REHABILITATING OILED AQUATIC BIRDS

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ABSTRACT

In the 1971 San Francisco oil spill, $900.00 was spent per successfully released bird, with 95% of the 4,686 treated birds dying in captivity. Through continuing research and development, those figures are improving. In 1973, the International Bird Rescue Research Center (IBRRC) treated 523 oiled birds with a 41% survival rate at a cost of approximately $15 per successfully released bird. The history, population effects, and physiological effects of oil pollution on birds are described here, and recommendations are given for treatment. The problems of maintaining aquatic birds in captivity are also discussed. Advance preparations of instructional materials, equipment, and supplies have been made by the IBRRC in anticipation of future oiled-bird incidents. Additional research is indicated.

INTRODUCTION

The decision to clean or to euthanize oiled aquatic birds has been a most controversial issue. Most past rehabilitation efforts have been negligibly successful and expensive, both in terms of money and manpower. The controversy is abating, however, as survival rates improve and costs diminish. Serious efforts by chemists, pathologists, veterinarians, zoologists, and nonprofessionals demonstrate that the problems do, in fact, yield to inspection and analysis. As a result, a technology of oiled-bird rehabilitation is emerging, and the result has been an increase in the percentage of treated birds being successfully reintroduced to their natural habitat.

In the 1971 San Francisco oil spill, approximately $900 was spent per successfully released bird, with 95% of the birds dying in captivity. This situation has changed remarkably. In 1973 the International Bird Rescue Research Center treated 523 oiled birds with a 41% survival rate at a cost of approximately $15 per successfully released bird (see Appendix I). These figures are likely to improve with further development of techniques and further advances in our knowledge of seabird physiology and pathology.

History

One writer has pointed out that oil pollution of birds is at least as old as the La Brea Tar Pits in Los Angeles [24]. More relevant to us historically would be the wreck in 1907 of the *Thomas W. Lawson*, a seven-masted schooner which released 2 million gallons of crude oil [10]. The incident occurred in the British Isles in the vicinity of extensive seabird rookeries. At the time, there were reported in excess of 100,000 puffins in the area. Many died then and many have since succumbed to oil pollution incidents. One hundred puffins are all that remain there today. It is likely that oil pollution is largely responsible for this devastation.

Both world wars of this century have caused widespread destruction of seabirds through oil pollution [8,49,83], though the most noteworthy disasters have occurred during peacetime accidents. Human error and mechanical failures continue to be the prime causes for oil pollution of birds [38].

In 1937, a passenger ship struck the oil tanker *Frank H. Buck* at the Golden Gate in San Francisco resulting in 2.7 million gallons (U.S.) of spilled oil [50]. The *Torrey Canyon* ran aground in 1967 spilling nearly 100,000 tons of oil when the captain selected a treacherous shorter route to save time [18]. A valve was inadvertently left open on a barge near Anacortes, Washington, in 1971 allowing nearly 200,000 gallons of #2 diesel fuel to flow out. Also in 1971, two tankers collided under the Golden Gate Bridge in a heavy fog. One wildlife agent, after reviewing the 1971 San Francisco oil spill incident, wryly recommended that the occurrence of accidental oil spills be prohibited [45].

The incidents are too numerous to list here, but a summary of birds killed by oil pollution in North America in 1970 serves to illustrate the high number of bird casualties [3].

Date (1970)	*Location*	*No. birds dead on shore*
February	Martha's Vinyard, Mass.	728
February	Chedabucto Bay, Nova Scotia	7,300
February 13	Tampa Bay, Florida	"thousands"
Feb.–March	Kodiak Island, Alaska	10,000
Feb.–March	Chesapeake Bay, Md. & Va.	4,780
April 25	Alaska Peninsula	86,600
November	Schuykill River, Penn.	200

Also, during January and February of that year, some 12,856 oiled birds were found dead or dying on the English coast [30].

It is reasonable to estimate that 6 to 25 times more birds may have been involved in the above incidents (excluding the Pennsylvania spill) than could be accounted for through beach surveys [26,76]. It is probable that over 50% of seabirds killed by oil pollution sink to the ocean floor [42].

Table 1 lists a number of oiled-bird rehabilitation attempts. Given the low survival rates for oiled birds, it is not surprising that many authors and organizations have recommended euthanizing all oiled birds or all but the least oiled of them [6,30,57,59].

