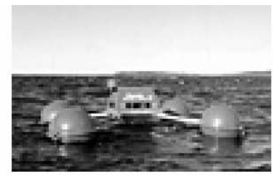
DETERRENT TECHNIQUES AND BIRD DISPERSAL APPROACH FOR OIL SPILLS





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ABSTRACT

An extensive literature review on oil spills that have occurred in various parts of the world has shown us that: 1) thousands of birds die annually due to oil spills; 2) that some bird species are more likely to be affected by such accidents and; 3) some regions of the world are especially at risk. Among the species which are most often contaminated, seaducks and alcids represent close to 97% of all deaths reported throughout the world. This phenomenon is explained in a large part, by the different types of behaviour particular to these groups; seaducks and alcids being, for instance, more closely associated with the marine environment. During the last three decades, efforts have been made to put an emphasis on cleaning soiled birds. Even if this approach is quite valuable, it is proven that bird caring allows us to save only a small fraction of birds impacted by the oil. It is therefore recommended to put more emphasis on prevention, especially on bird deterring. The following eight techniques are highly recommended: the aircraft, the motorboat, the Breco buoy, the Marine Phoenix Wailer, the propane canon, the bangers, the effigy and the ATV. These different deterrents will most likely provide an appropriate response for any oil spill occurring either ashore or offshore. An evaluation of their respective efficiency is also available, based on the literature review. This report also provides a description of different strategies to be implemented in order to successfully respond to a situation where an oil spill could threaten either offshore, ashore or colonial birds, while putting a special emphasis on offshore situations where birds are most vulnerable. These strategies include ways to assess the impact of an oil spill on birds with either aerial or ground surveys, on the best approach in deploying each of the different hazing techniques, taking into account the size of the oil spill, its location and the time of day. It is a well-known fact that an oil spill near a seabird colony remains one of the most intractable scenarios from a bird deterrence point of view. It is recommended that an investigation be conducted to determine whether a chemical dispersant or sensory aversion approach could eventually be the best strategy to use around those colonies. And finally, enclosed in the report, is a list of the recommended deterring material (number of items) that should be available to face any small or medium size oil spill.

Résumé

Une revue exhaustive de la littérature réalisée sur les déversements d'hydrocarbures survenus à travers le monde a permis de noter que: 1) milliers d'oiseaux meurent annuellement suite à des déversements pétroliers; 2) certaines espèces d'oiseaux sont plus sensibles d'être touchées par de tels accidents et; 3) certaines régions du globe sont particulièrement à risque. Parmi les espèces d'oiseaux les plus souvent contaminées, celles représentées par les canards de mer et les alcidés représentent près de 97% des mortalités rapportées à travers le monde. Ce phénomène est largement expliqué par un comportement particulier de ces espèces ; les canards de mer et les alcidés étant, par exemple, plus étroitement associés au milieu marin. Les efforts déployés au cours des trois dernières décennies ont surtout mis l'emphase sur le nettoyage des oiseaux souillés. Même si cette approche se veut des plus valables, il est démontré que la réhabilitation des oiseaux ne permet de sauver qu'une infime partie des oiseaux touchés par les déversements. Il est alors recommandé de mettre davantage l'accent sur la prévention, particulièrement sur l'effarouchement. Huit techniques d'effarouchement sont proposées. Ces techniques sont: les aéronefs, le bateau à moteur, la bouée Bréco, le «Marine Phoenix Wailer», le canon au propane, les balles explosives, les épouvantails et le véhicule tout terrain. Ces différentes techniques sont susceptibles de fournir une réponse efficace à tout déversement survenant soit au large des côtes ou sur les rives. Une évaluation de leur efficacité respective basée sur l'information trouvée dans la littérature est aussi fournie. Ce rapport procure de plus une description des différentes stratégies d'effarouchement à mettre en place pour répondre de façon efficace à toute situation où un déversement d'hydrocarbure menacerait des oiseaux en milieu maritime, sur les rives ou dans des colonies d'oiseaux, tout en mettant l'emphase sur les situations au large des rives soit là où les oiseaux sont les plus vulnérables. Ces stratégies comprennent notamment la façon d'évaluer les impacts sur les oiseaux à l'aide d'inventaires aériens ou terrestres, sur la meilleure approche à privilégier pour déployer chacune des techniques recommandées en tenant compte notamment de l'étendue de la nappe d'hydrocarbure, de sa position et de la période de la journée. Il est admis qu'une nappe d'hydrocarbure à proximité d'une colonie d'oiseaux continue de représenter la situation la plus difficile du point de vue de l'effarouchement. Il est recommandé que des recherches soient entreprises pour déterminer si l'utilisation de dispersants chimiques ou de dispersants gustatifs pourrait s'avérer une approche envisageable aux abords de colonies d'oiseaux. Finalement le rapport fournit une liste de l'équipement d'effarouchement requis pour faire face à tout déversement de petite ou moyenne envergure.

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1. Introduction

Birds are probably the most conspicuous elements during an oil spill, causing them to die or suffer and therefore attracting great public sympathy. That public concern has increased that much more since the recent Sea Empress, Exxon Valdez and Erika oil spills. Following the Exxon Valdez oil spill, it has been highly recommended to strengthen preparedness, and to enhance response capabilities (Skinner and Reilly 1989). One way to achieve that goal is to include a real technically sounded deterrence strategy in the existing and future birds contingency plans. This approach has been seriously neglected in the past; efforts being concentrated in rescuing and rehabilitating for oiled birds. In the absence of a realistic bird deterring approach, these plans are conceivably unrealistic and arguably serve to reinforce a dangerous complacency .

Deterrence strategies have been less systematic for several reasons, such as the fact that they are not always effective, can be expensive, sometimes require complex logistic and well trained people and don't provide the public and the media with the same visibility as the cleaning of birds. Besides, spill response plans which call for the use of deterrent techniques to prevent birds from reaching oiled waters are often inappropriate because they don't include the proper equipment or provide the guidance in equipment application. We must admit however that there has been little discussion over the techniques presently available, of their logistic feasibility and probable effectiveness and mainly of the best strategy approach. That is probably why spill responders often don't systematically use deterrents following spills or when they do so use equipment, most often the noisiest and cheapest, without really knowing the real effectiveness of their actions on the aquatic birds.

The current study tries to improve the scheme by not only focusing on the most promising deterrent techniques, but also by trying to explain why it is important to deter some bird species more than others. In this report, the potential effectiveness of each technique considered as the most valuable, is evaluated and a description of a recommended approach to first assess numbers of birds impacted and then determine the best strategy to effectively disperse the more vulnerable ones in the most common situations, is provided.

2. Bird vulnerability to oil spills

2.1 Historical data

One of the earliest accounts of oil pollution in birds in Europe, traces back to the wreck of a large schooner, the seven-mast Thomas W. Lawson on the Isles of Scilly in December 1907, with the release of her entire cargo of two million gallons of crude oil. This resulted in a vast mortality around one of the most important seabird colonies in Britain, said to have supported some hundred thousand puffins at the time. Such events, as underlined by Bourne (1968a), were exceptional before the First World War, when automobiles were rare and ships were generally coal-powered.

Even if oil spills were a regular occurrence between the two World Wars, their ornithological consequences attracted little attention because people had too much else on their minds to pay much attention to the sufferings of birds. The damage in Europe passed virtually unrecorded.

According to Bourne (1968a), the second World War resulted in an even greater destruction of shipping than the first, this time in an oil-burning economy. Afterwards, by the time ornithologists were able to get up and about again, the coasts of Europe were thick with oil speckled with dead birds. The situation was now made worse by an explosive expansion of oil transportation by sea, crude oil increasingly being taken for refinement near its destination rather than the products of refinement at the oil fields. This change was associated with increasing pollution from the washing of tankers at sea after each voyage as well as an increasing number of accidental spills, wrecks and collisions involving the growing number of larger tankers now being built.

Post war continues to be fairly detrimental to birds. Numbers of dead birds were reported regularly around the world. In the United Kingdom, an estimation of close to 100 000 dead birds in two decades (1966-1983) were reported by Stowe and Underwood (1984). During the second international conference on sea pollution by oil, in Copenhagen in 1959, it was found that similar conditions prevailed along many of the north-western coasts of Europe like Belgium, Holland, Germany and especially the Baltic, where tens of thousands of wildfowl were dying around a central oil-dumping area. A vast mortality of auks also occurred where shipping crossed the concentrated wintering area along the border of the Labrador current off the gulf of St. Lawrence. Elsewhere in North America, pollution had long been chronic and made worse by intermittent wrecks off both New England and California.

Nowadays, we estimate that over one million birds die annually just in the European North Atlantic as a result of oil spills; the extent of worldwide mortality is not known. Lillich (1997) reports that an additional estimated two million migratory birds die in the United States from contact with oil sludge accumulated on the surface of oil well skim pits and evaporation ponds in non-compliance with existing laws and regulations. Benquet and Laurenceau (1994) mention that at least one major oil spill occurs every month in different parts of the world, most of them not being reported. The number of birds oiled in major incidents is probably far less than those resulting from continuing chronic pollution of the seas. Table 1 summarizes some of the most important oil spills that occurred throughout the world during the last decades.

2.2 Measurement of the effects of oil pollution on birds species

An extensive literature review has allowed us to determine oil related mortality in water birds during the last five decades (Table 1). Even if the information found in literature is not always very accurate, it is obvious that certain species have been affected repeatedly, whereas others in the same habitat are reported to be impacted only sporadically. For obvious reasons the most susceptible birds are those which are gregarious, spend most of their time on the water and dive rather than fly up when disturbed.

TABLE 1. ESTIMATED OR REAL MORTALITY SUSTAINED BY BIRD POPULATIONS FOLLOWING SOME MAJOR OIL SPILLS SINCE 1937

Incident	Location	Year	Spillage	Collect. or estim. dead or oiled birds	Capt.	Cleaned and released	Major species impacted	Reference
Frank Buck	San Francisco, USA	1937	11 800t.	269	?	?	murre grebe gull	Aldrich 1938
?	owestoft beach, Britain	1940	?	264	?	?	gull (23%) guillemot (19%) scoter (13%) razorbill (11%) shorebirds (6%) scaup (5%) loon (3%)	Bourne 1968a
?	Apsheron penins. Caspian sea	1945	?	30 000	?	?	tufted duck coot	Vereshchagin 1946
?	Minnesota, USA	1951	?	500	?	no	goldeneye scaup merganser coot	Lee 1952
Fort Mercer + Pendleton	Massachusetts, USA	1952	22 400t.	> 3 000	?	?	eider (99%)	Burnet and Snyder 1954
?	Gotland, Baltic sea	1952	?	35 000	?	?	oldsquaw	Lemmetyinen 1966
?	Howacht bay, Baltic sea	1953	500t.	10 000	?	?	eider merganser scoter Long-tailed duck	Goethe 1968
Gerd Maersk	Elbe River, Germany	1955	8 000t.	500 000	?	?	scoter	Goethe 1968
?	Aland, Baltic sea	1955	?	10 000	?	?	oldsquaw	Lemmetyinen 1966

Incident	Location	Year	Spillage	Collect. or estim. dead or oiled birds	Capt.	Cleaned and released	Major species impacted	Reference
Seagate	California, USA	1956	?	3 035	?	?	scoter (69%) murre (30%)	Richardson 1956
?	Gotland, Baltic sea	1957	?	40 000	?	?	oldsquaw	Pehrsson 1981
?	Newfoundland, Canada	1959	?	12 000	?	?	eider (25%)	Horwood 1959
?	Denmark	1960	?	20 000	?	?	scoter	Lemmetyinen 1966
Oil tanker collision	Poole Harbour, England	1961	270t.	487	no	no	shorebirds (40%) gull (21%) merganser(10%) grebe (8%) shelduck (5%) loon (4%) goldeneye (3%) alcids (3%)	Ranwell and Hewett 1964
?	Newfoundland, Canada	1966	100t.	5 000	?	?	eider	Gillespie 1969
Seestern	Medway estuary, Britain	1966	1 700t.	2 778	?	?	gull (77 %) shorebirds (19%) malard (1%) swan (1%)	Harrison and Buck 1967
?	N.E. coast Britain	1966	?	805	?	?	guillemot (62%) gull (16%) razorbill (12%) puffin (4%) loon (2%)	Boune 1968a

Incident	Location	Year	Spillage	Collect. or estim. dead or oiled birds	Capt.	Cleaned and released	Major species impacted	Reference
?	Ken, Britain	1967	?	?	?	?	razorbill (19%) gull (22%) loon (7%) scoter (4%) grebe (3 %) gannet (2 %)	Bourne 1968a
Torrey Canyon	Cornwall, Britain	1967	119 328t.	10 000	7851	150	guillemot (81%) razorbill (17%) shag (1%)	Bourne and Parrack 1967
?	Gotland, Sweden	1967?	?	30 000	?	?	long-tailed duck	Goethe 1968
Esso Essen	Cape Peninsula, South Africa	1968	4 000t.	2 200 (min)	1 700	950	jackass penguin gannet cormorant	Westphal and Rowan 1971
Tank Duchess	Tay estuary, Scotland	1968	87t.	1 368	737	66	eider (82%) scoter (12%)	Greenwood *et al*. 1971 ; Greenwood and Heddie 1968
?	New-sealand, Denmark	1969	?	10 000	?	?	eider scoter	Joensen 1971
?	Laeso-Vendsysse,l Denmark	1969	?	>5 000	?	?	eider scoter	Joensen 1972
?	Terschelling, Holland	1969	?	35 000	>1 182	318	eider scoter	Dejager and Belterman 1970
Union Oil well	Santa Barbara, California, USA	1969	11 000t.	3 600	1 563	169	loon, grebe, cormorant, pelican	Straughan 1971
Hamilton Trader	Liverpool Bay, England	1969	700t.	4 407	2 339	0	guillemot (91%) razorbill (4 %) gull (2 %) gannet (1 %)	Hope Jones *et al*. 1970

Incident	Location	Year	Spillage	Collect. or estim. dead or oiled birds	Capt.	Cleaned and released	Major species impacted	Reference
Palva	Uto, Finland	1969	150t.	1 000	?	?	eider (100%)	Soikkeli and Virtanen 1972
?	North Zealand, Denmark	1969	?	10 000 (min)	no	no	eider (70%) scoter (25%)	Joensen 1972
?	Laeso-Vendsyssel, Denmark	1969	?	>12 000	no	no	eider (79%) scoter (20%)	Joensen 1972
supply-tank	Amer River, Holland	1970	16 000t.	5 000	no	no	dabblers (40%) geese (20%) pochard (10%) gull (8%) coot (6%)	Belterman and De Vries 1972
?	NB Britain	1970	1 000t.	50 000	?	?	sea duck auk	Greer and O'Connor 1994
?	Last Jutland, Denmark	1970	?	12 000	no	no	eider (47%) scoter (47%)	Joensen 1971
Delian Apollon	Tampa, Florida, USA	1970	43t.	9 000	?	?	loon, cormorant merganser scaup	Vermeer and Anweiler 1975
Arrow	Chedabucto bay, Nova Scotia, Canada	1970	10 400t.	567	no	no	alcids (43%) seaduck (33%) loon+grebe (11%)	Brown *et al*. 1973
Irving Whale	Newfoundland, Canada	1970	25t.	625	no	no	eider (89%) alcid (11%)	Brown *et al*. 1973
?	Diep-haringvliet, Holland	1970	9 000t.	2 000 oiled only	23 found dead		goose	Ouweneel 1971
?	South Kattegat, Denmark	1970	?	>15 000	no	no	eider (74%) scoter (21%)	Joensen 1972
?	Djursland-Anholt, Denmark	1971	?	1 500	no	no	scoter (80%) eider (8%)	Joensen 1972

Incident	Location	Year	Spillage	Collect. or estim. dead or oiled birds	Capt.	Cleaned and released	Major species impacted	Reference
tankers collision	San Francisco, California, USA	1971	2 700t.	7 830	1 285	192	grebe (57 %) scoter (20 %) murre (15 %)	Small *et al*. 1972
?	Denmark	1972	?	30 000	?	?	eider, scoter	Joensen 1973
?	Kattegat, Denmark	1972	?	4 768	?	?	scoter (80%) eider (15%) grebe (2%) loon (1%)	Joensen and Hansen 1977
?	Waddensea, Denmark	1972	?	9 153	?	?	scoter (50%) eider (48%)	Joensen and Hansen 1977
Dewdale	Cromarty Firth, Scotland	1972	30t.	1 000	?	?	goose	Vermeer and Anweiler 1975
?	Vadso, Norway	1973	50T.	2 500	?	?	eider	Lund 1978
British Mallard	Finsnes, Norway	1973	several thousands t.	3 000	?	?	eider	Lund 1978
Peter Maes	Pays de Caux, France	1974	?	275	26 (min)	10	guillemot (52% razorbill (44%)	Grandpierre *et al*. 1977
Olympic alliance	straits of Dover, England	1975	2 000t.	199	122	?	guillemot (30%) razorbill (25%) cormorant (15%)	Dixon and Dixon 1976
STC-101	Chesapeake bay, Virginia, USA	1976	800t. (approx.)	8 469	no	no	grebe (51%) oldsquaw (35%) scoter (5%)	Roland *et al*. 1977
Argo Merchant	New England, USA	1976	29 000t.	181	69	?	murre (27%) loon (18%) gull (17%) razorbill (14%)	Powers and Rumage 1977
?	Toronto, Ontario, Canada	1976	?	?	73	45	scaup (100%)	Snider 1977

Incident	Location	Year	Spillage	Collect. or estim. dead or oiled birds	Capt.	Cleaned and released	Major species impacted	Reference
Furnace fuel oil leaked	Dounreay, Great Britain	1977	9t.	1 000	?	?	guillemot (65%) razorbill (25%)	Bowman 1978
Amoco Cadiz	Brittany, France	1978.	223 000t.	4 572	258 (min)	?	puffin (31%) razorbill (21%) guillemot (16%) shag (10%)	Hope Jones *et al*. 1978
Christos Bitas	Great Britain	1978	2 420t.	2 541	?	?	auk (86%) gannet (9%)	Stowe and Morgan 1979
Esso Bernicla	Shetland Great Britain	1978	1 174t.	3 702	100 (approx)	no	cormorant (20%) alcid (17%) eider (15%) guillemot (9%) oldsquaw (8%) loon (4%)	Heubeck and Richardson 1980
Industrial premises	Firth of Forth, Scotland	1978	1t.	1 387	no	no	pochard (18%) grebe (17%) scaup (16%) gull (14%) eider (13%) guillemot (7%) razorbill (5%)	Campbell *et al*. 1978
Litiopa	Great Britain	1978	100t.	240	?	?	guillemot (33%) grebe (18%) scoter (9%)	Stowe and Morgan 1979
Andros Patria	Great Britain	1978	30 000t.	372	?	?	pufffin (100%)	Stowe and Morgan 1979
?	Shetland, Great Britain	1979	?	1 751	300	no	guillemot (67%) razorbill (12%)	Heubeck 1980
Bôhlen	Brittany, France	1979		268	?	12	guillemot auk gannnet puffin	Ballot 1979

Incident	Location	Year	Spillage	Collect. or estim. dead or oiled birds	Capt.	Cleaned and released	Major species impacted	Reference
Swedish tanker	Kattegat, Denmark	1979	500t.	50 000	?	?	eider (60%) scoter (22%) merganser (6%) grebe (1%)	Clausager 1983
?	Varangerf jord, Norway	1979	?	5 000	?	?	murre (94%) puffin (3%) eider (2%)	Diederich 1981
Russian oil tanker	Lettland, Sweden	1979	5 500t.	3413	459	?	eider (86%)	Broman and Hjernquist 1982
M/T Antonio Gramsci	Finnish archipelago	1979	6 000t.	1 770	?	?	eider (70%)	Tri-State Bird Rescue and Research Inc. 1999
?	Norway	1979	?	5 000	no	no	guillemot (91%)	Barrett 1979
Kurdistan	Cape Breton, Nova Scotia, Canada	1979	7 900t.	2 600	no	no	murre, dovekie, oldsquaw, eider	Brown and Johnson 1980
?	Magdalen islands, Quebec, Canada	1981	12t.	1 150	33	10	dovekie (94%) guillemot (2%) oldsquaw (2%) eider (1%) murre 1%)	Lehoux 1981
Deivos	Helgoland, Norway	1981	1 000t.	3 000	?	?	eider (30%) guillemot long-tailed duck	Rov 1982
Steve	Liege, Belgium	1981	100t.	3 000	176 (min)	?	dabbler (35%) coot (21%) swan (12%) moorhen (9%)	Clotouche and Schaeken 1982
?	Port Bolivar, Texas, USA	1982	?	?	37	37	scaup (100%)	Mueller and Mandoza 1993

