TRANSPORTATION IMPACTS TO WILDLIFE ON STATE ROUTE 37 IN NORTHERN SAN PABLO BAY, CALIFORNIA

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ABSTRACT: State Route 37 bisects conservation lands managed by San Pablo Bay National Wildlife Refuge (U.S. Fish & Wildlife Service) and Napa-Sonoma Marshes Wildlife Area (California Department of Fish and Game) in Solano and Sonoma Counties. The 2-lane highway connects Interstates 101 and 80 in northern San Francisco Bay and experiences ~26,000 vehicles per day. Road-killed wildlife between Napa River and Tolay Creek bridges (14.7 km) were counted in 2000 to ascertain species composition, relative abundance, and relative occurrence (animal fatality interval). The primary objectives of the study were to determine if endangered salt marsh harvest mice (*Reithrodontomys raviventris*), California clapper rails (*Rallus longirostris*), or other species of concern were represented, and to collect baseline data on transportation impacts to wildlife in the area. During 51 surveys, 291 dead birds (54.6%) and mammals (45.4%) were observed. Endangered species were not positively identified dead on the highway. In total, 28 bird, 10 mammal and 1 reptile species were positively identified along this section of highway that traverses tidal marsh and diked baylands (i.e., salt ponds, seasonal wetlands, and oat-hay agriculture fields). The mean animal fatality interval for both lanes was one road-kill every 2.1 km (2.1 km SD).

Key words: California, endangered species, road-killed wildlife, San Pablo Bay

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Road-kill surveys are a widely used and practical way to monitor transportation impacts on wildlife species (Stoner 1925, Dickerson 1939, Finnis 1960, Puglusi et al. 1974, Case 1978, Adams and Geis 1983, Swihart and Slade 1984, Rolley and Lehman 1992, Caro et al. 2000, Trombulak and Frissell 2000). Many researchers have investigated factors influencing the frequency of wildlife mortality on highways (Neu et al. 1974, Puglusi et al. 1974, Rolley and Lehman 1992, Gunther et al. 1998) and others have evaluated ways to reduce wildlife mortality on roads; some suggest underpasses (Foster and Humphrey 1995, Clevenger and Waltho 2000), culverts (Yanes et al. 1995, Hewitt et al. 1998) or reducing vehicle speed (Gunther et al. 2000). In this study, we investigated the effects of transportation on birds and mammals along a road crossing lands managed for wildlife conservation.

Wildlife mortalities associated with a 14.7-km (9.1-mile) segment of California State Route 37 were monitored between 29 December 1999 and 29 December 2000. Wildlife impacts along this highway in northern San Pablo Bay are of particular importance because the route bisects conservation lands managed by U.S. Fish and Wildlife Service and California Department of Fish and Game. The San Pablo Bay National Wildlife Refuge and Napa-Sonoma Marshes Wildlife Area are jointly responsible for protection and management of the resident, migratory, and endangered species in the region, particularly the Salt marsh harvest mouse (*Reithrodontomys raviventris*) and California clapper rail (*Rallus longirostris*), both federally listed. The objectives of this investigation were to: 1) determine all bird and mammal species impacted, including their relative abundance, relative occurrence, and average fatality interval along this stretch of highway; 2) associate mortalities with adjacent habitat types; and 3) compare our relative abundance estimates of impacted species to those reported for naturally occurring populations in the area.

STUDY AREA AND METHODS

Road-killed animals along a 14.7-km (9.1-mile) segment of Route 37 (Figure 1) were identified and recorded to class/species while traveling the speed limit (55 mph). Surveys were conducted about twice a month (weekdays) for both the westbound and eastbound lanes between Napa River bridge (north gate to Mare Island Naval Shipyard) and Tolay Creek bridge (Sears Point), and observations were recorded using a micro-cassette recorder. Vehicle odometer was used to enable determination of the animal fatality interval and for associating animals with adjacent habitat types (Figure 1). Animal fatality interval was computed excluding the first and last animal observed during each survey, so only those animals with known intervals were used to compute the value. Because a concrete K-rail barrier (Type 50) divides the 2-lane highway, we associated road-killed animals with the corresponding habitat type immediately north (westbound lane) or south (eastbound lane) of the pavement.

Habitat types along the highway included seasonal wetlands (5.3 km), open water (1.9 km; salt ponds), tidal marsh (3.7 km) and agriculture (2.9 km) north of the highway (east-west); and open water (1.0 km), agriculture field (1.5 km), and tidal marsh (11.7 km) south of the highway (west-east; Figure 1). Sonoma Creek bridge made up 0.73 km of each lane. The goal of this delineation was to associate animal mortality with adjacent vegetation covertypes (Mader 1984, Gunther et al. 2000) and to evaluate if frequency of wildlife mortality on the road differed by habitat. We recorded the number of birds and mammals found dead and their relative occurrence by habitat type. Mean fatality interval was calculated for each animal species, and percentages were calculated to determine relative abundance and relative occurrence of the observed road-kills.

RESULTS AND DISCUSSION

From 29 December 1999 to 29 December 2000, 51 surveys were conducted; 26 westbound trips, and 25 eastbound trips. The mean survey interval was 14.6 days (10.1 SD), and a total of 740.3 km were surveyed.