Effects on populations

It is common for terrestrial perching birds to reach breeding age within a year of hatching and to produce clutches of several eggs more than once a year. Following an unusually high mortality, these species can normally replace their numbers in just a few breeding seasons. For seabirds, the situation is quite different. The pattern for alcids (auks, murres, puffins) is as follows [13]:

1. long-lived
2. few, if any, predators once they are at sea
3. larger alcids do not breed until 3 or more years old
4. most have only a single egg per year
5. not all adults breed every year
6. on the average, only 1 chick for every 5 breeding adults survives to the age where it goes to sea.

After a chick enters the water, the parents must continue to care for it, diving to catch fish and feeding a share to the juveniles.

Every year we receive a number of murres that are found standing on the beaches too young to fend for themselves. Presumably, they were accidentally separated from the adults in spite of their ability to vocalize very loudly.

With all of these factors, it is surprising that alcids have sufficient reproductive potential to maintain their numbers even without unnatural mortalities such as those caused by oil pollution. C.L. Boyle [11] states that "Nature compensates by giving auks a long life, and few hazards after maturity." It is calculated that murres require 53 years to double their population size given optimal conditions. "In other words," according to R.B. Clark [13], "if an oiling disaster halved the number of birds in a colony it would take over half a century for it to recover its original numbers by natural growth."

It is highly unfortunate that the birds suffering the greatest losses in marine oil spills are the alcids—the very birds least able to afford inflated mortalities. In a table representing several oil spills in England, it is reported that of 10,186 oiled seabirds, fully 10,028 were alcids [17].

On the other hand, gulls are only minimally affected. Apparently when healthy gulls meet oil, they are able to take wing before becoming seriously involved. Following the 1971 San Francisco oil spill, I observed that as many as 20% of the gulls flying overhead had black stains on their breast feathers. These oil stains gradually faded until they were hardly noticeable a month after the spill. Minor oil stains during the nesting season, however, can have severe consequences since a small quantity of oil smeared on an incubating egg will kill the embryo [35].

Most diving birds, including alcids, seek escape when alarmed by plunging below the surface and resurfacing some distance away. This has been the observed response when murres *(Uria aalge)* meet oil [9]. With a large oil slick, such action could result in their surfacing through the slick which may account for a thorough degree of oiling observed when many diving birds are brought to bird-cleaning stations.

All factors and data considered, there is considerable circumstantial evidence that oil pollution has seriously reduced populations of certain seabirds in England and elsewhere [10,38].

Effects on individual birds

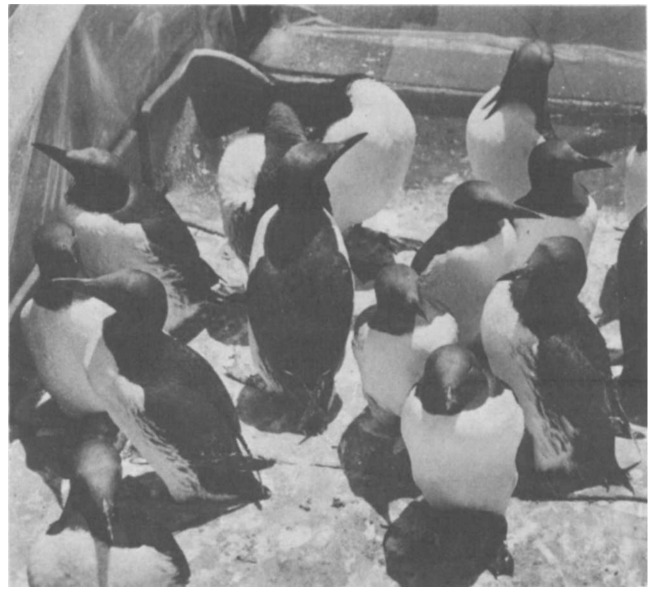
The effects of oil on individual birds vary with the properties of the oil, degree of contamination, quantity ingested, environmental factors, and the original condition of the bird. Even a small patch of oil on the feathers of an aquatic bird, however, means that without care it will perish.

The insulatory ability of plumage when oiled is reduced, thus allowing body heat to be lost to the surrounding cold water at a greatly increased rate [11,29,36,48]. The oiled bird must increase its metabolic rate by as much as a factor of 3 in order to maintain its normal body temperature. Oiled birds cease to forage for food resulting in catabolism of subcutaneous fat stores, and eventually catabolism of the pectoral muscles in order to supply needed energy [5,11].

In some oil spills where the oil deeply coated the water's surface, birds may have simply suffocated after surfacing through the slick.