Incident	Location	Year	Spillage	Collect. or estim. dead or oiled birds	Capt.	Cleaned and released	Major species impacted	Reference
?	Normandy, France	1983	?	5 000	700	150	guillemot (70%) auk (20%)	Duncombe 1983
Fanny	Scapa Flow, Scotland	1984	2t.	300	no	no	eider (32%)	Meek 1985
Mobiloil	Columbia River, Oregon, USA	1984	660t.	?	450	264	grebe (50%) murre (26%) scoter (17%)	Speich and Thompson 1987
?	Puget sound, Washington, USA	1984	25t.	1 509	447	50	grebe (32%) scoter (17%) loon (9%) goldeneye (9%)	Speich and Thompson 1987
Puerto Rican	California, USA	1984	4 900t.	1 300	?	?	murre (36%)	Ford *et al*. 1987
Arco Anchorage	Washington, USA	1985	600t.	1 917	1 243	281	grebe (58%) scoter (15%) guillemot (6%) murre (5%)	Speich 1986
Apex Houston	California, USA	1986	130t.	4 198	3 364	?	murre (83%) grebe (6%) auklet (4%) loon (3%) scoter (2%)	Page *et al*. 1990
Nestucca	Washington, USA	1988	787t.	12 446	2 098	1 046	murre (70%) scoter (12%) auklet (8%) grebe (7%)	Ford *et al*. 1991
Czantoria	Quebec, Canada	1988	400t.	10 000 oiled only	7	0	goose (50 %) black duck (30 %) scaup (15 %) gull (15 %)	Lehoux 1988
Exxon Valdez	Alaska, USA	1989	40 000t..	29 175	1 188	797	murre (74 %) alcids (7 %) sea duck (5 %)	Piatt *et al*. 1990

Incident	Location	Year	Spillage	Collect. or estim. dead or oiled birds	Capt.	Cleaned and released	Major species impacted	Reference
American Trader	California, USA	1990	2 000t.	?	569	309	scoter (40%) pelican (25%) grebe (18%)	International Bird Rescue Research Center 1990
Braer	Shetland isles, Great Britain	1993	45 000t.	1 538	230	112 max	shag (51 %) eider (23%) long tail. (13%) guillemot (9%) gulls+kitt. (3%)	Http...part 5 1997 ; Http...part 6 1997
Sea Empress	Welsh coast, Great Britain	1996	70 000t.	6 900	3 440	720	scoter (66%) guillemot (23%) razorbill (5%) loon, cormorant	SEEC 1998
Platform Irene	California, USA	1997	24t.	223	53	18	murre, pelican, gull, grebe, tern, cormorant, sanderling	Network news, winter 1998
Mystery spill	California, USA	1997	11t.	?	505	251	grebe, loon, scoter	Network news, winter 1998
M/V Kure	California, USA	1997	22t.	984	473	195	murrelet, pelican, murre, dunlin, sandpiper, scoter, grebe, loon, scaup, gull	Network news, winter 1998
?	California, USA	1998	?	1 535	635	290	murre, grebe, gull, loon, scoter, plover, pelican	Network news, spring 1998
Gordon C. Leitch	Quebec, Canada	1999	49t.	1078	640	66	eider (96 %) guillemot (4%)	Lehoux and Bordage 1999
Erika	Britain, France	1999	26 000t.	62 132	10 000	1 578 min	murre (82%) scoter (5%) auk (4%) gannet (3%)	LPO 2000

Information was obtained from published material including reviews by Vermeer and Vermeer (1975), Hopper et *al*. (1987) and Burger (1993). Where possible, the original sources were indicated but in some cases the data summarized in the review articles were reported.

Therefore, birds contaminated most frequently include open-water ducks (eiders, scoters and oldsquaws) and alcids (guillemots, murres and puffins). In fact, more than 95% of birds killed by oil spills since 1930 seem to be represented by seaducks and alcids alone, 1% by loons and grebes, 1% by cormorants and gulls and finally 1% by others (mainly dabbling ducks, geese and shorebirds) (Figure 1). We must however be careful with figures concerning loons and grebes. Since those species, especially the loons, are represented only by small populations of birds, even low numbers of dead individuals could lead to detrimental effects on their populations.

In terms of occurrence frequency in oil spills, seaducks and alcids are again well represented with respectively 75 % and 46% of occurrence, followed by gulls with 21%, loons, 18% and grebes, 10% (Figure 2). Species which should then be targeted first and dispersed in priority when an oil spill occurs, are not very numerous and include about a dozen species. To that list we must add species classified as vulnerable, endangered or threatened like the Harlequin Duck, the Horned Grebe, the Red-necked Grebe, the Least Bittern, the Piping Plover, the Yellow Rail, the Caspian Tern, the Roseate Tern, the Manx Shearwater and the Black-headed Gull. The priority level of protection for the latter group of species is crucial, since saving even a single individual is important, if considered from a strictly conservation-oriented point of view. Only when none of those endangered or highly vulnerable birds are present in an spill area, can efforts be oriented towards other less vulnerable species, and then again, only if they are considered as being really at risk, which isn't always obvious.

2.3 Birds' adaptation to a marine environment vs their vulnerability to oil

Alcids and seaducks are more vulnerable to spilled oil than others for two possible reasons, the first one being that some of these birds are often found in great abundance along busy shipping routes where pollution incidents occur regularly. Among the most dangerous sites, we find the coasts of the Baltic sea including the Danish Straits and the Kattegat, the North Sea along the eastern coast of the United Kingdom including the Shetland, the offshores of the Newfoundland coasts in the North Atlantic, the coastline of the United States north of Cape Hatteras and along the state of California (Tuck and Livington 1959, Joensen 1972, Pehrsson 1981, Taapken 1981, Stowe and Underwood 1984, Simons 1985, Durinck *et al.* 1994). The waters of northwestern Europe support approximately 50 million seabirds which forage for shellfish in winter, including 10 million seaducks, 10 million fulmar, 10 million alcids, 7 million kittiwake and over 3 million gulls (Durinck *et al,* 1994). During the surveys from 1987 to 1993 an average of 9 million seabirds (50% of those being represented by Long-tailed Duck and Common Eider) occurred in the Baltic Sea alone every winter (Durinck *et al* 1994). About 90% of the total estimated number of seabirds wintering in the Baltic Sea are recorded in ten major areas, that covers less than 5% of the Baltic Sea. Close to 2.5 million seabirds breed on the coasts of the North Sea (International council for the exploration of the sea 1994). We estimate that 1.5 million seabirds breed around the Newfoundland coast and that the number of eiders alone wintering around Newfoundland is most likely in the range of a quarter of a million birds (Lock *et al* 1994). The banks of Newfoundland are also the chief wintering area for Dovekies from

Figure 1. Groups of bird species involved

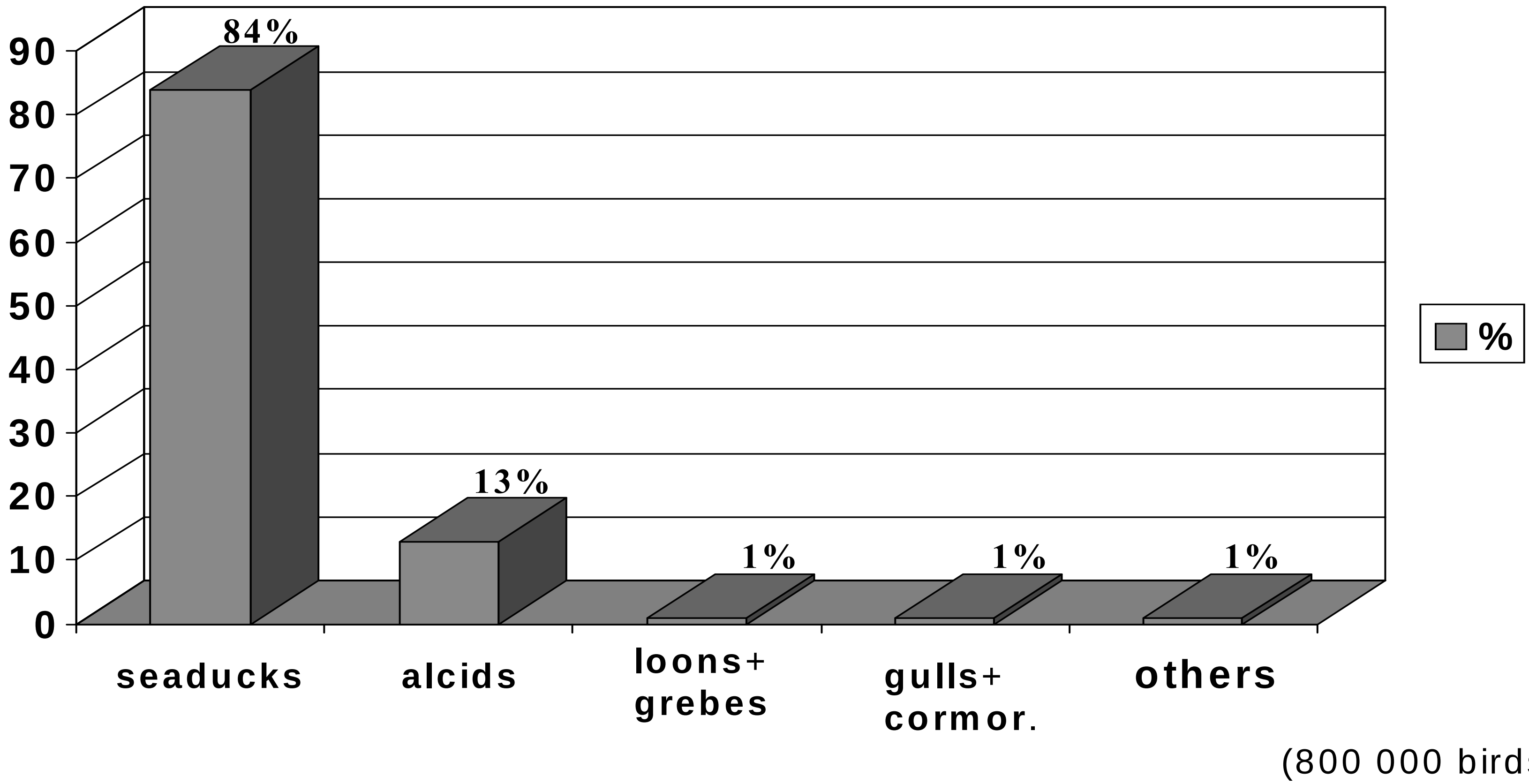
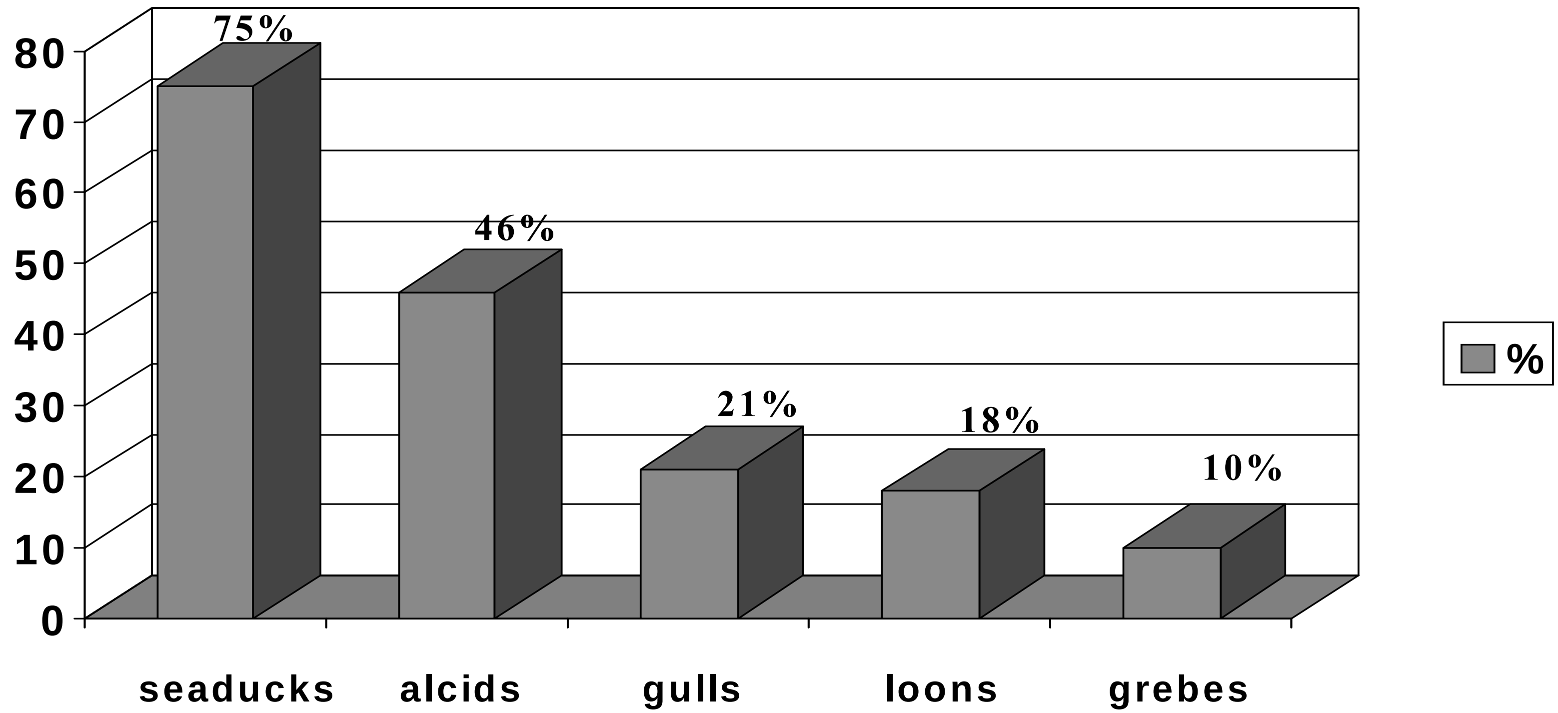


Figure 2. Frequency of bird species occurrence in oil spills



(52 oil spills)

the Arctic, whose breeding center in Northwest Greenland, supports at least 14 million birds and for Thick-billed Murres whose wintering flock contains approximately 4 million birds (Lock *et al* 1994). Results of midwinter waterfowl surveys in the Atlantic flyway states north of Cape Hatteras, reveal the presence of more than 1.8 million wintering birds (Serie 1996), most of them being associated with the different habitats found along the Atlantic coastline. Colonial water bird populations are also very abundant in coastal areas north of Cape Hatteras, where approximately 1 million birds breed (Spendelow and Patton 1988). Finally, close to 700 000 colonial birds also breed along the coastline of the state of California (Spendelow and Patton 1988).

It has already been mentioned that the number of oldsquaws in the main western European winter quarters, the Baltic, had been reduced to a tenth of what it was in 1937-1940 (Lemmetyinen 1966). In Danish waters, the number of dead birds reported every year has been in the thousands since 1930 (Pehrsson 1981). Almost all parts of the Baltic Sea area are dominated by sea traffic, including yachts , ferries and tankers, as well as cargo vessels carrying oil, chemicals and other environmentally hazardous substances (Durinck *et al* 1994). The scoters are also exposed to pollution all along their migration route down the west coast of Europe towards Iberia. They suffer severely in areas such as the straits of Dover, where their numbers are declining (Atkinson-Willes 1963). The mystery spills over the past 30 years have killed in excess of 1.6 million seabirds on the South West Coast of Newfoundland (Harvey 1997). Nowhere else in the world does this problem occur on the same level of frequency and magnitude. More alarmingly, as reported by Wiese and Ryan (1999), the oiling rate of birds in Newfoundland has consistently increased between 1984-1997. The problem is not that alarming for dabblers, geese and shorebirds because they are more often encountered in inland waters which are fortunately less exposed to heavy pollution.

The second major reason which could explain the high vulnerability of alcids and seaducks, comes from the fact that those birds have certain behaviours in common which could cause them to be more vulnerable to spilled oil. Bourne (1968a) has described that aspect admiringly well and the following pages summarize some of his conclusions. According to him, the adaptation to a marine environment varies with the role adopted by each species.

Gulls, terns and waders

These birds seem to get oiled along the shore fairly frequently, approximately 20% of frequency of occurrence in oil spills for gulls (Figure 2). Relatively few birds are killed. They seem to promptly fly away from the polluted areas except when taken by surprise in the dark (Bourne 1968b). They probably represent 1 or 2% of the overall mortalities around the world (Figure 1). The most dangerous moment for those birds is probably when they roost at night on the backwater or when waders are going to feed as the tide turns. The main effect of oil pollution in this group may be damage to the habitat. Those birds which tend to feed over shallow water and wet mud show adaptations for aerial, pedestrian and aquatic modes of life. This may reduce their intimate contact with pollution. Survival rates after oiling seem also to be more important for gulls and waders than for some other species. Gulls and waders often survive for months after even a heavy degree of oiling.

Geese and dabblers

Geese and dabblers often feed in the intertidal zone or in agricultural fields. The greater the time spent by birds feeding outside the marine environment, the lesser their chances of being seriously contaminated by oil. Once the oil has come ashore the mortality rate usually decreases rapidly, although birds continue to get dirty, probably because they come into less contact with the oil by walking on it, instead of swimming into it. These coastal species can paddle over it or squat in it on the shore, with fairly little damage. They then become dirty, possibly sick from eating the oil, eventually failing to breed, because of direct toxic effects or damage to their habitat (Bourne 1968a)

Fortunately, as mentioned by Bourne (1968a), these effects will likely be limited and temporary and the overall damage to waterfowl populations on the shore should not be serious, unless a particularly large volume of oil would spill onto a rather large concentration of feeding, moulting, roosting or breeding birds. Thus, only a few major accidents involving geese and dabblers are reported in the literature (Table 1). The number of casualties for these two groups of birds altogether seem to represent less than 1% of the overall mortality in the world.

The worst accident involving geese and dabblers is probably the one reported for the Amer River spill in Holland, where close to 3 000 geese and dabblers were recorded either dead or seriously contaminated (Belterman and De Vries 1972). One goose population that could possibly be at risk is the Greater Snow Goose population which migrates through the St. Lawrence River below Quebec city in eastern Canada. More than 400 000 birds are estimated to rest and feed upon the scirpus marshes during the fall and 350 000 during the spring migration (Reed 1995). In May 1988, the Czantoria sustained a punctured hull that resulted in the spilling of 400 tons of crude oil downstream of Quebec. Although the amount of oil spilled was relatively important and in spite of the fact that close to 60 000 Greater Snow Geese were surveyed in the area, only 4 Snow Geese were considered in serious trouble, captured and sent to the cleaning center (Lehoux 1988). That special accident confirms that for the geese, the risk of being oiled is probably highly variable according to the time of year, their behaviour and their abundance. In the case of the Czantoria the damage to the population was probably limited by the fact that geese were spending most of their feeding time in the cereal fields around the St. Lawrence estuary.

Loons and grebes

These birds regularly appear in low proportion of all major kills (occurrence less than 20%; abundance less than 1%) (Figures 1 and 2). They are highly aquatic birds, tending to concentrate and feed in offshore waters and thus they are highly vulnerable. Because their total populations are not very large, even if the number of birds reported is low, the percentage loss to their populations could be significant.

Gannets, petrels

These are all aerial pelagic species, steadily increasing despite a low reproductive rate. They are a minority in most marine pollution incidents and deaths are very few compared to the total population (less than 1%). According to Bourne (1968a), these pelagic birds are in search of waters with a fish density too low to allow them productive hunting on the water surface. They hunt mainly in flight, only taking to the water when they see food, which is not likely in an oil-covered area. However they could become polluted by sheer accident, just like the gannets of Sept-Îles did while collecting nest material along the shore during the *Torrey Canyon* disaster. In addition, they could however face a particular hazard when congregating in large rafts on the waters off their breeding sites at dusk as many other colonial birds.

Cormorants and shags

They are highly aquatic species that suffer locally during pollution incidents. Cormorants could be particularly vulnerable because they prey underwater, and could get killed by a sinking oil in any given incident. On the whole, they represent less than 1% of casualties.

Open-water ducks and alcids

These birds feeding in rich offshore waters with its high density of shoaling fish are much better equipped for an intense aquatic existence, with thick dense, waterproof plumage and short limbs adapted for swimming, causing them to be clumsy both on land and in the air. This renders them peculiarly defenseless when their plumage gets soaked with oil, breaking down their insulation from cold water.

In water, plumage oiling may cause the heat loss to exceed the bird's heat production capacity, resulting in hypothermia (Jenssen 1994). The heat loss of oiled eiders in water is 360% higher than normal (Jenssen and Ekker 1990). When oiled and water-soaked eiders are placed on land rather than water, their heat loss is only 57% higher than normal. After their plumage has dried, their heat loss is similar to unoiled eiders and they are able to regulate their body temperatures at a normal level. Since some aquatic birds and seaducks have no way of feeding ashore while allowing their plumage to dry, they are faced with two choices: starving ashore to decrease their energetic expenditure or staying at sea where they are forced to increase their energetic expenditure to remain normothermic. In other case, they will eventually die from hypothermia if the heat loss exceeds the metabolic rate peak.

