is partly due to endocrine responses, such as use of amino acids for hepatic glucose synthesis, that may persist despite feeding, and partly to needs for amino acids to synthesize proteins for new functions, such as antibody production and wound healing.

In general, herbivores are less tolerant of fasting than carnivores. Yet, from data on mortality of oil contaminated birds (Frink, 1989; Dein, 1986) and diets of birds (Rapley, 1973), it appears that carnivorous species such as loons and cormorants suffer greater mortality than the more omnivorous (diving ducks) or herbivorous (mallards, geese) species. Stress from both disease and intervention, rather than fasting, may play a primary role in mortality. In addition, feeding habits or other behaviors may result in greater oil consumption by carnivorous birds.

Dietary sources of fuels: Diets for oil contaminated patients should contain levels of protein, fat and carbohydrate in optimal ranges for that animal. Ranges depend on species' and the individual's metabolic state. Carnivores require higher dietary contents of protein and fat than herbivores. The fuel sources and their proportions likely to be utilized by patients are outlined (Tables 1 and 2).

Only a portion of the dietary ingredients will be absorbed by the patient. The percentage absorbed will decrease as dietary ingredients become more complex and as the patient's gastrointestinal function deteriorates. Conversely, the digestibility of a diet increases as ingredients become more simple and as gastrointestinal function improves.

Special liquid diets, termed enterals, contain simple ingredients, such as dipeptides and fatty acids, instead of complex carbohydrates, fats,and proteins. Optimal dietary ranges of nutrients differ between enterals and complex diets because of differences in bioavailabilities.

Calculating Calorie Needs

The number of calories used by an oil-contaminated patient depends on external factors, such as ambient temperature and humidity, and internal considerations, such as hypothermia and infection. The number of calories given to a patient will be determined by the the above components plus the patient's stage of rehabilitation.

The terms and measures of heat production and derived calorie needs can be confusing. The basal heat production, usually known in medicine as the *basal metabolic rate* (BMR), refers to the absolutely post-assimilative and deliberately inactive individuals. In practice, BMR is not measured; it is a mean value *predicted* for a given BW (Wilmore, 1977). BMR includes organ service functions (heart, lungs, liver, kidney) and tissue integrity functions (ion pumps, enzyme turnover). Hospitalized (as well as healthy) individuals exhibit additional functions, so increments must be added to BMR. The *resting energy expenditure* (REE) is measured in overnight rested, unfed, recumbent, awake individuals. It consists of the BMR plus further increments for thermoregulation, physical activity and, perhaps, waste formation and excretion. Measured REE in healthy subjects is usually 10 to 25% higher than the corresponding predicted mean BMR. Recent balance studies indicate mean REE is 1.4-times mean BMR (Heumsfield, 1988). If a patient is physically active (for example, an animal in a cage), or digesting and assimilating food, then further increments must be added. Even human ICU patients increased their energy expenditure 35% above REE with routine daily care (Weissman, 1984).

Maintenance energy represents the REE plus further increments for digestion (fermentative as well as enzymatic), absorption and assimilation, more waste formation and excretion, and variable physical activity. Cage-rest maintenance approximates the energy expenditure in hospitalized domestic animals more closely than BMR or REE. It is about 1.2-times BMR in cats and about 1.7-times BMR in dogs (Kronfeld, 1991). Further increments need to be added for retention of tissue in growing animals and for production (pregnancy, lactation, egg laying) (NRC, 1984, 1985, 1986).

In birds, the following predictive equations may be useful (Robbins, 1983):

i) $Y = 99\,(X)^{0.75}$

(ii) $Y = 169\,(X)^{0.53}$

(iii) $Y = 195\,(X)^{0.65}$

where Y = kcal/day and X = body weight in kg. The average existence (captivity) metabolism for nonpasserines is represented at 30°C ambient temperature by equation (i) and 0°C ambient temperature by equation (ii) (Robbins, 1983). Equation (iii) represents a general estimate of daily energy expenditure for most free-living birds (Robbins, 1983).

Energy goals for patients diagnosed as debilitated or suffering from severe gastrointestinal disease may be only 40 to 80% of average values calculated by predicted equations. Calories for patients diagnosed as stressed or suffering organ disabilities may gradually approach average values or, in extreme cases, up to 50% above average values calculated for given body weights.

Diet and Route Selection

Efficiency of nutrition support relates to provision of fuel sources in forms and amounts that require minimal conversion and metabolic perturbation. Stress is minimized physiologically as well as physically and emotionally with delivery of calories and nutrients by a method that minimizes discomfort to the patient. This often means feeding via a small-bore indwelling tube, rather than force-feeding via syringe, bolus, or repeated intubations.

Formulations may include: a) commercial pet foods; b) liquid enteral products produced for humans; c) modules of protein, fat and carbohydrate; d) solutions and emulsions for total parenteral nutrition (TPN) support.

Enteral versus parenteral nutrition. Enteral provision of food is the preferred route of nutrition support except in cases of total gut failure or when enteral feeding exacerbates disease. TPN is more costly and more dangerous than enteral support; more attention must be given to formulations, preparation, sterility of solutions and delivery systems, and patient monitoring (Shils, 1988).

While it can be used to rapidly correct deficiencies of vitamins and minerals, TPN will not rapidly replete LBM in malnourished patients (Heymsfield, 1987). Enterocytes receive about 50% of their nutrition from intraluminal digesta and patients receiving only TPN exhibit hypoplastic and hypofunctional enterocytes (Bristol, 1988), altered intestinal myoelectric activity (Weisbrodt, 1976), and increased bleeding in the upper gastrointestinal tract (Abbott, 1983). TPN is even inferior to enteral feeding in infants with severe diarrhea (Orenstein, 1986).

TPN complications include sepsis and thrombosis as well as intestinal atrophy. Peripheral TPN is contraindicated in patients with fluid restrictions, severe stress, inadequate peripheral venous access, and hyperlipidemia (Abbott, 1983).

The provision of intravenous micronutrients is complicated. Data on requirements were obtained by balance studies using enteral diets, and correct extrapolation may be non-linear (Shenkin, 1986). There is evidence that TPN changes micronutrient requirements, that TPN patients differ from healthy animals with regard to requirements, and that optimal requirements are not yet defined (Shenkin, 1986). It is unlikely that requirements for all essential nutrients are presently met with TPN in hospitalized wildlife.

Intravenous feeding via central or peripheral veins can provide needed kcal and protein and is indicated when enteral support is impossible, such as with gut failure or mechanical and functional intestinal obstructions (Shils, 1988). Carbohydrates and lipids are used to provide non-protein kcal in 60:40 to 40:60 ratios (Rombeau, 1986). Protein is recommended to be given to meet 15 to 30% of kcal (Robin, 1986).

Pet foods. Commercial pet foods are designed, formulated, and manufactured to be adequate diets for a wide assortment of relatively healthy dogs and cats. Unstressed house pets are assumed to be metabolically flexible in their needs for kcal, fuel sources, and adequate amounts of essential nutrients. Pet foods are designed for profit and may have variable formulas for least cost, expansion with air, adequate but not optimal nutrient quantities, and non-nutrient substances inappropriate in hospital diets.

Bioavailabilities of vitamins and trace minerals are in question in pet foods (Kronfeld, 1989). Estimates of digestibilities are readily biased experimentally and should serve only as rough guides for use in hospitals.

Many pet foods are based on grain and soy. The grain provides carbohydrate, often 50 to 55% kcalME, excessive for starved or stressed carnivores which utilize fat for over 70% of their total kcal. The soy is used to provide protein but also contains phytate, which binds divalents, goitrogens and galactosides. The latter are not digested

Table 3. Manufacturers of some enteral nutrition support products (Donoghue, 1989). Many other products are marketed.

MANUFACTURER	COMMENTS
Ross Laboratories Columbus, OH 43216	Carry a complete line of formulas and delivery systems. Examples of products are *Ensure*™, *Pulmocare*™, and *Osmolite* HN™.
Mead Johnson Evansville, IN 47721	Carry a complete line of formulas and delivery systems. Examples of products are *Isocal*™, *Traumacal*™, and *Criticare HN*™.
Norwich Eaton Pharm. Norwich, NY 13815-0231	Carry formulas such as *Vivonex T.E.N.*™
O'Brien Pharm. Parsippany, NY 07054	Carry formulas and feeding tubes. *Reabilan*™ contains taurine and selenium.
Biosearch Medical Products Somerville, NY 08876	Carry formulas and feeding tubes.

enzymatically in the small intestine, and their fermentation in the large bowel produces excess gas and, possibly, osmotic diarrhea (Meyer, 1984).

Blending pet foods with enterals is preferred. Blenderized foods tend to be cheaper than enteral products, but have more problems than enterals with viscosity, bacterial growth, settling of solid components, and inconsistency of nutrient composition (Donoghue, 1989; Romneau, 1984). Enteral products permit precise metabolic management of patients.

Enteral products. Commercially available defined liquid diets for humans are designed for tube feeding, are low residue, and have high nutrient availability. The products are widely available to clinicians through hospitals and distributors, and several over the counter in supermarkets and drug stores.

Enteral products are classified according to ingredients (Shils, 1988). They contain natural ingredients with or without protein isolates, or purified sources of carbohydrate, fat and micronutrients mixed with protein isolates, hydrolyzed protein, or crystalline amino acids. The formulas were originally classified as polymeric or elemental (monomeric), but newer products represent a continuum with a trend to increasingly purified components. Names and addresses of some of the manufacturers of diets appear in Table 3.

Enteral products vary in energy density (often 1.06 to 2 kcal/ml) and fuel source proportions. Rehabilitators may find it helpful to categorize diets according to proportions of protein, fat and carbohydrate, as in Table 4.

Enteral diets formulated for humans with trauma or respiratory disease contain low carbohydrate to minimize CO_2 production, hence contain relatively more fat and protein. They are most suited for carnivores (Table 4). Examples include *Pulmocare*™ (Ross) and *Traumacal*™ (Mead Johnson).

Most enteral diets formulated to meet human requirements without hypermetabolism contain more carbohydrate. Protein is low for carnivores but suitable for herbivores (Table 4). Examples include *Ensure*™ (Ross), *Isocal* ™ (Mead Johnson), and *Reabilan* ™(O'Brien).

Elemental diets, such as *Vital*™ (Ross), *Criticare* ™ (Mead Johnson) and *Vivonex*™ (Norwich Eaton) contain highly purified ingredients and very low fat contents (Table 4). They can be used alone when fat restriction is indicated or blended with pet foods for moderate fat restriction. Rehabilitators will find that the labeling of enteral products conveys much information, including caloric density, dietary fuel source proportions, nutrient contents, ingredients, and osmolality. The latter ranges from 300 to over 900 mosm/kg water. Hyperosmolar products should be diluted with water for the first few feedings.

Modules. Enteral products may be fortified with modules of protein, fat, carbohydrate or fiber. Protein modules for human use are available from the manufacturers listed in Table 3. Less expensive is dehydrated cottage cheese, marketed as *ProMagic*™ for domestic animals by American Nutritional Laboratories, Burlington, NJ. *ProMagic*™ is lactose-free and contains about 99% kcalME from protein. It is available in pet stores.

Carbohydrate modules are available, but their use is indicated rarely. Enteral products and pet foods usually contain over 40% carbohydrate

Table 4. Selected characteristics and indications of liquid enteral products (Donoghue, 1989). Examples of each type of product are given in the text.

TYPE	PRO	FAT	CHO*	INDICATIONS
	% kcalME			
LOW CHO*	>15	>39	<40	Hypermetabolism in most species. Normometabolism in carnivores.
HIGH CHO	<20	<39	>40	Normometabolism, often require supplementation with protein.
LOW FAT	<20	<10	>70	Hypometabolism. Fat restriction. Malabsorption.

* CHO = carbohydrate.

and its reduction, not supplementation, is usually of concern for starved or stressed animals.

Fat modules include corn oil for supplementation with long-chain triglycerides, and, from coconut oil, medium-chain triglycerides (MCT) oil or powder for patients with impaired fat absorption. Modules of MCT are used because of their direct absorption without need for micelles or chylomicra, bile salts, or lipoprotein. However MCT do not support fat-soluble vitamin absorption, tend to be metabolized in liver and not stored in adipose, and may cause vomiting (Shils, 1988, Cotter, 1987).

Fiber modules include *Solka Floc*™ (Brown Co., Berlin, NH), predominantly alpha-cellulose, and *Metamucil*™ (Proctor & Gamble, Cincinnati, OH), which contains methyl-cellulose. Regulation of intestinal motility in omnivores is facilitated by 5 to 10% (dry weight) fiber (Burrows, 1982). More fiber may be indicated in herbivores, although the form of the fiber may be as critical as the amount: important variables are length and lignification. Supplementation with fiber is rarely indicated in starved or stressed carnivores.

Initiate the Support Program

Basic guidelines for beginning nutrition support diets include:

i) Diets are fed at approximately body temperature, but store in a refrigerator.

ii) The first few meals are diluted with water, first 50:50, then 75:25.

iii) Elemental diets are hyperosmolar, hence dilution with water should continue for 24 to 48 hrs.

iv) Meals are administered slowly. Too rapid administration results in abdominal pain and diarrhea.

v) Sicker patients require smaller and more frequent meals. For example, a relatively healthy animal can receive its total daily calories in 4 meals. The relatively sicker patient may receive its total calories in 8 to12 daily smaller meals.

Provision of exogenous kcal decreases LBM catabolism and gluconeogenesis, decreases lipolysis and fat oxidation, and increases serum insulin and glucose utilization. These adaptations take time, however, so the initiation of support programs should be gradual.

Diets are diluted about 50% with water, and the meal size is reduced by about 50%, for the initial feeding of each patient. If the patient shows no signs of abdominal discomfort, vomiting, or diarrhea within 2 hours, then a second meal is given, followed by the prescribed feeding program. If pain or gastrointestinal signs occurred, meals should not be discontinued, but diluted further, reduced in volume, and administered more slowly and less frequently.

Diets can be given intermittently or continuously. Continuous infusions minimize gastric pooling and improve patient accommodation (Pemberton, 1988). Infusion pumps improve accuracy but require strict confinement; gravity delivery is usually adequate. Moreover, continuous feeding disrupts the usual feeding cycle, creating a new metabolic condition (Heymsfield, 1988, Heymsfield, 1987). Continuous enteral or parenteral feeding in humans is associated with cardiac failure, respiratory insufficiency and hypercapnia, and prerenal azotemia (Heymsfield, 1987).

Irrespective of method of delivery, route of administration, and diet, the initial nutrient source should be dilute, isosmolar, and delivered slowly. Initially, the patient should be monitored for signs of pain, vomiting, diarrhea, hypo- or hyperglycemia, and hyperlipidemia. Nutrient sources are made more concentrated and rates of delivery increased, only when the clinician is satisfied with patient response.

Once initiated, delivery of nutrients is maintained at initial rates until negative responses are minimized, but feeding is not discontinued. One exception is gastric tube-feeding and gastric stasis. If indicated, gastric residuals are checked 2 hrs. after every meal, and the feeding schedule decreased or terminated if residual volume is greater that 50% of the previous meal volume.

Evaluate Responses and Modify as Needed

Re-feeding causes an increase in energy expenditure, for example from 6 to 34% above REE (Allard, 1988). Food intakes need to be adjusted accordingly. In the author's experience, the concentration and delivery of the diet may be increased over the first 24 to 48 hours for most patients, and over the first 72 hours for critically ill animals. Patients are monitored as discussed above, but those with surgically placed tubes or TPN, are also monitored for signs of infection. Patients with milder illness tend to be robust in their adaptation to nutrition support. Those with more severe illnesses require more gradual provision of nutrients and more careful monitoring.

Assessment of patient responses is similar to assessment of nutritional status (step 1);

available data concern populations of humans and no data are yet available for sick wildlife. In every case, the clinician and clinical nutritionist must make a synthesis or subjective global patient assessment (Detsky, 1987) which integrates the available information on physical status, biochemistries, hematologies, and responses to therapies.

Patients are monitored for signs of excessive kcal intake. Excessive intakes are associated with increased metabolic rate, respiratory rate, heart rate, VO_2, and VOC_2 (Heymsfield, 1987). High carbohydrate formulas produce higher VCO_2; VCO_2 can exceed VO_2 (Heymsfield, 1987; Frayn, 1983). The "re-feeding syndrome" occurs in patients with compromised cardiac or respiratory function. High risk patients are severely malnourished. They should be monitored closely, fed low carbohydrate diets, fed controlled kcal for the first 5 to 7 days of feeding, and rehydrated carefully (Heymsfield, 1987).

Plan Transitions

As with its initiation, discontinuation of nutrition support is also a gradual transition. Prevailing circumstances tend to make discontinuation of enteral support too abrupt.

Patients, as they respond to treatment, are offered small amounts of fresh, natural food per os. Even those with nasogastric tubes can eat voluntarily. Tubes are left in place until the patient voluntarily consumes its caloric needs. Patients undergoing repeated orogastric intubations have the number of daily feedings reduced gradually. Use of feeding tubes in convalescing patients with adequate voluntary intake appears to shorten hospital stays and recovery times, and improve outcomes.

Care must be given when making transitions from one diet to another. The usual transitions involve diets of increasingly complex ingredients. More attention is given to rates of delivery and patient responses in patients with more serious illness. Thus patients move from TPN support to elemental diets, from elemental to polymeric, from enteral products to blended diets, and from blended diets to natural diets. Each transition may require about 4 days in patients with mild illness, 4 to 7 days with severe illness, and 7 to 14 days with severe gastrointestinal disease.

Transitions from captivity and controlled feeding to natural environments and independent feeding may need special study. Nutrition support in wildlife rehabilitation includes additional transition factors, such as determination of ample and wholesome food sources, assessment of patient recognition of and ability to procure food, and estimation of patient responses to the cumulative stresses of release.

Summary

Effective nutrition support requires sound knowledge of both basic and clinical nutrition as well as familiarity with products and delivery systems. Case management includes assessment of nutritional status and estimation of fuel sources. Most starved or stressed patients use fatty acids for over 70% kcal ME and for carnivores and perhaps 15% kcal ME for herbivores. Approximate kcal needs are calculated from maintenance energy equations. Most patients respond best to enteral nutrition. Pet foods, liquid enteral products, and nutrient modules are offered in slurries or tube-fed. Management includes careful monitoring of patients and gradual transitions to diets with more complex nutrient sources.

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Rehabilitating Oiled Seabirds During the Exxon/Valdez Oil Spill

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Introduction

During the Exxon Valdez oil spill a total of 1,961 oiled wild animals were rescued and taken to emergency oiled wildlife rehabilitation centers established at various locations along the coastline of Alaska. Another 100 Bald Eagles were captured, examined, and found fit for immediate release to the wild. From March 24 to October 1, 1989, the International Bird Rescue Research Center (IBRRC) managed the oiled bird rehabilitation efforts: operating two search and rescue programs in Prince William Sound and along the Kenai Peninsula and four oiled bird rehabilitation centers. Two other search and rescue programs managed by the U.S. Fish and Wildlife Service aided in the capture of oiled wildlife. Due to its strategic location, increased capabilities, and the availability of local resources, the Seward bird rehabilitation center became the central facility where animals were funnelled as the other centers (Valdez, Kodiak, and Homer) were eventually phased out.

