Evaluation of a Floating Bird Diverter

W. PAUL GORENZEL, *Department of Wildlife, Fish and Conservation Biology, University of California, Davis, CA, USA*
TERRELL P. SALMON, *Department of Wildlife, Fish and Conservation Biology, University of California, Davis, CA, USA*
CRAIG HAFFNER, *Office of Spill Prevention and Response, Fairfield, CA, USA*

ABSTRACT Hazing at oil spills can reduce bird mortalities. This study evaluated the effectiveness of the FireFly Pond Diverter™ (FireFly Diverters LLC, Grantsville, UT), a device that floats on the water and is claimed to use motion, reflectivity, and ultraviolet (UV) and visible light emissions to alert and repel birds. The diverter could be useful at a spill, but little is known about how waterbirds would respond. The objectives of this study were to determine if waterbirds were repelled to a greater degree by the diverter compared to a simple novel object (a life ring), to identify the species that responded to the diverter, and determine if birds habituate to the diverter. The study was conducted in December 2007 in a stormwater retention basin in Woodland, California. We divided the study into a 3-day pretreatment period and a 6-day treatment period and counted birds in the morning and afternoon each day. On each day during the treatment period we randomly selected 2 areas of the basin and anchored 2 diverters in one area and 2 life rings in a second area. We moved the diverters and the life rings to new locations daily. During the bird counts we recorded all birds within 15.2 m of each diverter or life ring. For the basin as a whole, we found the temporal pattern of use (fewer birds present in the morning than the afternoon) and number of birds using the basin did not change with the deployment of the diverters and life rings. Species composition was similar during the pretreatment and treatment periods. Gulls, geese, and diving ducks accounted for over 90% of the birds, with gulls most numerous. We observed 7 and 9 species of birds within 15.2 m of the diverters and life rings, respectively. Gulls represented 91% and 81% of the birds near the diverters and the life rings, respectively. There was no difference in the number of birds within 15.2 m of the diverters or the life rings. There also was no difference in the number of birds within 15.2 m of the diverters or >15.2 m from the diverters. We found the same relationship for the life rings. After field work concluded we were informed that rotation of the flappers on the diverters and an ultraviolet index (UVI) >2 were critical for the diverter to function. During the treatment period there was wind sufficient to spin the flappers during 7 of 12 counts. We observed birds within 15.2 m of the diverters on 6 out of 7 counts with wind. As reported in local newspapers, the UVI was never >2 during the treatment period. If UV radiation has any effect on performance, then December, a month with low UVI values in northern California, was not the optimum time to test. The diverters did not repel birds during this study. It is not known if the diverters will repel birds during conditions of higher UVI. Additional research should be undertaken.

KEY WORDS diverter, diving ducks, geese, gulls, hazing, oil spill, ultraviolet light, waterbirds

Hazing birds at oil spills has the potential to significantly reduce bird mortalities. Under the auspices of the California Department of Fish and Game, Office of Spill Prevention and Response (DFG-OSPR), bird hazing has been incorporated as part of spill response in California with the creation of the UC Davis Wildlife Hazing Group. Many of the standard bird hazing techniques (e.g., pyrotechnics, visual and auditory deterrents) used to reduce damage to crops and structures can be applied at a spill. However, unique conditions at a spill (e.g., flammable spill material) may prevent or limit the use of some hazing techniques such as pyrotechnics, necessitating the use of alternative or new techniques.

The purpose of this study was to evaluate a new product, the FireFly Pond Diverter™ (Fig. 1). The diverter consists of a plastic life ring with 2 L-shaped arms that can turn in the wind. Attached to each arm via a swivel is a 89 x 152 mm piece of acrylic plastic called the flapper. Attached to

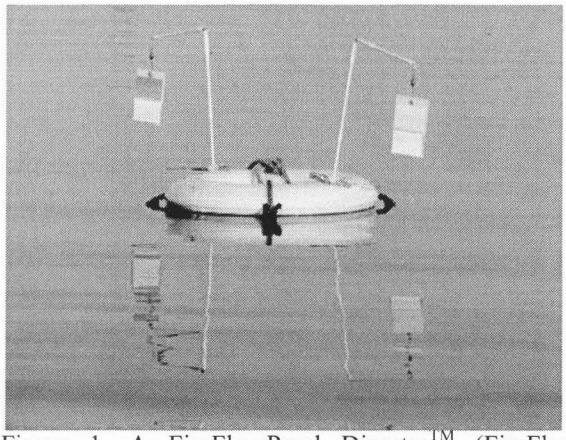

Figure 1. A FireFly Pond Diverter™ (FireFly Diverters LLC, Grantsville, UT).

each flapper is a patch of either red or yellow fluorescent material and second patch that is luminescent and reflects in the ultraviolet (UV) spectrum. The flappers begin to spin when the wind is 4.8 kph. It is claimed the diverter uses motion, reflectivity, and light emissions to alert and repel birds. See: http://www.birdbusters.com /agricultural_bird_control_product.htm. The diverter could represent a useful tool for hazing birds at spills, but no formal tests have been undertaken and consequently little is known about how species that could occur at a spill would respond.