Results from studies on plumage oiling on birds also suggest that some species of aquatic birds may respond differently to plumage contamination. It was suggested for instance that seaducks like eider were more susceptible to oiling than dabblers like mallard (Jenssen and Ekker 1991). The eider's soft and air-filled plumage probably collapses more easily than the more compact, but less insulating plumage of mallards. Bird species dependent upon feeding in water (such as diving birds) are therefore much more susceptible than semi-aquatic species that can feed ashore, to the harmful effects of oil pollution (Jenssen 1994) and probably have a higher value of thermal conductance. The highest and most frequent mortality rate (more than 95% of overall deaths) occurs in groups of birds such as seaducks and alcids (Figure 1).

Extreme adaptation for an aquatic environment eventually renders birds particularly susceptible to oil pollution by reducing their capacity for sustained flight and keeping them on the water surface where they are continually exposed to floating oil. Many seabirds rarely fly except during migration and to visit the breeding sites. Furthermore, they commonly loose their power of flight entirely when they molt. Seaducks also molt at sea. The propensity of auks to form large flocks on the water both at their breeding colonies in the summer and in their wintering areas, also increases the risk of large killings in some areas. Diving ducks such as scoters, oldsquaw, scaup and mergansers also suffer heavy casualties when concentrated on their winter feeding grounds (Riley *et al* 1985). The Common Eider appears to be vulnerable most of the year. Upon coming in contact with oil, aquatic seabirds are especially defenseless since they have no means of fighting this unnatural hazard. Such swimming species are compelled to bathe in it. It has been suggested that they deliberately settle in polluted areas in search of food or because the water is calm, but we have little evidence to support this. Bourne (1968b) suggests that they simply don't notice the oil slick until they swim into it. Aquatic species like alcids try to escape by diving, just like they would any other hazard.

Many authors suggest that birds are more vulnerable to an oil spill, especially during winter time (Bourne and Bibby 1975, Joensen and Hansen 1977). Some suggested that colder sea temperatures may increase the amount of time that floating oil remains in a dangerous state for marine birds. Evaporation of the oil's volatile fractions would be faster in warmer seas or temperatures, ultimately leaving tar balls which are relatively harmless to birds.

3. Cleaning efforts and their impacts on birds

Attempts to reduce mortality of birds following oil spills during the last three decades have been focused on trying to capturing and cleaning oiled birds. Although this approach is a valuable one and must continue to play a major role in marine spill response planning, we suggest that cleaning effectiveness has not met expectations for many reasons.

3.1 Difficulty in capturing oiled birds

Current techniques, based mainly on the use of nets, are usually successful in capturing only about 20% of the birds found impacted (dead or alive) along the shorelines following beach surveys (Table 2). Moreover, the birds found impacted, whether dead or alive, represent only a fraction of the overall impact. Many processes affect the proportion of oiled birds found, including the distribution and density of birds at sea, wind, ocean currents, distance between the spill and the shore, the number of people involved in the recovery of birds, topography, density of scavengers on beaches, sinking of carcasses at sea and burial of carcasses on beaches (Ford *et al* 1987). Several estimates of this error have been made with marked seabird corpses released at sea (Hope Jones *et al* 1970, Bibby and Lloyd 1977, Hope Jones *et* al 1978, Bibby 1981). Recovery rates on the shore varied from 0.3% to 60% depending on where the corpses were dropped in relation to the distance and direction of the coast, wind speed and direction and accessibility of the shoreline to observers. When processes affecting the retrieval of birds are poorly understood or cannot be quantified, the notion that the body count represents only 10% of the overall mortality becomes a rule-of-thumb. But, as reported by Burger (1993), there is no justification for this notion. Most mortality estimates are generally more conservative and averaged 4-5 times higher than the body counts. Even though it is risky to generalize, it is clear that the body counts underestimate (possibly by 3 or 4) the real number of impacted, therefore captured birds, which probably total only 5-10% instead of 20% of the overall oiled birds.

TABLE 2. EFFICIENCY OF CAPTURE MEASURES FOR OILED BIRDS

INCIDENT	LOCATION	YEAR	DEAD OR OILED BIRDS	BIRDS CAPTURED	%
Torrey Canyon	Cornwall, Britain	1967	10 000	7 851	78
Esso Essen	Cape Peninsula, South Africa	1968	2 200	1 700	77
Tank Duchess	Tay estuary, Scotland	1968	1 368	737	54
Mystery spill	Terschelling, Holland	1969	5 000	1 182	3
Union oil well	Santa Barbara, California, USA	1969	3 600	1 563	43
Hamilton trader	Ireland	1969	4 407	2 339	45
Tankers collision	San Francisco, California, USA	1971	7 830	1 285	16
Olympic Alliance	Straits of Dover, England	1975	199	122	61
Argo Merchant	New England, USA	1976	181	69	38
Esso Bernicla	Shetland, Scotland	1978	3 702	100	3
Amoco Cadiz	Brittany, France	1978	4 572	258	6
Russian oil tanker	Lettland, Sweden	1979	3 413	459	13
Mystery spill	Shetland, Scotland	1979	1 751	300	17
Steve	Liege, Belgium	1981	3 000	176	6
Mystery spill	Magdalen Island, Quebec Canada	1981	1 150	33	3
Mystery spill	Normandy, France	1983(?)	5 000	700	14
Mystery spill	Puget sound, Washington, USA	1984	1 509	447	52
Arco Anchorage	Washington, USA	1985	1 917	1 243	65
Apex Houston	California, USA	1986	4 198	3 364	80
Nestucca	Washington, USA	1988	12 446	2 098	17
Exxon Valdez	Alaska, USA	1989	29 175	1 188	4
Braer	Shetland Isles, Britain	1993	1 538	230	15
Sea Empress	Welsh coast, Britain	1996	6 900	3 440	50
Platform irene	California, USA	1997	223	53	24
M/V Kure	California, USA	1997	984	473	48
Mystery spill	California, USA	1998	1 535	635	41
T/S Command	California, USA	1998	178	76	43
Gordon C. Leitch	Quebec, Canada	1999	1 078	640	59
New Carissa	Oregon, USA	1999	598	175	29
Erika	Britain, France	1999	62 132	10 000	16
	TOTAL		211 784	42 936	20

3.2 Difficulty in cleaning huge numbers of birds

The most important factor in any serious incident in which large numbers of birds are oiled, is that the resources in the cleaning centers are often insufficient. Few cleaning centers around the world can in fact accommodate more than a few hundreds birds. As mentioned by Welte and Frink (1991), even in a small oil spill response, the need for resources is tremendous. If the rehabilitation center admitted and treated only 30 birds a day, it would need three wash lines, necessitating 10 bird-cleaning volunteers for each 8-hour shift. As much as 4 500 gallons of clean water would be required, half of which would become oil-contaminated, requiring special disposal. Workers would also be needed for each shift for operations control, medical and rehabilitation areas raising the number of people needed for one 24-hour day to 54.

3.3 Variable survival rates during cleaning operations

Of the birds rescued, the percentage successfully cleaned, treated and released seem to be highly variable, from 0% after the Hamilton trader spill in 1969 to as high as 100% after the incident in Port Bolivar, Texas in 1982, with an average of 18% (Table 3). Obviously, this table is not an exhaustive list of all spills where birds where captured and treated, but rather a sample of relatively well-documented ones and an indication that the survival rate is probably not extremely high. Sharp (1996) quotes figures from recent studies in which the mean proportion of oiled birds that survive treatment and are released is substantially higher than 18%, around 35% (range of 9-60%) The release rates also vary with species, type of oil and most importantly, the speed of retrieval of affected birds. Rehabilitation seems to be more effective with species like geese and dabblers where 90% of the birds are returned to the wild, 60% for seaducks, 50% for loons and only 5% for alcids (Frink 1987, Daigle and Darveau 1995).

3.4 Short life expectancy after release

Until recently, only the percentage of released birds has been used to measure the success of bird rescue efforts. However recent research shows that some bird species returned to nature after an oil spill, despite careful rehabilitation, typically die in a matter of months. Sharp (1996) examined band recoveries of wild, post-rehabilitation common murres, western grebes and white-winged scoters and found a mean recovery time between release and band recovery of only 39 days. This figure was between 5 and 100 times lower than for non-oiled birds. For oiled, cleaned Guillemots, post release life expectancy was only 9.6 days and long-term recovery rates were 10–20% of those of non-oiled birds. Measures of survival for those species were not greater for oiled birds treated in recent years with modern methods.

There are few other studies, but almost all indicate that oiled, cleaned birds do not usually survive long after release. Croxall *(in* Swennen 1977) found that the recovery rate of oiled auks released into the North Sea was 11% in the first 6 months, as opposed to a recovery rate for normal birds of 3% over their entire life span of several years. Swennen (1977) found that oiled, cleaned birds released into large enclosures had an annual mortality rate of 35-37%, even though fed and protected from mortality factors that would have been operative in the natural ecosystem, compared with a mortality rate of 7% for non-oiled controls. Anderson *et al.* (1996) found that only 12 to 15% of rehabilitated brown pelicans survived for two years. In contrast, 80 to 90% of pelicans that were never known to be exposed to oil survived as long. The study conducted by Goldsworthy *et al* (1997) is one of the rare studies which found different results in post-release survival of oiled-rehabilitated Little Penguins. For that species, the minimum estimate of post-release survival based on the recapture of banded oiled-rehabilitated birds was 59% after 20 months. Many factors seem to intervene to explain the survival of released birds. Larger birds in better condition with lower levels of oiling, probably have the greatest probability of surviving. The degree of oiling seems to influence the chances of survival (Sharp 1996). Birds released in an inappropriate place, ineffectively cleaned or with low body weight are also unlikely to survive (Cooke 1997)

TABLE 3. EFFICIENCY OF CLEANING MEASURES FOR OILED BIRDS

INCIDENT	LOCATION	YEAR	BIRDS CAPTURED	BIRDS RELEASED	%
Torrey Canyon	Cornwall, Britain	1967	7 851	150	2
Tank Duchess	Tay estuary, Scotland	1968	737	66	9
Esso Essen	Cape Peninsula, South Africa	1968	1 700	950	56
Mystery spill	Terschelling, Holland	1969	1 182	318	27
Union Oil well	Santa Barbara,California, USA	1969	1 575	169	11
Hamilton trader	Ireland	1969	2 339	0	0
Tankers collision	San Francisco, California, USA	1971	1 285	192	15
Mystery spill	Toronto, Ontario, Canada	1976	73	45	62
Peter Maes	Pays de Caux, France	1974	26	10	41
Mystery spill	Magdalen Island, Quebec Canada	1981	33	10	30
Mystery spill	Port Bolivar, Texas, USA	1982	37	37	100
Mystery spill	Normandy, France	1983(?)	700	180	26
Mobiloil	Columbia River, Oregon USA	1984	450	264	59
Mystery spill	Puget sound, Washington, USA	1984	447	50	11
Czantoria	Québec, Canada	1988	7	0	0
Exxon Valdez	Alaska, USA	1989	1 188	797	67
American Trader	California, USA	1990	569	309	54
Braer	Shetland Isles, Britain	1993	230	112	49
Sea Empress	Welsh coast, Britain	1996	3 440	720	21
Platform irene	California, USA	1997	53	18	40
Mystery spill	California, USA	1997	505	251	48
M/V Kure	California, USA	1997	473	195	41
Gordon C. Leitch	Québec, Canada	1999	640	66	10
Mystery spill	Carolina, USA	1999	97	5	5
New Carissa	Oregon, USA	1999	175	129	74
Erika	Brittany, France	1999	10 000	1 578	16
TOTAL			35 812	6 621	18

If we consider the previous figures as representative of the reality, it means that for 100 birds oiled in the wild, capture techniques will be able to bring less than 10 birds to collection centers. Among those 10 birds, existing caring procedures will allow the release of 4 birds which will probably die in the following weeks or months. A surprising 96 birds will then rapidly die a foul death despite all the best efforts of the rescuers.

In spite of these poor results, rehabilitation is a tool that is still worth-wile for the following reasons. Its efficiency will probably improve (especially the ability to capture birds) through the years. This expertise will be in heavy demand following impacts on endangered species or for species with a small world population. The medical care of oiled wildlife fits into a comprehensive program for pollution prevention and response. That special approach obviously has a real impact on the public which is then made more aware of the importance of the environment. Furthermore, in some situations, especially following mystery spills, caring for birds will be the only valuable approach : oiled slicks will be largely dispersed when first detected and birds will already be soiled when spotted. These results also strongly suggest that oil spill response planning and resources should at least be partially redirected to other more effective measures like prevention of damage, i.e., deterrent techniques.

4. Bird deterrent techniques

4.1 Existing techniques

A couple of dozen deterrent techniques are presently available on the market. The goal of the present paper is not to review each of those devices in detail, that kind of description being already available in two documents produced by Koski *et al* (1993) and Greer and O'Connor (1994). Tables 4 and 5 summarize some of the major advantages and disadvantages associated with those deterrents as reported in the two latter studies. Questions which still remain partially unanswered and on which we should focus, concern the type of deterrents we really need and the deterrents we should then favor in the event of an oil spill.

Everyone will agree that devices used to disperse birds should include a minimum of both visual and auditory techniques, using both simple and sophisticated devices in order to respond to different bird species, surrounding environment and spill situation. Some species, especially those found associated with a human environment can be deterred only with difficulty, especially if chosen deterrents mimic sounds or visual elements associated with that special surrounding. Moulting birds are not easily dispersed, therefore requiring a combination of different techniques. Birds may rapidly get used to one frightening device, so if multiple deterrents are available and used in association or in sequence, they become more effective. Some deterrents can also induce stress to local resident populations. The effects of sound emitting devices on humans, in terms or irritation and noise, especially during nighttime, will influence whether or not some techniques will be acceptable. Some types of oil, like fuel, are highly inflammable during the first hours following the spill, due to the presence of high concentrations of volatile oil fractions. Techniques with potential to induce sparks, should then be replaced, whenever required, by more safer practices. Oil spills occurring in offshore waters provide a peculiar situation in which some deterrent measures will be highly inoperative and will require a more sophisticated approach. Automatically operated devices which require checking only once a day or less will be quite more appreciated when manpower is rather limited, during bad weather or at night. Because oil spills may sometimes cover huge areas, high mobility deterring devices, able to cover large influence radiuses rapidly, are also required.

In order to fulfill those different requirements, we believe the eight following techniques to be the most promising and they should be available in the event of an oil spill: 1) aircraft ; 2) motorboat ; 3) Breco buoy ; 4) Marine Phoenix Wailer ; 5) propane cannon ; 6) pyrotechnics ; 7) scarecrows (human effigies) combined with a strobe light and ; 8) ATV. Several other methods might be useful and practical but have limited applicability and effectiveness, haven't been tested or are likely to have the same impact on birds as the deterrents already suggested.

TABLE 4. PROBABLE USEFULNESS OF VARIOUS DISPERSAL AND DETERRENT METHODS FOR OIL SPILLS IN DIFFERENT SITUATIONS IN THE BEAUFORT SEA REGION

	SEDGE LOWLANDS	SEABIRD COLONY	BAYS & LAGOONS	LEADS	OFFSHORE
Fixed-wing aircraft	*Good*	Unlikely	*Good*	*Variable*	*Variable*
Helicopter	*Very Good*	Unlikely	*Very Good*	*Variable*	*Variable*
Model aircraft	Unlikely	Variable	Fair	Possible	Impratical
Boats	No	*Variable*	*Variable*	Possible	Variable
Shotguns, shellcrakers and firecrakers	*Good*	Fair	*Good*	*Good*	*Variable*
Verey flares and tracer shells	Fair	Fair	Fair	Variable	Fair
Rockets and mortars	Good	Fair	*Good*	*Good*	*Good*
Gas Cannons	*Good*	*Good*	*Good*	*Good*	Unlikely
Distress and alarm calls	Fair	Untried	Possible	Untried	Impractical
Sounds of predators	Unlikely	Unlikely	Untried	Untried	Untried
Av-alarm	Fair	Variable	Fair	Fair	Doubtful
Phoenix Wailer	Probable	*Possible ?*	*Possible ?*	*Possible ?*	Possible
Dyes (oil soluble)	Unlikely	Unproven	Unproven	Unproven	Unproven
Searchlights and expanded lasers	Possible	Possible	Doubtful	Doubtful	Possible
Flashing lights	Possible	*Possible*	Doubtful	Doubtful	Possible
Models of dead birds/predators	Fair	Fair	Fair	Fair	Impractical
Effigies	*Fair*	Fair	*Fair*	*Fair*	Possible
Foam	Impractical	Unlikely	Unlikely	Possible	Impractical
Nets & Fences	Impractical	Doubtful	Impractical	Impractical	Impractical
Lure areas	Unlikely	No	Unlikely	Unlikely	Unlikely
Trapping	Impractical	Variable	Possible	Doubtful	Impractical

Source: Koski *et al.* (1993)

TABLE 5. SUMMARY OF WATERBIRD DETERRENT TECHNIQUES FOR OIL SPILL APPLICATION

DETERRENT DEVICE	MOST EFFECTIVE WITH THESE SPECIES	REPORTED ADVANTAGES	REPORTED DISADVANTAGES
Gas-operated Detonators	Waterfowl, gulls, herons, seabirds (?)	Limited manpower, compliment other devices	Must be moved frequently
Pyrotechnics	Waterfowl, gulls, herons, shorebirds, seabirds (?)	Standard technique, compliment other devices	Safety/fire hazard, labor intensive
Aircraft	Waterfowl, gulls, herons, seabirds	Large area covered, limited manpower, direction controlled	Expensive, hazard of bird-aircraft collision
Boats	Waterfowl, possibly seabirds	Large area covered, limited manpower, direction controlled	Weather/sea condition constraints
All Terrain Vehicles	Waterfowl, shorebirds	Reach inaccessible areas	Marsh habitat disturbance
Electronic Sound Generators	Geese, gulls, seaducks(?)	Effectiveness largely untested	Effectiveness largely untested
Air Horns	Waterfowl, gulls	Inexpensive	Rapid habituation
Biosonics	Gulls, some herons	Slow habituation	Highly species-specific
Underwater Acoustics	Unknown	Effectiveness unknown	Effectiveness unknown
Ultrasonic	None	None	Ineffective
Balloons	Waterfowl	Inexpensive	Rapid habituation, daytime only
Flags	Waterfowl	Inexpensive, materials readily available	Rapid habituation, daytime only
Lights	Waterfowl, gulls, some herons	Inexpensive	May attract birds, night only
Mirrors, Reflectors, Reflecting Tape	Waterfowl	Inexpensive	Rapid habituation
Human Effigies and Predator Models	Waterfowl	Inexpensive	Rapid habituation, daytime only
Trained Falcons and Hawks	Waterfowl, gulls	No habituation	Expensive, daytime only, may cause birds to dive into oil
Decoys	Waterfowl, gulls	Inexpensive	Must be moved frequently, daytime only
Dyes	Unknown	Effectiveness unknown	Effectiveness unknown
Lure Areas	Waterfowl	Passive	May attract birds to spill area

Source: Greer and O'Connor (1994)

4.2 Most promising deterring devices

4.2.1 Aircraft

Many aircraft are extremely manoeuvrable, especially helicopters. They can be used in most oil spill situations (offshore or onshore), fly quickly to spill locations and be used to disperse birds from a large area with a minimum amount of manpower.

However bird reactions to aircrafts depend on the species involved. Geese for instance, seem to be more easily frightened than any other group of birds. Owens (1977) has demonstrated that Brant geese were particularly susceptible to aircraft disturbance. Any pass lower than about 500 m and up to 1.5 km away could trigger their flight. Slow, noisy aircrafts were especially harmful and helicopters caused widespread panic. It took quite a while for the geese to grow accustomed to their noise. Blokpoel and Hatch (1976) reported that a light aircraft flying at an estimated height of 100 to 200 feet was able to cause panic amongst flocks of several thousand Snow and Blue geese feeding in a stubble field. Davis and Wiseley (1974) showed that flocks of Snow geese were equally prone to flush in response to fixed-wing aircraft and helicopters. They found that 48% of flocks flushed when overflights were ½ h apart and that 97% flushed when flight spacing was 2 h.

Sikstrom and Boothroyd (1985) found that Snow geese were the first species to flush among a mixed-species group of waterfowl. Staging Snow geese and other waterfowl flushed when an aircraft approached within 0.5 to 1.0 km. In response to aircraft flying at altitudes of 150-500 m above ground level, geese flew for up to 3 minutes before returning to their initial locations. Schweinsburg (1974) concluded that overflights by a Cessna 185 disturbed all resting snow geese at altitudes of 300, 700, 1 000, 7 000 and 10 000 feet. Geese tend to flush at greater distances when the aircraft is under 1 000 feet. Flocks flush as much as 9 miles away from the aircraft. Geese can be driven from an area roughly 50 square miles within 15 minutes by hazing with a Cessna 185. Bélanger and Bédard (1989) have observed that disturbance by aircraft affected Greater snow geese in many ways but it generally disturbed the entire flock. Time spent in flight and time to resume feeding was also greater after aircraft disturbance than after any other type of disturbance encountered in the study. Whenever staging Greater snow geese were disturbed at a rate of ≥ 2.0 disturbances/hour in 1 day, their numbers at the site would suffer a 50% drop the next day. Lehoux (1990) found that a helicopter flying at a low altitude (50 m) was able to readily disperse close to 300 Snow and Canada geese staging in a spartina tidal marsh during springtime. Frightened geese first gathered at the edge of the water and 90% of them finally left the area. Owens (1977) suggested that the intense response of geese to aircrafts and their slowness in getting accustomed to them could be attributed in part, to the similarity between aircrafts and large birds (raptors).