During the six months of operation, 1,604 oiled birds were captured and brought to the four centers for treatment. Of these birds, 1,534 were water birds, including 1,367 of pelagic species. Bald Eagles presented for rehabilitation amounted to 39, while other species of raptors, passerines, and terrestrial birds totaled 31 birds. Seabird species handled included the following:

Horned and Tufted Puffins,
Ancient, Marbled, and Kitlitz's Murrelets,
Common and Thick-Billed Murres
Pigeon Guillemots,
Cassin's, Parakeet, Rhinoceros Auklets,
Black-legged Kittiwakes,
Fork-Tailed and Leach's Storm-Petrels,
Sooty and Short-Tailed Shearwaters,
Red-Faced and Pelagic Cormorants,
Aleutian Terns and Arctic Terns.

In early April, as the oil began to exit Prince William Sound and move in a northwestward direction, it became clear that seabird colonies along the Kenai Peninsula could be in jeopardy if the oil reached that far. Glaciers, jagged islands, and high rocky cliffs make up the coastline of the Kenai Peninsula. These are nesting areas for over 10 million seabirds every year. In order to prepare for incoming oiled birds, IBRRC staff coordinated search and rescue strategy with the personnel at the Kenai Fjords National Park headquarters in Seward. A component of this program was identifying which species of seabirds were in the area currently and for which species, due to arrive from their winter feeding grounds, the centers needed to prepare. Park headquarters provided IBRRC with the exact dates that each seabird species would arrive in the area. Our search and rescue fleets were given this information and rescue efforts were directed towards the sensitive areas where these birds were likely to be found. Similar pre-identification of species was also done in Prince William Sound. Although each search and rescue fleet produced many species of birds, the fleet that focused on capturing birds in the Kenai Peninsula and Kodiak area brought in the majority of the pelagic species.

Preparations For Seabird Rehabilitation

Rehabilitating oiled seabirds requires patience and an understanding of the natural behavior, physiology, and captive requirements of individual species. The unique adaptations to life in the sea are the very elements that increase these birds' vulnerability in captivity. We were fortunate that a good portion of IBRRC's research over the past 20 years has been directed towards improving the captive care of both oiled and non-oiled seabirds. Because of our past efforts, IBRRC staff had a good idea of the special requirements and rehabilitation techniques that were needed in caring for oiled seabirds.

Transportation

The four search and rescue fleets covered over 600 miles of shoreline in search of oil-contaminated birds and carcasses. Once captured, the birds required initial care, warm temporary housing and quick transportation to the rehabilitation center. Rescuers were trained in gavage feeding and basic examination. Birds that had to wait long periods of time prior to transport were gavage-fed fluids on a regular basis and kept quiet. Search and rescue personnel were supplied with collapsible cardboard boxes and rags for the temporary housing of the birds. Puffins typically clawed and chewed their way out of these boxes and often a double box system had to be improvised (and constant monitoring maintained!) to keep these birds contained.

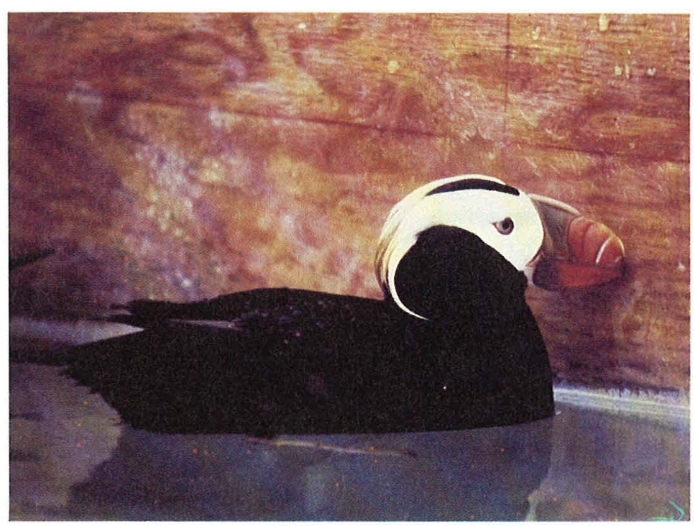
Designated high speed boats and float planes were used to transport seabirds from distant areas to the Seward center. Most birds waited an average 4 to 6 hours after capture before transport, but occasionally birds were required to spend the night on the boat until transportation could be arranged the next morning. Because of the enormous distances involved, even with four rehabilitation centers, transportation itself could take up to four or more hours.

Caging

In preparing for the influx of oiled birds, appropriate caging needed to be constructed. Fifty plywood pens approximately 4'x8'x2' with netting bottoms were built to house most of the species of water birds that we expected to see. These net-bottom indoor pens keep birds off hard surfaces and allow fecal matter to drop to the floor approximately two feet below. The soft netting helps in the reduction of keel and leg sores and aids in keeping feathers free of urates and other fecal matter that can slowly destroy their delicate feather structure (Holcomb, 1988). The pens work well for pelagic species, especially alcids and cormorants, as the solid sides provide shy birds with a good sight barrier. Puffins, auklets, and other burrowing or crevice-nesting seabirds find comfort in the shelter of these pens, also. White sheets are used to cover the tops of the cages, allowing light to penetrate but helping reduce visual stress. Clips made by cutting large PVC pipe into sections with on slip enabled the sheets to be clamped on the top of the pens. Puffins were adept at climbing the walls of these cages, so special wall extensions were built to reduce the escape factor. Additional clips were also fastened to Puffin pens to help hold in determined birds.

Once cleaned, seabirds require pools to swim in. Pools should provide each species of bird with enough water surface to bathe and move around freely, have enough depth so diving birds can exercise and search for fish, and include haul-out areas where animals can rest. At our central facility in Seward, eight pools were built out of plywood, 2"x4"s, and other support beams. The cover was made of 2"x2"s covered with netting. Each pool was 2 feet deep and had a water surface area of 60 sq ft. A 2' x 6' netting area for hauling out was available and small ledges were provided for cliff roosting species such as Black-legged Kittiwakes, Puffins, and Murres. The ceiling was 4' above the water providing some flight area for gulls, terns and kittiwakes. Two doors made bird capture easier.

A salt water pump and plumbing system which was installed in oil-free Resurrection Bay provided on-going salt water supply to the pools.



A Tufted Puffin swimming in fiberglass lined wooden swimming pool.

This worked well for non-oiled or already clean birds and sea otters but was discontinued for recently cleaned oiled birds, due to problems associated with hard water.

Rehabilitation Procedures

Through excellent radio communication between the search and rescue teams and the rehabilitation centers, the centers were notified of the quantity and species of incoming birds. This proved to be valuable in that appropriate holding pens and equipment were made ready for new arrivals.

Upon arrival at the center, the species were identified and a plastic in-house identification leg band was fitted to each bird. An individual record form was begun that stayed with the animal through its stay at the center. Record-keeping is of utmost importance: it provides an invaluable chronology of treatment and clinical findings on each animal.

Particular attention was paid on intake to clearing the nose, mouth, and eyes of any oil — often abundant in those locations. In cases of heavy oiling, the body was wrapped with cloths to absorb globs of oil and water from the feathers.

An initial physical examination was performed to insure that the bird did not have other injuries or disease. Warm oral fluids were then gavage-fed to help combat dehydration. Blood was taken from each bird to assess the internal health of the animal. Blood work was repeated on a strict schedule throughout each bird's stay.

Sea birds arrived with different degrees of oiling. Often birds that were partially oiled or had only spots of oil arrived in the worst physical shape. This is due to the fact that seabirds are very cautious and will spend most of their time in the water where they feel safe. With only small areas of oiling, they can withstand the cold water and air temperatures longer than a bird that is covered in oil. Birds covered in oil leave the water quicker and are more susceptible to predators and capture by humans. Spotty birds attempt to feed but have to leave the water to preen because their insulation is impaired. They tend to avoid capture because they are still able to float for short periods of time. By the time they are actually caught, they are usually weak from not eating and in the advance stages of dehydration, starvation, and hemolytic anemia (Fry, 1987).

By the time these birds are captured, they often require more intensive care and can have a higher mortality rate due to their weakened condition. Because they are not strong enough to withstand the stresses of washing and rinsing, they must be given supportive care until their PCV increases to the point that the staff veterinarian approves them for washing. This is a dangerous time for the birds, as they are susceptible to secondary problems such as leg and keel lesions, fecal contamination, and diseases such as aspergillosis. Some birds are so impacted by the oil that they require whole blood or plasma tranfusions. Birds contaminated early in the spill often have damaged lungs from the fumes.

A pair of oiled cormorants prior to washing.

Except for those animals who are poisoned beyond the point of return, problems associated with oiled bird rehabilitation can be minimized with the proper facilities and experienced, trained staff. Good ventilation and cage cleaning was provided to significantly reduce the possibility of aspergillosis and staff monitored the birds' feathers, legs, and keels for signs of housing impact. Since the facilities built for birds in Alaska were excellent, birds had few housing-related problems. (For an example, see "New Advances in Captive Housing for Common Murres," this issue.)

Medical Data Collected

Due to the size of this spill and the willingness of the spiller to fund medical procedures, more information was collected on the birds than in any previous spill. Attempts were made to take initial blood samples, mid-stay blood samples, and pre-release blood samples. Basic hematological information collected included the packed cell volume, percentage of the PCV which was buffy coat (white blood cells), total solids (from a refractometer), and two blood smears for an avian estimate and differential. Serum chemistry information was collected on 13 species of birds for a total of 157 samples. The tests performed included blood glucose, uric acid, triglycerides, Alkaline Phosphatase, Asparate Amino Transferase (AST and formerly SGOT), Alanine Amino Transferase (ALT and formerly SGPT), Lactate Dehydrogenase (LDH), Total Bilirubin, Calcium, Creatinine Phosphokinase (CPK), Total Protein, and Creatinine. The choice of tests included in the panel was influenced by the availability of the tests for use in the Abbott™ Visions machine. All work was performed on-premises.

Since 39 Bald Eagles were presented for care, some additional tests were performed on them. Those tests included direct fecal examinations, tracheal cultures, and manual white blood cell counts done through a local human hospital.

All the information was computerized and was reviewed as birds were evaluated for further care or release.

Research

During the spill, some hatchling Gadwalls and Red-breasted Mergansers were brought in, having been separated from their parents during search and rescue operations. The Red-breasted Mergansers had been contaminated by diesel fuel in an unrelated event. All were successfully reared, and weights and serial blood sampling were taken to help establish normals for these birds. That information will be published in a future issue of the *Wildlife Journal*.

While we had developed the data base on the oiled birds, we had no normal values for these northern species. During the summer of 1990, we worked with a USFWS staff biologist, John Piatt, Ph.D., to obtain about 160 blood samples from healthy birds of the same species for a normals data base. Statistical analysis of those values and then comparison to the oiled birds is in progress during 1991.

Release

Birds were evaluated for release based on a number of important factors. In the pools, normal behaviors such as feeding, diving abilities, preening, and general activity level were evaluated. Weights were monitored to ensure that the the birds were released at their normal Alaskan weights (which are heavier than in lower latitudes). Blood samples were taken to ensure that their PCV's were in the normal range so that they would have the carrying capacity for the oxygen they need to fly, dive, and hunt for food.

Before release, all birds were banded with USFWS leg bands. Selecting release sites was more difficult in this spill since the oil would not be completely removed from the environment during 1989. Additionally, in some cases, it was the nesting areas of the affected species that were hit as the oil left Prince William Sound. It was summer, and no matter where the birds were released, they would proceed to their nesting areas. However, it was not feasible to hold all the birds in captivity until the oil was completely removed. Therefore, judgments were made regarding the species being considered for release, where they were likely to go, and what that area looked like at the time of release.

Post-release information on these birds is currently unavailable due to the on-going litigation between the government and Exxon USA.

Conclusion

The sea bird rehabilitation efforts in the Exxon Valdez spill were the largest scale efforts attempted to date. The environment and conditions were severe, made the program difficult to execute, and necessitated large scale transportation efforts to one of four seabird facilities. Yet, in spite of the challenges, the program successfully rehabilitated 50% of the birds that were presented alive.

This was an effort that continued for nearly six months and the gamut of problems seen was wide. We had very early acute poisoning cases all the way to the birds affected only by sheens in the water.

Much new information was collected on Alaskan species and a computerized data base was established for the spill from which data analysis has been performed and will continue for sometime into the future.

It was very difficult to set up in such remote locations and currently recommendations have been made to establish a permanent facility in Anchorage so that an on-line facility can be made available within hours of such a spill for either sea birds or Sea Otters. While prevention of such spills is certainly the priority issue, when they do happen, it is imperative that a response be made quickly and that adequate facilities be available immediately to help affected wildlife.

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Advances in Rehabilitating Oiled Sea Otters: The Valdez Experience

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Introduction

Although at least 28 oil spills have been larger than Valdez, the March 1989 accident represents the first oil spill to affect a large number of Sea Otters. This paper describes some of the ground-breaking developments concerning SeaOtter rehabilitation. It focuses on rehabilitation facilities, staffing, and the collection of scientifically valuable data.

Of the area's estimated 45,000 Sea Otters (Townsend, 1989), more than 16,000 inhabited those portions of Prince William Sound and the Gulf of Alaska that were impacted by oil (Degange, 1990).

At the request of the U.S. Department of the Interior and the U.S. Fish and Wildlife Service (USFWS), Exxon Company USA initiated an unprecedented effort to rescue and treat sea otters that became oiled. They built rehabilitation and pre-release facilities in Valdez, Seward, and Homer—each with a capacity of about 100 otters. All the facilities remained in operation until September, 1989. At its peak, the Sea Otter rehabilitation program had over 350 paid and volunteer staff, 11 capture vessels, and a dedicated helicopter to transport otters from the capture boats to the rehabilitation centers.

The three centers treated a total of 357 sea otters during the program. We released 197 adult otters into Prince William Sound and along the Kenai Peninsula at the direction of the USFWS. In addition, the centers transferred 13 pups—many of which had been born in captivity—to seaquariums because they were too young to be released. Another 24 adult otters were sent to seaquariums for health reasons.

The Sea Otter Rehabilitation Program in Alaska led to many new and innovative techniques for treating fur-bearing marine mammals, especially sea otters. Earlier research (Williams *et al.*, 1989; Davis *et al.*, 1989) had produced an effective method for cleaning oiled Sea Otters, but most other aspects of the rehabilitation process were untested and speculative. The scientists and veterinarians at the rehabilitation centers were constantly discovering unforeseen problems and, as a result, developing innovative solutions. For example, in the area of facilities, the original centers had to be designed from scratch and constructed in a remote area within a few days. In the area of treatment, no one had even established the potential for petroleum hydrocarbon toxicosis in Sea Otters, much less developed veterinary treatments for it.

Because Exxon realized information from this effort would be invaluable if ever there were another spill, the company initiated a thorough documentation effort. Staff collected as much information as possible concerning sea otter husbandry, veterinary care, toxicology, and other topics (Williams and Davis, 1990). Research and data analysis initiated during Exxon's Sea Otter rehabilitation program has already resulted in significant advances in treatments for oiled otters and preparations for future oil spills. More breakthroughs can be expected as the data is analyzed further.

Facilities: The Flow-through System

To handle the influx of a large number of sea otters, a rehabilitation center must be designed for the efficient yet careful handling of the animals. By using a flow-through system, animals can be rehabilitated quickly, efficiently and safely.

This section outlines rehabilitation and holding facilities that have been inspired by the experiences in Alaska. It describes what would, in many ways, be premiere facilities. The explicit needs of each component within the facilities, as well as the arrangement of each component to the others, have been identified and incorporated. Space requirements for each component have been extrapolated from the Alaskan experience, and may still have room for further optimization.

The facilities described below would not only be appropriate for Sea Otters, they would also serve effectively for the treatment of any pinnipeds. *Development of the rehabilitation facilities represents the combined efforts of many people, but I would especially like to recognize the contributions of Dr. T.M. Williams, J. Styers, Dr. T. Gornall, T. McCloskey, J. Stewart, T.D. Williams, and G. Van Blaricom.*

Primary Rehabilitation Facility

The primary rehabilitation facilities in Alaska quickly evolved into a flow-through system with several specialized areas. Sea Otters could be moved in assembly-line fashion through areas for triage and sedation, cleaning and rinsing, drying, recovery from sedation, critical care, and pens with seawater pools for short-term holding. Sea Otter pups require constant attention and should receive care in a separate nursery area. A kitchen is also needed to prepare the large amounts of seafood that sea otters require to maintain their normally high metabolic rate.

In Appendix 1, the space needs and possible configuration for a flow-through primary facility are described. This sample design would allow simultaneous treatment of 200 otters, with holding pens for 120 otters and space in large pools for another 80. This size was selected because it matches the total capacity of Exxon's two Sea Otter rehabilitation centers and should be adequate for most moderate-to-large oil spills when combined with a pre-release (i.e., post-treatment) facility (details below). The total number of animals that could be moved through this primary facility to the pre-release facility depends on the rate of rehabilitation. The indoor space measures about 80 ft x 275 ft while the outdoor holding area measures 60 ft x 250 ft.

Because large pools and a filtered seawater system are needed for holding Sea Otters, the primary rehabilitation facility needs to be a permanent structure. Even with detailed plans and the identification of sites with essential amenities, it may take several weeks to build an otter rehabilitation center. To enable a rapid response that would minimize the exposure of otters to crude oil and reduce mortality, policy-makers would need to consider the development of pre-existing facilities. The more rapid the response, the more effective future rehabilitation efforts can be.

Triage and Sedation

The area for triage and sedation should be designed and stocked to meet the medical and hygienic needs of the in-coming otters. When oiled sea otters first arrive at the rehabilitation center,

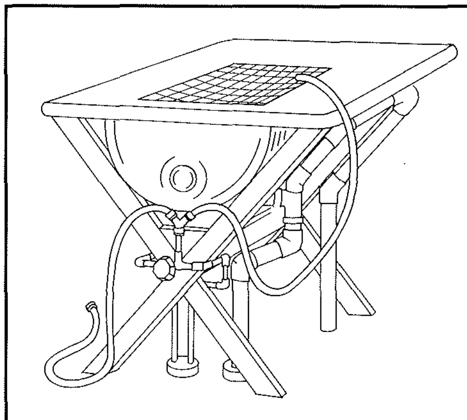

Figure 1

Cleaning Table

they are brought to the triage room for initial examination, medical stabilization, weighing, and sedation prior to cleaning. The veterinary staff treats any immediate problems such as dehydration, hypothermia, hyperthermia and shock. The room should have a sink and cabinets that can be locked for storing drugs and other medical supplies. The floors should be covered with a nonporous surface that can be easily cleaned. The temperature should be controlled at 18° C (65°F).