Oil that has aged, that is, lost some of its more valuable constituents through evaporation, is generally less toxic than fresh oil [16]. Fresh bunker oil is more topically irritating to aquatic birds than old bunker oil spilled with ballast water. This is not to say that one kind of oil is less fatal to the bird than another. The loss of body heat through contaminated feathers is more than sufficient to kill seabirds. Most aged heavy oils, however, are not significantly irritating to bird skin over a period of up to 3 days but may be irritating to soft mouth tissue and conjunctivae.

Oiled birds usually abandon all other activities and attempt to clean off their feathers by preening; they ingest oil in this process [34]. Oiled seabirds commonly suffer from an inflammation of the lining of the gut [17,27,33,37,63,72,78]. Blood seeping into the lumen from the hyperemic intestinal walls may take on the appearance of black oil or tar, which may also be present.



California Murres (Uria aalge) ready for release 6 days after cleaning following contamination from a #1 diesel-oil spill (May 1973).

Bleeding may, in some cases, be controlled with an intestinal antispasmotic and demulcent.

Seabirds drink seawater. This requires an active transport of sodium ions through the intestinal wall. It has been found that domestic ducks (*Anas platyrhynchos*) are able to drink a hypertonic seawater solution (60%) indefinitely and therefore demonstrate active sodium transport. This has also been demonstrated in vitro [20,39]. Some oils are able to block this active transport mechanism resulting in the dehydration of ducks drinking a hypertonic saline solution [40]. Should this effect be at work in seabirds that have ingested oil, and it is likely, then acute dehydration is a serious problem as long as the birds only have access to seawater. Oiled birds have been observed going inland and seeking out fresh water [79]. It is interesting to note that none of these birds are a fully pelagic species, but they are birds that spend a portion of each year (breeding season) on fresh water. Fully pelagic birds, such as alcids, cannot be aware of the existence of fresh water or how to locate it. The fact that recently oiled birds often show considerable weight loss and appear emaciated may, in part, be due to dehydration of the pectoral muscles and other tissues. Also, dehydration exacerbates acidosis, i.e., abnormally low plasma pH, that is caused by the catabolism of fat stores and other tissues [72].

Another effect that may be important in the oiled seabird is that hypoglycemia, or low blood sugar, may cause the inability of the nasal salt gland to function fully, allowing a fatal increase in the tonicity of body fluids [39]. Certainly oil-covered birds would be expected to be hypoglycemic after several hours of increased metabolism and reduced food intake.

Birds that ingest oil, whether artificially introduced by catheter or consumed as a result of preening, often demonstrate some loss of equilibrium and depressed activity due to toxic effects on the nervous system [32,34,37]. Respiratory depression is a common symptom in mammals suffering toxic effects of oil ingestion and may very well be a problem with oiled birds.

Liver tissue suffers fatty degeneration, and kidneys, likewise, show pathologic changes following ingestion of some oils by birds [17,34,37,63,72]. Some investigators found damage but did not report fatty degeneration of the liver [5,78], while another investigator found no internal pathology whatever using Santa Barbara crude oil [32].

Aspiration of oil into the lungs, even in small quantities, causes lipid pneumonia. This has been true in 24% of ducks fed oil in a laboratory investigation [37]. Pulmonary disorders are reported routinely in birds caught in oil spills [5,17,63,78], but it is not

Table 1. Rehabilitation attempts (partial list)

Reference	Date	Location	Number and Species Treated	Released
84	November 1941	California	1 murre (Uria aalge)	1
80	195?	England	500 swans	Unknown
54	July 1965	South Africa	8 penguins(Eudyptula abborignata)	8
17,73	March 1967	England & France	7,849 mostly alcids	Unknown, under 400
17	1967	England	58 mostly alcids	26
11	June-Aug. 1968	South Africa	1,700 penguins(Spheniscus demersus)	Unknown
1	Jan.- Feb.1969	California	1,731 mostly ducks	Unknown, under 50
41	February 1969	Holland	1,282 mostly ducks	Unknown, under 352
44	1969-1970 ?	Sweden	Unknown - Anatidae(ducks, geese, swans)	75
19	November 1970	South Africa	523 penguins (S. demersus)	Unknown, 200-300
31,43	December 1970	Holland	About 100 - mostly Anatidae	Unknown (14?)
21,45,81	January 1971	California	4,686 mostly grebes and ducks	220
47,12	April 1971	Washington	360 mostly alcids & ducks	0
78	January 1972	England	18 Murres	11
78	February 1972	England	247 mostly ducks	About 100
55,56,70	January 1973	California	308 coots, ducks, & grebes	143
69	May 1973	California	77 murres	41
27	June 1973	England	4 murres	0
27	October 1973	England	110 mostly murres	Unknown, under 19
7	December 1973	California	105 mostly murres	26

clear whether these are cases of lipid pneumonia or the result of other factors.