The objectives of this study were to: 1) determine if waterbirds are repelled to a greater degree by the diverter compared to a simple novel object - a deactivated diverter represented by a plastic life ring; 2) identify the number and species of birds that respond to the diverter; and 3) determine if birds habituate (stop responding) to the diverter.

STUDY AREA

The study area was located in Woodland, California, at the Woodland Storm Water Retention Basin. The basin was about 16. 2 ha in area and was divided into 2 pools connected by a channel. We used the pool to the west, which was about 7.3 ha in area. The shoreline of the basin was uniformly barren, except for 2 islands in the northwest corner covered with willow (*Salix* spp.) saplings. The basin depended on storm events to fill up. Sufficient rain had fallen by December so that field work could proceed.

METHODS

We divided the basin into 4 distinct sections based on natural features and sight lines from the 3 bird counting locations. For example, a sandbar which ran across the basin served as a boundary between section 4 and sections 2 and 3. The 4 sections served as defined areas within which we could anchor the diverters and life rings (see below) and count birds.

This study was conducted from 11 through 19 December 2007. We divided the study into a 3-day pretreatment period and a 6-day treatment period. On each day we counted birds twice, once in the early morning (starting between 0700 hours to 0800 hours) and once in the afternoon (starting between 1430 hours to 1500 hours). Counts were done at 3 fixed locations from a vehicle to reduce bird disturbance. We recorded the total number of birds by species in each section of the basin. We paid particular attention to not recount birds if they moved from one section to another within the basin. This was possible because we could see most of the basin from each count location.

During the treatment period, we selected at random 2 sections of the basin for treatment. In the first section we anchored 2 diverters 30.5 m apart. In the second section we anchored 2 life rings 30.5 m apart. Within each selected section the diverters and life rings were anchored in locations where bird activity had been observed. The diverters and life rings were anchored ≥50 m apart. During the treatment period the diverters and the life rings were moved daily after the afternoon counts, with the new sections selected at random. During the treatment period bird counts, we also

recorded all birds within 15.2 m of each diverter or buoy.

We wanted to determine if the diverters and the life rings had any effect on the temporal pattern of use and the numbers and species of birds using the entire basin. Secondly, we wanted to determine if the diverters had an "area effect." We conservatively established an area of 15.2 m radius around each diverter. Our assumption was if the diverter had a hazing effect, birds would avoid flying within that conservative zone of influence. We assumed that the life rings, as novel floating objects minus the moving parts on the diverters, would not repel birds within a 15.2 m radius.

The null hypotheses we tested were: 1) the total number of birds in the basin was no different during the pretreatment vs. treatment periods; 2) the number of birds within 15.2 m from the diverters is no different than the number within 15.2 m from the life rings; and 3) the number of birds within 15.2 m of the diverters (or life rings) is no different than the number of birds >15.2 m from the diverters (or life rings) in the section of the basin where the diverters (or life rings) were located. We transformed data as needed to achieve normality and equal variances, or used non-parametric tests.

We did not collect weather-related data onsite, but later used a weather database (www.wunderground.com) for hourly wind and cloud cover information. We used 2 newspapers (Sacramento Bee and Woodland Daily Democrat) for data on the ultraviolet index (UVI).

This study was conducted under a protocol (07-12999) issued by the Institutional Animal Care and Use Committee at the University of California, Davis.

RESULTS

We recorded 21 species of birds during the pretreatment period and 22 species during the treatment period (Table 1) using the basin. Species composition was similar during the 2 periods; with only 2 species per period not being recorded during the other study period. Three groups of birds (gulls, geese, diving ducks) accounted for over 90% of the birds during each period. Gulls were most numerous, accounting for 72 to 75% of all birds.

For the basin as a whole, there were fewer birds present in the morning than the afternoon (Fig. 2) during the pretreatment and treatment periods ($F = 3.98$; $df = 3, 14$; $P = 0.03$). However, there was no apparent difference when comparing the number of birds in the morning periods to one another or the afternoon periods to one another. The temporal pattern of use and number of birds using the basin did not change with the deployment of the diverters or the life rings.