Aircraft seem to be less effective in deterring dabbling ducks and seaducks. Lehoux (unpublished data) found that even after four slow helicopter flights over a spartina tidal marsh meant to disperse or harass birds, close to 70% of the dabbling ducks initially outnumbered (400), were still present. Sugden (1976) noted that some experimental aircraft-hazing tests on ducks and Sandhill cranes in agricultural areas on the Canadian prairies had produced poor results, but other tests were more successful. Lehoux

(1990) also demonstrated that 1.5 hours of helicopter harassment was required to decrease two thousand seaducks (eiders and scoters) gathered offshore by 80% in an area of roughly 300 ha. He concluded that the operation was difficult and required an intensive and constant effort.

Sharp (1978) used a helicopter to haze moulting seaducks (mainly oldsquaw) to test the effectiveness of this technique along the coast of the Beaufort sea. The first helicopter flight (85 minute) succeeded in reducing by 76% the numbers in the study area from 124 to 30. During the 70 minute pause for refueling, the numbers present increased to 101. The second flight (135 minutes) reduced the numbers present to 23. Numbers did not increase during the second refueling interval of 55 min and even decreased to 16. Six of those birds remained on the site after the last flight. This study showed that between 11 and 18 minutes were required to disperse birds per km^2. Sharp (1978) concluded that dispersing birds with a helicopter may be an efficient and effective method for birds that can fly, whereas it appears feasible but less efficient for flightless birds. Attempts to herd birds were unsuccessful when approached too closely (50 m); they responded by diving and scattering. Sharp (1978) suggested to herd flightless birds by hovering behind them at a distance of 70-100 m and an altitude of 0-10 m.

Barry *et al* (1981) conducted surveys for moulting seabirds and brood rearing (mostly Common Eiders) in the Beaufort sea and observed that many species of moulting birds had a propensity to dive when approached by a noisy aircraft flying at low level. This observation is also confirmed by Ward and Sharp (1974) and by Johnson *et al* (1976) who noted that some species such as moulting seaducks and alcids tend to dive as an aircraft approaches. Ward and Sharp (1974) mentioned that helicopter disturbances at an altitude of 100 m have an immediate but no apparent lasting effect on bird behaviour. Stott and Olson (1972) reported that when approached by a low-flying aircraft, non moulting birds like Goldeneye and Red-breasted merganser don't dive. They consistently flushed and flew away from the aircraft until they were about to be overtaken. At this point, they either flew back under the aircraft or circled back away from the aircraft and landed on the water close to their original location. Oldsquaw, like scoters, on the other hand, seldom flushed from the water when approached or flown over by an aircraft, but rather dove just like moulting seaducks.

Lehoux and Bordage (1999) also tested a helicopter to disperse eider ducks following an oil spill in Quebec. Eiders' response was immediate. Birds (less than one hundred) flew readily hundreds of meters away from the contaminated area. However, they came back rapidly since the site was an important nesting ground.

<u>Advantages</u>

1. able to reach remote and inaccessible (by roads) areas in a short amount of time;

2. able to disperse birds in different types of habitats (marsh birds, offshore birds);

3. can be used to rapidly deter birds while oil is still offshore and bird mortality rate consequently higher;

4. requires limited manpower;

5. very efficient to deter geese.

Disadvantages

1. less efficient to deter species other than geese, especially when moulting;

2. less efficient when birds are gathered in very attractive sites like feeding or nesting grounds;

3. increased potential of bird-aircraft collisions during low flying activities;

4. not effective at night;

5. can't be used or have a reduced feasibility when bad weather conditions prevail (especially fog);

6. time consuming in deterring birds on a large scale basis;

7. helicopters are in heavy demand during an oil spill; so it may be difficult to get one to be available for several hours a day for the sole purpose of deterring birds;

8. the cost of a charter aircraft can be relatively high;

9. aircraft scaring may require a permit from governmental agencies.

4.2.2 Motorboat

Motorboats can be used to deter birds located offshore where hazing from shoreline with other techniques is ineffective in driving birds away. A few studies conducted during the last 20 years have demonstrated the potential of boats as an effective deterrent.

In Nova Scotia, harassment by boat helped in deterring seaducks from cultured mussel beds at locations otherwise difficult to reach (Parsons *et al*, 1990). Seaducks flushed at distances of 75 m to more than 300 m, depending upon their previous exposure to the boats.

Korschgen *et al* (1985) reported that on many occasions the flushing distance of diving ducks (canvasbacks) extended as far as 1 km. They believed that birds were more sensitive to boats propelled by outboard motors. Powerboats at high speeds approaching within 550 m of Common goldeneyes flushed them even though strong winds muffled the motor's noise (Hume 1976). On one occasion, the deterring distance even reached 700 m. A powerboat causes virtually instantaneous flight as soon at it appears on the water, the majority of birds leaving. There is some speculation that the larger the flock, the more sensitive it is to an approach (Batten 1977).

Lehoux (1990) demonstrated, in two of his experiments, the possibility of deterring seaducks by using a motor boat along with bangers. In the first experiment, about 2 500 seaducks, mainly scoters, were successfully dispersed after one hour of harassment. Birds immediately responded to the presence of the motorboat, by diving. After a few minutes, they dispersed into small flocks in different directions. They were so frightened afterwards, that they took to flight at a distance of roughly 1 km from the boat. In the second experiment, 450 seaducks that had previously been deterred by helicopter flights, were also dispersed from the area after 2.5 hours of harassment. However, 300 of them were back on the site two hours later and had to be hazed during one more hour. Lehoux (1990) concluded that deterring seaducks with a motorboat remains a difficult operation, particularly because it was not easy to accurately locate birds.

Advantages

1. useful in deterring birds located at some distance from the shoreline;

2. can rapidly be used to deter birds while oil is still offshore and bird mortality rate is consequently higher;

3. not highly species specific;

4. covers relatively large areas;

5. requires limited manpower.

Disadvantages

1. deployment can be hazardous during bad weather, ice conditions or during the night;

2. can't locate birds easily especially in rough seas;

3. if difficult in locating the oil slicks, can't be sure that dispersed birds will land on unoiled waters.

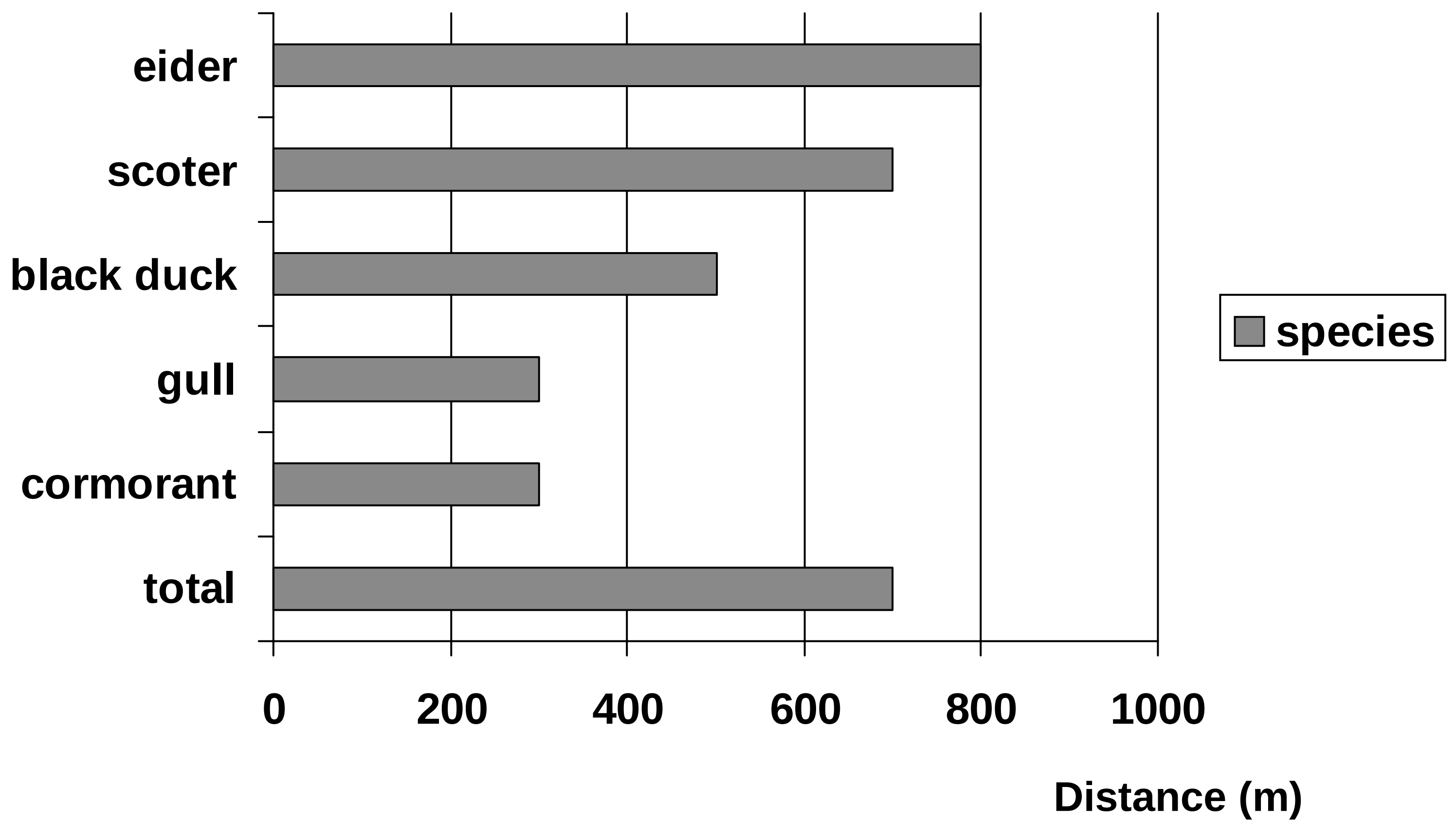
4.2.3 The Breco buoy

The Breco buoy is a new deterrent device that has recently become commercially available. Based on initial evaluations, it appears to have good potential especially for offshore birds. This device includes a miniaturized playback system, including an amplifier, speaker and integrated circuits mounted inside a buoy. The resulting system produced 30 different high intensity sounds up to 130 dB at 1 m. Other major features of the buoy include: frequency range of sounds between 1 000 and 12 000 Hz; emission intervals ranging between 30 s and 5 min.; signal length between 20 and 50 s.; weighs 36 kg; freeze-proof (down to -30°C) construction; operational over at least 72 hours; fitted with four submersible corrosion-proof loud speakers; shock-proof when thrown overboard from a helicopter or launched from a boat or a pier; designed to drift with an oil slick equipped with a radio signal beacon for immediate location and has a storage battery life of up to 10 years (Breco 1995)

Three field tests have been conducted with the Breco buoy. The first field test was conducted by Lehoux and Bélanger (1995) in the lower estuary of the St. Lawrence River in Quebec, Canada. This area was chosen because it is a well known staging area for moulting Common Eiders in summer and early autumn. Furthermore, the area was fairly distanced from residential areas. The area was not submitted to any disturbances during tests (aircrafts, fishing boats, sailing boats...). A fairly straight road ran along the entire length and submitted birds to noises from road traffic only. In the first field test, the buoy was anchored approximately 500 m from the shore and was allowed to operate for 42 consecutive hours. A 5 km-long stretch of road was divided into 30 units of 100 m and 4 of 500 meters covering shoreline habitats each side of the anchored buoy. All species present and the number of individuals of each species present inside each unit were recorded 16 times before the buoy was installed and 5 times when the bird scarer was in operation. That first experiment demonstrated that an anchored buoy was able to decrease by 85 % the number of seabirds initially present within a 700 m radius (Figure 3; Table 6). It was particularly effective in deterring Common Eider and scoters and less effective on gulls for which the radius of efficiency was limited to 400 meters. The authors were not able to determine the impact or radius of effectiveness of the scaring system on the other species present in the study area (dabblers and cormorants) because of the insufficient density of those birds.

In the second experiment, Lehoux and Bélanger (1995) observed the behaviour of birds when the buoy was used as a drifter and positioned with a motorboat in the middle of a raft of approximately 4 000 moulting eiders and scoters. The buoy was then allowed to drift with tides and currents during 4 consecutive hours. The motorboat first noticeably disturbed the birds present. The raft broke up into two separate flocks; the buoy being just in the middle of those two flocks. Once the disturbance caused by the boat had ceased, the flock of birds on the western side of the buoy began to swim towards their conspecifics on the eastern side. When they reached a point approximately 700-800 m (estimated with the truck's odometer) from the buoy, they altered their course to avoid the buoy, moving either closer to shore or farther offshore, still maintaining a distance around 700-800 m from the drifting device. Once they had passed the buoy, the birds that had moved closer to shore headed offshore again, still maintaining at least 700-800 m distance. Some birds were occasionally found at distances of less than 700 m during the experiment but most were observed at 700 m or over. They estimated that one buoy would probably be able to protect a 150 area.

Figure 3. Deterrent effectiveness of the Breco buoy on bird species



source: Lehoux and Bélanger (1995)

TABLE 6. VARIATION IN BIRD NUMBER/100 M BEFORE AND DURING THE OPERATION OF THE BRECO BUOY (1994)

Distance from the buoy (m)	Eider		Scoter		Gull		Cormorant		Black Duck		Total		Total (without Gull)	
	Before	During P	Before	During P	Before	During P	Before	During P	Before	During P	Before	During P	Before	During P
0	104.5 ± 21.8	26.6 ± 26.6 NS	63.5 ± 23.0	0.0 ± 0.0 +	22.6 ± 11.9	0.0 ± 0.0	0.3 ± 0.1	0.0 ± 0.0 +	1.3 ± 0.1	0.0 ± 0.0 +	196.4 ± 44.1	26.6 ± 26.6 **	153.1 ± 38.2	26.6 ± 26.6 **
100	101.6 ± 21.0	0.5 ± 0.5 ****	61.4 ± 16.2	0.0 ± 0.0 +	26.7 ± 6.8	0.0 ± 0.0 +	0.3 ± 0.2	0.3 ± 0.3 NS	1.8 ± 1.2	0.0 ± 0.0 +	194.5 ± 33.4	0.8 ± 0.5 ****	167.8 ± 31.3	0.8 ± 0.5 ****
200	76.7 ± 27.9	1.8 ± 1.6 **	50.5 ± 16.2	0.0 ± 0.0 +	13.0 ± 4.1	0.1 ± 0.2 **	0.4 ± 0.1	0.0 ± 0.0 +	0.4 ± 0.2	0.0 ± 0.0	141.7 ± 37.3	2.0 ± 1.6 ***	128.1 ± 37.0	1.8 ±1.6 **
300	91.0 ± 26.0	0.8 ± 1.4 **	24.4 ± 11.3	1.6 ± 1.3 *	6.3 ± 2.0	3.1 ± 3.0 NS	0.6 ± 0.2	0.0 ± 0.0	1.3 ± 0.6	0.2 ± 0.2 NS	125.7 ± 27.2	5.8 ± 3.4 ****	119.3 ± 27.4	2.7 ± 1.5 ***
400	41.3 ± 11.1	8.1 ± 4.2 **	48.0 ± 15.5	0.0 ± 0.0 +	1.4 ± 0.4	0.0 ± 0.0 +	0.1 ± 0.1	0.3 ± 0.3 NS	0.4 ± 0.2	0.0 ± 0.0 +	92.8 ± 20.8	8.5 ± 4.5 ***	91.3 ± 20.8	8.5 ± 4.9 ***
500	16.5 ± 6.2	4.3 ± 4.1 NS	34.6 ± 13.6	0.0 ± 0.0 +	6.1 ± 3.1	3. 1 ± 2.3 NS	0.0 ± 0.0	0.0 ± 0.0 +	1.6 ± 1.0	0.3 ± 0.3 NS	59.1 ± 17.5	11.5 ± 5.3 *	53.0 ± 15.0	8.3 ± 4.9 **
600	26.4 ± 11.2	1.1 ± 0.8 *	18.4 ± 8.0	0.0 ± 0.0 +	8.6 ± 3.4	18.8 ± 14.8 NS	0.3 ± 0.2	0.0 ± 0.0	2.9 ± 1.1	1.6 ± 1.1 NS	58.3 ± 17.9	22.5 ± 16.0 NS	49.6 ± 16.8	3.7 ± 1.5 **
700	51.7 ± 20.3	5.5 ± 4.9	12.4 ± 5.3	0.0 ± 0.0 ±	13.4 ± 35.8 NS	0.9 ± 0.4	3.5 ± 3.5 NS	0.6 ± 0.5	0.6 ± 0.5	8.8 ± 8.4 NS	79.8 ± 22.3	67.5 ± 37.1 NS	66.4 ± 22.1	18.5 ± 10.6
800	27.4 ± 11.2	7.3 ± 4.1 NS	7.5 ± 3.3	1.3 ± 1.3 NS	12.2 ± 2.8	78.1 ± 35.6 NS	0.5 ± 0.3	2.3 ± 2.0 NS	1.8 ± 0.9	2.1 ± 2.0 NS	44.9 ± 11.5	92.6 ± 37.1 NS	32.2 ± 11.8	14.5 ± 3.2 NS
900	16.0 ± 6.0	8.6 ± 8.3 NS	5.0 ± 2.8	0.3 ± 0.3 NS	9.6 ± 3.4	9. 1 ± 6.3 NS	0.4 ± 0.3	0.3 ± 0.3 NS	9.7 ± 4.2	3.5 ± 1.9 NS	45.5 ± 11.5	22.0 ± 8.0 NS	36.4 ± 10.5	12.8 ± 7.7 NS
1000	13.0 ± 5.3	4.8 ± 3.1 NS	5.9 ± 2.7	2.0 ± 1.6 NS	2.9 ± 1.4	15.1 ± 13.0 NS	0.3 ± 0.2	0.3 ± 0.3 NS	3.5 ± 2.6	2.2 ± 2.2 NS	28.0 ± 9.1	24.6 ± 17.0 NS	25.0 ± 9.1	9.5 ± 5.7 NS
1500	11.1 ± 2.7	3.2 ± 2.2 *	7.6 ± 1.5	8.1 ± 6.7 NS	1.5 ± 0.3	0.1 ± 0.1 ***	0.2 ± 0.1	0.1 ± 0.1 NS	0.6 ± 0.6	0.0 ± 0.0 +	20.3 ± 4.2	11.5 ± 8.8 NS	18.7 ± 4.1	11.5 ± 8.8 NS
2000	8.3 ± 1.5	4.5 ± 3.0 NS	3.8 ± 1.3	0.8 ± 0.6 *	2.3 ± 0.8	0.9 ± 0.8 NS	0.4 ± 0.2	0.2 ± 0.2 NS	1.2 ± 0.4	1.2 ± 0.9 NS	16.0 ± 2.9	8.2 ± 3.8 NS	14.3 ± 2.7	7.3 ± 3.4 NS
2500	26.8 ± 5.4	10.7 ± 5.0 *	12.6 ± 4.5	7.8 ± 3.0 NS	8.4 ± 1.0	6.8 ± 6. 7 NS	2.0 ± 0.3	1.3 ± 0.2 ***	1.2 ± 0.3	0.1 ± 0.1 *	57.9 ± 8.7	26.1 ± 11.2 NS	43.5 ± 8.9	19.2 ± 6.7 *
TOTAL	35.9 ± 3.5	5.3 ± 1.2 ***	20.7 ± 2.4	2.5 ± 1.2 ***	7.9 ± 0.8	11.1 ± 3.7 NS	0.5 ± 0.1	0.5 ± 0.2 NS	1.8 ± 0.4	1.3 ± 0.6 NS	68.0 ± 5.1	21.2 ± 4.3 ***	60.2 ± 4.9	10.1 ± 2.1 ****
P	****	NS	****	NS	****	**	****	NS	**	NS	****	**	****	NS