Oiled birds suffer from stress. They are stressed by cold, toxic effects of the pollutant, starvation, dehydration, electrolyte imbalance, and, if they are captured for treatment, people. (It is well to remember that the only contact that seabirds have with larger animals is due to territorial behavior or predation.) Long-term stress is evidenced by enlargement of the adrenal gland, heightened vulnerability to infections, kidney and liver damage, shock, and death. Manifestations of stress have been found routinely by investigators in connection with oiled birds [5,16,17,37,72].

Dispersants used to control oil slicks are often more damaging to birds than the oil [5,27]. Some dispersants are very irritating both topically and internally while all chemical dispersants will cause feathers to readily soak up water. The use of dispersants increases the area of ocean that is lethal to aquatic birds [27].

Secondary problems and husbandry

There is a whole series of problems encountered in an oiled-bird rehabilitation effort that are not directly related to the original problem of oil contamination. The problems are mostly because confined species do not adapt well to being held in captivity. Robert W. Lassen [45] states that "murres, western grebes and scoters are exclusively aquatic, and as such are unable to cope with the terrestrial environment except for short periods of time. . . . Long-term care challenges your capacity to innovate a dry environment in which an aquatic bird can be sustained until able to repel water."

Stress is a major problem that can, by itself, be fatal. Judicious administration of corticosteroids such as dexamethasone or corticosterone can be helpful in controlling physiological stress. It is also essential to avoid subjecting the birds to stressful stimuli any more than necessary. Threatening visual stimuli, such as an approaching human, are very stressing and can be minimized by the use of opaque barriers.

One study indicates that dexamethasone facilitates a stressed animal to extinguish nonproductive responses, e.g., continuous defense or escape activity [46]. In agreement with that study, we have noticed that dexamethasone apparently helps the bird learn to adjust to its radically new environment and more readily begin to eat, drink, and preen.

Dehydration and hypoglycemia may be controlled by oral administration with syringe and catheter (intubation) of a 2.5% dextrose solution or the hydrating solution described in Appendix II. 40 ml/kg is a suitable dose to be given every hour initially. Many seabird species cannot be expected to drink out of a container but will drink copiously when placed in a pool. Dehydration of aquatic birds held in captivity has undoubtedly been a major cause of mortality [52].

The feet of aquatic birds easily dry out and provide an entry for pathogenic bacteria which may lead to the infection of joint capsules. An infrequent light coating of vasoline or diaper rash ointment helps to control this problem [5,17,33,61,67].

Decubitus ulcers, or pressure sores, will develop along the keel of fully aquatic species when maintained on a surface that is not deeply cushioning [41,74,75]. A thick layer of clean rags on the enclosure floor provides for sufficient distribution of weight to avoid this condition.

Bacterial infections will occur if a bird is kept in less than ideally healthful surroundings. The sites of infection and species of bacteria are numerous. Septicemia was encountered in many long-captive seabirds following the 1971 San Francisco oil spill [72]. The four most common pathogenic bacteria found in that study were: *Erysipelothrix* spp., *Salmonella* spp., *Pasturella multocida*, and *Staphylococcus aureus*. As is the case with human medicine, we do not recommend broad-spectrum antibiotic treatment in anticipation of bacterial infection but believe that antibiotics should be reserved for proven infections. Proper diet and a clean, healthful, nonstressful environment are the best prevention.

Aspergillosis, an infection by the common fungus *Aspergillus fumigatus*, is the greatest cause of mortality among aquatic birds when their ability to resist disease is compromised by stress or malnutrition [5,6,16,33,60,66,77]. Normally, the respiratory system is initially infected, but other tissues may become involved before the bird dies. Straw, hay, or moldy material must never be used in a rehabilitation center because of the chance of elevating the *A. fumigatus* spore concentration. Some control over this disease might be possible with Pimaricin®, a relatively new drug that has no deleterious side effects that we have observed during our minimal experience with it.

It is possible that the fish selected for feeding birds may contain thiaminase, an enzyme that destroys thiamine (Vitamin B_1) [28,53]. To insure against this possibility, a vitamin supplement is recommended. Multiple vitamins used in moderation are probably not harmful and possibly even beneficial.

Post-mortem examinations have revealed impaction of the cloaca in grebes and loons kept out of water [33,53,72]. Merely lifting these birds off the ground by hand, however, will cause them to void. There may be an inhibitory mechanism associated with nesting in these species that would account for these observations.