We observed 7 species of birds within 15.2 m of the diverters and 9 species within 15.2 m of the life rings (Table 2). Gulls represented 90.8% of the birds near the diverters and 80.8 % near the life rings.

There was no difference in the number of birds observed (Table 3) within 15.2 m of the diverters or the life rings ($t = -0.69$, $df = 22$, $P = 0.50$). There also was no difference

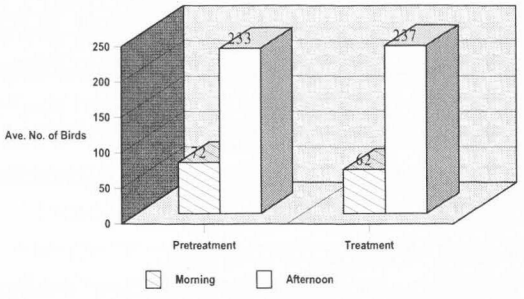

Figure 2. Average number of birds present on the Woodland Storm Water Basin, Woodland, California, during morning and afternoon counts during the 3-day pretreatment and 6-day treatment periods from 11–19 December 2007. Average number of birds per count and SD: pretreatment morning, 72.0 ± 35.5; pretreatment afternoon, 233.0 ± 67.0; treatment morning, 62.2 ± 29.5, and treatment afternoon, 237.2 ± 146.5.

Table 1. Bird groups, total number of birds counted in the Woodland Storm Water Basin, Woodland, California, during morning and afternoon count periods during the 3-day pretreatment and the 6-day pretreatment periods from 11–19 December 2007.

	Pretreatment			Treatment		
Group[a]	AM	PM	Total	AM	PM	Total
Herons, egrets	5	6	11	12	10	22
Geese	29	32	61	1	192	193
Dabbling ducks	10	7	17	63	31	94
Diving ducks	52	53	105	54	58	112
Other diving birds	8	13	21	23	29	52
Shorebirds	2	11	13	10	3	13
Gulls	108	478	586	205	1225	1430
Total	214	600	814	368	1548	1916

[a]Group: Herons and egrets: great blue heron (*Ardea herodias*), great egret (*Ardea alba*), snowy egret (*Egretta thula*)
Geese: Canada goose (*Branta canadensis*), greater white-fronted goose[b] (*Anser albifrons*)
Dabbling ducks: mallard (*Anas platyrhynchos*), gadwall (*Anas strepera*), northern shoveler[c] (*Anas clypeata*), hybrid ducks (species unknown)
Diving ducks: lesser scaup (*Aythya affinis*), common goldeneye (*Bucephala clangula*), bufflehead (*Bucephala islandica*), ruddy duck (*Oxyura jamaicensis*)
Other diving birds: horned grebe[c] (*Podiceps auritus*), eared grebe (*Podiceps nigricollis*), pied-billed grebe (*Podilymbus podiceps*), western grebe (*Aechmophorus occidentalis*), American white pelican (*Pelecanus erythrorhynchos*), double-crested cormorant (*Phalacrocorax auritus*), American coot[b] (*Fulica americana*)
Shorebirds: killdeer (*Charadrius vociferus*), greater yellowlegs (*Tringa melanoleuca*), unidentified sandpipers (*Calidris* spp.)
Gulls: ring-billed gulls (*Larus delawarensis*)
[b]Observed only during treatment period.
[c]Observed only during pretreatment period.

in the number of birds within 15.2 m of the diverters or >15.2 m from the diverters in the section of the basin where the diverters were located (Mann-Whitney U test, $Z = -0.29$, $P = 0.77$). We found the same relationship for the life rings; there was no difference in the number of birds within 15.2 m of the life rings or >15.2 m from the life rings in the section of the basin where the life rings were located (Mann-Whitney U test, $Z = -0.17$, $P = 0.86$).

As gulls were the predominant bird present at the basin, we conducted the same tests as above on gulls with similar results. There was no difference in the number of gulls observed (Table 4) within 15.2 m of the diverters or the life rings ($t = -0.76$, $df = 22$, $P = 0.46$). There also was no difference in the number of gulls within 15.2 m of the diverters or >15.2 m from the diverters in the section of the basin where the diverters were located (Mann-Whitney U test, $Z = 0.48$, $P = 0.63$). There was no difference in the number of gulls within 15.2 m of the life rings or >15.2 m from the life rings in the section of the basin where the life rings were located (Mann-Whitney U test, $Z = 0.80$, $P = 0.42$).