When large numbers of otters might be captured more than 300 miles (a four-hour helicopter flight) from the primary facility, a remote mobile triage unit would be beneficial.

Cleaning

Unlike pinnipeds and cetaceans—which have a subcutaneous layer of blubber—Sea Otters rely on their fur for thermal insulation in water. If otter fur becomes sufficiently oiled, it loses the insulating layer of air that is normally trapped against the skin. Without this air layer, the otter's fur loses approximately 70% of its insulation (Williams *et al.*, 1988), and the otter may suffer a lethal decrease in core body temperature (hypothermia) and die. Earlier research had shown

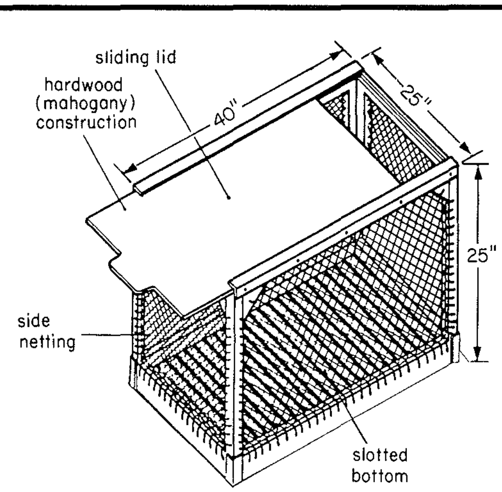

Figure 2

Inside Critical Care Holding Pen

that Dawn™ dishwashing detergent was effective and safe for cleaning oiled Sea Otters (Williams *et al.*, 1989; Davis *et al.*, 1989).

Once an otter has been medically stabilized and sedated in triage, professional wildlife handlers should transfer it to the cleaning room. Here it is placed on one of the cleaning tables (Figure 1) and washed with repeated applications of a solution of Dawn™ (1:16) until all traces of oil on the fur have been removed. Thorough rinsing is very important because residual detergent in the fur prevents the pelage from regaining its water repellency and thermal insulation in water. For otters that are heavily oiled, the entire cleaning procedure requires two to three hours (Williams *et al.*, 1989; Davis *et al.*, 1989).

To enable the simultaneous washing of multiple otters, the hot water system requires a capacity of about ten gallons per minute per otter. The floors should be waterproof and sloped toward the floor drains. Air temperature should be regulated at around 18° C (65° F). Wash water should be no hotter than 85°-90°F and the otters' core temperature must be monitored constantly.

Drying

After washing and rinsing, the otter's fur needs to be dried completely. The importance of thorough drying was first recognized by Dr. Tag Gornall (Marine Mammal Resource Center, Seattle, WA). When thoroughly cleaned and dried, full restoration of the fur's water repellency and insulation occurs within five to ten days if the otter grooms normally.

We found it most effective to transfer otters to a separate drying room, isolated from the humidity and spray of the cleaning room. Staff employed high speed pet dryers, set at room temperature, to accelerate the drying process. Using these methods, drying required about one hour.

Portable / Transport Pens

After drying, the animal is placed in a portable cage in the recovery room while the effects of sedation wear off. 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 recovery room until they are alert and begin grooming.

The specially designed cages (Figure 2) used in the critical care facility have a slatted bottom to allow the passage of feces and urine, which helps keep the otter's fur clean. The walls are made of pliable netting that prevents injury to teeth and gums. The sliding, plywood door on top allows easy access to the animal for physical examination and medical treatment. The cages are placed over a shallow trough in the floor that is coated with fiberglass. Feces and urine which fall into the trough are washed into drains that are connected to the sewer. This makes sanitation easier.

Holding Pens

After recovery from sedation, the otter should be taken to an outdoor holding pen with a small seawater pool where it can groom and feed (Figure 3). To protect the animals from injury, cage frames should be made of polyvinylchloride pipe or other plastic material with rounded edges. Because otters will attempt to chew away the cage lining, the framework of the pens should be covered with two-inch stretch-mesh herring net to prevent any injury to the otters' teeth and gums.

To encourage the grooming that is crucial for restoration of the fur, the pens should have pools that are at least three feet square and two feet deep. In addition, haul-out platforms (two feet by three feet) should be placed on either side of the pool. The surface of the haul-out platforms should be smooth but perforated with small holes to allow water to drain.

The pools should be plumbed with a continuous supply of filtered seawater to maintain good water quality and low bacterial concentrations. We found it advantageous to place the pens in a shallow spillway that collected overflowing seawater and returned it to the ocean. In areas where there might be a heavy snow fall, the outdoor pen area should be covered by a translucent, plastic roof.

Holding Pools

Once the recuperating otters have restored the water repellency of their fur and are in good health, they should be moved to larger pools that enable greater movement (Figure 4). These pools can be any shape that allows the animals to socialize in larger groups and maintain muscle strength. We used two designs: one round (12 feet diameter by four feet deep) and another with long raceways (60 feet long by eight feet wide). The raceways can be left open for swimming or divided with moveable partitions to separate groups of animals by sex or age. Haul-out platforms must be

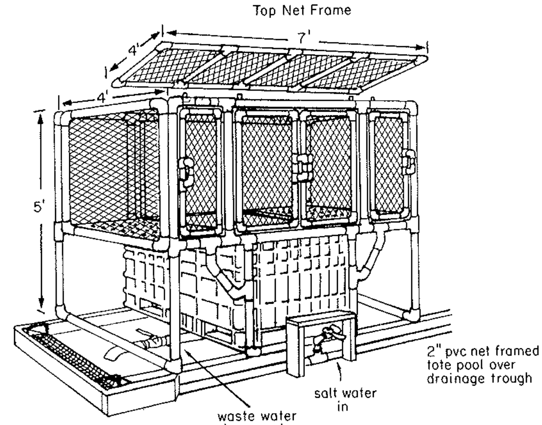

Figure 3

Initial Outdoor Holding Pen

provided in each pool or raceway.

Whichever design is chosen, there should be a large skimmer drain at the surface and the bottom should be sloped toward a large drain that collects debris and uneaten food. Seawater flow should be adequate (100% turnover per hour) to keep the coliform bacterial concentrations at acceptable levels.

Veterinary Clinic

To treat the medical problems associated with oil spills—as well as captivity, pregnancy, parasitism and aging—a well-equipped veterinary clinic is essential (see Tuomi, this volume). It should include storage for medical supplies and a clinical laboratory for the analysis of blood and urine. An examination table should be provided for minor surgical procedures. In addition, a separate necropsy laboratory would be needed to perform postmortem examinations. Freezer space (about 500 cubic feet) would be needed to store specimens and tissue samples.

The oil spill could, in effect, be divided into two phases with regard to the rehabilitation of oiled Sea Otters. The first phase occurred during the first two or three weeks when otters were exposed to the volatile components (i.e., benzene and toluene) and polycyclic aromatic hydrocarbons. During the second phase, the toxic components of the oil had evaporated and been diluted to relatively low levels.

Many of the otters brought to the rehabilitation center during the first phase exhibited symptoms of pulmonary emphysema, liver dysfunction, and mild anemia (see Williams, this volume). Because sea otters spend much of their time resting, swimming, grooming and feeding on the surface of the water, systemic exposure to fresh crude oil can occur through skin absorption, inhalation of volatile components, and ingestion. Although the primary route of absorption has not been determined, the natural history of sea otters makes all three avenues possible.

During the first three weeks following the spill, staff usually had to medically stabilize animals arriving at the rehabilitation centers. The otters were offered food to prevent further weight loss and rebuild physical stamina. Lactated Ringer's solution was infused subcutaneously to correct dehydration and improve appetite. In documented cases of hypoglycemia, dextrose (5% w/v) was added to the Lactated Ringer's solution.

Some heavily oiled otters were intubated and given oral Toxiban™. This product is a slurry of activated charcoal that binds petroleum hydrocarbons and prevents their absorption in the gastrointestinal tract. The charcoal is eventually passed with the feces. However, because we could not verify that the ingestion of oil had occurred, the beneficial effect of this treatment remains uncertain.

By the third week of the oil spill in Alaska, the detrimental effects of the oil were limited primarily to contamination of the fur, which could be treated with cleaning. As a result, mortality decreased dramatically, and more than 70% of the otters arriving at the rehabilitation centers after the third week survived.

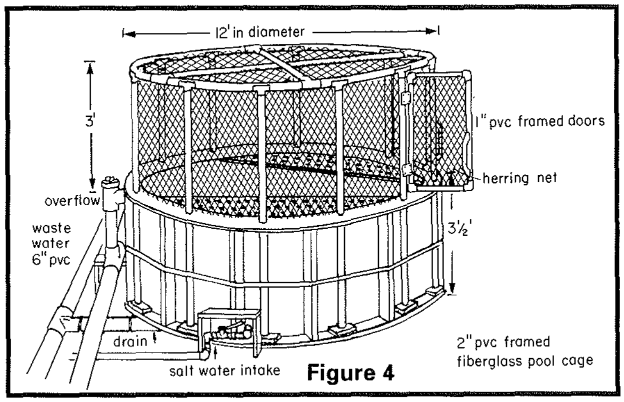

Figure 4

Round Holding Pool

Recognition of the the two distinct phases of a crude oil spill should enable veterinarians and animal care specialists to anticipate the medical problems and prepare for them in future spills. In addition, new, more effective treatment protocols can be devised now that we better understand the clinical effects of crude oil on Sea Otters.

Pup Nursery

Successful techniques to raise sea otter pups have been perfected by the Monterey Bay Aquarium and Sea World. The nursery should occupy a separate room to create a quiet, low stress environment. The basic requirements include a small kitchen (sink and refrigerator) for preparing and storing formula, a second sink and counter top for washing and grooming the pups, and a waterbed on which the pups can rest and play. The unheated waterbed has been shown by animal care specialists at the Monterey Bay Aquarium to be beneficial for the successful rearing of young otter pups, possibly because it is pliable and simulates the surface of the ocean. Because Sea Otter pups require 24 hour care, we found it useful to place a cot in the room for the caretakers to use at night.

Husbandry Facilities

Throughout the rehabilitation process, the primary responsibility of the husbandry staff is to feed and monitor the otters in their pens. If a rehabilitation facility has 200 adult otters each weighing 20 kg and eating 25% of their body weight in food each day, then the kitchen staff must thaw 1000 kg of seafood daily. The food preparation kitchen should have at least 1000 cubic feet of freezer space for frozen seafood. This is enough space to store three to four days of frozen seafood for 200 Sea Otters. Ten stainless steel sinks (3 feet x 3 feet x 2 feet deep) are used to thaw the frozen food which is placed into plastic bags, weighed (one kilogram portions), placed in buckets with ice and distributed by the husbandry staff. Pre-weighing the food in plastic bags makes it easier for the husbandry staff to estimate the food consumption of each otter, at least while it is in one of the holding pens. The waterproof floor and stainless steel counter tops should be sanitized at least once per day. For convenience, a commercial ice maker should be in or adjacent to the kitchen.

Other Facility Considerations

When choosing the site for a primary rehabilitation facility, additional requirements include all-weather access by road and aircraft, telephone communications, and easy access to fresh seawater and a commercial seafood supplier.

Although the primary function of the facility is to clean and rehabilitate oiled animals, the Valdez spill proved the wisdom of allocating space for administration, staff training, and public relations.

To ensure the health of the otters and the staff, coveralls should be issued to all persons to wear over their street clothing. A dressing room with small lockers to store personal belongings should be provided. Staff members should eat only in a designated lounge, which can also be used for training programs and staff meetings.

To prevent the introduction of domestic animal diseases into the wild population, quarantine procedures are essential in the rehabilitation centers. Transport cages should be cleaned and sanitized after use. All pets and unnecessary visitors should be excluded from the site. Ideally, visitors and press corps should be confined to an interpretative center or allowed to view the otters from behind a glass partition.

Pre-release Facilities

Normally about two weeks are required to rehabilitate an oiled sea otter, although the duration may be longer in cases of severe petroleum hydrocarbon toxicosis. Rehabilitated otters should be moved to seawater pens in a pre-release facility as soon as they satisfy the following criteria:

1. Fur is water repellent; otter is able to thermoregulate (does not become chilled) in water;
2. Otter exhibits regular grooming behavior; fur appears healthy and retains loft;
3. Otter is eating well; body weight is either stable or increasing;
4. Otter appears alert and socializes with pen mates;
5. Plasma variables (i.e., glucose, electrolytes, metabolites, and enzymes) and hematology (i.e., hematocrit and white blood cells) are normal.

It may be necessary to hold the otters in a pre-release facility long after they are rehabilitated. Sufficient time must pass before it is safe to return otters to the previously oiled areas, and, as we learned in Alaska, the federal trustee needs time to develop a release strategy. In Alaska, the trustee required that the pre-release facility remain open about three months longer than we

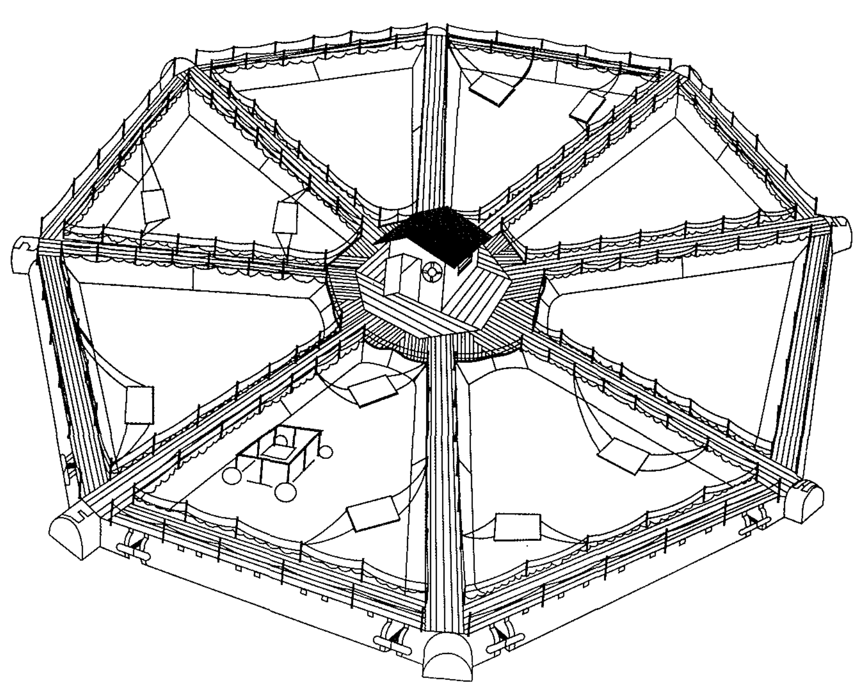

Figure 5

Figure 5. Floating Pre-Release Facility

anticipated. Because of the many factors that may influence the timing of release, pre-release facilities may be needed to hold Sea Otters for six months to a year.

Holding pens in the pre-release facility should be large enough for the otters to swim and dive (at least 100 feet long x 20 feet deep) and have good seawater circulation. Figure 5 shows one type of pre-release facility that was successfully used in Alaska. Although this facility was built to hold young salmon, it also proved suitable for holding up to 200 Sea Otters. The spokes and perimeter of the octagonal pens are made of steel tubes (4 ft diameter) that form a flexible articulation when connected. This type of construction allows the structure to bend and ride over waves. Each pie-shaped section is draped with netting that is secured four feet above the water line. A small hut in the center provides protection from the weather for the animal monitors.

Additional requirements for the pre-release facility include a food preparation area, freezers, and accommodations for staff. These amenities are most easily obtained near developed areas. If a large preemptive capture effort is planned immediately after a spill, quick access to seawater pre-release pens would be vital. A modular system like the one above would allow rehabilitators to store and quickly assemble the pens when needed. A modular design also enables the addition of new pens as needed, thereby allowing unlimited capacity.

Staffing and Management Issues

To avoid misunderstandings and inefficiency, the management at a Sea Otter rehabilitation center requires well-defined authority from the USFWS (the federal trustee for sea otters). The organization needs to be interactive and encourage the free exchange of information in order to improve operations, but staff members also need a clear understanding of the chain-of-command.

Otters require continuous care, so a core professional staff of administrators, veterinarians, veterinary technicians and animal care specialists is required. Volunteers can be a valuable supplement to the core professional staff if they are properly trained and supervised. Jobs that can be filled by volunteers include animal monitors, kitchen staff, and logistical support for the rehabilitation center (i.e., transportation of personnel and otters, radio and telephone communications, administrative support).

The total staff should be large enough to accommodate 12 hour shifts while providing 24 hour care for the animals. Some overlap in shifts will allow the exchange of information among staff members, especially among the husbandry staff. We learned that appropriate staff size is a function of the number and health status of otters in the facility. A ratio of one to three staff per otter (1/2 to 1 1/2 people per 12 hour shift) is usually adequate.

A training program for volunteers with yearly refresher courses needs to be an integral part of a pre-existing facility if one were built. This ensures that a group of knowledgeable and highly motivated volunteers could be immediately available if an emergency arises. Training programs for volunteers should include instruction on sea otter behavior, health effects of exposure to crude oil, common veterinary procedures and their purposes, sanitation and hygiene in animal facilities, record keeping, and quarantine procedures for disease control. Following the Valdez oil spill, training videos were produced on some of these topics to accompany lectures for new staff members.

Data Collection and Analysis

Much valuable information was collected during the 1989 Sea Otter Rehabilitation Program in Alaska that will be used to develop new medical and husbandry protocols. The most useful information fell into five categories:

1. Sea Otter biographical data
   a. Date, location of capture, tag number
   b. Body weight at time of capture
   c. Degree of oiling and medical condition
   d. Pregnancy and birth data
   e. Final disposition

2. Medical treatments
   a. Anesthetics
   b. Antibiotics
   c. Other drug therapies

3. Clinical laboratory results
   a. Blood chemistry
   b. Urinalysis

4. Food consumption

5. Necropsy results

For a detailed list of variables for each category of data, see Appendix 2.

Preliminary analysis of the data have been published in a report entitled "Sea Otter Rehabilitation Program: 1989 Exxon Valdez Oil Spill" (Williams and Davis, 1990). Further analysis of the data is planned and should provide additional recommendations for the husbandry and veterinary care of oiled sea otters.

Science and wildlife rehabilitation will continue to benefit for some time from the quality of the Valdez data acquisition and analysis. This documentation process has proved worthwhile to help evaluate treatment protocols. In addition, this facilitates the sharing of information with other rehabilitation programs.

Research

Research is not always included in the activities of rehabilitation centers, but many opportunities exist at these facilities to improve our knowledge about the clinical effects of oil exposure and methods of treatment, especially during an oil spill. However, to take advantage of these opportunities, a detailed research plan is required and personnel and resources must be allocated before an oil spill occurs. During the 1989 Valdez oil spill, four research projects were conducted:

1. Clinical evaluation and treatment of oiled otters.
2. The pathological and toxicological effects of fresh crude oil on Sea Otters (see Williams, this volume).
3. Development and testing of improved methods of cleaning oiled Sea Otters.
4. Development and testing of a field protocol for determining degree of oiling.