The plumage of water birds will deteriorate when kept out of water because of contamination, mechanical disruption, and diminished care by the bird. Seabirds in the wild depend upon the impeccable condition of their plumage for protection from cold air and water, and when kept in warm and dry surroundings, they neglect their plumage to some extent. Putting a weakened bird immediately into a harsh environment is not the answer because exposure adds to the bird's state of exhaustion and stress. Intermediate steps are needed such as lightly spraying the bird occasionally or placing it into a pool that is somewhat protected from the weather and from which the bird can easily leave. In practice, a properly cleaned bird may be put into a protected artificial pool 8 hours after cleaning and then be put into an unprotected environment (with plenty of food) within two or three days. An interesting effect that we have observed is that many aquatic birds refuse to remain in the water of a small pool (1.2 meters square) but will more willingly remain in the water of a larger pool (2 m × 3 m). Loons refuse to stay in the water of our larger pool, but we are hoping that they will be content to remain afloat in the sizeable pool (3 m × 6 m) planned for our new facility.

The final physiological factor to be considered before releasing a waterproof seabird concerns salt metabolism. Murres suffer dehydration when suddenly introduced to seawater following several weeks in fresh water pools [71]. This problem might not exist if murres were kept for shorter periods in captivity, but that has not been proven. Gradually raising the salinity of the pools to seawater levels over a period of 4 days had no deleterious effects on the murres. This problem does not exist with grebes.

Feathers and cleaning

The rehabilitation of oiled aquatic birds must not only be concerned with rectifying the considerable physiological problems discussed above but also must solve the problem of cleaning the feathers and restoring them to a water repellent status. To date, there has been no completely satisfactory method found for accomplishing this. Numerous cleaners and methods have been tried, yet each has its drawbacks and most are totally unsuitable.

Many authors have regarded water repellency of feathers to be largely dependent on feather waxes and oils and have therefore concluded that the waxes and oils must not be removed or, if removed, they must be replaced before the bird is released [6,22,49,64,80]. Some authors have attributed water-repellency to a combination of the feather waxes and the microscopic grid structure characteristic of feathers [6,29].

At present, the water-repellent property of a bird's plumage appears to be dependent on the following:

1. hydrophobic property of keratin (feather protein) surface
2. imbrication or interlacing of the microscopic feather barbules
3. directional watershedding (determined by the pattern and sizing of imbrication)
4. absence of foreign matter.

The feather oils and waxes may aid the surface keratin to remain hydrophobic, as well as play a minor part in the direct repulsion of water. Certainly it has been well established that a bird's plumage does not immediately lose its water-repellency following complete removal of all waxes and oils by solvent [16,53,62]. It has been shown, however, that the feathers of ducks become rough, dry, brittle, and non-water-repellent several weeks following removal of the preen gland by surgery [23]. Frayed feathers lose their fine imbrication and, therefore, their water-repellency. Apparently, the preen gland oils are necessary for long-term maintenance of the suppleness and integrity of feather material.

Feathers have a marked tendency to shed water in the direction of the tip, which in a live bird would be away from the body and out from between the overlying layers of feathers. It may be possible for individual feathers to be waterproof when considered singly although the plumage may contain a considerable quantity of water between the feather and adjacent to the skin [15].

Foreign matter can interrupt the surface geometry of interlacing or may cause feather barbules to abandon their proper alignment. In either case, the water repellency is compromised. Oil, for example, tends to clump barbules together leaving larger than normal interstices through which water can seep [25].

Detergents are, by their very nature, hydrophilic, actively attracting water molecules. Unfortunately, it is very difficult to completely rinse detergent residues out of a bird's plumage and detergent residues prevent feathers from being waterproof [15,53]. Detergent solutions also cause the swelling of feather keratin which may have detrimental effects on feather structure and integrity [53]. Investigations have shown that some detergents are less tenacious than others and rinse out of the plumage somewhat more readily, leaving the bird with a watertight plumage [63]. Thorough rinsing requires large quantities of clean warm water dispensed under pressure for many minutes [61]. In practice, detergents are unable to clean birds efficiently that are soiled with aged heavy oils or oils such as lubricating oils that are principally straight-chain hydrocarbons [68].