We found 2 newspapers, the Sacramento Bee and the Woodland Daily Democrat, that

Table 2. Bird groups, total number of birds counted within a 15.2 m radius of either the diverters or the life rings, and the number of counts during which the birds were observed within a 15.2 m radius of the diverters or life rings at the Woodland Storm Water Basin, Woodland, California.

	Diverters		Life Rings	
Group[a]	No. counted	No. of counts	No. counted	No. of counts
Herons, egrets	1	1	0	0
Geese	0	0	36	1
Dabbling ducks	11	3	12	3
Diving ducks	0	0	10	1
Other diving birds	2	2	2	1
Shorebirds	1	1	3	1
Gulls	149	5	266	7

[a]Group: Herons and egrets: snowy egret[b] (*Egretta thula*)
Geese: Canada goose[c] (*Branta canadensis*)
Dabbling ducks: mallard[c] (*Anas platyrhynchos*), gadwall[d] (*Anas strepera)*, hybrid ducks[d] (species unknown)
Diving ducks: common goldeneye[c] (*Bucephala clangula*)
Other diving birds: pied-billed grebe[b] (*Podilymbus podiceps*), American white pelican[d] (*Pelecanus erythrorhynchos*)
Shorebirds: killdeer[d] (*Charadrius vociferus*), greater yellowlegs[c] (*Tringa melanoleuca*)
Gulls: ring-billed gulls[d] (*Larus delawarensis*)
[b]Observed within 15.2 m of diverters.
[c]Observed within 15.2 m of life rings.
[d]Observed within 15.2 m of both diverters and life rings.

reported the UVI for the local and regional area. The UVI values reported for San Francisco, Sacramento, and Woodland differed little and none of the values were >2 (Table 5). The Woodland newspaper provided values for 3 time periods, 0800 hr, 1200 hr, and 1600 hr. On every day during the treatment period UVI = 0 for 0800 hr and 1600 hr. The UVI is a calculated value, not a measurement. See: http://www.epa.gov/sunwise/uvcalc.html. The calculation starts with satellite measurements of the total ozone amounts for the entire globe. These data are used to produce a forecast of ozone levels for the next day. A model then determines the amount of ultraviolet (UV) radiation reaching the ground from 290 to 400 nm in wavelength, using the time of day, day of year, and latitude. This information is weighted according to how human skin responds to each wavelength. The weighted irradiances are totaled over the 290 to 400 nm range resulting in a value representing the total effect a given day's UV will have on skin. Once adjusted for elevation and clouds, the weighted value is divided by a conversion factor of 25, resulting in a UVI that can range from 0 to the mid-teens. Higher values represent increasing levels of damage to human skin from UV radiation.

During the treatment period, there was measurable wind during 7 of 12 count periods (Table 6). Wind speed > 4.8 kph is sufficient to spin the flappers on the diverters. We observed birds within 15.2 m of the diverters on 6 out of 7 count periods with wind.

Table 3. Number of birds observed either within a 15.2 m radius from diverters or life rings or elsewhere (>15.2 m away) within the section of the basin where the diverters and life rings were placed.

		Diverters		Life Rings	
Date	Time	<15.2 m	>15.2m	<15.2m	>15.2m
14 Dec	AM	0	0	0	9
	PM	66	79	2	191
15 Dec	AM	4	5	2	8
	PM	43	200	0	1
16 Dec	AM	0	7	0	6
	PM	1	2	146	0
17 Dec	AM	1	7	12	4
	PM	5	0	41	38
18 Dec	AM	12	3	0	0
	PM	24	4	14	43
19 Dec	AM	0	1	59	6
	PM	8	25	53	25
$\bar{X} \pm$ SD		13.7 ± 20.9	27.8 ± 58.6	27.5 ± 43.3	27.6 ± 53.5

DISCUSSION

The diverters did not repel birds during this study conducted in December 2007. On 9 of 12 count periods during the treatment period we observed birds within 15.2 m of the diverters. In addition, we did not observe a situation where a few birds were close to the diverters while greater numbers were at a distance in basin. We documented the same number of birds within a 15.2 m radius around the diverters and life rings as outside that 15.2 m radius. The area encompassed by a 15.2 m radius around 2 diverters or life rings is considerably less than the area outside that radius, ranging from 1.2 to 2.8 ha less depending on the section of the basin. Based on area alone we expected to find more birds away from the diverters. However, that was not the case.

After the field work was completed, we were informed by the manufacturer that the rotation of the flappers and a UVI >2 was critical for the proper functioning of the diverters (T. Chervick, FireFly Diverters LLC, personal communication). The UVI was never >2 during the treatment period. If UV radiation has any effect on the performance of the diverters, then that effect could have been removed or at least diminished by the low UVI values. December, a time of year with low UVI values in northern California, was not the optimum time to conduct the test.