The first project involved the detailed clinical evaluation of each otter that arrived at the rehabilitation center. During the first week of the oil spill, otters that arrived at the rehabilitation center in Valdez were examined for the degree of oiling and indications of dehydration, pulmonary distress, and shock. In addition, body weight and core body temperature were measured on arrival and as indicated by the animal's medical condition. By the second week, we had expanded the clinical evaluation to include hematological, serological, and blood chemistry analyses.

Gathering this information served two purposes. First, it was used by the veterinary staff to monitor the immediate clinical condition of the otters and to revise treatment protocols during the rehabilitation process. Second, we knew that the availability of this type of information was unprecedented and would be useful in improving methods of treatment.

The second research project revolved around the detailed postmortem examination of all sea otters that died at the centers. In addition to preparing necropsy reports on each animal, duplicate tissue samples from most major organ systems were taken for histopathology and toxicology (petroleum hydrocarbon analysis). The analysis of polycyclic aromatic hydrocarbons and aliphatic hydrocarbons was directed by Dr. Terrie Williams and conducted at Battelle Ocean Sciences (Duxbury, MA). When evaluation of the results is completed, it may indicate which organ systems were most susceptible to damage from systemic exposure to oil. These data will be correlated with the types and concentrations of petroleum hydrocarbons in the tissues. In some sea otters, blood petroleum hydrocarbon levels were also measured (Williams, 1990). In acquiring a better understanding of the basis of petroleum hydrocarbons' effects on Sea Otters, we hope to improve veterinary protocols for oiled Sea Otters and thereby increase survivorship.

The third research project examined new techniques to restore the water repellency of Sea Otter fur after cleaning.

While the method for cleaning the fur of oiled otters worked well, the Sea Otters' fur did not fully regain its water repellency until several days after cleaning. As a result, cleaned otters could not be placed immediately into water because their fur wetted and they became chilled. Although the reasons for the delayed recovery of the water repellency of the fur are not known with certainty, possible explanations include: 1) the alignment of the dense underfur had been disrupted during washing so that it no longer trapped an air layer next to the skin; 2) the normally hydrophobic surface of the hairs retained a monolayer of detergent molecules which made their surface hydrophilic; and 3) washing had removed natural oils which normally contributed to the hydrophobic properties of the fur.

To discover if the time needed for fur restoration could be abbreviated, the rehabilitation centers invited Dr. Lee Hunter of Redkin Laboratories (Canoga Park, CA) to investigate the beneficial effects of applying squalene (an oil similar to the natural oils produced by the otter's sebaceous glands) to the fur of Sea Otters after they had been cleaned with Dawn™ dishwashing detergent. Our hypothesis was that the application of squalane would replace the natural oils that are removed with crude oil during washing, thus returning the fur to its hydrophobic state. Squalene in ethanol was sprayed on the fur of several otters after their fur had been washed and thoroughly dried. The water repellency of their fur was compared to otters in a control group which were not sprayed. The fur of the treated group appeared to dry quicker when the animals were out of the water. Although the results are preliminary, this research may result in a modified cleaning method, which will not only remove crude oil but will also restore the water repellency of fur immediately. Such a method could shorten the rehabilitation process by one to two weeks.

One problem that we had not anticipated in 1989 was how to decide when to stop capture operations. During the first few weeks of the spill, oil was visible on the fur of otters that were brought to the rehabilitation center in Valdez. However, as the oil dispersed and weathered, it became more difficult to decide when an otter was lightly oiled or unoiled. The situation was further complicated by the absence of information on safe levels of exposure to oil. As a result, the USFWS continued to capture Sea Otters in the oil-affected area, probably longer than necessary.

In an attempt to provide more objective criteria for determining when otters should be brought to the rehabilitation centers, Dr. Ken Hill (staff veterinarian) developed a field test for detecting the presence of petroleum hydrocarbons on the fur of lightly oiled otters. This simple test involved placing a small hair sample from an otter in a 3 ml glass vial with dichloromethane (an organic solvent), which solubilized the oil and visually changed the color (clear to dark brown) of the solvent. The color was compared to a series of standards to provide a semi-quantitative estimate of the amount of oil on the fur. This test could be made more sensitive and quantitative by measuring the spectrophotometric absorbance of the sample at 240 nm, but this required bringing the otter to the rehabilitation center. Further research and testing are needed to verify this method of detecting oil on Sea Otters in the field. Animals that are unoiled should be immediately transferred to a pre-release facility or translocated outside of the oil-affected area.

Discussion and Conclusions

While Valdez may have been the first oil spill to involve large numbers of Sea Otters, it may not be the last. Should there ever be another oil spill that threatens Sea Otters, the wildlife rehabilitation community is far better prepared to respond effectively because of programs conducted at the sea otter rehabilitation centers. We understand the types of facilities and staff that will be needed, and we understand more clearly the types of treatment strategies that will be most effective for sea otters and other marine mammals.

The 1989 Valdez oil spill may, in fact, represent a watershed in rehabilitation programs for Sea Otters and other marine mammals. Because of the size of the spill, the investment by Exxon Company USA to save the oiled Sea Otters, and the scientific programs that were instituted, the Valdez spill experience will result in better wildlife oil spill contingency planning. In the future, rehabilitation programs should strive, as Exxon's did, not only to care for oiled wildlife, but also to advance our scientific understanding and create a rational basis for improved facilities and veterinary treatment.

Summary

The March 1989 Valdez accident was the first oil spill to involve large numbers of Sea Otters. Similarly, the response to the Valdez spill involved the largest effort ever to rescue and rehabilitate oiled Sea Otters. Volunteers and employees captured and delivered 357 otters to the Sea Otter Rehabilitation Centers following the spill. While many of these animals regrettably died, the majority (197) were eventually returned to the wild. Another 37 were placed with seaquariums.

The Sea Otter Rehabilitation Program demonstrated that large numbers of oiled Sea Otters could be successfully rehabilitated following an oil spill. The experience was often painful and always trying, but it nonetheless contributed enormously to the wildlife rehabilitation community's understanding of what is needed to successfully rescue and treat Sea Otters after an oil spill.

Acknowledgments

In addition to those previously mentioned in the text, I would like to acknowledge the many people who worked at the rehabilitation centers. Also, I gratefully acknowledge the support of Exxon Company, USA, who sponsored this report and the 1989 Sea Otter Rehabilitation Program.

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Appendix 1

Primary Rehabilitation Center

A floor plan for a hypothetical, stand-alone, flow-through primary rehabilitation center designed for a capacity of 200 Sea Otters at a time is shown in Illustration 1.

Illustration 1 Legend:
C =custodial room, CC = cage cleaning area, CENT. FILE = central files, CL RM = class room, CLNG = animal cleaning room, COM = communi-

cations room for VHF radios and telephones, CONF = conference room, CRITICAL CARE = critical care holding area, DIR OFF = Director's office, DRESS'G = dressing rooms for men and women staff, DRYING = animal drying room, FOOD PREP = kitchen for animal food preparation, FREEZER = freezer for animal food, ICE = ice machines, LUN = staff eating area, LAUNDRY = washing machines, dryers, water conditioners, NEC = necropsy room and pathology laboratory, NURSERY = nursery for sea otter pups, PENS = raceways (spillways) for sea otter pens, PEN STORAGE = storage area for sea otter pens, P. SEC = plant security, POOLS = pools for sea otters and pinnipeds, REPRO. = document reproduction (xerography), REC. & WTG. = waiting and reception area, STAFF SEC. = secretarial area, SHOP = machine shop, U = utility room, VET CLINIC & LAB = veterinary clinic

The recommended space requirements for a rehabilitation facility that can treat and hold 200 sea otters are as follows.

I. Outdoor Space

A. Concrete holding pools (6 @ 12 ft x 60 ft) and walkways (animal rehab.)	8,400ft^2
B. Concrete raceways for pens (12 @ 3ft x 50ft) and walkways (animal rehab.)	6,780ft^2
C. Helicopter pad (animal rehab.)	10,000ft^2
D. Parking	4,500ft^2
E. Sea water treatment (2000 gal/min)	600ft^2
TOTAL OUTDOOR SPACE	30,280ft^2

II. Indoor Space

A. Administration	
1. Conference room for 30 persons	800ft^2
2. Reception/waiting area	300ft^2
3. Secretarial staff offices	300ft^2
4. Director's office	300ft^2
5. Administrative personnel (3 offices)	450ft^2
6. Reproduction room (xerox)	200ft^2
7. Central files room	200ft^2
8. Communications room (outdoor antenna)	150ft^2
9. Plant security / personnel ID room	200ft^2
10. Administration lounge/kitchenette	200ft^2
11. Corridors/toilet/custodian/utility	1,100ft^2
TOTAL	4,200ft^2
B. Animal Rehabilitation	
1. Weighing and sedation	480ft^2
2. Animal cleaning room (6 stations)	570ft^2
3. Animal drying room	530ft^2
4. Critical care room	1,020ft^2
5. Animal food preparation room	1,000ft^2
6. Nursery	475ft^2
7. Veterinary clinic/laboratory	.1,000ft^2
8. Utility room (laundry)	510ft^2
9. Dressing room-volunteers,staff	1,360ft^2
10. Personnel lunch room	540ft^2
11. Freezer space for animal food	870ft^2
12. Ice machine room	300ft^2
13. Carpentry and machine shop	310ft^2
14. Corridors/toilet/util./loading dock	2,200ft^2
15. Necropsy laboratory	560ft^2
16. Cage cleaning	310ft^2
TOTAL	12,035ft^2
C. Classroom	360ft^2
D. Pen storage	6,000ft^2
TOTAL INDOOR SPACE	22,595ft^2

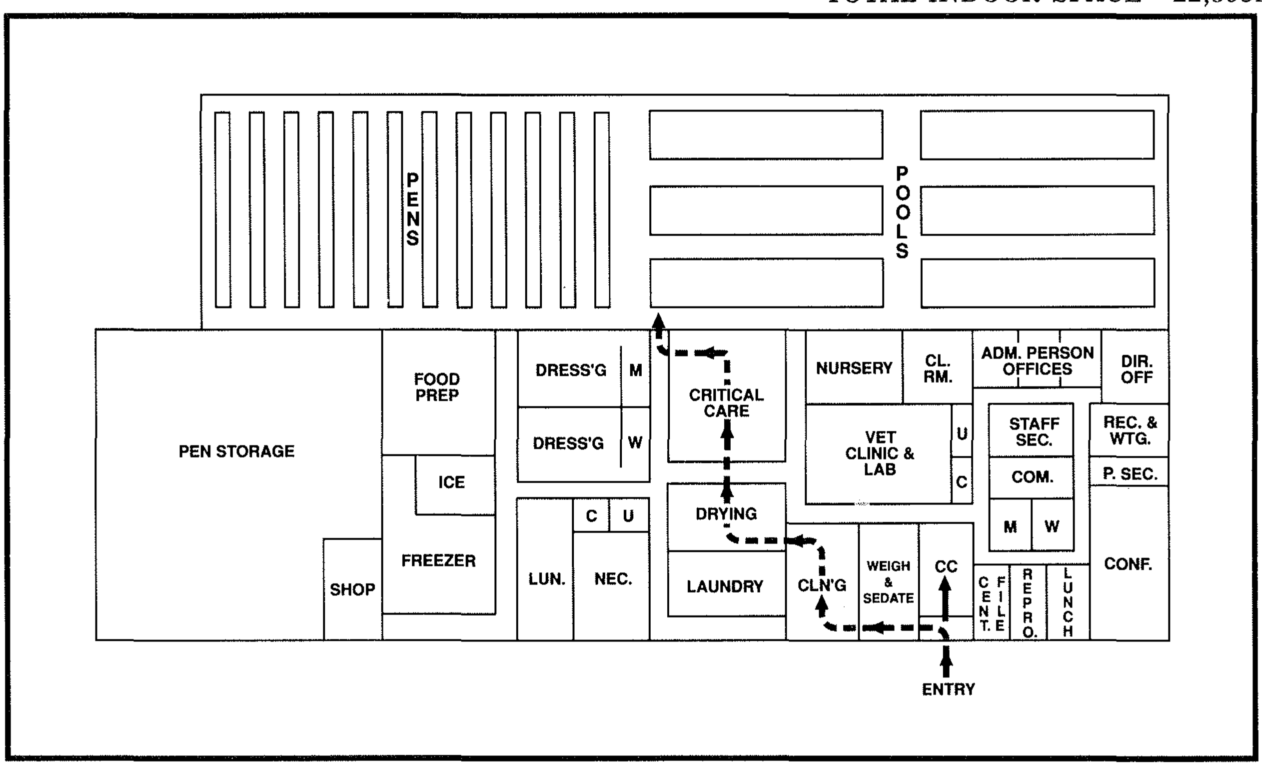

Illustration 1. Primary Rehabilitation Center Floor Plan

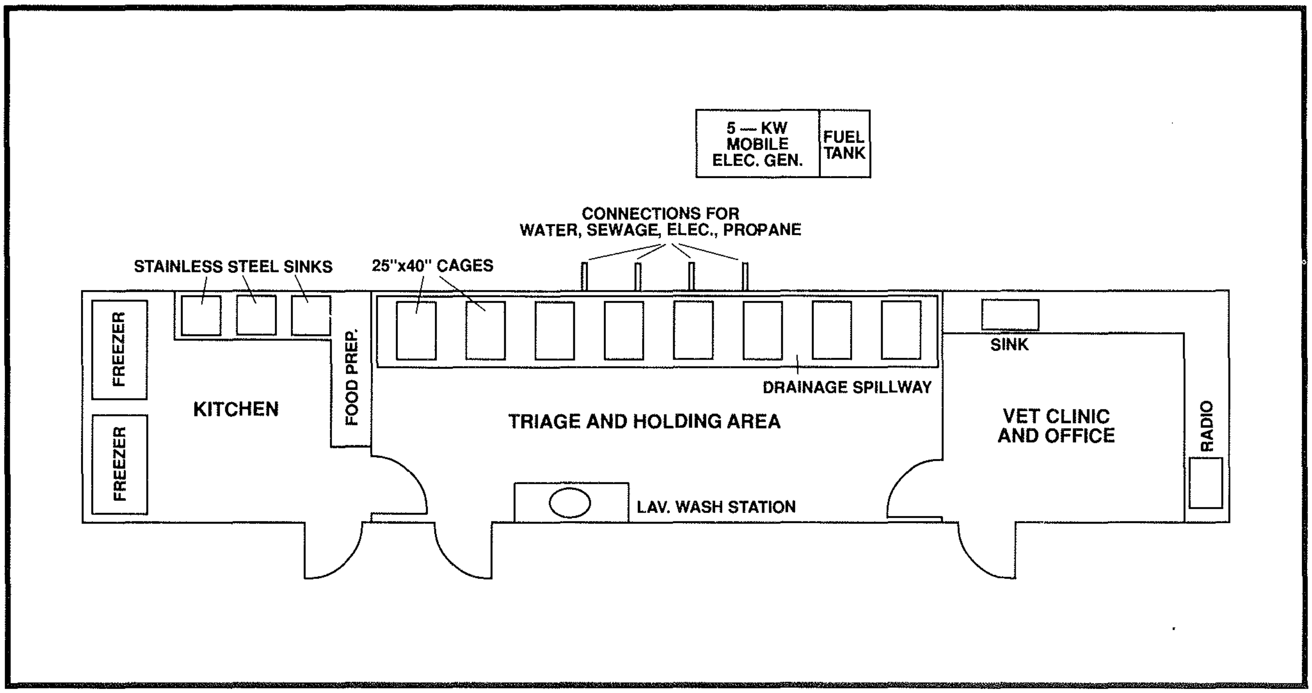

Illustration 2. Mobile or Remote Holding Facility

Appendix 4.

Summary of data collected at the Alaska Sea Otter Rehabilitation Centers.

A. Bio-summary data
1. Identification number assigned to each otter at the centers (usually sequential numbers based on order of arrival and two letters to indicate the rehabilitation center where the animal was admitted—the letters are important only if there is more than one primary center)
2. Tag number (three digit number and color of tag attached to hind flipper)
3. Sex
4. Admission date and time at the rehabilitation center
5. Admission body weight and length
6. Age class (pup, juvenile, adult)
7. Pregnant (yes or no)
8. Capture date and time
9. Capture location (geographical name or latitude and longitude)
10. Capture method (dip net or tangle net)
11. Name of capture boat
12. Mode of transportation to rehabilitation center (aircraft, boat or ground transportation)
13. Core body temperature at time of admission (important if hypothermia is evident)
14. Evidence of subcutaneous emphysema (yes or no)
15. Toxiban administered (yes or no)
16. Date and time of Toxiban administration
17. Type, dose, date, and time of chemical restraint used during washing
18. Type, dose, date, and time of reversal drug if narcotics are used for chemical restraint (i.e.Naloxone)
19. Degree of oiling (light, medium, heavy)
20. Date and time of washing
21. If not washed, why (minor oiling or no evidence of oiling)
22. Birth date and sex if a pup is delivered in captivity
23. Final disposition of otter (died, released, transferred to a seaquarium)
24. If released, date, location, and final body weight
25. If radio transmitter is surgically implanted in the abdomen, date and performing surgeon
26. If identification transponder chip is implanted subcutaneously, chip number
27. If animal is retagged on hind flipper, new number

B. Medical diagnosis
1. Otter identification number
2. Date and time of examination
3. Overall condition and symptoms
   a. alertness
   b. body weight (food consumption, see below)
   c. core body temperature
   d. heart rate
   e. respiratory rate (evidence of respiratory distress)
   f. occurrence of seizures
   g. pelt condition (includes degree of oiling)
   h. skin disorders
   i. appearance of teeth and gums
   j. appearance and consistency of feces
   k. additional symptoms and veterinary comments
   l. comments from husbandry records
4. Blood analysis (see below)
5. Urinalysis (see below)
6. Diagnosis (veterinarian's diagnosis and recommended therapy)
7. Chemical restraint if required (type and dose)
8. Drug therapy (drug types, doses, and frequency)