Student T test

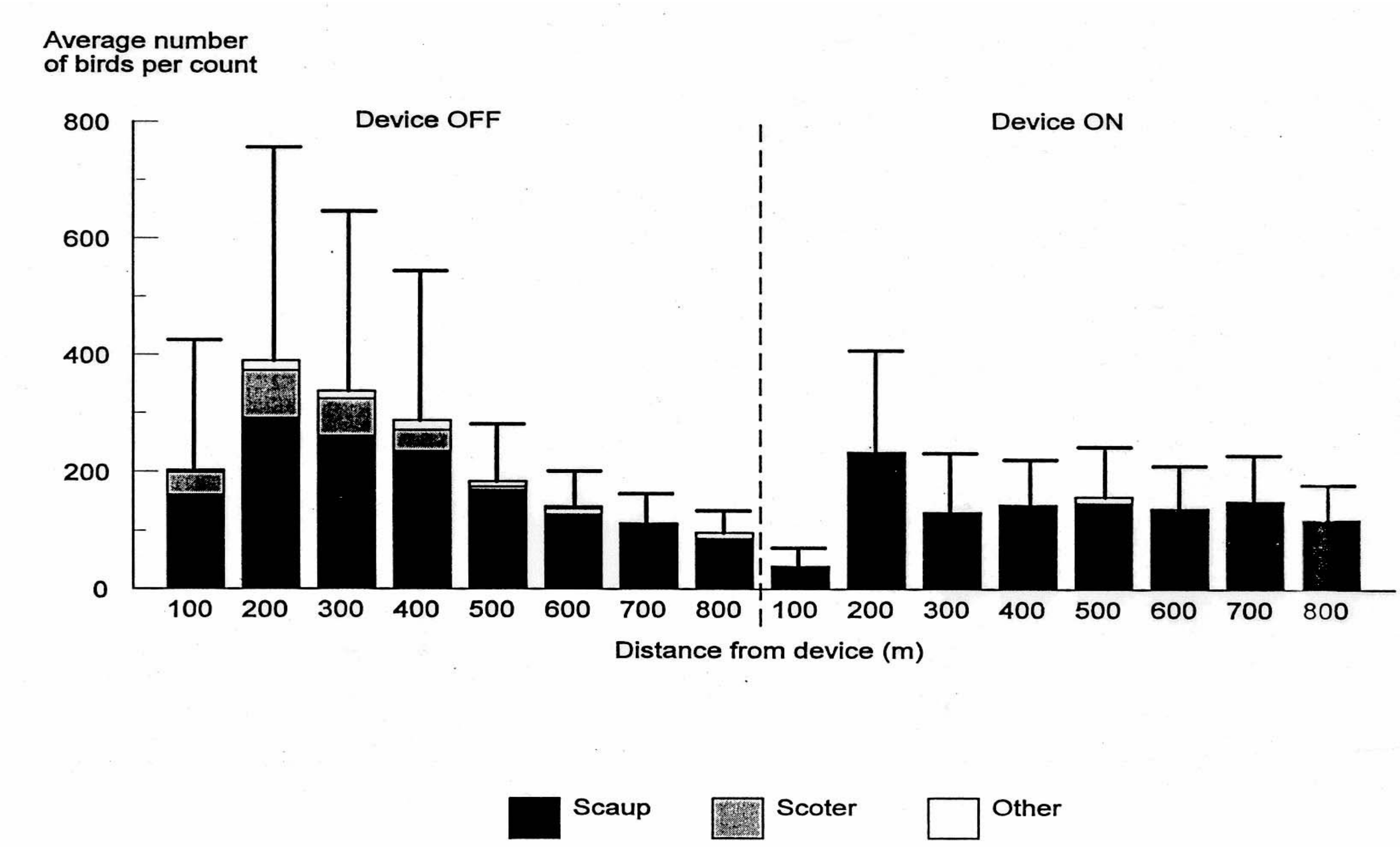
Source: Lehoux and Bélanger (1995)

*: $p < 0.05$
**: $p < 0.01$
***: $p < 0.001$
****: $p < 0.0001$
NS: $p > 0.05$
+: means differ, (no variance)

A third experiment with the Breco buoy was conducted in California (Whissom and Takekawa 2000). They designed field trials to examine the effectiveness of the scarer in deterring waterbirds, predominantly surf scoters and scaups in the northern San Francisco bay estuary during the spring of 1996. The field trials suggest that the hazing device had only a limited effectiveness on waterbirds. Aerial surveys did not detect a significant change in distribution of any species or total numbers within a 4 km radius following deployment of the device. Ground surveys of birds provided greater resolution than aerial surveys in determining the number, species composition, and distribution of water birds within an 800-m radius of the device, but as in the aerial surveys did not demonstrate a significant effect of the device on number or distribution of ducks (Figure 4). Furthermore, birds did not display any signs of distress or alarm on encountering the device, and did not change their course of movement when approaching the device. In many instances, flocks of several thousand birds were observed surrounding the device while it was operating. A significant result was found for surf scoter, which were present in lower numbers when the device was operating. However, scoter were present during only 6 trials, their numbers exceeding 100 individuals during 3 of those trials. These poor results could partially be explained by the fact that the buoy was not operating in an ideal manner. Sound levels testing at the site ranged between 102 to 122 dB at one meter compared to 130 dB as promoted by the manufacturer. Furthermore, San Francisco bay is an urbanized area subjected to disturbance by boat traffic. Consequently, birds may have already been accustomed to noise disturbance so were not scared by the device. Finally, tests, contrary to Lehoux and Bélanger experiments, were conducted on non moulting birds

In 1998, the Canadian Wildlife Service tested all 30 different sounds emitted by the buoy individually. One hundred and thirty eight (138) field tests were conducted on 204 groups of birds including 29 000 individuals belonging to 17 species during the spring migration of aquatic birds along the St. Lawrence River in Quebec. During each field test, bird behaviour was documented during the emission of one sound that lasted up to two minutes. A response was considered positive when birds immediately left the site by either swimming or flying away. This new study revealed that the majority of sounds emitted by the Breco buoy were indeed inefficient to substantially deter non moulting aquatic birds on large distances. Range of efficiency was more often less than 200 m. Even if these tests gave better results than those of Whissom and Takekawa (2000), altogether only 15% of the birds were successfully dispersed (swimming or flying away; Table 7). These results suggested that the bird state (moulting *vs* non moulting) was probably the major factor to explain the non effectiveness of the initial sounds, even though other factors (habituation of birds to loud noises, a less effective buoy) could have played a certain role.

Figure 4. Mean number of birds (with 95 % C.I.) counted in each distance interval in ground surveys prior to and during operation of the device.



Source: Whissom and Takekawa (1998)

Following those results, the Canadian Wildlife Service modified the sequence of sounds produced by the Breco buoy in order to attempt a better response from non moulting birds. They first retained the most performing sounds originally produced by the buoy to which they added banger sounds as well as alert calls of gulls, dabblers and geese. The sequence emitted and tested was then a combination of 18 different sounds that could last 6.3 minutes (instead of a sequence of a single sound emitted at once lasting between 20 and 50 seconds like in the original Breco buoy). The maximum intensity to 1 meter still remained at 130 dB. They tested this new combination of sounds 49 times on 84 groups of birds including 8 000 birds belonging to 23 species during the 1998 spring migration of aquatic birds along the St. Lawrence River. This new sequence successfully dispersed (swimming or flying away) 74% of all non moulting birds, instead of 15% with the initial sounds (Table 7). Successful deterring was noted for estimated distances ranging between 50 m and approximately 1 km. However, the duration of sound emissions had to be increased by an average of 1 minute to be efficient for larger distances (>500 m). All species responded positively and relatively rapidly (duration of bird dispersion between 30 sec and 6.3 minutes with an average of 3.5 minutes) to the scarer. Some species however, were less easily frightened than others, especially gulls and cormorants. For assessing only species for which they were sufficient bird numbers, they can be categorized into one of the three following classes (Table 8):

1. very easily frightened: Common Goldeneye, Brant and Black Guillemot
2. easily frightened: mergansers, scoters, Common Eider and Greater Snow goose
3. frightened with difficulty: gulls and cormorant

Efficiency of the scarer was significantly reduced when heavy winds prevailed (>30 km/hour) or when birds were confined to very secure habitats (small ponds). No studies were conducted to assess the duration of the lasting effect. The new breco buoy is now designed to fulfill the following requirements:

- sounds produced at a high intensity: up to 130 dB;
- diversity of sounds including bangers sounds and alert calls of gulls, dabblers and geese;
- signal length of at least 2 minutes, but ideally 3.5 minutes to enable the deterring of birds located on larger distances;
- variety of sounds included in each signal: 10–12.

TABLE 7 . SUMMARY RESULTS OBTAINED WITH OLD AND NEW SOUNDS EMITED BY THE BRECO BUOY

GENERAL INFORMATION

	TESTS (n)	GROUPS OF BIRDS (n)	BIRDS (n)	SPECIES (n)
Initial sounds	138	204	28 933	17
New sounds	49	84	7 846	23

NUMBER OF BIRDS INVOLVED PER SPECIES

SPECIES	INITIAL SOUNDS	NEW SOUNDS
Snow Goose	24 830	4 510
Black and Surf scoters	1 476	1 934
Common Eider	824	301
Black Guillemot	536	109
Red-breasted Merganser	473	112
Common Merganser	256	136
Herring and Black Backed Gulls	238	354
Canada Goose	160	---
Brant	---	94
Mallard	33	5
Ring-Necked Duck	32	16
Lesser Scaup	22	14
Common Goldeneye	22	50
Black Duck	11	25
Double-Crested Cormorant	10	143
Oldsquaw	10	2
Northern Gannet	---	20
Blue-winged and Green-winged teals	---	11
Common Loon	---	6
Gadwall	---	3
American Wigeon	---	1

TABLE 7 (CONTINUED)

EFFECT OF RANGE ON BIRDS DISPERSION (%)

	≤100 m	101 - 500 m	> 500 m	all included
Initial sounds	20	15	*14	15
New sounds	95	73	87	74

* Only 4 tests including 27 birds.

TIME REQUIRED (S) TO DISPERSE BIRDS ACCORDING TO THE RANGE

	≤100 m	101 - 500 m	> 500 m	all included
Initial sounds	*nd	nd	nd	nd
New sounds	192	200	256	206

*nd = not determined

EFFECT OF WIND ON BIRDS DISPERSION (%)

	<5 km / hr	5 - 20 km / hr	20 - 30 km / hr	> 30 km / hr
Initial sounds	16	17	8	9
New sounds	72	85	73	26

TABLE 8. VARIABILITY IN SPECIES' REACTION TO THE NEW SOUNDS

SPECIES	SWIMMING AWAY (%)	FLYING AWAY (%)	NUMBER INVOLVED	NUMBER OF HAZING TRIALS
Common Goldeneye	0	100	50	1
Brant	0	100	94	2
Black Guillemot	0	98	109	4
Red-breasted Merganser	17	83	112	8
Common Merganser	25	75	101	3
Scoters	20	62	1 934	13
Greater Snow Goose	12	60	4 510	6
Common Eider	50	29	301	20
Gulls	1	28	354	8
Double-Crested Cormorant	21	24	143	3

Advantages

1. can deter offshore birds;

2. can be rapidly deployed to deter birds when oil is still offshore or in open waters, therefore when birds are more at risk and when the bird mortality rate is higher (within a few hours);

3. can protect a large area (between 100-150 ha or one buoy every 1.0-1.5 km);

4. can be used as a drifter to follow the drifting oil;

5. when used as a drifter within the drifting oil slick, minimizes chances of hazing birds directly into the contaminated waters and minimizes chances of bird habituation because the buoy is always moving and regularly encountering new groups of birds;

6. can be operated day and night;

7. can be operated during bad weather (fog and rain);

8. limited habituation of birds, even when the buoy is anchored, due to the diversity of sounds produced;

9. easily traceable;

10. easily handled and operated by two persons;

11. made of fiberglass for weathering the hazards of fire and explosion associated with gases hovering over oil slicks;

12. long storage battery life (>10 years).

Disadvantages

1. probably less efficient in areas where birds are accustomed to loud background noises, where hunting pressure is low or where birds congregate in very secure habitats;

2. decreased range of effectiveness during windy days (> 30 km/hr) and on rough seas;

3. operational for only 72 hours without changing batteries;

4. requires a boat or a helicopter to be deployed offshore;

5. possibilities of loss or difficulties of retrieval after batteries are exhausted;

6. when used as a drifter, needs to be regularly located (two or three times daily) to be sure that the device stays in the oil slick;

7. unknown duration of efficiency when the buoy is used in a stationary mode;

8. broadcasting high intensity sounds may create a problem particularly if the scaring system is to be used near residential areas or close to responders;

9. expensive (roughly $6 000 US). Even more expensive if the costs of radio beacon transmitters and receivers are included;

10. expensive change of batteries (roughly $1 000 US);

11. not rapidly available (1-2 months).

4.2.4 The Marine Phoenix Wailer

The Marine Phoenix Wailer is another new deterrent device that has recently become commercially available. The Wailer is an electronic sound-generating device that broadcasts a programmable variety of sounds (64) like digitized alarm calls and shotgun blasts at up to 130 dB through four speakers, one in each direction, with an option of four additional remote speakers. The frequency range of sounds from a speaker is 450-4 000 Hz and the frequency range of sounds produced by a horn tweeter is 3 500- 30 000 Hz. The sounds can be broadcast in a randomly selected order and the source level is adjustable. The time between broadcasts is adjustable from 5 to 40 min. The duration of the blast is also adjustable from 5 to 40 s. A strobe light option is also available. Power is supplied to the unit by two 12-volt marine batteries which can power the unit for up to 5 days of daytime operation. The Wailer can be used in aquatic situations when equipped with a quadrapod attached to floats.

Although the Wailer seems promising, few test data are available. Some trials were conducted by the New Brunswick Department of fisheries and aquaculture at mussel sites in the Maritimes in Atlantic Canada. The unit is reported to have been extremely effective in deterring seaducks. In 1995, a Marine Phoenix Wailer was tested in New Brunswick, Canada, for effectiveness in keeping scoter ducks away from juvenile mussel collector lines (Hounsell and Reilly 1995). Two study plots were established at the site. Six mussel spat collector lines were installed at each plot. Each line was one hundred meters in length and lines were spaced thirty meters apart. Two meters of spat collector lines were attached to each line at two meter intervals. Each study plot was approximately 0.30 ha in size. Observation blinds were constructed on land at each of the two plots. Colored buoys were used to indicate various distances (up to 1 000 meters) from the deterrent or a marker buoy. The Marine Phoenix Wailer was operated continuously during the daylight hours only. Bird numbers and locations were monitored and recorded during 17 days between October 10 and November 7. Throughout most of the monitoring period small flocks (6-40 birds per flock) of Common Scoters frequented and fed within 100 meters of the center buoy at control plot (Table 9). At the site of the Wailer, no scoters were seen to approach closer than 500 meters of the deterrent while the Wailer was operated (i.e. 17 days) (Table 10). It was concluded that the Marine Phoenix Wailer appeared to be an effective open-water bird deterrent device within an effective range of approximately 500 meters. This suggests that the effective aerial coverage of a single Wailer could be approximately 75 ha.

Advantages

1. can be operated in open water situations especially where oil is well confined and where birds are highly susceptible to be impacted;

2. protect relatively large areas (75 ha);

3. can be operated day and night;

4. can be operated during bad weather (fog, rain, snow, wind..);

5. not expensive to operate (required four marine batteries: two in the Wailer and two on full charge);

6. can produce a wide variety of sounds that may be able to deter many species of birds at once and minimize chances of birds habituations;

7. can be assembled relatively rapidly by two persons within thirty minutes;

8. easily deployed;

9. long lasting effect (> two weeks).

Disadvantages

1. regular monitoring (daily) is recommended to insure proper operation of the unit;

2. sounds emitted by the Wailer could be a major irritant near residential areas or responders;

3. relatively expensive to purchase ($3 000 U.S.);

4. requires a boat to deploy the unit to its operation site;

5. possibility of electrical hazards associated with gases hovering over oil slicks;

6. decreased range of effectiveness during windy days and rough seas;

7. not rapidly available.

TABLE 9. SUMMED MORNING AND EVENING BIRD OBSERVATIONS AT SITE (WITHOUT THE MARINE PHOENIX WAILER)

Date	100 m	200 m	300 m	400 m	500 m	700 m	1000 m
10/10/95							200 cs
10/11/95					100 cs	150 cs	350 cs
10/12/95					1 cs	10 cs	
10/13/95						35 cs	20 cs
10/14/95						2 cs	45 cs
10/16/95							17 cs
10/18/95		2 cs			12 cs		6 cs
10/19/95	6 cs	7 cs			6 cs		1 ss, 15 cs
10/21/95	6 cs						12 cs
10/23/95	10 cs					20 cs	60 cs
10/24/95	12 cs				2 cs		
10/25/95	6 cs						
10/27/95					60 cs		
10/28/95				20 cs			
11/02/95		40 cs					
11/03/95	40 cs					15 cs	
11/04/95	50 cs	10 cs					
11/06/95	40 cs	6 cs					
11/07/95	20 cs	10 cs					

Source: Hounsell and Reilly (1995)

cs: Common scoter
ss: Surf scoter

TABLE 10. SUMMED MORNING AND EVENING BIRD OBSERVATIONS AT SITE (WITH THE MARINE PHOENIX WAILER)

Date	100 m	200 m	300 m	400 m	500 m	700 m	1000 m
10/10/95						500 cs	200 cs
10/11/95						325 cs (fl)	400 cs (fl)
10/12/95							7 cs
10/13/95							4 cs
10/14/95						10 cs	35 cs
10/16/95						5 cs	
10/18/95						18 cs	
10/19/95						36 cs	12 cs
10/21/95						7 cs	90 cs
10/23/95						7 cs	
10/24/95	3 cs			20 cs		40 cs	50 cs
10/25/95			50 cs				
10/26/95							500 cs
10/27/95					450 cs		
11/02/95							
11/03/95							
11/04/95							
11/07/95						500 cs	200 cs

Source: Hounsell and Reilly (1995)

cs: Common scoter
fl : Flying birds

4.2.5 Propane cannon

Detonators consist of a bottled gas supply, separate pressure and combustion chambers, an igniting mechanism and a barrel to aim and magnify the blast. Gas cannons produce a loud directional shotgun-like noise by slowly filling a bellows with propane gas from a tank then rapidly transferring this gas to a firing chamber and igniting it with a spark. Blasts are emitted at adjustable time intervals. The interval between detonations can be varied from less than one minute to 30 minutes. Some gas cannons can be set to fire at random intervals and rotate after each explosion so that subsequent shots are aimed in different directions. The sound level is approximately 120 dB. A cannon can operate for about two weeks without refueling.

Most studies on the efficiency of gas cannons have been conducted in airport, agricultural or landfill settings. A few studies have however dealt with the use of cannons to deter and disperse birds in coastal areas. For example, the effectiveness of a propane cannon to deter moulting seaducks (mostly oldsquaw) was tested in the Beaufort Sea (Sharp 1978). The deterrent was mounted on a raft anchored in the center of an experimental plot. The cannon was operated at a volume of approximately 120 dB and at a firing rate of 13/hr. The scaring radius for sitting birds on the first day of operation was 1 000 m. The numbers of birds within 1 000 m of the cannon were less than 10% of the number present during the control period. That scaring radius decreased to 600 m the second day and the density of birds 600-800 m from the cannon was 89% of the control density. By the third day of operation, the number of birds in the general area increased, being even higher than the average numbers during control periods, indicating that the effectiveness of the cannon was substantially waning.

In a second experiment, gas detonators detonated from an anchored raft in the intertidal zone and in a drifting boat in the open water habitat, were tested in coastal areas near Vancouver, British Columbia (Biggs *et al*. 1978). The detonators were usually set for one explosion every 20 to 25 seconds. The interval was decreased to one explosion per minute or five minutes in some trials. Explosions were measured to be about 125 dB at 200 m from the source over water under optimum conditions. The gas detonator from the anchored raft in the intertidal zone, was able to keep all waterfowl away within 200 m radius of the detonator. It was especially effective on mallard, pintail, teal and widgeon (Table 11). The range of efficiency on Great blue heron was equivalent to dabblers. Range of effective scaring was considerably less for shorebirds and gulls (≤ 30 m). In the open water experiment, divers (scaup, canvasback and scoter) were frightened by the explosions up to 150 m away. Once deterred, some birds would patter above water for 100 to 200 m, eventually landing approximately 300 to 400 m away. Grebes showed no responses unless explosions occurred less than 50 m away. Loons responded even less to the explosions (10 m). The most common response of open water birds to the explosions was a swimming response. This response is not as dramatic as flight or diving, but all open water birds tested avoided explosion in this way. The detonators were found to be effective in dispersing waterfowl feeding at night. It is expected that the effective range is at least the same at night as in daylight. The average distances for the 31 species of water birds recorded, varied between 10 and 250 m. Habituation was observed in most of the major groups of water birds tested. Some bird species (shoveler and teal) appeared to become very tolerant to blasts after 4 hours of continuous firing.

Lehoux (1990) tried to deter 400 aquatic birds (80% dabblers; 10% Canada geese and 10% gulls, herons and mergansers) from a 120 ha of spartina tidal marsh in the St. Lawrence estuary, Canada. Two propane cannons, with a firing rate of 1/ 2 minute, were able to rapidly deter by 80% the number of birds in the marsh. The non deterred birds (teals, a few black ducks and a few herons) remained at a short distance from the cannons. Deterred birds, on the other hand, first gathered at the tide line, but slowly returned to the marsh in the following five hours. Once back in the marsh, dispersed birds maintained a distance of roughly 700 m from the two propane cannons during 48 hours. The zone of effectiveness was estimated to vary between 30 and 40 ha.