Hydrocarbon solvents are able to clean quickly any type of oil from a bird without any detectable damage to feathers [15,51,53,63,65]. The plumage of a solvent-cleaned bird would doubtlessly be fully waterproof except for previous disruptions in barbule alignment caused by rough handling, attempts at preening by the bird while matted with oil, and barbule clumping caused by viscous oil. In practice, however, the toxic properties of solvents become one more factor to add to the already severe health problems experienced by the bird. Birds cleaned in solvent show temporary severe loss of equilibrium and abnormal behavior, often stupor. It is likely that birds are affected both by inhalation of solvent fumes and direct cutaneous absorption. Therefore, it is absolutely essential that solvent-cleaned birds be quickly and thoroughly dried with warm-air blowers. Although this is time consuming, it does not require handling of the bird because warm air can be directed upward through a perforated polypropylene box where the bird is placed until dry. This method requires protection for the feet because they blister and burn easily.

Hydrocarbon solvents are readily available with varying properties. Fortunately, some have been formulated for tasks requiring low toxicity and fairly rapid evaporation. Solvents suitable for cleaning birds must have absolutely no aromatic compounds as they are extremely toxic. Flammability is of prime importance and is usually measured in terms of flashpoint (the lowest temperature at which a spark will cause combustion). For the above reasons, we can easily rule out the use of gasoline, kerosene, paint thinner, or lighter fluid (British equivalents: petrol, paraffin oil, turpentine, lighter fuel) [59]. In other words, there are no solvents available in retail stores that are suitable. One is forced to acquire a proper solvent by the barrel through industrial distributors.

Another agent that can be used to clean oiled birds is mineral oil (British equivalent, medicinal paraffin). Mineral oil is, in essence, a heavy-weight, nontoxic hydrocarbon solvent with low volatility. It can be used most effectively, especially when warmed, on birds coated with a highly toxic and irritating fuel or fuel oil. At present, it is the only suitable cleaner for oiled mammals and other-than-aquatic birds since it is completely nontoxic and nonirritating. For aquatic birds, however, it leaves them with neither a water repellent nor thermally insulating plumage. A healthy, active murre requires about 3 weeks of bathing and preening before the plumage is returned to normalcy after being cleaned in mineral oil. It is possible that the application of some absorbent powder might shorten this time period but only at the risk of acting as an abrasive while the bird preens or as a particulate contaminant acting to reduce water-repellency. A better solution would be to wait 2 to 4 days after cleaning with mineral oil and then reclean with a solvent such as Shell Sol-70.

Recommended Treatment

Our recommendations are listed below for the treatment of oiled birds at this time (October 1974).

1. Loosely wrap body of captured bird in cloth (rags, towels, or diapers), place in a covered ventilated cardboard box (one bird to a box), and immediately transport to a treatment center. This prevents further ingestion of oil, slows heat loss, and minimizes visual stress.

2. Band the bird when it arrives at the center and begin individual records. This allows a biologist to establish differential treatment for purposes of research.

3. Introduce 40 ml/kg hydrating solution (see Appendix II) into the proventriculus (upper stomach) with a size 14-18 (French) catheter on a large disposable syringe. Repeat every hour for the first 3 hours and then four times a day thereafter.

4. Administer intravenously or intramuscularly 3 mg/kg dexamethasone or corticosterone and 1 ml/kg 50% dextrose. Place a poncho on the bird and delay further treatment for 30 minutes.

5. Introduce 10 ml/kg heavy medicinal mineral oil into the proventriculus. Wipe the exterior of the catheter dry before intubation to minimize the possibility of aspiration of the mineral oil. Delay further treatment for 30 minutes.

6. Provide suitable food, deep bedding (except for alcids), and an ambient temperature between 24°C and 27°C (75-80°F).

7. Decide which birds are ready to be cleaned and with what cleaning agent. A decision key is provided in Appendix III.

8. Before cleaning, check the bird's record to determine whether it has had an injection of dextrose and dexamethasone or corticosterone within the previous 4 hours. If not, it should receive another dose and be given 40 ml/kg 5% dextrose. Then the cleaning begins.

Cleaning with solvent. The first requirement is for human safety. Shell Sol-70 has produced fair results and does not ignite easily (flash point 40°C or 104°F), but once burning, burns fiercely. Therefore, it is necessary to ban smoking and provide adequate fire extinguishers. The area should be well-ventilated and everyone should wear a suitable respirator [57]. Some people find the solvent irritating to their skin and perhaps should not participate in the cleaning.

Warm solvent (35°C or 95°F) is placed in 3 to 5 basins and the bird is given serial baths, taking care not to damage feathers [53].

Following the baths, the plumage needs to be rinsed out with flowing solvent. We have built a portable unit that dispenses warm solvent under pressure to 12 nozzles arranged in 6 stations. For lightly-oiled birds this rinsing unit is all that is needed for cleaning. When the bird is clean, it is blotted with clean diapers and thoroughly dried with a warm-air dryer such as those used for show dogs.