9. Fluid therapy (type, quantity, and frequency)
10. Surgical intervention (full description)
11. Daily progress reports

C. Blood analysis
1. Otter identification number
2. Date and time of blood sample
3. Reason for blood sample (admission, routine, toxicology, monitoring medical treatment, etc.)
4. Laboratory performing the analysis
5. Hematology
   a. hematocrit (%)
   b. buffy coat
   c. serum color (clear, hemolyzed, etc.)
   d. erythrocyte sedimentation rate (min)
   e. hemoglobin concentration (g/dl)
   f. red blood cell count
   g. mean corpuscular volume (cubic microns)
   h. mean corpuscular hemoglobin concentration
   i. platelets (adequate, increased, decreased, clumped)
   j. white blood cell count
   k. neutrophils (%)
   l. bands (%)
   m. lymphocytes (%)
   n. monocytes (%)
   o. eosinophils (%)
   p. basophils (%)
   q. unidentified leukocytes
   r. Heinz bodies
   s. other cell types and quantities
   t. comments
6. Serology
   a. glucose (mg/dl)
   b. blood urea nitrogen (BUN, mg/dl)
   c. creatinine (mg/dl)
   d. BUN to creatinine ratio
   e. uric acid (mg/dl)
   f. cholesterol (mmol/l)
   g. triglycerides (mmol/l)
   h. alkaline phosphatase (U/l)
   i. GGTP (U/l)
   j. SGOT (U/l)
   k. SGPT (U/l)
   l. lactate dehydrogenase (U/l)
   m. total bilirubin (mg/dl)
   n. direct bilirubin (mg/dl)
   o. total protein (g/dl)
   p. albumin (g/dl)
   q. globulin (g/dl)
   r. albumin to globulin ratio
   s. iron (ug/dl)
   t. triiodothyronine (T3) uptake (%)
   u. thyroxine (ug/dl)
   v. amylase (U/l)
   w. lipase (U/l)
   x. ammonia (umol/l)
   y. comments
7. Electrolytes
   a. sodium (mEq/dl)
   b. potassium (mEq/dl)
   c. calcium (mg/dl)
   d. phosphorous (mg/dl)
   e. magnesium (mmol/dl)
   f. chloride (mg/dl)
   g. polychromasia
   h. poikilocytosis
   i. macrocytosis
   j. microcytosis
   k. nucleated RBC to WBC ratio
   l. hyperchromasia
   m. hypochromasia
   n. degree of sample hemolysis (slight, moderate, severe)
   o. comments

D. Urinalysis
   a. pH
   b. total protein
   c. glucose
   d. ketones
   e. bilirubin
   f. hemoglobin
   g. specific gravity
   h. sediment (bacteria, blood, crystals, epithelial cells, casts)

E. Husbandry Records
1. Name of animal monitor and date
2. Notations on each otter
   a. otter identification number
   b. most recent body weight
   c. pen number
   d. fur condition (percent recovery of normal fur condition, problem areas, etc.)
   e. behavior (estimated amount of time spent grooming, resting, swimming)
   f. feeding behavior (appetite, quantity and type of food at each feeding- see food records)
   g. females with pups (nursing behavior, attention to pup, grooming pup)
   h. social behavior (interaction with pen mates)
   i. obvious health problems (labored breathing, anorexia, hypothermia, hyperthermia, seizures, fur and skin disorders, oral lesions, etc.)
   j. feces (frequency, color, and consistency)
   k. date, time and purpose of physical or chemical restraint for medical treatment
   l. husbandry staff comments
   m. veterinary comments

F. Food Consumption
1. Otter identification number
2. Date
3. Most recent body weight
4. Food consumption (kg and % of total)
   a. geoduck clams
   b. fish
   c. scallops
   d. clams
   e. squid
   f. shrimp
   g. crab
   h. mussels
   i. other
   j. total food consumption

G. Necropsy Records
1. Otter identification and tag number
2. Pathology report number and name of pathologist
3. Date and time of necropsy
4. Date and time of death
5. Body weight and body length at time of death
6. Sex and age class
7. Carcass condition at post-mortem (good to severe autolysis)
8. Fur condition (healthy, poor but clean, oily, etc.)
9. Nutritional condition (thin, poor, good, obese)
10. Necropsy observations
   a. oral cavity (appearance of mucosa and teeth) and nasal passages (color, necrotic tissue, edema, or parasites)
   b. muscle and skeletal system
   c. subcutaneous fat (none to obese)
   d. intraperitoneal fat (none to obese)
   e. color of peritoneum and presence of fluid
   f. liver condition (size, color, texture, comments)
   g. gall bladder (thickness, fluid color, fluid viscosity, parasites, comments)
   h. stomach (appearance, color of mucosa, color and consistency of contents, parasites, presence of ulcers, comments)

intussusception, parasites, comments)
j. large intestine (appearance, color of mucosa, color and consistency of contents, presence of ulcers or necrotic tissue, intussusception, parasites, comments)
k. pancreas (color, size, and comments)
l. bone marrow (color, texture, and comments)
m. lymph nodes (color, size, and comments)
n. thymus (description for fetus only)
o. spleen (color, size, and comments)
p. thyroid (color, size, and comments)
q. adrenal (color, size, and comments)
r. kidneys (color, evidence of congestion, cysts)
s. urinary bladder (wall thickness, urinary system comments)
t. genital system (appearance of testes, ovaries, uterus; recent parturition; description of fetus; genital system comments)
u. lungs (color; presence of emphysema, congestion, or bullae; tracheal congestion or blood; respiratory system comments)
v. heart (size, color, presence of pericardial fluid or sinoval fluid, cardiovascular system comments)
w. brain (appearance, presence of congestion or hematomas, central nervous system comments)
x. eyes (corneal opacity, cataracts, parasites)

11. Summary of all parasites seen
    a. acanthocephalids
    b. ascarids
    c. nematodes
    d. trematodes
    e. helminths
12. Summary of tissue samples taken for toxicology
13. Tentative diagnosis as to cause of death
14. General pathological diagnosis
15. Summary and comments

Alaskan Sea Otter at Sea World in San Diego. Photo: Courtesy of Sea World

Evaluating the Long Term Effects of Crude Oil Exposure in Sea Otters: Laboratory and Field Observations

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Introduction

Previous studies have demonstrated the vulnerability of Sea Otters (*Enhydra lutris*) to the detrimental effects of crude oil (Costa and Kooyman, 1982; Davis *et al.*, 1988). Sea otters face two types of problems from exposure to crude oil. While external contamination of the fur results in decreased insulation (Williams *et al.*, 1988) and potentially lethal hypothermia, internal exposure to petroleum hydrocarbons contributes to another set of health problems. We diagnosed pulmonary emphysema, anemia, and hypoglycemia (low blood sugar) in otters contaminated during the Valdez spill. The incidence and severity of such problems correlated with the date of exposure, and hence, with the extent of oil weathering.

From the perspective of the otters' health problems, the Valdez spill can be divided into two distinct periods. During the initial phase, lasting three weeks, contaminated otters showed the greatest degree of oiling (Figure 1), encountered oil containing the most harmful crude oil components, and had the highest incidence of severe health problems. Although the rehabilitation program lasted several months, 54% of the deaths in the centers occurred during this initial three week period. During the second phase, 70% of the otters captured within the spill area were lightly oiled or unoiled. These animals were probably exposed to fewer harmful components, had comparatively fewer health problems and, hence, greater survivorship (Williams *et al.*, 1990).

Primary concerns for otters that survived the initial phase of the spill included: 1) long term effects due to oiling; and 2) continued contamination from residual oil in the habitat or in food items. To examine the former, we monitored the health of eight adult sea otters (seven females, one male) and four otter pups (three females, one male) for twelve months after the spill. For each animal, we determined: 1) general health, 2) body weight, 3) coat condition, 4) blood chemistry and hematology, and 5) reproductive status.

All of the adults in this study were captured during the initial phase of the spill and were severely impacted by the oil. Unlike the 197 adult otters that had been released back into the wild after rehabilitation, these eight adults were judged unsuitable for release and were therefore transferred to seaquariums for long term care. The pups used in this study were admitted to the centers during the latter phase of the spill (Table 1).

We determined the likelihood of continued oil contamination in wild otters by assessing habitat conditions in previously oiled areas of Alaska. Major goals were

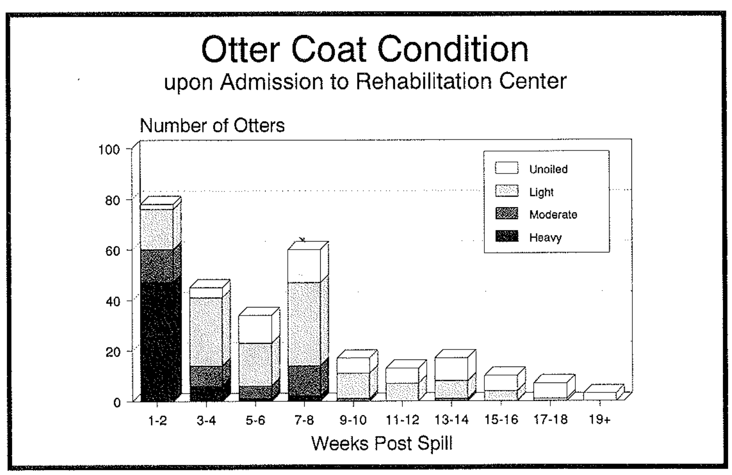

Figure 1. Degree of oiling on the coats of Sea Otters on admission to the rehabilitation centers. Note the rapid decline in the number of heavily and moderately oiled otters 3 weeks after the spill.

to evaluate the condition of beaches and coastal waters in terms of the potential impact on sea otters, and to observe the general behavior of Sea Otters in previously oiled areas. These August 1990 field studies were qualitative observations; we do not consider them comprehensive. However, when compared to observations made in 1989, these studies provide a framework for evaluating general changes in the sea otters' habitat.

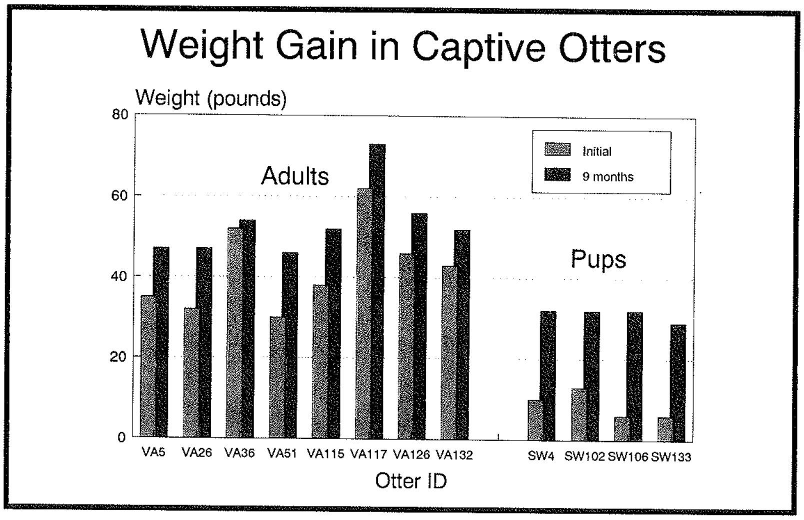

Figure 2. Changes in body weight of adult Sea Otters and Sea Otter pups on arrival at the rehabilitation centers and after nine months in captivity.

Status of Captive Otters

The condition of captive otters is summarized in Table 1. Several factors were assessed including coat condition, health status, body weight, blood parameters, and reproductive status.

Coat Condition

A water repellent coat is essential for thermoregulation in sea otters. Therefore, it was important to thoroughly clean fur that had been contaminated with oil. The amount of oil on the fur (i.e., the degree of oiling) varied among the otters brought to the rehabilitation centers (Figure 1). Rankings ranged from heavily oiled to unoiled, and reflected the percentage of surface area covered and the level of saturation to the skin (Williams *et al.* 1990). Five of the eight adult otters used in the study arrived at the rehabilitation center moderately or heavily oiled; two other adults were lightly oiled.

All of these animals were cleaned successfully using methods outlined in Williams *et al.*, 1988 and Davis *et al.*, 1988. Because of the loss of natural oils from the washed fur (Davis *et al.*, 1988), a seven to ten day delay in the recovery of water repellency is normal. Grooming activity by otters facilitates restoration of the oils and the original condition of the fur. Until then, areas of the pelt will saturate when the otter enters the water.

In the rehabilitation centers the pelt restoration process was complicated in clinically ill Sea Otters. These animals were often lethargic, did not groom, and therefore had consistently poor coats. Following several weeks in the rehabilitation centers, the animals began grooming and coat condition gradually returned to normal. By August 1989, coats of the adult otters had fully regained water repellency. The animals' coats remain in good condition.

The fur of Sea Otter pups also requires constant care to remain in good condition. In the wild, this activity is provided by the mother; in the rehabilitation center, members of the husbandry staff groomed the pups. In contrast to the adult otters, the sea otter pups were captured 5-10 weeks after the oil spill and arrived unoiled at the center. Although washing was not necessary, towel drying and daily combing were required to remove mats from the pups' hair. After two months in captivity the pups were able to groom themselves, no longer requiring human assistance. The fur of the pups has remained in good condition since December 1989.

Health Status

During the initial phase of the spill, Sea Otters showed a wide range of health problems (i.e., gastrointestinal dysfunction, respiratory distress, poor thermoregulatory control, anemia, and fluctuations in blood cell counts). Some of these conditions, particularly gastrointestinal problems and stress, may have been complicated by captivity. In addition, oiled Sea Otters often demonstrated chronic bloody nasal discharge, lethargy, diarrhea, and poor motor coordination in the water (Wilson *et al.*, 1990). Subcutaneous emphysema was documented in three study animals that were heavily oiled and captured during the initial phase of the spill (Table 1). Body temperature was variable in these animals and ranged from 95°F to 102°F during the first few days in the rehabilitation centers. (Body temperatures of healthy otters range from approximately 99°F to 100°F; Costa and Kooyman, 1982.)

The general health of the captive adult otters improved after cleaning. Thermoregulatory problems were quickly corrected as water repellency of the coat was regained. Recovery from the initial health problems occurred within 3-4 months of exposure to the oil. Gastrointestinal problems were often corrected after two weeks, but the anemia persisted for over 45 days (Figure 3). Corneal damage in one otter and minor locomotor problems in two other animals persist, but these conditions do not appear to impair their general health. Treatments (i.e., antibiotic therapy) were unnecessary after September 1989. The appetite and activity level of the captive otters remain high, and indicate a general recovery from the initial effects of oil contamination. Currently, the health status of captive otters is good.

Unlike the adults, the Sea Otter pups did not appear oiled when captured. Often the pups were found abandoned in the wild or were separated from female otters that were unable to care for them. Despite the absence of surface oiling, general health of the pups on arrival at the rehabilitation centers was varied. For example, body temperatures were highly labile, three of the pups were underweight and anemic, and diarrhea was common until the diet was adjusted.

Raising Sea Otter pups in captivity is difficult because of their nutritional and thermoregulatory demands. Yet, the appetites of the otter pups indicated that the animals quickly acclimated to the seaquariums. The health of the pups has been good to excellent from October 1989 to present. One exception is a male pup (SW106) which has experienced several health problems (hypoglycemia, anemia, acute nephritis, and a moderate nonspecific infection). This animal showed a gradual improvement during November and December 1989, but it remains in guarded condition. Reasons for his persistent problems include oil related and non-oil related factors (e.g., an individual response to captivity or susceptibility to disease, exposure to petroleum hydrocarbons before or after birth). Because of the absence of surface oiling, it is unlikely that external contamination was a significant factor.

Body Weight

The resting metabolic rate of Sea Otters is almost 2.5 times higher than other similarly sized mammals (Costa and Kooyman, 1982), and results in a voracious appetite. Inadequate food intake or poor nutrition will accelerate weight loss in these animals. Because lethargy and anorexia were common problems in oiled otters, many of the animals were underweight during the first weeks in the rehabilitation centers. As the otters' health improved, their appetites returned and body weights quickly increased. From March 1989 to January 1990, the body weight of non-pregnant adults increased an average of 12.3 +/- 2.3 lb. (Figure 2). Similarly, all of the pups gained weight, with a mean increase of 22.6 +/- 3.0 lb. during the first nine months in captivity.

Blood Parameters

Blood panels were generated throughout the rehabilitation process and provided a good indication of the health status of the otters. When the oiled animals arrived at the rehabilitation centers, hypoglycemia and anemia were commonly diagnosed (Wilson *et al.*, 1990). White blood cell counts were quite variable in many of the otters (Table 1). Much of this variability was attributed to the presence of infection or possible immunosuppression.

Recovery from many of these conditions occurred within four months of captivity. White blood cell counts, creatinine levels, and enzyme levels (SGOT, SGPT, and CPK) returned to normal in all of the study animals except for two adults and one pup. Periodic elevations in white blood cell counts and enzymes (CPK, LDH, and to a lesser degree SGOT) continued to occur in the two adults. The male pup shows consistently abnormal blood variables (elevated WBC and LDH, anemia) that are attributed to infection.

Anemia persisted for approximately eight weeks in 11 of the sea otters (Figure 3). Hematocrit of these animals was less than 40.0% during the first two months after the spill. This increased to 47.4% during the third month and was within the normal range for captive otters (50.0 - 62.0%; T.D. Williams, pers. comm.) after four months. The hematocrit of the otters has remained normal since that time.

In addition to the routine analyses, we determined total paraffinic hydrocarbon (TPH)

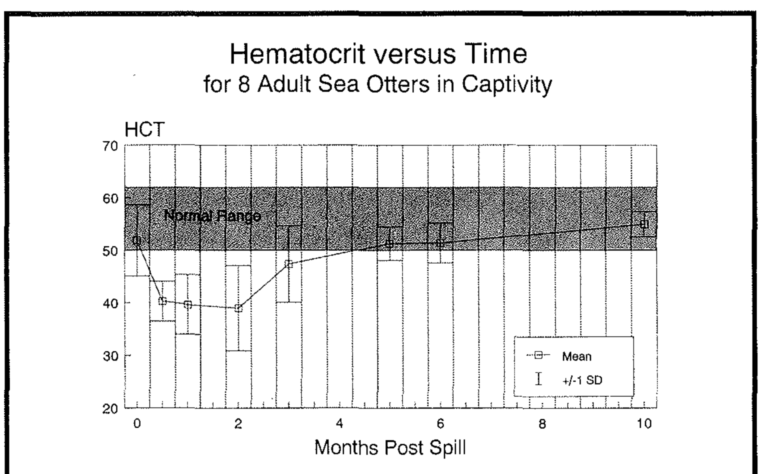

Figure 3. Hematocrit of adult Sea Otters in relation to time post spill. Mean values ± 1 SD are indicated.

levels in the blood samples. TPH in blood provides an indication of systemic exposure to oil and can be useful in predicting survival (Williams, in prep.). We found that the concentration of TPH ranged from 19 ppm to 800 ppm in Sea Otters admitted to the rehabilitation centers (Williams *et al.,* 1990). Levels above 80 - 120 ppm were associated with mortality. In comparison, total paraffinic hydrocarbon concentration was insignificant in captive Sea Otters examined twelve months after exposure to crude oil (Table 1). These levels were well below the lethal threshold range determined for otters.

Reproductive Status

Mating among rehabilitated otters was often observed when male and female adult otters were housed together. The male in this study, VA117, became active in August 1989 after introduction into the female pool and recently sired a healthy pup. The females varied in responsiveness to VA117; although two animals were reproductively active in August 1989, the remaining females did not appear active for three to four months after that date. Currently, all of the captive adult otters are demonstrating reproductive behaviors.