TABLE 11. EFFECTIVE RANGE WATERBIRDS' RESPONSE TO DETONATORS

Species	Mean Effective Range (m)	Mean Area of Effect (ha)
American coot (*Fulica americana*)	10	0.03
Common loon (*Gavia immer*)	10	0.03
Red-throated loon (*Gavia stellata*)	10	0.03
Glaucous-winged gull (*Larus glaucescens*)	20	0.13
California gull (*Larus californicus*)	20	0.13
Mew gull (*Larus canus*)	20	0.13
Bonaparte's gull (*Larus philadelphia*)	20	0.13
Herring gull (*Larus argentatus*)	20	0.13
American golden plover (*Pluvialis dominica*)	30	0.28
Long-billed dowitcher (*Limnodromus scolopaceus*)	30	0.28
Dunlin (*Calidris alpina*)	30	0.28
Pigeon guillemot (*Cepphus columba*)	50	0.79
Common Murre (*Uria aalge*)	50	0.79
Red-necked grebe (*Podiceps grisegena*)	50	0.79
Horned grebe (*Podiceps auritus*)	50	0.79
Western grebe (*Aechmophorus occidentalis*)	50	0.79
White-winged scoter (*Melanitta delandi*)	75	7.07
Double-crested cormorant (*Phalacrocoras auritus*)	100	3.14
Surf scoter (*Melanitta perspicillata*)	100	1.77
Northern shoveler (*Anas clypeata*)	100	3.14
Canvasback (*Aythya valisineria*)	100	3.14
Greater scaup (*Aythya marila*)	150	7.07
Red-breaster merganser (*Mergus serrator*)	150	7.07
Canada Goose (*Branda canadensis*)	150	7.07
Mallard (*Anas platyrhynchos*)	200	12.56
American wigeon (*Anas americana*)	200	12.56
Pintail (*Anas acuta*)	200	12.56
Great blue heron (*Ardea herodias*)	225	15.90
Green-winged teal (*Anas crecca*)	250	19.63
Blue-winged teal (*Anas discors*)	250	19.63
Western sandpipier (*Calidris mauri*)	250	19.63

Source: Biggs *et al*. (1978)

Another study attempted to evaluate the effectiveness of a scaring raft containing a cannon set to fire at 1 min intervals, a scarecrow (bright orange) and two permanent dim lights (Ward 1978). The raft was effective at excluding birds from portions of the tailings pond, but not the entire body of water. Waterbirds tended to congregate along the shorelines, the most distant part of the pond from the raft. Lesser scaup were the most sensitive to the raft. The scaring radius for this species was approximately 400 m. A density of 2 rafts/km^2 (100 ha) reduced the number of ducks (scaups) by 60%. A density of 4 or more rafts/km^2 reduced the number of scaup by at least 85%. Experimental variation was such that densities of more than 4 rafts/ km^2 did not appear to have any greater effect on scaup than did a density of 4 rafts/km^2. Ducks responded much more readily than coots and grebes.

<u>Advantages</u>

1. can be deployed in onshore and offshore situations (when placed on anchored rafts) specially when the oil is well confined and where birds are particularly susceptible to be impacted;

2. can protect relatively large areas (200 - 1000 m or 30 - 50 ha);

3. can be moved very rapidly;

4. are automatically operated and require only minimum manpower and checking (once a day);

5. they are effective both during day and night;

6. especially effective in deterring dabblers and geese;

7. inexpensive to operate and little maintenance requirements;

8. inexpensive to purchase ($300 U.S.);

9. widely available.

<u>Disadvantages</u>

1. birds rapidly habituate to the sound of the blasts (no more than two or three days and sometimes less than a few hours for some bird species);

2. not effective in deterring most shorebird species as well as gulls, coots, grebes and loons;

3. effective range and sound intensity is significantly reduced when used in fog and wind;

4. could be difficult to install and operate on an anchored raft in open water and in bad weather;

5. could be an element of disturbance in populated areas or to responders.

4.2.6 Pyrotechnics

These devices produce a whistling noise, explosion and flash of light. They can be projected either by shotguns or blank pistols to approximately 45-90 m. Biggs (1978) measured the explosions produced by banger shells. It was estimated to be about 120 dB at 200 m from the source over water under optimum conditions.

Pyrotechnics like shellcrackers, are usually deployed to disperse birds at airports, at landfill sites, in fruit orchards or in cereal crops areas. Only a few experiments have been conducted in an aquatic environment, one of those testing the banger and the whistler cracker shells from a boat allowed to drift towards waterbirds (Biggs 1978). Occasionally the cracker shells were shot from the shore towards sandbars or mudflats frequented by birds. In the experiment conducted in open water, 20 000 birds (scoters, loons, grebes and cormorants) were counted just before the test began. The group surrounded the boat before the blasts, the closest individuals being less than 20 m away. After firing 19 cracker shells (bangers and whistlers), at one minute intervals, a circular area of 600 m in diameter was entirely cleared of birds. The clearing took approximately 20 minutes. All birds began swimming away from the vicinity of the boat as soon as the explosions began. Shellcrackers used on sandbar/mudflat habitat were ineffective in deterring gulls, and were unable to completely clear shorebirds, even at close range. Dabbling ducks such as widgeons, mallards, teals and pintails on the other hand, were also effectively dispersed by explosions from cracker shells during daylight and at night. The range of efficiency on some dabblers (teals and mallards) seems to be at least 200 m. While testing the cracker shells at night, a bright trace of light was observed after firing the whistler shells. Although the visual impact of this trace is not known, one assumes that it may have an additional deterring effect. Biggs (1978) concluded that cracker shells are an effective short term method of deterring and dispersing dabbling ducks, great blue herons and some species of diving ducks from intertidal areas, vegetated shorelines and from large embayments.

Lehoux (1990) tested the value of shellcrackers in deterring 60 seaducks (scoters, goldeneyes and oldsquaws) from a small embayment of 2.5 km in depth. Three shots were required to deter the birds at one km from the shoreline. Three hours later, 34 birds were back in the bay. Two more shots were used to frighten the birds again at one km from the shoreline. One hour later, 60 birds were surveyed in the area. Five shots were sufficient to deter 54 of them outside the bay. Lehoux (1990) then concluded that it was possible to deter seaducks from an area using shellcrackers. The radius of efficiency was estimated to be less than 1 km in ideal conditions. The duration of effectiveness in that special situation was estimated to approximately two hours.

Advantages

1. effective day and night;
2. can be directed close to water birds;
3. especially efficient in deterring open waterbirds;
4. relatively high radius of efficiency (at least 200 m from the source and up to 1 km for some bird species);
5. can be used on land or in offshore situations;
6. can be used as complementary devices with other deterrents (motorboats, ATV, effigies);
7. relatively inexpensive (roughly 50 $ U.S. per hundred).

Disadvantages

1. short duration of efficiency (one or two hours);
2. less efficient in deterring dabbling ducks;
3. ineffective in deterring gulls and shorebirds;
4. could be an element of disturbance in populated areas or to responders;
5. effective range and sound intensity is significantly reduced when used in windy situations;
6. operator continuously required;
7. can pose hazards to operators and bystanders if not used carefully;
8. safety goggles and ear protection are highly recommended;
9. could present a hazard if used in areas containing volatile oil components

4.2.7 Scarecrows (human effigies) and strobe lights

Scarecrows are constructed of a wide variety of materials, shapes and color. Ideally, scarecrows should be as realistic as possible, appear lifelike and have a human shape and facial features. In order to increase their detectability, it is recommended to paint or build the scarecrows with a bright color (orange for instance), to select those which can move or inflate in the wind, to make them highly visible and combine them with a strobe light in order to be able to use them at night.

Boag and Lewin (1980) tested the efficiency of 27 human effigies (orange and yellow clothed commercial manikin) placed around 150 ha tailings ponds. Their presence led to a 95% decrease in the number of ducks, compared to control ponds. Since the control ponds also showed a decline of 20% during the same period, the net effect of the effigies was estimated to be 75%. Ring-necked duck and lesser Scaup contributed the most to this decline. Resident waterfowl showed habituation to the deterrents at all of the ponds and with continual exposure, approached them more closely. The human effigy initially caused ducks landing on the pond to either leave the pond or move into the emergent vegetation. Resident broods would approach within 5 m but nonresident waterfowl were never seen closer than about 20 m from the effigies.

Heinrich and Craven (1990) also tested the efficiency of human effigies for deterring Canada geese from agricultural crops during fall migration in Wisconsin. Human effigies were built with 2.6 m x 0.6 m pieces of plywood dressed in orange rain suits. They were deployed at a rate of 1 per 4 ha. They significantly reduced the number of geese used in both study years. No geese were sighted in fields ≤ 8 ha with no pronounced low spots and defined by a physical boundary such as a road, woven wired fence or wood lot, after the effigies were in place. They were sighted, on the other hand, in all paired control fields. Geese did not use an effigy protected field during more than 15% of observations in either study year, compared to an average of 51% use of the paired control fields. Habituation was not observed within or between years.

Lehoux (unpublished data) demonstrated some effiectiveness in deterring Snow geese using scarecrows from agricultural fields during their spring migration along the St. Lawrence River in Quebec. Scarecrows were made of orange plastic bags hung from net poles. They were deployed at a rate of 1 per 6 to 9 ha in 5 different fields. Numbers of geese during 35 days of observation (all fields combined) before deterring, were estimated to be 37 700 or the equivalent of 1 100 geese/day. Numbers of geese during 40 days of observations (all fields combined) during deterring, were estimated to be 20 500 or the equivalent of 500 geese/day for a decreased use of 55%. Geese did not use a scarecrow protected field during more than 13% of observations as compared to a 43% use of the non protected fields. Those results are somewhat equivalent to those of Heinrich and Craven (1990). The effect of the scarecrows lasted for at least five days.

Ward (1978) tested a bird-scaring raft equipped with a fluorescent orange scarecrow, two burning lights and a gas cannon. Single rafts deterred birds within 100 m. They were unable to deter all birds. Ducks, especially lesser Scaup, were the most sensitive to the raft.

Advantages

1. readily put in place;

2. easily and rapidly moved;

3. can be installed near populated areas or responders;

4. effective range not seriously reduced in bad weather (winds, rain, etc.);

5. relatively inexpensive (≤200$ US).

Disadvantages

1. effective only during daytime except if equipped with lights or combined with audio deterrents;

2. rapid habituation by birds (a few days);

3. small range of efficiency (100 m or 4-8 ha);

4. mainly used to deter birds along the shorelines.

4.2.8 The ATVs

California Dept of Fish and Game (1997) mentioned that all terrain vehicles (ATV) can produce auditory and visual deterrence where their use is appropriate. They are also excellent taxis for shuffling other hazing devices. Lehoux (1990) used ATV combined with bangers to deter 300 dabbling ducks and geese in spartina tidal marshes along the St. Lawrence River, Quebec. The ATV was used to patrol the 120 ha of spartina tidal marsh back and forth four times. One hour and a half of harassment was required to successfully disperse the birds. Ten bangers were shot during the operation.

Advantages

1. allow the protection of larger areas (between 3 and 5 km instead of 1-2 km by foot);

2. allow other deterrents (bangers) to be more efficient.

Disadvantages

1. mainly used to deter birds ashore;

2. mainly used during the day;

3. limited efficiency in some areas (poor access, heavy sedimentation, very rough ground).

5. Recommended approach for protecting birds following oil spill

5.1 Database value

In order to be fully efficient when an oil spill occurs, it is important to get ready well in advance. As underlined by Hay (1977), a knowledge of the distribution, abundance and natural yearly fluctuations of bird species is a prerequisite for accurate assessment work. It surely represents the first step of a well prepared oil spill contingency plan. Although it is important to initiate surveys to obtain the basic required information during staging, wintering and breeding periods, it is clear that accurate and up-to-date surveys of entire populations over large areas could often prove to be difficult and expensive. However, a substantial body of information already exists for many regions. Some of the information is even periodically updated and should then be accounted for in contingency planning. Data from population surveys of aquatic birds can be obtained from wildlife agencies, the biology department of universities and the records of local ornithology groups. Whenever possible, the information gathered should be computerized in such a way that it **ideally** responds to the following needs:

- data on bird <u>locations</u> from any area along a coastline, estuaries and embayments, open sea and bird colonies. The studied territory should be divided into units of 10 to 20 km in length for shorelines, quadrants of 0.25° latitude and 0.5° longitude for the open sea and into individual islands for bird colonies.

- data on bird <u>presence</u> for different seasons to enable the evaluation of periods with the most intense bird activity within each of the predetermined areas. To be as accurate as possible, the data should be computerized in order to provide weekly information for spring and fall migrations as well as for the winter period. Length of time spent on islands for birds nesting in colonies should also be available for the summer period;

- data on bird <u>abundance</u>. The data base should indicate the number of birds counted for each calendar week for the migrations and winter period and the number of breeding pairs for the different colonies. The year of the most recent survey should also be indicated;

- data on bird <u>species</u>. The information should be available at least for the most important bird species or groups of species for the migrations and the winter period such as: brant, snow geese, Canada geese, dabblers, loons, grebes, gulls, cormorants scaups, goldeneyes, scoters, oldsquaw, eiders. This information rapidly allows us to locate areas where the more vulnerable species are present. All major bird species nesting in colonies, especially alcids, should also be adequately identified;

- data on <u>rare or endangered</u> bird species. The information concerning those species should be clearly emphasized in order to be able to undertake protection measures rapidly.

Table 12 gives a general idea of the type of report that can be generated by a database for a section of the St.Lawrence River immediately adjacent to Quebec city.

The first thing to do when an oil spill occurs, is to consult the database in order to obtain information quickly for decision-making. If the data don't indicate any major wildfowl population in the area where the oil spill is reported, the involvement of wildlife biologists could end there or be focused on other elements of the ecosystem like habitats (ways to protect some major marshes, or ways to clean some shorelines, priorities of protection or cleaning). However, if we believe that significant numbers of wildfowl, especially species highly vulnerable to oil spills, are gathered in the area, or if the datebase can't provide accurate information because no surveys have previously been conducted in the area of the spill, we should rapidly send observers in the field to collect data on birds abundance and distribution.

5.2 Preliminary surveys

5.2.1 Aerial surveys

Surveys should be done as rapidly as possible (within three hours) following the spill. Ideally, the aerial survey should be done by helicopter, but fixed wing could also be used. The main objective of aerial surveys is to evaluate the number of birds that could be impacted by the oil spill. Recommended altitude of flight should be under 100 m to allow to accurately identify birds species. Aircraft speed should be about 100 km per hour for helicopter and as low as possible for fixed wing. At no time should this method be relied upon for assessing the number of contaminated birds, but it may help in locating birds in difficulty that are unable to fly. The location and number of birds should be plotted on 1: 50 000 scale charts. Experience is essential for aerial surveillance. As underlined by Hay (1977), the observer should be an ornithologist with enough knowledge to properly identify species and record behavioral characteristics and other pertinent observations. The best procedure is the use of a tape recorder and detailed maps.

Information requested at this early stage is:

- the number of birds present in the area. Are there hundreds, thousands or tens of thousands of birds ? This information is fundamental and could make a huge difference in the deployment of the contingency plan in terms of manpower and required equipment;

- the species involved, especially endangered species or highly vulnerable birds such as seabirds or seaducks. The presence of seabirds and seaducks in abundance within the area of the spill will mean that chances of having oiled birds in the next few days are extremely high and that rehabilitation centers could eventually be opened.

- The location of bird in relation to oil distribution. What are the chances of the drifting oil eventually reaching the large bird concentrations within the next following hours? If those birds are really at risk, it will be important to quickly launch the deterring procedures.

TABLE 12: EXAMPLE OF INFORMATION PRODUCED BY THE CANADIAN WILDLIFE SERVICE EMERGENCY PLAN DATABASE* FOR OIL SPILL IN QUEBEC, CANADA

WEEK	YEAR	METHOD	SPECIES	MAX	MIN	AVERAGE	NB OF SURVEYS
January 3**	Before 1980	Aerial	Others	0	0	0	2
January 3	Before 1980	Aerial	Sub-total	0	0	0	2
January 5	Before 1980	Aerial	Others	4	4	4	1
January 5	Before 1980	Aerial	Mergansers	15	15	15	1
January 5	Before 1980	Aerial	Dabblers	4	4	4	1
January 5	Before 1980	Aerial	Goldeneye	3	3	3	1
January 5	Before 1980	Aerial	Sub-total	46	26	34	4
April 1	Before 1980	Aerial	Canada Goose	28	5	12	4
April 1	Before 1980	Aerial	Dabblers	190	35	112	2
April 1	Before 1980	Aerial	Divers	150	150	150	1
April 1	Before 1980	Aerial	Goldeneye	3	3	3	1
April 1	Before 1980	Aerial	Laridae	3	1	2	2
April 1	Before 1980	Aerial	Snow Goose	35770	30	16669	5
April 1	Before 1980	Aerial	Sub-total	36144	224	16949	15
April 2	1980 and +	Aerial	Dabblers	124	2	49	5
April 2	1980 and +	Aerial	Goldeneye	9	9	9	1
April 2	1980 and +	Aerial	Snow Goose	803	35	419	2
April 2	1980 and +	Aerial	Sub-total	936	46	477	8
April 2	Before 1980	Aerial	Mergansers	2	2	20	1
April 2	Before 1980	Aerial	Canada Goose	20	20	20	1
April 2	Before 1980	Aerial	Dabblers	120	13	68	3
April 2	Before 1980	Aerial	Goldeneye	50	50	50	1
April 2	Before 1980	Aerial	Laridae	3	1	2	2
April 2	Before 1980	Aerial	Snow Goose	8610	6572	8020	4
April 2	Before 1980	Aerial	Sub-total	8805	6658	8162	12
April 3	1980 and +	Aerial	Mergansers	2	2	2	1
April 3	1980 and +	Aerial	Dabblers	369	1	50	23
April 3	1980 and +	Aerial	Scaup	1	1	1	1
April 3	1980 and +	Aerial	Snow Goose	2953	112	1039	5
April 3	1980 and +	Aerial	Sub-total	3325	116	1093	30

* For more information on the database contact the following Internet address : http://www.qc.ec.gc.ca/faune/urgences/urgences.html

** January 3 = third week of January

5.2.2 Ground surveys and use of indicator species

Preliminary ground surveys should also be conducted very rapidly following an oil spill (within six hours). The primary objectives of the ground surveys are to evaluate the number of birds contaminated by the oil spill. More specifically, ground observers should be able to provide the following information:

- the number birds being contaminated or possibly contaminated because of particular behaviour (preening intensively, unable to fly when approached..);

- the exact location of contaminated birds that could possibly captured and sent to the rehabilitation center (birds' location could be pinpointed on 1:50 000 scale charts);

- the number of birds per species in the zone identified as critical to improve the aerial estimates. It is recommended to cover an area slightly larger than the one reported as being contaminated (suggestion: 15 km on each side of the problematic area).

It won't always be easy to answer this last question accurately. Even with a telescope, it is difficult to detect signs of contamination in aquatic birds that continually remain in the water, far from shore especially for dark plumage species. We therefore recommend that a probable contamination rate for birds be established on the basis on indicative species such as seagulls. There are three advantages in using such species: they are present all over the world, can be censused almost annually and are easy to observe because they usually gather on land, mainly when they have been oiled. We must keep in mind that the percentage of contamination determined for gulls is just an indication of the percentage of contamination for the other bird species in the area of the spill. It will probably underestimate the real contamination of species like seaducks, which are true offshore birds, and overestimate the one of more ashore birds species, like geese and dabblers. In Quebec, where this approach is systematically used when an oil spill is reported, the following differences were noted: for eider, a daily possible underestimation of close to 50%, with an average of 10% (3 surveys combined); for geese, a daily possible overestimation of 25% with an average of 3% (6 surveys combined; Lehoux and Bordage 1999).

A systematic count of the total number of seagulls present in the area directly affected as well as in the immediate vicinity (15 km as suggested previously), the percentage of birds contaminated and their degree of contamination will provide us with an indication of the prevailing situation, the risk for birds and type of problem we might be confronted with.

The degree of contamination should be assessed according to the following scale:

Class 0: no visible stains on body
Class 1: one or two stains of less than 5 mm or 10% or less of the whole body showing contamination;
Class 2: 10 to 33% contamination
Class 3: 33-66% contamination
Class 4: 66% or more

It would also be useful in documenting birds under stress that are unable to fly. They may be placed in a special class. Clearly recorded and located on maps, this information will be very valuable if we decide to rescue birds. It will help us determine where to concentrate our efforts.

We could try to apply this system of classification to the other species observed in the area whenever possible. These surveys will systematically be conducted from shore in a truck by a team of two persons linked by walkie-talkie to the operation center, unless the inaccessibility of the area requires that only spot checks be made from the most accessible sites or that boats be used. Binoculars and 10X30 telescopes as well as 1:50 000 scale maps of the area are required. Table 13 contains a sample of the prescribed observation sheet.

5.3 Deterring approach

If the aerial surveys reveal the presence of hundreds of birds close to the oil slick and at risk, or if those birds are represented by endangered species or species highly vulnerable to oil (seaducks and alcids) or if, on the other hand, the ground surveys reveal that many gulls (10% or more) show signs of severe contamination (class 3 and up), thought should be first given to rapidly launching the second phase of the emergency plan which is the dispersion of the birds.