One might ask if given low UVI values and the possible diminishment of any UV effect, is the rotation of the flappers sufficient to repel birds? During the 7 bird counts with wind sufficient to rotate the flappers, there were birds within 15.2 m of the diverters during 6 of those counts. The rotation of the flappers, as novel, moving objects, did not repel the birds.

We could not determine if habituation to the diverters occurred. In the context of the diverters, habituation is the process in which birds no longer react to the sights or motions that were originally frightening or repellent. In this study we never observed any movement away from the diverters, thus there was not any behavior demonstrating habituation to observe.

It is now thought that most birds can see

Table 4. Number of gulls observed either within a 15.2 m radius from diverters or life rings or elsewhere (>15.2 m away) within the section of the basin where the diverters and life rings were placed.

		Diverters		Life Rings	
Date	Time	<15.2 m	>15.2m	<15.2m	>15.2m
14 Dec	AM	0	0	0	0
	PM	66	75	2	106
15 Dec	AM	0	0	0	0
	PM	40	200	0	0
16 Dec	AM	0	0	0	1
	PM	0	0	100	0
17 Dec	AM	0	0	4	0
	PM	0	0	40	38
18 Dec	AM	11	0	0	0
	PM	24	0	11	38
19 Dec	AM	0	0	56	0
	PM	8	18	53	23
$\bar{X} \pm$ SD		12.4 ± 21.0	24.4 ± 59.4	22.2 ± 32.7	17.2 ± 31.8

in the near UV (320–400 nm) part of the light spectrum (Honkavaara et al. 2002). UV vision has been conclusively demonstrated for over 35 species of diurnal birds from a variety of orders. Goldsmith (2006) and Withgott (2000) provided review articles that described how birds make use of UV vision. UV vision influences mate choice, may serve as an indicator of health of male birds, and may be useful in foraging for foods.

It has not been documented that UV is repellent to birds. It is not known if the diverters will repel birds under conditions of higher UVI. We know the conditions under which the diverters did not work (e.g., the low UVI during our test). Although such conditions (low UVI) may occur at many locations in California, especially in winter, there are other times when conditions may be suitable. Part of the flapper is luminescent, which is claimed to impart some effectiveness at night. We did not collect any data at night. Thus our study did not examine this aspect of the diverter.

MANAGEMENT IMPLICATIONS The diverters did not repel birds during our test conducted in conditions with low UV levels. The diverters should not be deployed at an oil spill to manage waterbirds when the UVI is <2. Additional research during periods with high UV levels will be necessary to determine the effectiveness of the diverter. We did not test at any coastal or bay locations. Testing should be undertaken at brackish or saltwater locations to increase the number of species evaluated. In particular we need more information on how brown pelicans (*Pelecanus occidentalis*), loons, cormorants, grebes, and marine ducks will respond to the diverter.

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Table 5. Ultraviolet index (UVI) values as reported from the weather pages of local and regional newspapers.

			Woodland[b]		
Date	San Francisco[a]	Sacramento[a]	0800 hr	1200 hr	1600 hr
14 Dec 07	2	2	0	2	0
15 Dec 07	2	2	0	2	0
16 Dec 07	1	2	0	2	0
17 Dec 07	1	2	0	1	0
18 Dec 07	1	1	0	1	0
19 Dec 07	1	1	0	1	0

[a]Source: Sacramento Bee
[b]Source: Woodland Daily Democrat

Table 6. Wind speed during morning (AM) and afternoon (PM) bird counts, the predicted ultraviolet index (UVI) at 1200 hours, and the presence of birds within 15.2 m of the diverters during the treatment phase of the study at the Woodland Storm Water Basin, Woodland, California.

	Wind Speed (kph)[a]			Birds Present <15.2 m	
Date	AM	PM	UVI[b]	AM	PM
14 Dec	0	0	2	no	yes
15 Dec	0	0	2	yes	yes
16 Dec	0	7.4	2	no	yes
17 Dec	9.3	9.3	1	yes	yes
18 Dec	27.8	16.7	1	yes	yes
19 Dec	7.4	5.6	1	no	yes

[a]Wind speed data from Weather Underground, History for Sacramento, CA; http://www.wunderground.com/history/airport/KSAC/2007/12/14/DailyHistory.html?req_city=NA&req_state=NA&req_statename=NA
[b]Predicted ultraviolet index values for 1200 hours taken from the Woodland Daily Democrat, 14–19 December 2007.

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