In the wild, female SeaOtters are capable of producing a pup annually. However, age of the female, health, and previous pregnancy, among other factors, will affect the reproductive interval (Rotterman and Simon-Jackson, 1988). The average time between copulation and birth ranges from 6-7 months for wild otters to 7-8 months for captive animals. Two of the four reproductively active females showed evidence of pregnancy during the study period. Serum progesterone for one animal sharply increased to approximately 6500 pg/ml in August 1989, and indicated possible pregnancy. However, serum levels gradually decreased over the following two months with no ensuing gain in weight. Another female, VA126, had serum progesterone levels of 7630 pg/ml in April 1990 and gained 15 lb. in 2.5 months. On May 31, 1990 she gave birth to a healthy pup. The pup was nursing within three hours of birth and quickly gained weight. Although the pup had to be separated from its mother for several weeks because of poor fur condition, they have recently been reunited. Both animals are in excellent condition.

Field Observations of Wild Sea Otters

Approximately 100,000-200,000 Sea Otters are found throughout the coastal areas of Alaska (Rotterman and Simon-Jackson, 1988). Of these, almost 16,000 animals inhabited areas within the oil spill zone (DeGange *et al.*, 1990). Currently, we do not know the exact number of otters impacted by the spill. Reliable counts show nearly 900 Sea Otter carcasses retrieved from the spill area (DeGange and Lensink, 1990) and 357 live animals brought into rehabilitation centers (Williams & Davis, 1990).

The degree of oiling and consequent mortality in wild otters declined early in the spill, paralleling the pattern observed in rehabilitation centers. By May 19, 1989 approximately 70% of the otter carcasses had been retrieved (DeGange and Lensink, 1990). An estimated 80% of these mortalities were attributed to exposure to oil. After the initial phase of the spill, the major concerns for wild otters were the possibility of fur contamination from residual oil on the water or beaches and toxicoses from eating contaminated prey. A toxic response from direct contact with the oil was unlikely because most of the volatile petroleum hydrocarbons had dissipated within days of the spill (Neff *et al.*, 1990).

Field studies were conducted to determine the potential for continued contamination of wild Sea Otters. In August 1990, we examined areas of Prince William Sound and the Kenai Peninsula that were primary capture sites of oiled otters following the spill. These sites, visited by boat and helicopter, included Rocky Bay (40+ otters captured), Windy Bay (65 otters), Tonsina Bay (27 otters), Green Island and Applegate Rocks (40+ otters) and Evans Island (17 otters captured). In addition, we examined Sleepy Bay, a site of persistent heavy oiling and active cleanup activity during 1989 and 1990. The observation period for each site was less than a day, therefore this is not considered an exhaustive otter count.

Each field site was evaluated in terms of its potential for contaminating Sea Otters. General beach condition was inspected visually for the presence and type of oil on the substrate. The presence of invertebrates and kelps was considered indicative of beach recovery. Evidence of sheen oil on the water surface was also determined.

Otters and Pups

We observed Sea Otters of all age classes (adults, juveniles, and pups) at many of the field sites in Prince William Sound and along the Kenai Peninsula. Other marine mammals, including Steller sea lions, harbor seals, killer whales, and humpback whales were also seen in these areas. In this study, the largest concentration of otters (more than 150 adults and several pups) was found around Montague Island. We saw 43 individuals in La Touche Passage, more than 80 otters, including juveniles and mother-pup pairs, near Green Island and Applegate Rocks, and small groups of otters along the Kenai Peninsula (including eight adults and two pups in Windy Bay and a raft of 40 animals by Gore Point). Few otters were seen in areas around the northern islands of Prince William Sound (i.e., Herring Bay, Smith Bay, Prince of Wales Passage, Naked Island). We did not see any otters in Tonsina Bay, although other investigators have observed them at this site.

The Sea Otters observed within the spill area appeared healthy. All animals were active and displayed typical behaviors. When approached by boat, the animals slowly swam away. If observed from the shore, the otters groomed, dove, and rested on the water's surface. In general, the coats of the animals appeared water repellent; dark areas indicative of saturation were not observed.

Suitability of the Habitat for Sea Otters

Sea Otters forage along shore areas and feed on a variety of bottom-dwelling invertebrates, and rarely on fish in Prince William Sound (Estes, 1980). The otter's diet reflects local prey abundance; in Alaska, prey items include sea urchins, mollusks, crustaceans, and some epibenthic fishes. Because many of these prey items are located in shallow areas and are known to accumulate petroleum hydrocarbons (Neff, 1979), exposure to crude oil or toxic hydrocarbon metabolites through ingestion of tainted food was a concern for wild Sea Otters. Current evidence, however, indicates that contamination of invertebrates was limited to isolated areas of Prince William Sound, the Kenai Peninsula, and Kodiak (Varanasi *et al.*, 1989). In a previous study, edible tissue samples of mollusks had levels of aromatic hydrocarbons in excess of reference samples taken from Angoon, an Alaskan village outside the spill area. Three of four sites (Kodiak, Chenega Bay, and Old Harbor) may have been contaminated by spilled or discharged marine fuels from boat traffic in the village areas. Windy Bay mollusks, which appeared to have been contaminated by the *T/V Exxon Valdez* spill, showed light aromatic hydrocarbons up to 16,000 ppb and heavy aromatics up to 2,500 ppb (Varanasi, 1989). However, even these levels of contaminants, the highest measured in the Subsistence Food Safety Study, were not considered a serious health risk for human consumption (USFDA, 1990).

It is difficult to predict whether these isolated areas of contaminated prey pose a significant threat to wild Sea Otters. We do not know if otters can detect petroleum hydrocarbons in food or if they will avoid contaminated prey. Nor do we know the amount of contaminated prey that would have to be ingested before a toxic response occurs. In view of these uncertainties and the isolated location of residual oil, it is unlikely that a large segment of the Alaskan Sea Otter population would locate and digest harmful quantities of contaminated prey.

Although most of the harmful components of the oil dissipated within days of the spill (Neff *et al.*, 1990), residual oil on beaches or on the water surface could be detrimental to the fur of Sea Otters. Previous studies have shown that weathered oil does not have as great an impact on insulation as fresh crude (Williams *et al.*, 1988) because it is more viscous, remains on the tips of the hair, and is less disruptive to the insulating air layer. Likewise, the absence of hypothermia in lightly oiled Sea Otters at rehabilitation centers indicates that sheen oil is less disruptive to insulation than fresh oil (pers. obs.).

For most of the sites visited, oil on the substrate was limited to isolated areas of beach. Usually, traces of oil had hardened in thin layers on rock, sand, or pebbles. We occasionally found spots of tar between rocks, but saw little evidence of oil sheens on the water. This situation contrasts with conditions on capture beaches in 1989, when fresh oil or thick layers of mousse covered the beaches to upper tidal lines. Sheens of oil were often observed on water surfaces near heavily oiled shores.

In 1990 we surveyed two beaches, Herring Bay and Sleepy Bay, that were exceptions. At these worst case sites, we saw areas of standing oil and some sheening in the water. Although Sea Otters were not seen near these beaches, the potential for contamination of their fur does exist. However, neither USFWS nor the cleanup crews at these beaches reported sightings of oiled Sea Otters.

Prognosis for Captive and Wild Sea Otters

Behavioral, medical, hematological, reproductive, and toxicological parameters indicate that it is possible for otters to recover from many of the initial effects of oil exposure. Except for one pup, the captive otters recovered from many effects within 3-4 months. Coat condition, a critical factor for Sea Otters, was restored to normal water repellency within one month of thorough cleaning. Blood petroleum hydrocarbon levels that were comparatively high initially, were insignificant after twelve months of captivity. Consequently, the current prognosis for the captive animals is good.

Because the otters in this study received veterinary care and *ad libitum* food, it is difficult to extrapolate to animals in the wild population. Preliminary results from radio-instrumented animals indicate that rehabilitated otters are initially vigorous following release into the wild. Mortality increased during winter month, suggesting a susceptibility to environmental factors (Monnett *et al.*, 1990). Before conclusions can be drawn, however, further research is needed to determine the relationship between the degree of oiling of otter fur and survivorship in free-ranging sea otters.

Conditions in Prince William Sound and the Kenai Peninsula have improved, in terms of the suitability of the habitat for sea otters. Water column and subsistence fisheries reports, as well as the present study, indicate few traces of oil. In many cases the oil is: 1) inert; 2) limited to isolated shores and prey items; and 3) in a form which poses little threat to Sea Otters. Large numbers of adults and pups were found in previously oiled areas, and they appear to feed and behave normally. These results suggest that many of the previously contaminated areas are able to support Sea Otters. With time and further research, we will be able to determine the resiliency of both the sea otter population and its habitat in Alaska.

Summary

Sea Otters continue to inhabit the area that was impacted by the March 1989 Valdez oil spill. Their presence raises questions about the long term effects of the spill and the ability of the habitat to support Sea Otters.

To examine the long term effects of exposure to petroleum hydrocarbons on Sea Otters, we monitored the general health, fur condition, blood parameters, and behavior of twelve sea otters placed in captivity following the Valdez oil spill. We compared the behavior and coat conditions of these captive otters to wild otters residing in previously oiled areas of Prince William Sound and the Kenai Peninsula, Alaska. In addition, we evaluated the current suitability of the area's habitat for Sea Otters.

Major findings of the study are:

1. The current prognosis for captive otters that survived the initial effects of hydrocarbon exposure is good.
2. Petroleum hydrocarbon levels in the blood of captive otters were at background levels within twelve months of the spill.
3. Clinical evaluations indicate that captive otters gradually recovered from poor thermoregulatory control, respiratory distress, and anemia which were associated with short term exposure to crude oil.
4. Eighteen months after the Valdez spill, crude oil was found only on isolated sections of shoreline. In addition, the oil had weathered so that it presented little if any threat to SeaOtters.
5. Several hundred Sea Otters were observed eating, grooming, and resting in previously oiled areas of Prince William Sound and the Kenai Peninsula.
6. Captive and wild otters were reproductively active. One captive female, which had been moderately oiled, gave birth to a pup within one year of the spill. Many females with pups were observed in previously oiled areas of Prince William Sound.

Acknowledgments

I would like to thank R. Davis for generously providing his field notes. Sea World (San Diego), the Shedd Aquarium (Chicago), the Point Defiance Zoo, and the Vancouver Aquarium provided invaluable information about their Alaskan sea otters; the enthusiasm of T. Goff and J. Robinnette is especially appreciated. J. White, M. Barker, D. O'Connor, and R. Mastracchio reviewed numerous drafts of this manuscript and provided insightful comments. In addition, I gratefully acknowledge the support of Exxon Company, USA who sponsored this research project through the 1989 Sea Otter Rehabilitation Program.

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Condition of Captive Sea Otters

Otter #	Coat Condition		Health Status		Weight			Blood Panel		Paraffinic Hydrocarb. in Blood
(Date)	Initial	Final	Initial	Final	Initial	Final	% Gain	Initial	Final	TPH (ppm)
Adults										
VA-5 (3-31)	Heavy Oil	Good	Lethargic Emphysema	Normal	35	47	34	Anemia elev. CPK	Normal	ND *
VA-26 (4-1)	Heavy Oil	Good	Emphysema	Normal	32	47	47	elev. WBC	Normal	ND
VA-36 (4-2)	Heavy Oil	Good	Lethargic Diarrhea	Normal	52	54	4	Normal	Normal	ND
VA-51 (4-4)	Not Documented	Good	Emphysema	Normal	30	46	53	elev. WBC, LDH & CPK	Normal	-
VA-115 (4-10)	Light Oil	Good	Fair	Normal	38	52	37	elev. SGPT, LDH & CPK	occasional elev. WBC	-
VA-117 (4-11)	Light Oil	Good	Fair	Normal	62	73	18	elev. WBC	Normal	ND
VA-126 (4-16)	Mod. Oil	Good	Emaciated	Normal	46	56	22		Normal	ND
VA-132 (4-17)	Heavy Oil	Good	Lethargic Diarrhea	Normal	43	52	21	elev. WBC	occasional elev. WBC	-
Pups										
SW-4 (5-1)	No Oil	Good	Thermal Instability	Normal	10	32	220	-	Normal	ND
SW-102 (5-10)	No Oil	Good	Underweight	Normal	13	32	146	Anemia	Normal	ND
SW-106 (5-21)	No Oil	Good	Underweight	Fair	6	32	433	Anemia	Abnormal	ND
SW-133 (6-13)	No Oil	Good	Hypothermic	Normal	6	29	383	Anemia	Normal	ND

* ND = Non Detectable Amounts

CPK = Creatine Phosphkinase
LDH = Lactate Dehydrogenase
WBC = Total White Blood Cell Count
SGPT = Alanine Aminotransferase
TPH = total paraffinic hydrocarbons

Note: TPH measurements were made at 12 months.

Results of the Eagle Capture, Health Assessment, and Short-term Rehabilitation Program Following the Valdez Oil Spill

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Introduction

Shortly after midnight on March 24, 1989, the Exxon Valdez collided with Bligh Reef in Alaska's Prince William Sound, spilling nearly 11 million gallons of North Slope crude. The oil eventually fouled 10% to 15% of the area's shoreline (USFS, 1990). According to the U.S. Fish and Wildlife Service, more than 5,000 bald eagles are associated with the area's intertidal habitats (USFWS, 1989).

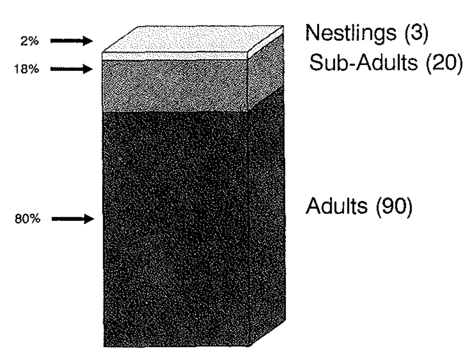
USFWS began to develop a program addressing concerns about the area's bald eagles shortly after the spill. Very little, if any, study had been conducted on the effects of oil exposure on bald eagles, but the raptor biologists had various concerns. There was, for example, the possibility that oil ingestion might cause harmful reactions or affect future reproduction and that external oiling would inhibit flight.

Based on such initial concerns, the USFWS developed a capture and treatment protocol for bald eagles in late May, 1989. This original protocol called for capturing and holding many of the area's bald eagles in captivity for one year. It reflected fears that all the eagles in Prince William Sound faced immediate danger, that many were heavily oiled, and that few were nesting.

USFWS directed Exxon to hire specific qualified personnel to implement the capture and long term treatment programs. As soon as weather conditions allowed capture teams to work safely in the Sound and around Kodiak in late May, two groups of three people systematically surveyed the area to identify specific eagles that might have been exposed to oil. Although the surveys focused on the heavily oiled areas, most eagles in these areas evidently were not oiled, and none appeared moderately or heavily oiled. Also, in spite of the large-scale clean-up activities, many of the birds were maintaining territorial boundaries and hunting as usual. Many pairs were even breeding, an unexpected event because of the disruptive human activity and suspicions that food sources might have been contaminated.

Using the information from the May 1989 surveys, the capture teams began working with USFWS to amend the initial protocol. Although most of the eagles observed during the surveys appeared to be in good health, the teams wanted to feel secure that

Figure 1
Age Distribution of Captured Eagles



the eagles could survive in their natural habitat. For those birds in the nesting cycle, they also wanted to be certain the adults were strong enough to feed and raise young.

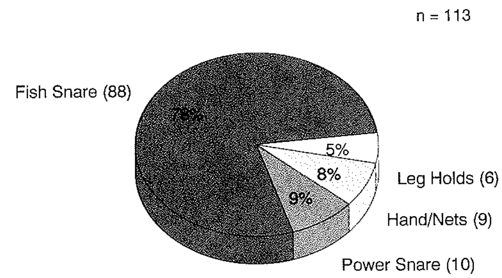
The revised protocol reflected these concerns, the realities of conditions in Prince William Sound and around Kodiak, and the preference for keeping nesting pairs together in their natural habitat. The revised protocol called upon the capture teams to assess the health of as many eagles in the spill area as possible. Teams were to capture eagles, visually inspect them for signs of oil ingestion, and conduct rudimentary bloodwork. If the birds were not injured and showed no evidence of distress from oiling, teams were to release the trapped eagles as soon as possible (in practice, the entire exam required from 20 to 30 minutes). All the captured birds were to be banded with USFWS bands before release.

Capture Data

The capture teams trapped 113 eagles between June 3 and August 14, 1989. Adults represented 80% (90) of the total, with sub-adults and immatures comprising 18% (20), and nestlings, 2% (3) (Figure 1). The preponderance of adults is probably a function of the season and that we targeted prime nesting locations. During the nesting season, breeding adults claim the prime areas, forcing non-breeders and younger birds to less desirable areas with more dispersed feeding sites and carrion sources (Brown, 1969).

The most successful capture technique proved to be a modified floating fish snare (see Appendix A for a description of this technique). The teams employed the floating fish technique to trap more than three-fourths (88) of the total sample. Nine eagles that had been weakened by injuries could be captured by hand or with nets. One team used power snares early in the program to trap ten birds, six of which were immature eagles. Another team used padded leg holds to successfully and safely trap four immature birds and two adults (Figure 2).

Figure 2
Capture Techniques Employed



Results of On-Site Health Assessment

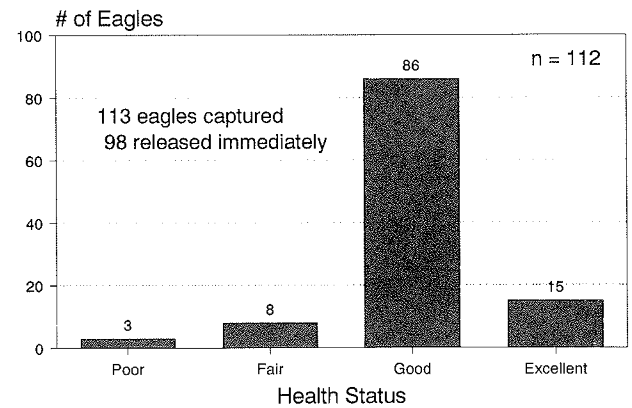
The vast majority of the captured birds met USFWS release criteria; teams immediately returned 98 (87%) of the eagles to the wild. Fourteen of the non-released eagles were transferred to IBRRC in Seward for short term rehabilitation and, in nine cases, cleaning (a fifteenth -- severely injured -- bird from the capture teams was transferred to Anchorage, where it was later euthanized). Of the 14 birds sent to IBRRC by capture teams, 12 were returned to the wild eventually, most after about two weeks. Of the remaining eagles, one is non-releaseable, and the other which had broken its wing, is on loan from the USFWS to one of the authors for educational purposes.

Physical Examinations

Of the 113 captured eagles, 101 (89%) were rated as being in excellent or good condition (15 and 86 birds, respectively), eight were considered in fair condition, three were in poor condition, and body condition was not recorded for one bird (Figure 3). Records are incomplete for a few eagles, particularly from early in the program.