5.3.1 <u>Deterrents for situations offshore</u>

Our current experience indicates that the principal impact on birds occurs in the early stages of an oil spill, while oil is still on the water and before it comes ashore. Information gathered from previous spills even suggest that oil is 15 to 20 times more dangerous for aquatic birds when offshore compared to when it reaches the shoreline. Where seaducks and other waterfowl are highly concentrated, even small quantities of oil on the water can be a major hazard (Campbell *et al* 1978). It is therefore urgent to act fast (within a few hours) in order to initiate preventive deterring. Prompt and continuous action can often reduce mortality substantially as well as the number of birds eventually brought to the cleaning centers. An oil spill in offshore waters would provide one of the most critical situations in the deployment of bird dispersal and deterrent measures. The extent of the spill could be huge since there are no physical barriers to contain the oil. Following the Exxon Valdez spill, for example, the oil slick scattered over 3 000 square miles (Skinner and Reilly 1989). However, the majority of oil spills would not induce such huge patches. Even if it is difficult to get valuable information on the sizes of the slicks produced during maritime accidents, it

TABLE 13: SURVEY OF AQUATIC BIRDS IN AN AREA CONTAMINATED BY AN OIL SPILL

DATE:________________________ OBSERVER(S):________________________

LOCALITY:________________________ ________________________

				CONTAMINATED BIRDS							
					DEGREE OF OILING						
ZONE	**HOUR**	**SPECIES**	**NB TOTAL**	**NB**	**1**	**2**	**3**	**4**	**?**	**DIFF**	***REMARKS***

1 = 10 % OR LESS OF THE WHOLE BODY SHOWING CONTAMINATION 2 = 10 - 33 % CONTAMINATED
3 = 33 - 66 % CONTAMINATED 4 = 66 % AND MORE

DIFF.: BIRDS UNABLE TO FLY, SWIMMING WITH GREAT DIFFICULTY PREENING CONTINUOUSLY
REMARK: LOCATE BIRDS IN DIFFICULTY AS ACCURATLY AS POSSIBLE (PREFERABLY ON A MAP)

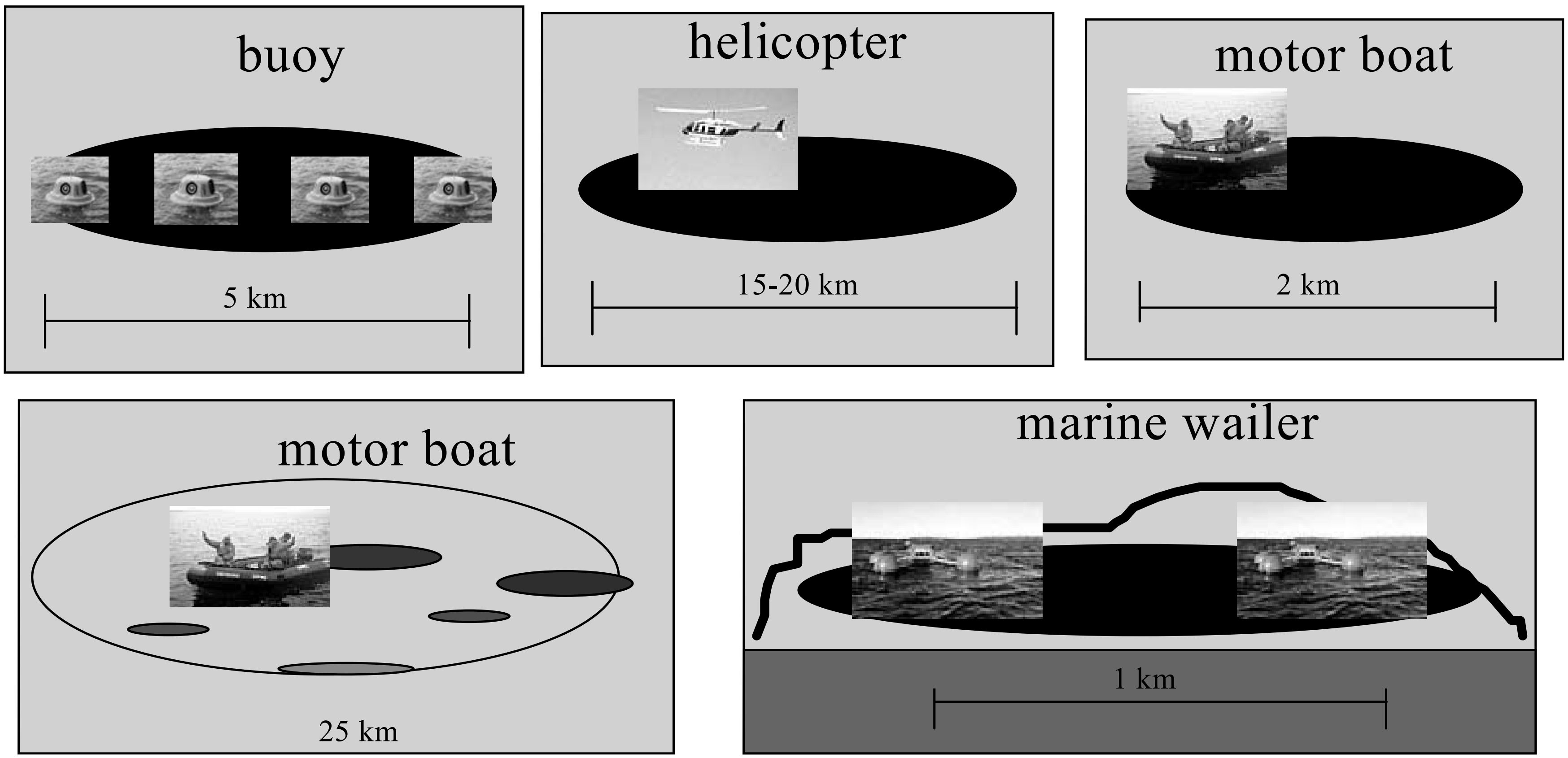
seems that in most cases, slicks would cover only a few tens of km (Aldrich 1938, Ranwell *et al* 1964, Harrison and Buck 1967, Belterman and De Vries 1972, Dixon and Dixon 1976, Bowman 1978, Speich and Thompson 1987, Network news 1998b). However, in the event of an open-water spill, it is highly probable to eventually see the formation of not only one, but numerous slicks and areas of sheen interspersed with oil-free water. The locations of slicks and sheen could then be difficult to determine.

As the majority of the oil found in offshore situations will probably not be contained by booms but rather drift freely, either close or far from the shoreline through the action of currents, winds and tides, the use of deterrents to be anchored or placed on platforms would be of little use. The only feasible techniques would be hazing by buoy, aircraft or boat. They should be deployed as soon as possible following the spill (within 6 hours, wind and weather permitting), while the oil is still concentrated, more easily detected and represents a real threat for highly vulnerable groups of birds like seaducks and seabirds. The buoys should be launched directly into every major and dense oil slick either by helicopter, boat or from the shoreline or a stationary station (a drilling platform, pier, a promontory..). They should be spaced approximately 1.0 to 1.5 km apart or one buoy every 150 ha (Figure 5). Since tests on the drifting Breco buoy, were only conducted for 12 hours (Breco 1995), aircraft should ideally patrol over the slick regularly (every three or four hours) from daylight till sunset and soon after sunrise in order to closely monitor the position of the buoys and to ensure that they remained in contact with the spill. By doing so, aircraft will also play the role of a supplementary deterrent device and reinforce the effectiveness of the buoys. Normally, habituation should not be expected when the buoy is used in a drifting mode. The buoy will, in fact, regularly encounter new groups of birds within a few hours as it moves more or less rapidly according to tides, currents and winds. The buoys have a limited operating time (around 72 hours) and, after three days, operators must locate the buoys, remove them from the water to replace the batteries.

If no buoys are available, hazing should be done by aircraft (especially helicopters) or boat. However, as previously mentioned, the effectiveness of the aircraft and boat will depend, on the species being dispersed (geese *vs* other species), time of year (moulting or non moulting birds), weather conditions, time of day (day or night). It is highly recommended, when deterring with an aircraft, to stay continuously over the oil slick, more often in front of it, in order to deter birds well in advance and prevent them from swimming or flying into the oil. A biologist should be aboard to help in locating the birds, making the appropriate identification, observing the reactions of the birds, planning the most effective dispersal strategy and maintaining a watch for collision hazards.

Flight altitude should be between 100 and 200 m in order to locate birds easily and be effective in deterring. If flightless birds are encountered, it is then suggested to lower the altitude of flight under 100 m and to hover behind the birds at a distance of 70-100 m. Frequency and duration of flights should be as often and as long as possible during daylight (e.g. one hour of flight at every two hours), at least during the first two or three days when slicks are still normally easily spotted and not too dispersed and as long as birds are abundant in the area.

Figure 5. Recommended deterring strategies for offshore situations



One aircraft should be assigned to every large scale slick (15-20 km). If the slicks are larger, numerous and well distanced from one another, more aircraft could be required. It could be difficult or impossible to control the directions of movements of the displaced birds. Special attention should be paid to bird species like goldeneye and merganser which have a tendency, when flushed or deterred, to fly back under the aircraft or circle back away and land on the water close to their original location.

Motorboats could also be used to deter offshore birds. An inflatable boat (a Zodiak type) is recommended since it is more stable and safer on the water surface than other motorboats. It should be at least 5 m long and equipped with a 40 HP. Larger boats could be required in offshore areas or rough seas for safety reasons. Koski *et al* (1993) also recommend that each boat that is deployed requires two or more people and appropriate safety equipment (e.g. life jackets, signal flares, bailer lights, emergency survival rations, radio..) in addition to binoculars and deterrent equipment (bangers) One boat should be deployed for each one or two km of oil slick. They should preferably be placed at the front of the slick for smaller oil slicks ($\leq$1 km), in order to deter birds in advance and at every one or two km afterwards for larger ones. They should then be left drifting along with the oil, motor stopped, to prevent the dispersion of hydrocarbons and reduce possibilities of offshore recovery by skimmers or booms wherever scheduled.

Since the detection of birds on the water could be difficult from a motorboat, even during calm seas, it is recommended to use bangers regularly, even if birds are not in sight. When in sight, direct the shots towards the birds you aim to disperse, the sound being most effective in a 30 degree arc from the muzzle. Depending on the importance of currents and winds, the slick will move more or less rapidly. It is however fair to assess that it could move as rapidly as 5 km/hour. At a speed of 5 km/hour, birds resting on the water and standing at 500 m (the estimated average range efficiency of the bangers) from the drifting slick, could get oiled within 5 minutes assuming they stand still, in the same spot and don’t drift with tides and currents. To avoid any birds contamination, it is recommended to launch one banger every 5 minutes or so, even if birds are not in sight. If birds are in sight, launch 3-4 bangers in succession. The first round will usually cause them to take flight and repeated shots will keep them going. Since it could be difficult to rapidly load the one shot pistol, especially if the temperature is very cold, we suggest to equip each person with a six-shot pistol. The boats’ occupants should keep in regular radio contact with aerial observers who will assure that boats are always located at the best places inside the drifting slick.

Sometimes, oil can still be a threat to birds, even if well dispersed and scattered over huge areas in slight sheen. On such occasions, drifting boats will no longer be very efficient. It is therefore recommended to deter birds by approaching them with boats rather quickly. That way, one boat could cover an area of approximately 25 km^2.

Such deterring techniques for offshore situations should be used as long as dense drifting oil slicks are present in areas where birds have been censused or as long as it might threaten aquatic birds as mentioned previously. As suggested by Ward (1977), birds appear to be most susceptible to contacting oil during the hours of darkness when it is also the time when there is the least amount of activity associated with cleanup operations. Therefore, offshore deterrents must be also functional during the dark as well as during daylight hours.

5.3.2 Deterrents for confined oil in aquatic situations

As soon as the floating oil has come closer to the shoreline and has been well confined, sometimes with the help of booms, in bays or lagoons known to be important feeding, moulting or staging grounds for aquatic birds, buoys, helicopters or motorboats can be removed and another deterring approach can be applied. The Marine Phoenix Wailer and/or the propane cannon and the human effigy placed on anchored boats or anchored floating rafts are among the recommended deterrents in these situations.

One Marine Phoenix Wailer should normally protect 75 ha of confined oil, while one propane cannon should keep 40 ha of aquatic habitats relatively free of birds. In order to decrease chances of habituation, devices could be put into operation within the oiled area. Those devices should function 24 hours a day as long as the oil is still present on the water surface. Once in a while (two or three times a day), a helicopter could slowly fly over the confined oiled area in order to reinforce the deterring effect of the Wailers and propane cannons. If the confined oil is not too far from the shoreline (< 1 km), it could also be possible to supplement those techniques by bangers launched from the shoreline once every hour. In very populated areas, where loud sounds could rapidly annoy people or even the responders, human effigies combined with strobe lights, should have the preference at least during the night. This last approach could be somewhat limited in areas where confined oil covers large surface areas (> 100 ha). Human effigies should be deployed at a density of 1/5 ha.

5.3.3 Deterrents for situations ashore

It is important to keep in mind that the drifting oil slick should always be tracked by buoys, helicopters and motorboats as long as it hasn't reached the shoreline or been well confined by booms. An oil slick, drifting towards the shoreline and not followed by hazing devices, could represent a serious threat to birds we want to disperse from a non contaminated marsh or lowlands located nearby. Very often the escape reaction of the disturbed birds is to flush from terrestrial locations and land in the water. By doing so, they could easily get oiled by the arriving slick. If we really want to deter birds from a marsh or lowland before the arrival of an oil slick in which no deterrents devices preventing birds to get oiled have been set up, it is recommended to do so well in advance (two hours or more). Therefore we will leave plenty of time for the successful dispersion of birds, not only from the marsh but also from the surrounding waters. On the other hand, if we want to deter birds from an already contaminated marsh, we must make sure that no oil is present on the surrounding waters before flushing the birds.

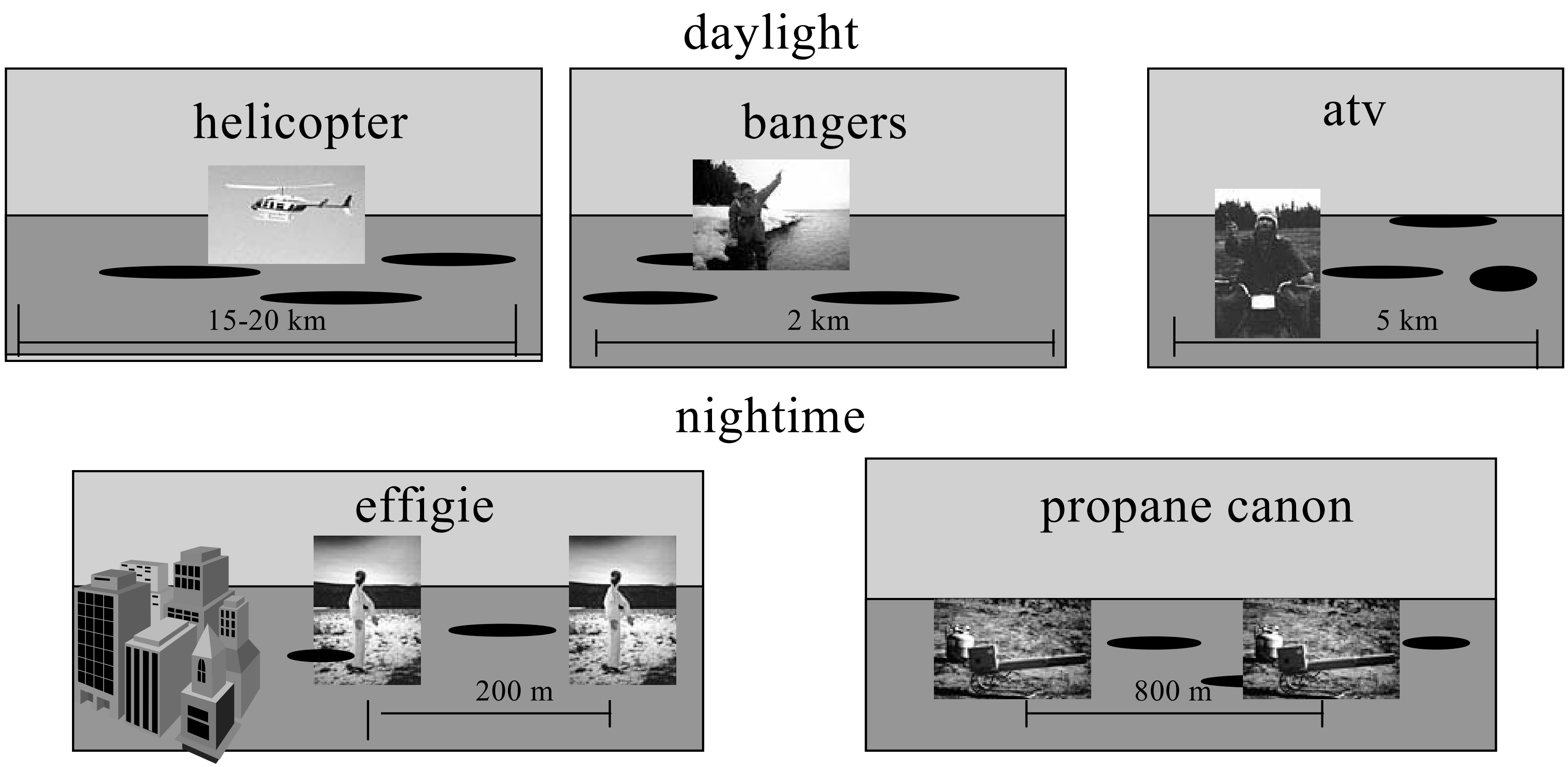
It could be difficult with the existing devices to deter and disperse birds from an oil spill which could affect a large area of lowland or tidal marsh (hundreds of kilometers of shorelines) heavily used by waterfowl or shorebirds. However, if those birds are excluded from their normal staging or breeding areas, it is possible that no equally suitable alternate feeding and resting places may be available. If they are continuously deterred and if they cannot build up the energy reserves that they normally accumulate during migration or the breeding season, birds could face up to many severe impacts: birds could die, be severely stressed, have lower reproductive capabilities, have lower clutch sizes, have their pair and family bonds disrupted and then be more vulnerable to hunting pressure or have difficulties in completing their migration, (Bentgson and Ufstrand 1971, Bentgson 1971, Krapu 1977, Raveling 1979, Wypkema and Ankney 1979, Thomas 1983, Bartelt 1987, Bélanger and Bédard 1995). That is why it is important to make sure that birds have access to alternative feeding sites. Otherwise, it is better not to disturb them. Besides, geese, dabblers and shorebirds aren't known to be especially impacted by oil. As previously noted, marsh birds are more likely to get dirty by walking over oil rather than being completely soaked with oil.

Deterring could be appropriate if 1. a large volume of oil is likely to land among a particularly large concentration (thousands) of feeding, moulting, roosting or breeding birds, 2. alternative sites are available within a few tens of kilometers and 3. the threatened area is not too wide (less than 50 km). Hazing by aircraft would provide a practical method of rapidly dispersing birds especially if huge areas are involved and if geese are particularly abundant. One aircraft should be assigned to every 15 or 20 km of contaminated shoreline (Figure 6). Helicopters are preferred to fixed-wing aircraft because they are more manoeuvrable. The aircraft needs to remain close to the ground (50-150 m) and behind the birds (70-100 m). Since dispersed birds will have a tendency to return, birds will have to be continuously harassed as long as they are still present in the area. However, it is most likely impossible to operate an aircraft all day long over a period of several days or weeks. Hence, additional deterrent measures will be needed.

Shellcrackers should be used to increase the helicopters' efficiency during the day and propane cannons and effigies could replace them during the night. One person equipped with shellcrackers should be able to effectively protect one or two km of shoreline. Wherever the topography allows the utilization of an ATV, one operator should then be assigned an area of four or five km long. As previously mentioned, bangers should be regularly launched to prevent birds from landing or to disperse birds already loafing or feeding on the ground. It is recommended to shoot three or four bangers in a row when dispersing birds at sight.

Many duck species are active at night for foraging purposes (McNeil et *al* 1992). That behaviour may oblige some night flight movements. Furthermore, waterbirds are also likely to change places during night hours, especially in bad weather when they are looking for some more quiet and well protected bays. Therefore, some of the areas deterred during daylight could then be reinvaded by birds after sunset and required additional hazing. It is recommended to keep hazing devices which require no operators, like propane cannons and effigies, for night time operations. Propane cannons should be placed in areas where loud sounds won't disturb the population. A radius of effectiveness of roughly 400 m (30-50 ha) should be used in the determination of the number of propane cannons required. To increase their effective range,

Figure 6. Recommended deterring strategies for ashore situations



cannons should be elevated above the surrounding vegetation or landscape to prevent the muffling of the explosion and directed downwind. The detonator should be set to fire at intervals of 1 or 2 minutes. One cannon can operate during at least two weeks without refueling. The noise can be intensified by directing the firing through a hole at the end of a small steel drum from which the opposite end has been removed. In very windy situations, it is suggested to cover the combustion chamber and igniting mechanism of the cannon with a plastic bag to prevent gas dispersion.