Final steps in the process involve hydration and rest in a "drunk tank" for 6 to 9 hours until the bird recovers from its intoxicated state caused by the solvent. The bird can then be immediately placed in a pool with easy egress where it can swim, preen, drink, and eat. An audiovisual teaching package is available to train volunteers in the details of this cleaning technique.

Cleaning with mineral oil. When cleaning with mineral oil, use all of the techniques used for cleaning with a solvent except for warm air drying. Respirators, fire extinguishers, and the drunk tank are unnecessary. The bird must be kept warm and introduced to water gradually as its plumage will neither be waterproof nor provide effective thermal insulation for some days after cleaning.

Cleaning with detergent. We simply have not been able to effectively clean nor subsequently release aquatic birds in excellent condition using detergent. Those who have been successful recommend serial baths of a 1% detergent solution warmed to 40-45°C (104-113°F). Thorough rinsing with jets of warm water (40-45°C) is necessary to remove hydrophilic detergent residues.

The reason for our lack of success with this method is probably related to the types of polluting oil we have been encountering. Most of the birds we have received were covered with either very aged heavy oils or lubricating oils, neither of which can be readily emulsified by detergents.

Recoveries

The banding (ringing) of birds released after rehabilitation has provided some information for evaluating the success of treatment. Information from banded birds released following the 1971 San Francisco oil spill has not yet been fully compiled, but the following data are available. Of the 218 banded birds, 14 were found dead by December 1971; a canvasback (*Aythya valisineria*) was shot by a hunter January 5, 1972, 10 months after release; a western grebe (*Aechmophorus occidentalis* was found in March 1972, 11 months after release; and another western grebe was found January 26, 1973, 21 months after release, in Washington, 650 miles from point of release [2,4,45]. These last band recoveries demonstrate that at least some rehabilitated oiled aquatic birds were able to survive in the wild quite nicely.

Feasibility

It is not possible to put a price tag on the life of an aquatic bird, yet, at the same time, it is hardly reasonable to expect oil companies to spend $900 for each rehabilitated bird in every oil spill. Mortality rates can only be kept low by efficient and proper treatment that will ultimately minimize the length of time that the birds need to be held in captivity [14,58]. Coincidentally, these factors also minimize the cost involved. Inexperience, poor advice, misinformation, or the lack of proper facilities and equipment can very quickly turn an oiled-bird rehabilitation effort into a nightmare of dying birds and runaway costs. With this in mind, the International Bird Rescue Research Center was founded in 1971 as a nonprofit corporation to research the problems of oiled-bird rehabilitation. Instructional materials, specialized equipment, and supplies (record forms, veterinary paraphernalia, and thousands of numbered aluminum bands) are kept in readiness at our center to be taken to the scene of an oil spill whenever and wherever needed.

At present, however, there are numerous species of birds that cannot be treated with a significant probability of survival, and there are simple but crucial questions that have not yet been investigated. Without additional research, the emergent technology of rehabilitating oiled aquatic birds could very conceivably become bogged down on a pathetically low plateau of its learning curve. Such a situation would inevitably result in the continuing significant losses of aquatic birds treated for oil pollution, irrespective of money and manpower expenditures.

CONCLUSIONS

An oil or chemical dispersant on an aquatic bird's plumage is usually fatal unless the bird is promptly and properly treated. For uncaptured birds, toxicity of the soiling substance is often not as important a factor as is its ability to compromise the waterproof status of the plumage. Toxicity of the contaminant is of considerable importance, however, when rehabilitation is attempted.

Mortalities of oiled birds during attempted rehabilitation usually result from one or more of the following conditions:

1. exhaustion (hypoglycemia, hypothermia)
2. dehydration
3. poisoning by the pollutant, the cleaner, or both
4. chronic stress
5. chronic malnutrition
6. viral, bacterial, or fungal infections.

Most contaminated birds are probably never found after an oil spill along open coastline. These spills, therefore, destroy a large portion of local aquatic bird populations regardless of the degree of success attained with the rehabilitation of captured birds.

Recent improvements in rehabilitation methods mean that the destruction of aquatic birds by oil can be mitigated through the use of properly equipped cleaning centers staffed by trained personnel. This may require a modest amount of regional planning and preparation, keeping in mind that persons with expertise may be flown in with specialized equipment to lend assistance when needed.

Many aspects of oiled aquatic bird rehabilitation need additional study in order to maximize the number of successfully treated birds for the amount of effort and funds expended. Promising areas of research include: cleaning agents, cleaning methods, plumage maintenance, behavior, electrolyte metabolism, blood chemistry, nutrition, antibiotic therapy, steroid therapy, and endocrinology.