Teams marked 108 of the captured birds as alert, while three were rated as lethargic. All three of the lethargic eagles had been injured, two definitely

Figure 3
General Health Status upon Capture



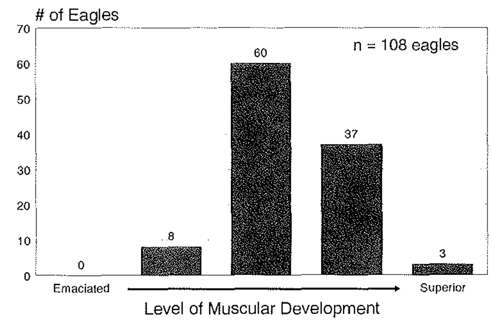
had not been oiled, and there is no record of oiling for the third. After short-term treatment by IBRRC, the three were sent to a facility in Anchorage, where they were held in captivity for one year and then released.

Physical examinations of eyes, nares, oral cavities and respiratory systems showed no abnormalities. Except for one non-oiled bird with bloody nares and corneal opacities, all records noted bright eyes and clear nares. One bird's oral cavity appeared cyanotic, seven appeared pale, and 98, pink. As a result, capture teams determined that five of the birds with pale oral cavities were healthy enough for release. This determination was based on the totality of physical examination information including clinical pathology data. The average packed cell volume (PCV) of the five birds was 49%.

Capture teams also rated body condition of the eagles on a scale from one to five. A "one" would have indicated the bird was emaciated, and none of the birds received the "one" rating. A "five" indicated superior pectoral muscle development — a relatively rare condition for wild birds, particularly during breeding season (Gibson and Bloom , unpublished). Only three eagles received a rating of "five." The vast majority (60) of the birds rated as a "three"; 37 as a "four"; and eight as a "two" (Figure 4).

Figure 4

Body Condition upon Capture



External Oiling

The capture program documented evidence of oiling on the captured birds. Team members took field notes and photographs for documentation. They were particularly concerned about signs of oil around the beak, neck or vent, as this would denote possible ingestion.

Records indicate that 39 eagles (35%) exhibited no evidence of oiling. In addition, degree of oiling was not specifically noted for 35 birds (31%). A blank on the form was understood to represent no oiling. Since oiling was the focus of the capture program, it is likely, but not certain, that birds without oiling notations were also non-oiled. Of the 39 eagles (35%) for which oiling was noted, one was classified as heavily oiled, two as moderately, and 37 as lightly (i.e., spots, stains or sheens along the tail fringe or on the feet; Figure 5). Most of the 39 oiled birds appeared in good condition overall. Their health ratings were as follows: five, excellent; 29, good; four, fair; and one, the heavily oiled bird, poor.

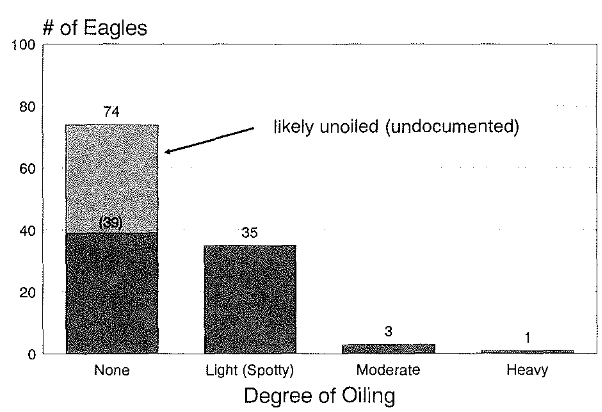
Because oiling was typically limited, often to a spot the size of a dime, capture teams would occasionally "spot clean" eagles on the capture vessel. Teams were able to wash thirty of the oiled birds and release them immediately. They forwarded the other nine birds to the IBRRC for processing and washing.

Bloodwork

Because of earlier studies of oiled seabirds, it was feared that eagles in the spill area might suffer from hemolytic anemia and kidney and/or liver insult (Williams, 1985; Fry, 1987). In addition, PCV is a good clinical indicator of health stamina and is an important criteria for release. To determine the PCV of the blood, each capture boat was equipped with a microhematocrit centrifuge. To obtain a sense of a bird's nutritional status, as well as get an indication of liver or kidney problems, teams measured total solids using a refractometer. Total solids are the amount of plasma substances found in healthy birds (glucose, uric acid, plasma proteins, etc.). In debilitated birds, this value is often depressed.

Figure 5

Oiling on Captured Eagles

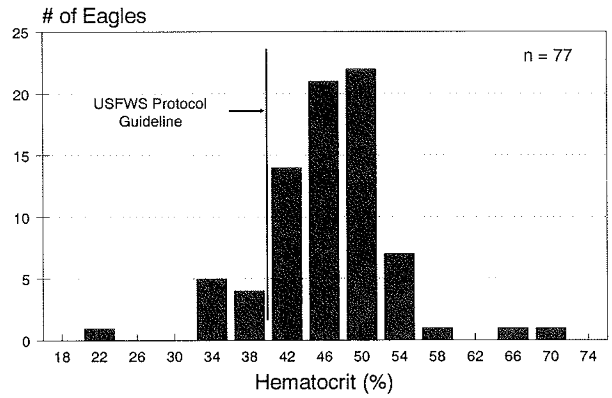


The capture teams drew blood (approximately 10 cc's) from the brachial vein using a heparinized 20-25 gauge needle. With the same needle, the team leader immediately made four blood smears on alcohol-cleaned slides. The slides were then air dried, fixed in absolute methanol, and stored in microscope slide boxes.

In general, the results indicated that the hematopoietic (i.e., blood manufacturing) systems were functioning well. We collected 77 acceptable samples for PCV counts — 10 from treated birds and 67 from immediately released birds. Among the 67 samples from immediately released birds, the minimum was 35%; the maximum, 68%; the mean, 46.6%; and the standard deviation, 5.8%. For the 10 treated birds, hematocrit levels ranged from 20% to 68%, with a mean of 46.0% (standard deviation is 6.8%). Using a total of 85 samples, including 10 treated birds, total solids ranged from 2.5 g/dl to 7.3 g/dl, with a mean of 4.1 g/dl (standard deviation is 0.7 g/dl); (Figures 6 and 7). Among the 75 samples from immediately released birds, the statistical results are identical to those for the total sample of 85.

Based upon data from rehabilitated birds in captivity, the USFWS determined that rehabilitation care might be justified for birds with total solids below 4.0 g/dl or PCV below 40%. However, standards were not based on data from a wild population and were viewed as guidelines, not as firm criteria. USFWS directed capture teams to consider blood levels in the context of the birds' overall conditions. Low total solid values only compelled rehabilitation when combined with other signs of distress. With this in mind, the capture teams considered and released 17 birds with total solids below the 4.0 guideline. Release in each case was justified by the evident health of the bird.

Figure 6
Distribution of Hematocrit Measurements



The two on-board blood tests were micro-techniques, requiring less than 0.5 cc's of blood. The microscopic slides and the remaining blood (six to nine cc's) was put in heparinized tubes, separated, and frozen for shipment to Dr. Pat Redig at the Raptor Center of the University of Minnesota. Dr. Redig subsequently conducted comprehensive blood chemistry and hematological examinations, which have confirmed the positive findings of the field examinations (Redig, 1990).

Short-Term Rehabilitation Center

Background

The non-profit International Bird Rescue Research Center served as the short-term eagle rehabilitator following the Valdez spill. IBRRC has a long history of developing and directing rehabilitation efforts for wildlife affected by oil spills. Since 1971, IBRRC staff has consistently provided professional advice about rehabilitating oiled wildlife and, on more than 25 major spill responses, established and directed emergency oil spill rescue and rehabilitation programs.

The Alyeska Pipeline Company, which manages spill response for the Trans-Alaskan Pipeline and the Valdez area, had contracted with IBRRC since 1979 to serve as wildlife rehabilitators in the event an oil spill impacted wildlife in Prince William Sound. When the Valdez accident occurred on March 24, 1989, Alyeska contacted IBRRC and requested immediate action. By early the next morning, March 25, IBRRC staff had begun to set up and operate a response.

During the next month, bird rehabilitation centers or initial care sites were established in Valdez, Seward, Kodiak and Homer. The IBRRC bird rescue program operated through mid-September. While the IBRRC centers focused their efforts on the area's seabirds, they were also prepared to handle eagles.

In total, rehabilitation centers handled 39 eagles between April 11, 1989 and August 20, 1989. As noted above, eagle capture teams supplied 15 of those birds. Members of the public and, in one case, USFWS personnel delivered the other 24.

Medical Evaluations and Treatments

Upon arrival at the IBRRC facility, each of the 39 eagles was given a physical examination and checked visually for oil on feathers. The veterinary staff weighed each bird and, when warranted, performed tracheal cultures to check for candidiasis and aspergillosis, common respiratory ailments. Fecal samples were examined by direct microscopy, as well as floated for parasites. We also drew blood to assess red blood cell status and to conduct serum chemistries. We used two off-site labs for bloodwork, as well as an in-house lab equipped with an Abbott Visions™ machine.

While at IBRRC facilities, eagles were monitored routinely with serial serum chemistries (approximately weekly) and hematology (PCV, total proteins, total solids, white cell counts). Beginning in mid-June, staff performed routine tracheal cultures on most of the birds. Routine parasitology proved unrewarding, but was performed on in-house birds. Eagles were photographed to document their condition while in the program.

Only nine of the eagles had enough oil on them to warrant cleaning (see appendix B for cleaning techniques). No parasites were found in fecal flotation or direct examinations. Staff performed tracheal cultures in-house on 14 birds for fungal/yeast growth. Only two cultures showed any growth; neither showed fungus.

On the whole, blood work performed on these birds was within normal ranges. Birds presented with old infected injuries exhibited elevated white cell counts and slightly depressed PCV, as would be expected with chronic anemia or disease. Many eagles had slightly elevated enzyme CPK, a natural occurrence given that they would have exerted significant muscle activity during trapping.

Birds from the capture teams typically had some oil to be evaluated for removal (usually spots on tail feathers) and slightly depressed total solids. After a week to ten days of rest and good food, these birds usually responded well and the total protein levels would climb to about the 4.0 g/dl level, allowing release according to the USFWS protocol.

Two of the birds from capture teams had medical problems thought to be unrelated to the oil spill. One immature bird had avian pox and was sent to the Raptor Center in Minnesota for surgical treatment of lesions. It was returned before the end of the summer and flown back into the exact territory in which it had been caught. Another was missing the tip of its wing, making it non-releasable.

In contrast, most of the birds delivered by the public had the types of serious medical injuries that are seen regularly in wildlife care centers. At least five bald eagles had fractured limbs. Various other cases included one bird that had been hit by a car, two that had lead poisoning, and others that had problems ranging from old facial wounds, leg lacerations, wing droop, to swollen legs. Most of these injuries were old and were likely to be non-spill related.

The records indicate that 11 of the public-captured birds had some evidence of oiling; ten were not oiled, and there were no notations for three of the birds. Although it is not likely that many of the public-captured birds had spill-related problems, IBRRC admitted them for humanitarian reasons. Many of these birds would have died if a program to save oiled bald eagles had not been in place.

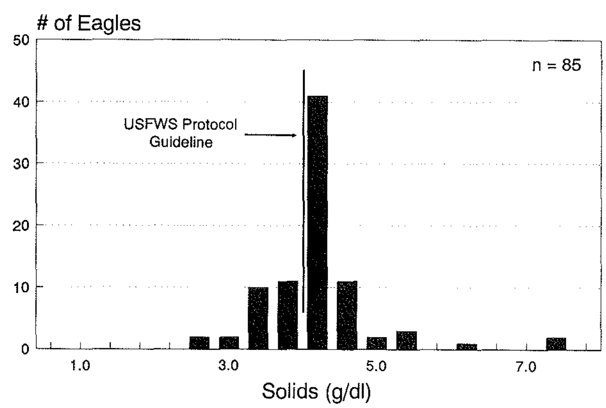
The serious medical problems of public-captured birds were reflected in hematological tests and total solid readings. The incoming PCV on this group of birds ranged from 17% to 50% with an average value of 36% — about 10 percentage points less than field captured eagles. Total solid readings ranged from 1.0 g/dl to 4.4 g/dl, with an average of 3.4 g/dl. While not dramatically depressed, this figure is significantly lower than the capture team birds.

Release Criteria

To determine whether bald eagles met release criteria, the staff conducted physical exams and pre-release blood work. Additionally, we tested eagles for flight ability in large flight aviaries or on flight lines (creance lines). We completed serum chemistries and blood counts in-house, or at Seward General Hospital. In this way, timely results could be obtained and the period of captivity could be kept as short as possible.

Using the established protocol, IBRRC released eagles when the bird's hematocrit exceeded 40%, total solid readings exceeded 4.0 g/dl, and, when relevant, medical problems had been re-

Figure 7
Distribution of Protein Measurements



solved. At release, the birds were measured, weighed, and banded.

Of the 15 capture team birds, nine were released in 1989, three others were released in June 1990, one was euthanized, one is on loan from the USFWS to one of the authors for educational purposes, and one is held. Of the 24 public-capture birds, eight were released in 1989 and another four were returned to the Sound in 1990. That is, 24 of the 39 birds (62%) were eventually released. Six eagles are non-releasable and remain in captivity, including four at the Bird Treatment and Learning Center in Anchorage, and one at a facility in New Mexico.

Conditions in 1990

USFWS Survey of Active Nests

In preparation for the summer 1990 Exxon beach clean-up operations, USFWS surveyed eagle nests in the oil spill area to assess whether clean-up operations might disturb nesting pairs. Their appraisals covered segments of Prince William Sound, the Kenai Peninsula, Kodiak Island, and the Alaskan Peninsula.

Wherever active nests were observed, access to the immediate area was restricted jointly by Exxon and USFWS in order to prevent the possibility of nesting loss. Initially, clean-up crews and boats were prohibited from approaching closer than 1/4 mile of the nest; aircraft were not to approach closer than 1/2 mile. These restrictions were all reduced to 1/4 mile due to the program's success, and ultimately USFWS dropped these restrictions altogether.

Geographically, the breakdown of active nests in previously oiled areas is as follows:

Region	No. of Active Nests
Prince William Sound	268
Kenai Peninsula	105
Kodiak Island	407
Alaskan Peninsula	251
TOTAL	1,031

Field Observations

The authors visited the Prince William Sound area in 1990 to gauge qualitatively the reproductive success of eagles in previously oiled areas. The trip was made in August when the nestlings neared fledging age.

We observed numerous eaglets and recent fledglings throughout the area. In 1990, many pairs were not only occupying previously oiled territories, but they had also nested, laid eggs, incubated, and hatched chicks that had developed normally. These sightings, along with the 1,031 active nest count, are a positive contrast to 1989, when, according to USFWS, only about 200 young were produced in the Prince William Sound portion of the spill area (USFWS, 1989). If oil were still a problem, it would most likely have prevented the completion of the nesting cycle.

During our habitat observation trip, we also revisited many of the islands and bays that had been most heavily oiled in 1989. Again, the contrast between 1989 and 1990 was significant. We returned to beaches that in 1989 had several inches of black oil covering everything. This year those same beaches appeared restored, not only by continuing clean-up operations but also the natural cleansing forces of Alaska's harsh winter storms.

Our visit also coincided with the return of pink salmon to the area's spawning streams. Their presence underscored the ample food supplies available to eagles in Prince William Sound. Because these fish had been juveniles during the spill, there had been concern about the size of this year's catch. Such concern was put aside, however, as local fisherman celebrated the largest commercial catch of pink salmon in Prince William Sound ever recorded (Wall Street Journal, 1990).

Because so many birds were fledging during our visit, and because there were two chicks in many of the nests, we concluded that food sources were more than adequate. We also concluded that oil did not pose a threat to the area's bald eagles in 1990.

Discussion and Conclusion

The evidence from the 1989 Eagle Capture and Assessment Program, as well as the qualitative observations in 1990, indicate that the Valdez oil spill was not the catastrophe for bald eagles that we had originally feared. There was indeed eagle mortality in 1989. USFWS recovered 153 carcasses during the summer of 1989, and many of those were likely victims of the oil spill. But preliminary fears that most of the area's estimated 5,000 eagles would die have not been supported by the facts. A year after the spill, the bald eagle population in the area seems healthy.

Most theories about why the eagles tolerated the oil spill so well are related to the bird's physiology (Duke, 1986). Like other birds of prey, bald eagles have the ability to collect in their crop undigestible products such as the large bones, fur, and feathers of their prey. The eagle egests this material daily. It may be that the eagles can egest tar balls in this manner without an effect to the bird (Duke, pers. comm.).

There is, of course, significant doubt about whether most eagles even ingested oil. It seems that eagles could have easily found non-oiled areas in which to hunt and eat. First, large portions of Prince William Sound and the Gulf of Alaska were never oiled in 1989. The tanker spill impacted only about 10% to 15% of the area's linear shoreline. Second, because the pattern of oil dispersal was dictated by the ocean currents, the oil was not evenly distributed in 1989. Where one beach might be loaded with crude, another only a mile away might be totally clean. Finally, within a couple of months, there was little oil left on the waters in Prince William Sound (Neff, 1990). This is important because the primary prey for eagles in the area is fish.

While initially there were reports that the eagles were attracted to oiled carrion, the capture teams did not notice the bald eagles hunting in oiled areas. We trapped eagles in some very heavily oiled areas in 1989, but the captured birds were usually not only healthy but also clean . We also found that eagles would ignore our floating fish snares if they were set near an oiled shoreline (within 30 meters) or other contaminated areas. Only after teams reset in a clean area within the same territory would a bird respond.

The nature of crude oil also might have mitigated the impact of the oil spill. Within a few days after the spill, most of the volatile components of crude had already evaporated (Neff, 1990). Within a few weeks, the crude had altered chemically enough that it posed a reduced threat to wildlife. By the time it reached Kodiak Island, the oil had formed into a biologically inert oil-water emulsion commonly called mousse. Therefore, few birds were oiled.

Whatever the reason, the bald eagle population in Prince William Sound is evidently thriving. In spite of the Valdez oil spill, we can be generally optimistic about the future of the Prince William Sound bald eagles.

Summary

Initial concerns about the impact of the Valdez oil spill on bald eagles in Prince William Sound are being set aside, as accumulating evidence indicates the area's eagle population is generally healthy and thriving. This paper presents and discusses some of that evidence. It reviews the 1989 data collected during the Prince William Sound and Kodiak Island Eagle Capture and Short-term Rehabilitation Programs, as well as 1990 data from the U.S. Fish and Wildlife Service's (USFWS) operational field surveys.

The authors participated in an unprecedented effort to capture bald eagles and assess their health following the Valdez spill. Three teams captured 113 eagles, or about 2% of the area's estimated 5,000 eagles. Although the teams focused their efforts on capturing eagles within the most heavily oiled areas, they noted evidence of oiling on only 35% of the captured eagles.

After conducting a physical exam and rudimentary bloodwork, the teams concluded that 98 (87%) of the captured eagles met release criteria. Those birds were immediately returned to their territories. Fifteen (13%) of the captured eagles required medical treatment or cleaning, and most of these birds were transported to the International Bird Rescue Research Center (IBRRC) in Seward for short term rehabilitation. In addition, IBRRC processed 24 birds that had been delivered by the general public and, in one case, by USFWS.