Wherever loud sounds could be detrimental to citizens, effigies combined with strobe lights should be used . The « shock value » of a strobelight that intersperses with darkness, is considered desirable as birds can more easily habituate to regular predictable stimuli. Searchlights are also partially effective in dispersing feeding and flying waterfowl at night; however, some species of birds are more likely to be attracted by such lights especially during conditions of rain, fog or heavy cloud (Ward 1977). Neurophysiological tests of strobes using three species of birds, suggest that the optimal color may be red and that the optimal flashing rate may be 6 to 12/sec. A density of one effigy/4-8 ha of contaminated marshland is recommended. People dressed in orange rain-coats and equipped with strobe lights and spot-lights could also be used as effigies. A single person could then cover between one and two kilometers of shoreline. It is highly recommended that a supervisor be available round the clock to regularly check the equipment in place, make sure it is functioning properly and not stolen.

5.3.4 Deterrents for colonial birds

The occurrence of an oil spill close to a seabird colony would certainly represent a most difficult situation in the deployment of deterrent measures. As underlined by Koski *et al* (1993), it is very questionable for instance, whether the dispersal of adult murres from their colony would be feasible. The success of dispersal efforts would probably depend on the stage of the nesting cycle. Adults will be difficult or impossible to disperse if they have eggs or young on the cliffs. The reaction of adults to dispersal attempts would probably be to land in the water near the colony. This could increase rather than decrease adult mortality. As also concluded by Koski *et al* (1993), any significant spill affecting the waters near a seabird colony, will kill a significant proportion of the birds present. No known combination of bird dispersal and deterrent systems can prevent this mortality.

Chemical treatment of oil has been suggested as a way to reduce the impact of oil spills, especially for colonial birds. Application of chemical dispersants onto a slick reduces the surface tension of the oil-water interface and distributes the oil into a larger volume of the water column. Birds at sea will thereby encounter smaller amounts of petroleum hydrocarbons and the effects are thought to be diminished, ultimately causing a decrease in seabird mortality (Peakall *et* al 1987). Because most bird oilings occur on the surface not in the water column, dispersants should be effective in reducing the birds exposure to oil. On the other hand, trials off Norway by Litchenthaler and Daling (1985) showed that although the major action of dispersants is to disperse oil into the water column, they also increase the surface area of the slick within hours, often breaking it up within a day. The net result could be the increasing risk of more birds being exposed, although to less oil per individual, during the period before the slick breakup. Even then, the small patches of oil still continue to pose a significant risk until they coalesce and form tar balls. However, very few reports seem to have addressed the effects of chemically treated oil on the thermal balance of birds, and the results from one study actually indicate that oil treated with dispersants may be more harmful to birds than the oil itself. **We therefore stress the urgent need for more information about the effects of chemically treated oil on aquatic birds.**

Another promising technique which could eventually be used around colonies is the sensory aversion technique. Sensory aversion approach deals with taste sensory receptors of an animal. If effective, it could then eliminate problems associated with sounds close to active colonies. According to Thomas (1994), methyl andhranilate (grape flavoring) chemical is an aversive to birds and has been used effectively to deter them from landfills and public parks where they pose a health threat to humans. The application for use in oil spills especially where bird colonies are at risk would be to create a buffer zone around the slick to preclude birds from swimming into it. This application would only have an effect on birds which swim on the surface and less on diving birds. However, it is the former situation that normally prevails around islands where birds nest in dense colonies.

Table 14 summarizes the different steps to be followed when an oil spill is reported.

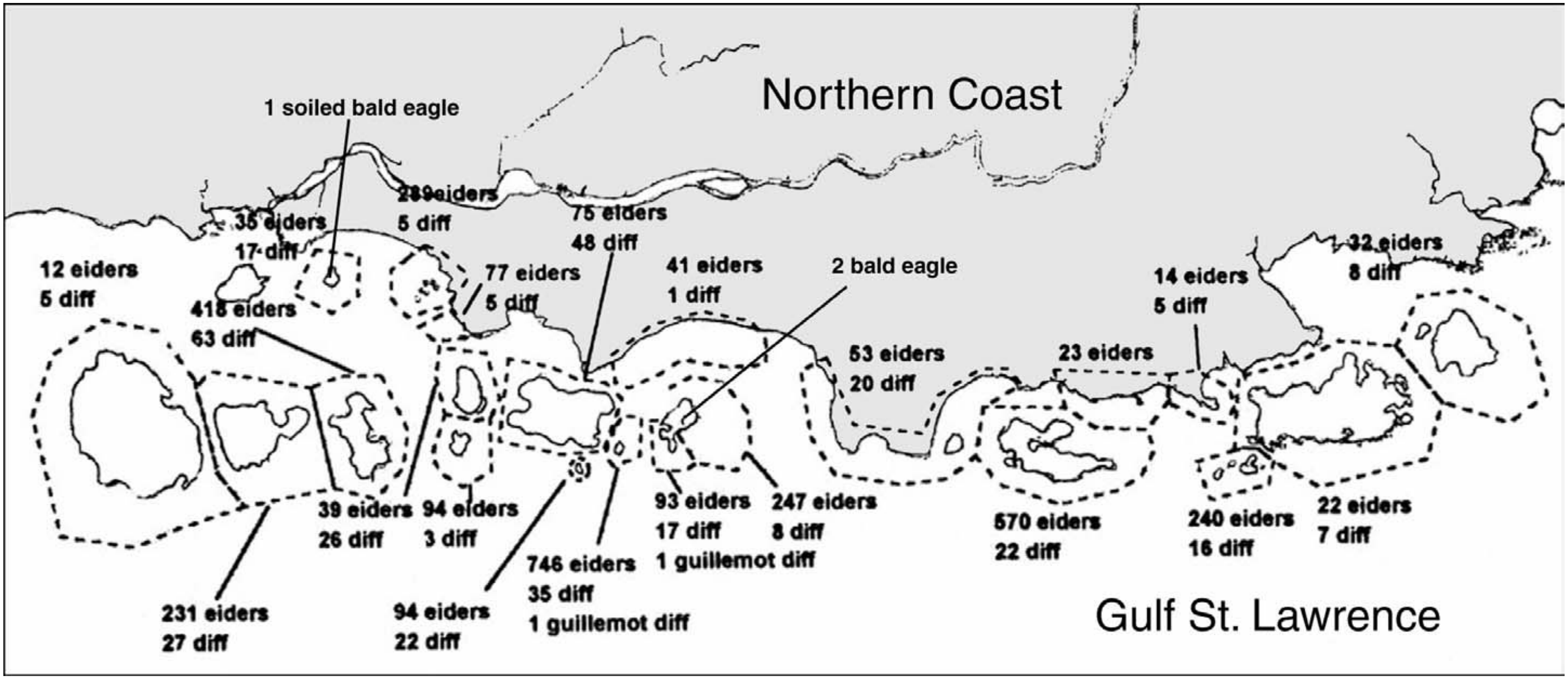
5.4 Daily surveys

Throughout the period of oil recovery operations, it is important, to obtain the daily most accurate picture possible, of the prevailing situation as far as birds are concerned. This will be done by surveys conducted from the air, on land and by boat if necessary. We must remember, however, that each type of survey provides particular information which, though often incomplete in itself, can help in complementing data obtained by other means.

5.4.1 Aerial surveys

The whole contaminated area should be surveyed every day, either by air or ground. Ideally, the aerial survey should be conducted by helicopter. It should be carried out as early as possible during the day, so that it may be used to guide ground teams of surveyors to sites accessible by land where birds are concentrated. Daily aerial observations will make it possible to obtain the same information as during the preliminary aerial surveys such as: an estimate of the number of birds still present in the spill area, species that may pose problems (offshore seaducks and seabirds, endangered species) and the distribution of the oil slick and buoys (if already deployed) in relation to the distribution of the birds. It can also provide valuable information on the location of some birds that are in trouble, unable to fly, that could eventually be captured, on the efficiency of existing deterring operations and the relevance of keeping them in place or implementing new ones. The rules to be followed during those daily aerial surveys are essentially the same as during preliminary surveys. Figure 7 gives an example of a daily aerial report produced following an oil spill in the gulf of St. Lawrence in March 1999.

Erreur! Signet non défini.**Figure 7. Exemple of a daily report produced following the Gordon C. Leitch incident in the Gulf St.Lawrence (Québec, Canada) in the spring of 1999.**



Date of survey: 2th of April
Total birds censused: 3345
Total birds in difficulty: 360
Species in difficulty: 358 Eiders, 2 Guillemots

TABLE 14: SUMMARY OF THE DIFFERENT STEPS TO FOLLOW IN OIL SPILLS SITUATIONS IN ORDER TO DETER AQUATIC BIRDS

STEP 1	Consult existing databases. If major wildfowl populations could be present or if no data are available = STEP 2.
STEP 2	Preliminary ground and aerial surveys. If birds are effectively abundant (hundred), specially seaducks and alcids, if indicator species (gulls) are contaminated (>10%) = STEP 3.
STEP 3	Launching of the Breco buoys (1,0 - 1,5 km or 1/150 ha) as rapidly as possible (within 6 hours) or deterring with helicopters (1/15 km of oil slick) and/or drifting motor boats (1/ km of oil slick) and / or moving motor boats (1 / 25 km^2 of aquatic habitat) and maintain deterring operations as long as slicks are highly visible, not too dispersed and have not reached the coastline. When oil reaches the shoreline = STEP 4.
STEP 4	Deter preferably with pyrotechnics (one person/km or one ATV/5 km) and deploy propane cannons (1/400 m or 1/40 ha) or effigies (1/5 Ha) or persons (1/2 km) with orange coats and lights. If some oil is confined with booms in open water areas, use Marine Phoenix Wailers (1/75 ha) or propane cannons (1/40 ha) on rafts or effigies (1/5 ha) on rafts.

5.4.2 Ground and boat surveys

The primary objectives of daily ground surveys are to evaluate the percentage of contaminated birds and to spot birds that are in trouble (Table15). Daily counts help monitor changes in the situation. Here again, directives to be followed during those daily ground surveys are essentially the same as during preliminary surveys.

At the end of each day, the information provided by different surveys allows the production of reports giving a detailed evaluation of the prevailing situation, the impacts of the oil spill on birds and actions to be taken during the hours following the spill. Table 16 gives an example of the kind of report that was produced during the Gordon C. Leitch spill in 1999.

6. Recommended material to adequately deter aquatic birds following an oil spill

Table 17 summarizes the quantity and type of suggested equipment to be kept readily to face a situation where an oil slick could cover an area of 15 to 20 km in length and where no more than 50 km of shoreline could eventually be contaminated. That material should also be sufficient to cope with the majority of all small and medium sized oil spills. Hazing could probably be possible but difficult for larger areas. It remains difficult to anticipate the manpower and the material needed to respond to a very large, very widespread spill, since so many factors could intervene.

Before attempting any deterring along the shorelines, the response personnel must make sure that adjacent and nearby safe and clean habitats are available to attract deterred aquatic birds. They must also make sure that the entire contaminated area can be hazed as continuously as possible. Otherwise deterred birds risk being driven into some adjacent oiled areas.

Table 15: Example of report produced from a boat survey conducted in early April following the Gordon C. Leitch incident in the gulf St.Lawrence (Québec, Canada) in 1999.

Islands	Bald Eagle Total/Soiled	Black Guillemot Total/Soiled	Eider duck Total/Soiled	King Eider Total/Soiled	Brant Total/Soiled	Oldsquaw Total/Soiled	Black Duck Total/Soiled	Winged Teal Total/Soiled	Black Legged-Kittiwake Total/Soiled	Terns spp. Total/Soiled	Merganser spp. Total/Soiled	Iceland Gull Total/Soiled	Glaucous Gull Total/Soiled	Herring Gull Total/Soiled	Ring-billed Gull Total/Soiled	Black-Backed Gull Total/Soiled	Species Total/Soiled
Rocher de la garde	0 / 0	0 / 0	600 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	600 / 0
Petite Ste-Geneviève	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	2 / 0	0 / 0	0 / 0	0 / 0	0 / 0	33 / 0	0 / 0	2 / 0	37 / 0
Grande Ste-Geneviève	1 / 0	3 / 0	6 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	14 / 0	0 / 0	8 / 0	32 / 0
Ile à la Chasse	0 / 0	0 / 0	51 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	1 / 0	17 / 0	0 / 0	13 / 0	82 / 0
Refuge Calculot des Betchouanes et Innu	0 / 0	0 / 0	263 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	3 / 0	0 / 0	1 / 0	267 / 0
Fausse Passe	0 / 0	0 / 0	77 / 5	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	1 / 1	48 / 0	0 / 0	15 / 0	141 / 6
Fausse Passe à Anse de Grande-Pointe	0 / 0	2 / 0	84 / 14	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	3 / 0	89 / 14
Nord-Est de Marteau	0 / 0	0 / 0	150 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	150 / 0
Sud de Caye à Foin	0 / 0	0 / 0	300 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	300 / 0
Grosse Marteau	0 / 0	3 / 0	5 / 1	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	8 / 1
Petit Marteau	0 / 0	1 / 0	157 / 4	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	2 / 0	0 / 0	0 / 0	0 / 0	35 / 0	0 / 0	8 / 0	203 / 4
aux Goélands	0 / 0	0 / 0	65 / 43	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	60 / 2	0 / 0	21 / 0	146 / 45
à Calculot	0 / 0	0 / 0	87 / 11	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	51 / 1	0 / 0	12 / 0	150 / 12
du Havre	0 / 0	0 / 0	234 / 42	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	5 / 0	0 / 0	3 / 1	248 / 43
Fantôme	0 / 0	0 / 0	59 / 26	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	104 / 0	0 / 0	0 / 0	0 / 0	0 / 0	4 / 0	0 / 0	1 / 0	169 / 27
Caye Sud Fantôme	0 / 0	0 / 0	88 / 86	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	14 / 0	0 / 0	5 / 0	107 / 86
Firmin	0 / 0	0 / 0	85 / 6	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	80 / 4	0 / 0	0 / 0	0 / 0	0 / 0	95 / 1	0 / 0	12 / 1	272 / 12
Pointe aux Morts	0 / 0	0 / 0	5 / 4	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	5 / 4
Gazon	0 / 0	0 / 0	11 / 11	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	1 / 1	0 / 0	0 / 0	12 / 12
Caye à Meck	0 / 0	0 / 0	160 / 35	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	18 / 2	Few/Qlq	3 / 0	189 / 38
Ouest Caye à Meck	0 / 0	0 / 0	55 / 2	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	4 / 0	0 / 0	6 / 0	66 / 2
Petite Romaine	0 / 0	1 / 0	16 / 3	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	17 / 3
Grosse Romaine	0 / 0	0 / 0	12 / 3	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	8 / 0	20 / 3
Niapiscau	0 / 0	4 / 0	515 / 33	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	2 / 0	0 / 0	0 / 0	42 / 0	0 / 0	8 / 0	571 / 33
Quarry	0 / 0	2 / 0	179 / 29	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	48 / 0	0 / 0	21 / 0	250 / 29
Grande Île	0 / 0	4 / 0	57 / 49	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	104 / 0	0 / 0	2 / 0	167 / 49
Bouleau du Large	0 / 0	0 / 0	15 / 11	0 / 0	0 / 0	0 / 0	2 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	11 / 0	0 / 0	3 / 0	33 / 11
Bouleau de Terre	0 / 0	1 / 0	19 / 8	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	143 / 0	0 / 0	12 / 0	175 / 8
Ile Nue	0 / 0	0 / 0	118 / 11	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	53 / 0	0 / 0	0 / 0	1 / 0	0 / 0	128 / 1	0 / 0	42 / 0	342 / 12
Wreck	0 / 0	0 / 0	8 / 1	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	4 / 0	0 / 0	12 / 0	24 / 1
de la Maison	0 / 0	7 / 0	2 / 1	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	2 / 0	0 / 0	9 / 1	20 / 2
Caye Noire	0 / 0	0 / 0	79 / 4	0 / 0	100 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	1 / 1	2 / 0	0 / 0	2 / 0	184 / 5
aux Perroquets	0 / 0	0 / 0	2 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	1 / 0	0 / 0	0 / 0	0 / 0	0 / 0	65 / 0	0 / 0	3 / 0	71 / 0
Birds Soiled	**1 / 0**	**34 / 0**	**3564 / 443**	**0 / 0**	**100 / 0**	**0 / 0**	**2 / 0**	**0 / 0**	**240 / 4**	**2 / 0**	**2 / 0**	**1 / 0**	**12 / 3**	**951 / 8**	**0 / 0**	**236 / 4**	**5145 / 462**
Birds Soiled Ratio	**0%**	**0%**	**12.4%**	**0%**	**0%**	**0%**	**0%**	**0%**	**1.6%**	**0%**	**0%**	**0%**	**25%**	**1%**	**0%**	**1.6%**	**9.0%**

TABLE 16. EXAMPLE OF A DAILY REPORT PRODUCED FOLLOWING THE GORDON C. LEITCH SPILL IN THE GULF ST. LAWRENCE (QUEBEC, CANADA) IN 1999

Day 11:

Aerial survey:

- birds at risk in the area of the spill: 3 345
- surveyed species at risk: 3
- relative importance of species at risk: Common Eider (99%), Black Guillemot (<1%), Bald Eagle (<1%)
- threatened species: Bald Eagle
- species in difficulty (unable to fly): 357 eiders and 2 guillemots
- efficiency of existing deterrents: over 30% decrease in bird numbers in the most contaminated area compared to previous days
- location of birds: see Figure 7

Boat survey:

- birds (all species) in the area of the spill: 5 145 including 3 564 Common Eiders, 34 Black Guillemots and 1 Bald Eagle
- larids censused as indicator species of contamination: 1 442
- gulls found soiled: 19 (1.3%)
- other species found soiled: 443 Common Eiders
- location of birds: see Table 15

Conclusions:

- 359 birds, especially Eider duck, are still in difficulty (unable to fly)
- close to 100 more soiled birds could become in difficulty
- one individual of a threatened species has been found soiled. Important to try and do a follow up of the individual if possible
- capture operations will have to continue with the same number of capture teams (5). Areas in which to concentrate our capture efforts are located on the map
- the rehabilitation center will still receive many oiled birds during the following days and will probably stay open for at least a couple of weeks
- deterring seems to be efficient. We should keep the same deterring approach.

TABLE 17. RECOMMENDED DETERRENTS TO BE USED IN OIL SPILLS SITUATIONS WHERE OIL SLICKS COVER LESS THAN 20 KM IN LENGTH AND WHERE 50 KM OF SHORELINES ARE CONTAMINATED

DETERRENT	MINIMUM	IDEAL	PRICE / ITEM (U.S.)
Breco Buoy	10	12	$ 6 000
Marine Phoenix Wailer	2	5	$ 3 000
Propane cannon	20	30	$ 300
Bangers	5 000	10 000	$35 / 100
Blanks	6 000	12 000	$ 6 / 100
Pistol launcher (6 shots)	25	50	$ 60
Zodiac (6 m with 40 hp)	3	5	$ 10 000
Effigie	50	100	$ 50
ATV	3	5	$ 5 000

Recommended material includes a variety of devices that can cope with offshore and ashore situations. Since all the recommended equipment can become quite expensive (over $150 000 U.S.), you have to determine if your area is really at risk. History of spills for your region (frequency, quantity, location) as well as information concerning aquatic birds (abundance, presence of highly vulnerable or rare and endangered species) could be of help. Even if some of the material has to be rapidly deployed (sometimes within a few hours), it could be possible and advantageous to gather all the required equipment in one place and ship whatever is needed to areas involved with oil spills. Make sure however that those areas are located within a distance of a few hundred kilometers and that easy transportation (by trucks, by planes) is available in order to intervene rapidly. Some of the equipment could even be purchased at the last minute provided distributors can guarantee a quick supply of the requested item. Keep in mind that the rapidity of intervention is the key to success, especially in offshore situations.

7. Conclusion

Prevention should be the first and the principal defense against oil spills. The old adage that one pound of prevention is worth a pound of cure remains extremely valid. Even if a deterring program can be relatively expensive to set up, those expenses may be considered minimal, as suggested by Whissom and Takehawa (2000), compared to the costs incurred in cleaning oiled birds, which in California have been estimated at $ 500 per bird (Jessup 1997). Thus a deterring strategy approach which would prevent the oiling of only dozens of birds would then be very cost-effective.

Although it is difficult to estimate the number of birds which would really be saved with a good deterring strategy, we believe that those numbers could be substantially important provided deterrents are rapidly put in place. Available information previously discussed suggests a potential decrease of soiled and cleaned birds varying between 15% and 75 %.

Preparedness not only includes the purchase of adequate equipment but also a good training program. Appropriate personnel training, including field exercises that fully test the response system, both in the techniques and limitations of each deterrent is also critical to the success of each contingency plan. No matter how prepared we are, we must realize that there is no fail safe deterring response system. New technology and a good human organization will probably reduce bird mortality substantially, provided contingency plans continue to be improved.

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