Oil spills continue in spite of technological improvements and increased efforts aimed at prevention. Aquatic birds become soiled and die in spite of improved equipment and contingencies designed to control oil slicks. Conceivably, oil spills will continue to wreck havoc as long as there is oil to transport. It is right and proper that we do whatever is necessary in the meantime to mitigate damage to wildlife caused by oil spills. Only with this level of commitment can our legacy to future generations be an undiminished and dynamically stable wildlife community which inhabits our precious and irreplaceable biosphere.

APPENDIX I

1973 Oiled Bird Summary
International Bird Rescue Research Center

	No. Received	*No. Surv'd*	*% Surv'd*
Western grebe (*Aechmophorus occidentalis*)	40	10	25
Horned grebe (*Podiceps auritus*)	14	0	0
Eared grebe (*Podiceps caspicus*)	11	1	9
Pied-billed grebe (*Podilymbus podiceps*)	26	2	7
Red-throated loon (*Gavia stellata*)	2	0	0
Rhinoceros auklet (*Cerorhinca monocerata*)	1	0	0
Common murre (*Uria aalge*)	190	67	35
Glaucous-winged gull (*Larus glaucescens*)	1	0	0
Western gull (*L. occidentalis*)	3	2	66
Herring gull (*L. argentatus*)	1	0	0
California gull (*L. californicus*)	1	1	100
Mallard (*Anas platyrhynchos*)	25	19	76
Canvasback (*Aythya valisineria*)	12	9	75
Scaup (*A. marila & A. affinis*)	32	22	68
Goldeneye (*Bucephala clangula & B. islandica*)	22	8	36
Scoter (*Melanitta deglandi & M. perspecillata*)	5	2	40
Ruddy duck (*Oxyura jamaicensis*)	17	1	5

APPENDIX I—Continued

	No. Received	No. Surv'd	% Surv'd
Black-crowned night heron (*Nycticorax nycticorax*)	1	1	100
Clapper rail (*Rallus longirostris*)	6	3	50
American coot (*Fulica americana*)	113	70	61
Total	523	218	41%

APPENDIX II

Medications and Solutions

Corticosteroid
  azium solution® (dexamethasone) (Schering)
    3 mg/kg intramuscularly or intravenously once or twice only
Intestinal antispasmotic
  Biosol-M® (Upjohn)
    3 drops/kg orally every 6 hours
  Darbazine® (Beecham–Massengill)
    As directed
Gastric demulcent
  Kaopectate® (Upjohn)
    10 mg/kg stomach tube every 4 hours
Hydrating solution (hypotonic, for dehydration and hypoglycemia)
  Mix: 5 g (1 level teaspoon) table salt
    25 ml 50% dextrose *or* 12 g table sugar (3 level teaspoons)
    1 liter (or 1 quart) fresh water
  40 ml/kg by stomach tube
Isotonic sugar solution (approximately 5%)
  Mix: 100 ml 50% dextrose *or* 50 g table sugar (4 level teaspoons)
    1 liter (or 1 quart) fresh water
  40 ml/kg by stomach tube

APPENDIX III

Cleaning Key For Oiled Aquatic Birds

1.a. If oil is nearly solid and caked on, proceed to step 2.
  b. If oil is fairly fluid, proceed to step 4.
2.a. If bird is energetic, alert, and its cloacal temp. is 39-41°C, proceed to step 10.
  b. If bird is weak or hypothermic, proceed to step 3.
3. Feed and water for 2 days. Maintain clean enclosure at 24-27°C. Go to step 2.
4.a. If oil is easily emulsified by detergents, go to step 5.
  b. If oil is *not* easily emulsified by detergents, go to step 6.
5.a. If oil is apparently non-toxic, go to step 2.
  b. If oil is apparently toxic, go to step 7.
6.a. If bird is showing severe toxic effects, go to step 8.
  b. If bird is showing mild toxic effects, go to step 9.
  c. If bird is showing minimal or no toxic effects, go to step 10.
7.a. If bird is showing severe toxic effects, go to step 8.
  b. If bird is showing some toxic effects, go to step 11.
  c. If bird is showing no toxic effects, go to step 10 or 11.
8. Euthanize.[1]
9. Clean in warm mineral oil. Go to step 2.
10. Clean in warm solvent.
11. Clean in warm detergent solution.

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[1]The decision to euthanize might also be dependent upon the rarity of a particular species or upon other extenuating factors.

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