The positive findings in 1989 have been corroborated by 1990 USFWS operations-related active eagle nest surveys. In May the USFWS pinpointed 1,031 active eagle nests in the general area that had been oiled in 1989. The authors' own August 1990 field observations confirmed sightings of hundreds of eaglets and recent fledglings in the previously oiled areas.

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We specifically thank Phil Schempf of USFWS for introducing us to the "Robards" trapping technique, and to Dave Harlow and staff at the Anchorage USFWS for working with us to develop protocols under crisis conditions. Thanks to Ed Henckel, Judy Henckel and Peter Harrity of the Kodiak II capture team, who helped refine the capture techniques and gave helpful advice on this paper.

We are grateful as well for the advice and encouragement given by Pat Redig and Peter Bloom. Also to Pat Redig's staff (Jean Dunnette, Paula Lind, and Barbra Talbot) at the University of Minnesota Raptor Center for their roles in the medical assessment.

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Finally, we want to underscore our appreciation of families, friends and colleagues who understand our extended absences from home and offer unflagging moral support.

Appendix A

Eagle Capture Techniques

While capturing bald eagles is always a challenge, conditions in Prince William Sound and Kodiak Island made trapping even more difficult than usual. Such conditions inspired the capture teams to refine trapping techniques. This appendix describes the development of the technique that proved superior.

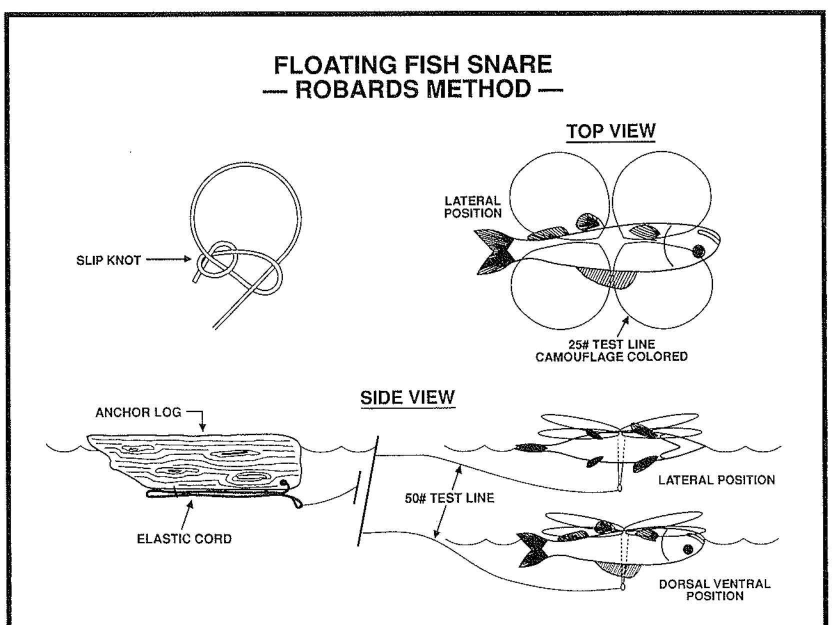
The teams considered four general capture techniques: 1) net gun; 2) power snares; 3) padded leg-holds; and 4) floating fish snares. Because of the Sound's harsh weather, occasionally violent seas, and near freezing water temperatures, the net gun techniques were considered too dangerous to employ. The risk of injuries or fatalities for the birds and the capture teams was simply too great.

Land sets were used on a limited basis with some success. In June, the first team based in Kodiak employed power snares to capture eight birds, six of which were immature eagles (Immature birds appeared to be more susceptible to carrion-baited traps). The Valdez team caught six eagles, including two adults, using leg holds. Trap safety did not present any problems with either technique, but conditions such as the following did preclude more extensive use:

- Tide shifts of 20 feet and more prevented teams from using shoreline sets for extended periods.
- Extended daylight made unobserved placement difficult.
- Other native wildlife, most notably bears, would often abscond with the bait.
- Because all animal carcasses in the spill area were picked up for necropsy studies, bait for the traps could not be found in the area easily (The most successful bait came from a single seal carcass, which was hauled around for several weeks).
- Purchasing fish stocks from local fishing villages also proved futile. The local bear population would often devour the cache before it could be used.

The capture method of choice became the floating fish snare. Used historically by the USFWS in the area with great success, the general technique is based on the "Robards method" (unpublished citing and Cain and Hodges, 1989 *Journal of Raptor Research*). We refined the technique to meet the peculiar conditions of Prince William Sound, as well as seasonal conditions and feeding habits.

The floating fish snare is an eagle-triggered multi-noose system. For bait, we preferred either trout or black cod ranging from 20 cm to 30 cm in length. Eagles seemed disin-



terested in herring, perhaps because the oily sheen it creates either seemed distasteful or because the sheen made the snare more visible. An attempt was also made to bait with seal blubber, but it was so soft that nooses would slip from it.

To enable floatation, two methods were used. If the fish had been gutted, we sewed a styrofoam plug into the abdominal cavity with cotton thread. If not, we carved a styrofoam plug for each fish and inserted it behind the gill. A single, high density styrofoam plug is recommend. If the eagle escaped with and ate the styrofoam, it would be best able to cast the single piece.

We configured a clover-leaf shaped noose (Illustration 1) using 25 pound test clear monofilament line. Four 18 inch segments were tied into four slip-knot nooses, each about four inches in diameter. A hole was punched through the dorsal, the styrofoam plug (if necessary) and the ventral side at the center of the fish. We tied the four nooses to a separate 25 pound monofilament line that ran through the fish and connected to an elastic (Bungee®) cord, which was in turn attached to a log. The nooses protruded from the dorsal side of the fish, clustered above the fish and stood clearly out of the water (The bait floats ventral-side up). Knots were tied at the ventral and dorsal openings to provide stability to the snare. If the punch holes were so large as to inhibit stability, they were reduced in size with a few stitches of cotton thread. A second variation of the floating fish mounted the nooses on the fish's lateral side with all other specifications remaining the same as the dorsal ventral version.

The size and shape of the anchor log was crucial to capture success. If the log offered too much resistance, the eagle would drop the bait before the noose tightened firmly. We found a cylindrical log approximately two feet in length and four inches in diameter was ideal.

Before setting the trap, an eagle was located on a hunting perch overlooking the water. A team using a skiff would place the fish in direct view of the eagle. The distance between the snare and the eagle was usually between 100 and 200 meters, depending upon tide and wave activity. The skiff moved away from the snare but kept both the bird and the trap constantly in sight. The skiff had to be prepared to seize the eagle within 45 to 60 seconds of ensnarement.

Once caught in the noose, the eagle would lift the fish and the anchor log from the water with little difficulty. However, the pendulum motion of the log would inhibit the bird's flight, and the weight would bring the eagle quickly and gently to the water's surface. The team on the skiff motored into place to seize the eagle, restrain its wings, and place a hood. The bird was transported immediately to the main vessel for processing.

As improvements were made in snare setting techniques, the capture success rate rose. Teams initially used 50 pound monofilament line for the noose configuration, a large block-shaped log as the anchor, and water surface noose placement. Capture success improved about 75% when teams began employing the more difficult to see 25 pound monofilament, the less resistant log, and the above water noose placement.

Appendix B

Short-term Rehabilitation Techniques

Nine of the bald eagles delivered to IBRRC during the Valdez oil spill required cleaning. As far as we know, our care and treatment of these birds comprise the wildlife rehabilitation community's entire experience with oiled bald eagles.

Cleaning and rehabilitation methods for bald eagles are similar to those used for other oiled birds, but there are important differences. Eagle feathers, for example, absorb rather than repel water. In addition, eagles are capable of inflicting serious injury to unwary staff.

Because cleaning can be stressful, we stabilized all eagles for at least 24 hours before initiating treatment. Un-hooded eagles were housed in individual wooden mews (8'x 8'x 6'H) with netted tops covered with sheets. Natural perching was provided.

Before cleaning, staff placed hoods on the eagles to block visual stimuli and to calm the birds. Three or more people held the eagle as washing proceeded. We wrapped the talons in sturdy tape, and one person was responsible for holding the head at all times.

We used a solution of fresh water and 1% Dawn dishsoap for cleaning. A large circular metal bucket (about 30 gallons) served as the cleaning tub. Depending on degree of oiling, cleaning required from 30 to 60 minutes. Rinsing, which took place in the same stalls as were used for seabirds, required about an hour.

Because eagle feathers had become saturated with water during cleaning and rinsing, staff returned the birds to the wooden mews for drying. Pet dryers were placed in windows and heated the mews to 95 degrees F. The birds would perch until completely dry, usually about six hours.

One of the cleaned birds had broken its wing, and it was transferred to Anchorage. Staff placed the other eight birds in one of two outdoor flight pens (32'L x 24'W x 16'H) until they could be released. We also equipped these pens with natural perches.

Marge Gibson releasing a Bald Eagle back into Prince William Sound. Photo by George Simple.

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Vancouver, British Columbia, Canada

Come to Vancouver for the best wildlife rehabilitation conference yet! We have pulled together the experts to share with all of us an exciting array of topics for the wildlife rehabilitator. This year our special focus for papers will be on keynote species: waterfowl, raptors, marine and large mammals.

IWRC will be have our first international site this year in beautiful Vancouver, British Columbia. Our hotel is the Coast Plaza at Stanley Park located in downtown Vancouver for the convenience of shopping and sightseeing while on the edge of a lovely park for us to enjoy the wildlife. Conferees will be able to dine in any of thirty nearby restaurants, visit the aquarium or zoo, or go on field trips in the area. Come early and take a basic skills seminar or see the local sites. This is a lovely site for a working fall vacation. Come network with your peers and share the knowledge with IWRC!

Scheduled Topics and Speakers

General Topics:

Public Speaking for the Rehabber• Alyssa Ottomeier, Corvallis, OR
The Role of Home Care in WL Rehabilitation• Marnie Allbritten, Roseburg, OR
Wildlife Restraint & Handling Techniques•Loretta Simonds, Antrim, NH
Release Criteria for Rehabilitated Wild Animals • Cheryl Stokhaug, Milwaukee, WI
The Importance of Euthanasia in Wildlife Triage•Ken Langelier, DVM, Nanaimo, BC
Codependence: An Issue for Wildlife Rehabilitators•Ira Slotkin, MSW, Austin, TX
Grief Issues in Wildlife Rehabilitation•Ira Slotkin, MSW, Austin, TX
Wildlife in Distress: Educational Programs of the 90's•Walter Crawford, Eureka, MO
How to Give Effective and Education Wildlife Programs• Marjorie Gibson, Antigo, WI

Avian Topics:

Care of Rails, Coots, Plovers, and Sandpipers• Meryl Faulkner, La Jolla CA
Intensive Care Techniques (with emphasis on waterfowl)•Anne McDonald, DVM, Vancouver, BC
Aspergillosis in a Rufous Hummingbird Colony• Chris Harvey-Clark, DVM, Vancouver, BC
Artificial Incubation and Handrearing of Raptors•Walter Crawford, Eureka, MO
Rehabilitation of Orphaned Raptors: The Fostering Alternative•Brian Woodridge, Macdoel, CA
Rescuing Trapped Raptors from Large Structures•Anne Miller, Birmingham, AL
Preliminary Investigation into the Diseases of Bald Eagles of British Columbia•Ken Langelier, DVM
Nutrition in Raptors•Kathy Hobson, San Francisco, CA
Handrearing the Orphan Kingfisher•Loretta Simonds, Antrim, NH
Physical Examination for Song Birds• Juanita Heinemann, Belmont, CA
Oiled Bird Rehabilitation Update• Jay Holcomb, Berkeley, CA
Emaciation and How to Deal with it• Louise Shimmel/ Jan White, DVM, Eugene, OR/Berkeley, CA

Mammal Topics:

The Role of Research in Bottle-raising Orphaned Wildlife•Charles Robbins, Pullman, WA
Care and Physical Therapy of Injured Bats•Karen Yaremkowych, Milwaukee, WI
Harbor Seal Pup Rehabilitation Program•Laurence Braun, DVM/Bob Kingston, Vancouver, BC
Emergency Care of Newborn Seals and Sea Lions•Jessica Porter, DVM, Friday Harbor, WA
Rehabilitation of the Coyote•Jeanne Wasserman, Lynnwood, WA
Rehabilitation of Sea Otters• Julie Hymer, Monterey, CA

And that's not all! We are planning panel discussions on Lyme Disease, Fund-raising for Small Organizations, Environmental Release Concerns, New Products in Wildlife Care, Caging Alternatives: the good, the bad and the ugly!, Volunteer Burnout, and Conflict Resolution. We also are planning a special hands-on laboratory session on Hematology with Vickie Joesph, DVM of the California Veterinary Diagnostics Laboratory. Final Program details are still being arranged and there is more to come!

Plan to join us in our first international conference! Conference registration forms will be mailed to IWRC members in June. For more information, call the IWRC office at ~~(707) 864-1761~~ during business hours (P.S.T.).

If your group or center has an employment or internship opening coming up, send IWRC the information and we will place the ad as an insert to the next issue of the **WILDLIFE JOURNAL**. In addition, we use these ads as references for the people who often contact our office for employment and internship information. Send Job-Line information to our office at:

~~IWRC~~
~~4437 Central Place, Suite B-4~~
~~Suisun, CA 94585~~

LOOKING FOR SPONSORS FOR INTERNSHIPS. INTERNSHIPS AVAILABLE through Bucknell University in Pennsylvania. On-campus recruiting for employers, employer information sessions, monthly job newsletter, resume referrals, employer literature/ video library, credential service. For more information, contact The Bucknell Internship Connection, Career Development Center, at 107 Carnegie Building, Bucknell University, Lewisburg, PA 17837. Phone: (717) 524-1238. Contact: Pamela Keiser, Assistant Director.

ASSOCIATE DIRECTOR being sought by HOWL, the PAWS Wildlife Rehabilitation Center in Lynnwood, Washington, near Seattle. The position involves all aspects of wildlife rehabilitation, including rehabilitation of birds, mammals, and occasional reptiles, assisting the public, supervising staff, volunteers, and student interns. Position is full time; salary is $1,700 per month, plus health benefits and three weeks leave time during first year of employment with PAWS.

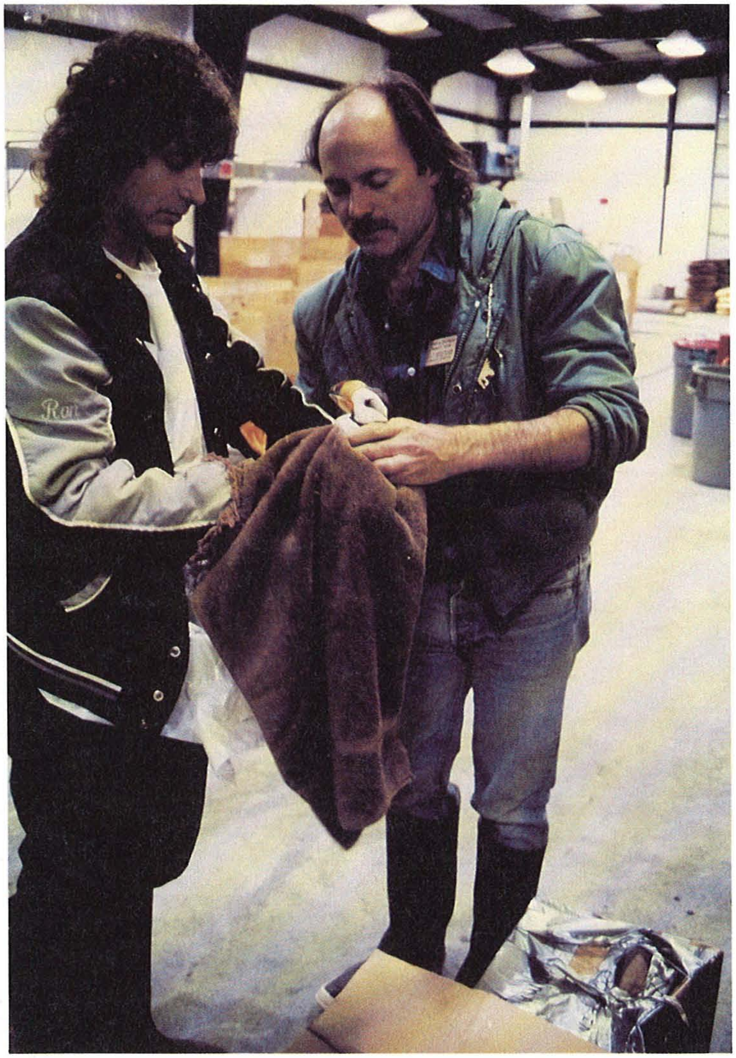
HOWL is a medium-sized progressive wildlife rehabilitation center (3000+ patients a year) with a modern (one year old) facility. Has full-time staff of four people plus volunteers and student interns. Located on a wooded two acre section of the ten acre PAWS property, 20 miles north of Seattle.

Interested parties should call Jeanne Wasserman at (206) 743-1884 or 742-4142, or at her home number, (206) 329-6243.

JOB OPPORTUNITIES LISTED free of charge by Turning Point, a career resource center at the University YWCA in Berkeley, California. Provides job listings about current employment openings in the Bay Area. Clients are primarily university-educated and represent a broad range of ages and backgrounds. Majority of clients are interested in positions in the non-profit sector. For information contact: Turning Point Career Center, University YWCA, 2600 Bancroft Way, Berkeley, CA 94704. Phone: (415) 848-6370. Contact: Katherine Smith, Resource Specialist.

MAKE YOUR JOB SEARCH EASIER with *The Job Seeker*, a job listing service that specializes in the environmental and natural resources fields. Vacancies from private, local, state, and federal employers across the nation. Two issues each month, mailed First Class. Special summer/seasonal listing from December through April. Contact: *The Job Seeker*, Rt. 2, Box 16, Warrens, WI 54666. Phone: (608) 378-4290.

Have an unusual animal or problem?
Call the *IWRC HOTLINE* for Assistance.



WILDLIFE HOTLINE! Get a helping hand from your collegues!

Wildlife rehabilitation can be either challenging or frustrating depending upon whether you are stumped by a problem. When you are, avoid that feeling of hopelessness or isolation and give us a call. The *Wildlife Hotline* is designed to help wildlife rehabilitators (not the general public) by connecting you to the expert that can give you the answers you need. IWRC office staff man the beeper and make referrals to any number of specialists in our diverse field. So if you stumped—give us a call and we will try to help. Calls should be placed during business hours (PST) for the fastest response.

How to use the hotline: call ~~(707) 426-8757~~; ~~listen for three beeps and then punch in your area code and phone number. If you have a rotary phone, have the operator punch in the numbers. Your will hear eight beeps followed by a busy tone. Hang up. The *Wildlife Hotline* will return your call COLLECT and help you with your problem~~.