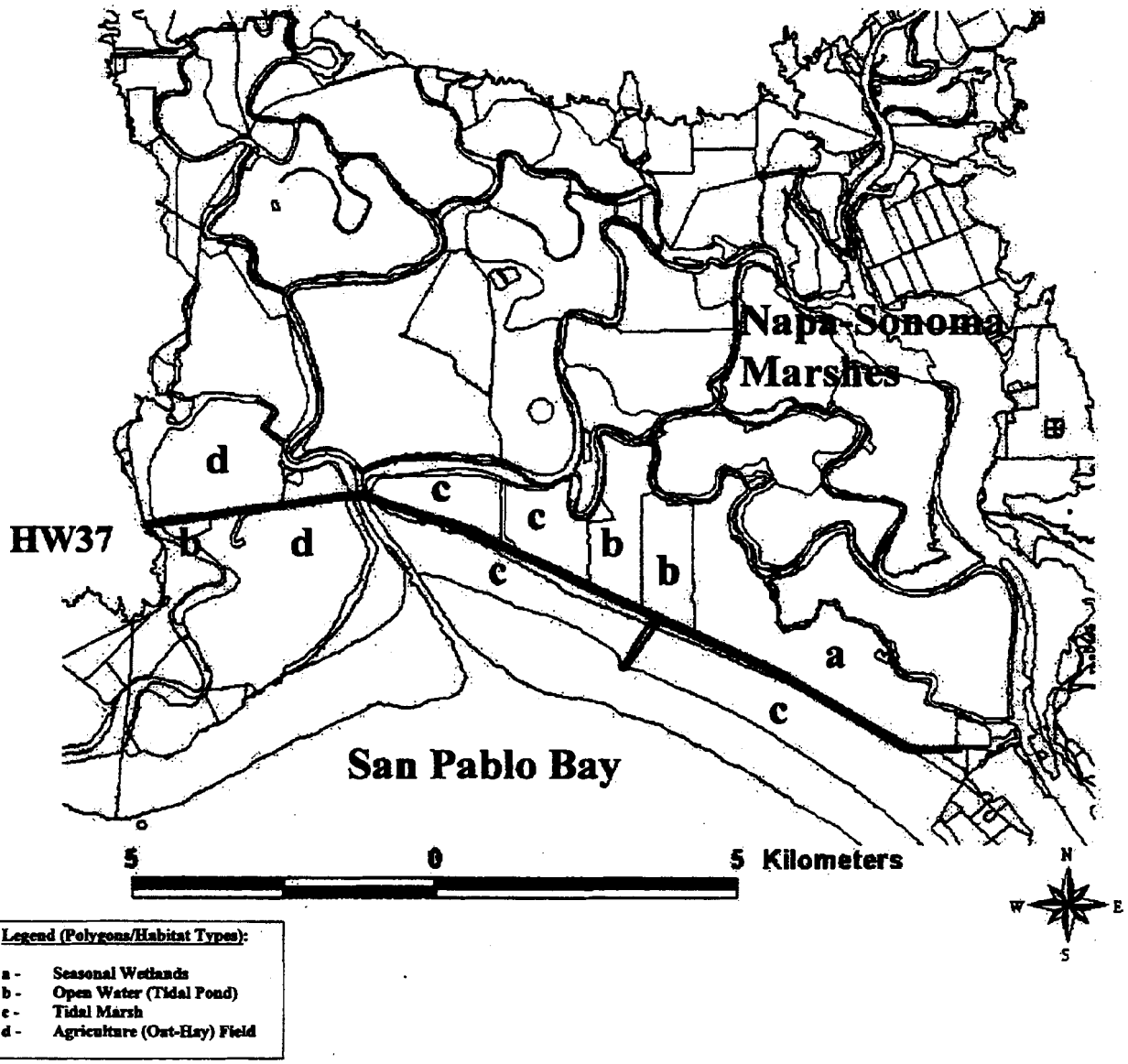

Figure 1. State Route 37 and adjacent habitat types in relation to San Pablo Bay National Wildlife Refuge and Napa-Sonoma Marshes Wildlife Area – Federal and State conservation lands in the northern San Francisco Bay Estuary. (Figure modified from EcoAtlas, San Francisco Estuary Institute)

A total of 291 animals was observed dead on the pavement or immediately adjacent to the highway shoulder; 159 birds (54.6%) and 132 mammals (45.4%; Table 1). Twenty-eight bird species and 10 mammal species were positively identified. Two reptiles also were observed, both gopher snakes (*Pituophis melanoleucus*). Twenty-seven animals could not be positively identified to species (21 birds; 6 mammals).

The majority of wildlife observed dead (Table 1) was associated with seasonal wetlands north of the westbound lane (43.7%); and tidal marsh south of the eastbound lane (43.7%). However, seasonal wetland habitat north of State Route 37 represented only 36.3% of the westbound lane (5.3 km), whereas tidal marsh south of State Route 37 represented 72.5% of the eastbound lane (10.6 km).

Waterfowl species (Order Anseriformes) were the bird group with the highest mortality (Table 2). One San Pablo Bay song sparrow (*Melospiza melodia samuelis*; State threatened species) was observed. No California clapper rails, brown pelicans (*Pelecanus occidentalis*), least terns (*Sterna antillarum*), northern harriers (*Circus cyaneus*), burrowing owls (*Athene cunicularia*) or other listed bird species were observed.

Rabbits and furbearers were the most represented of the mammals killed (38.6% each, 77.2% total; Table 3). Brush rabbits (*Sylvilagus palustris*) and muskrat (*Ondatra zibethica*) were the species with the highest mortality (Table 3). More muskrats were killed in the eastbound lane because of the greater availability of farmfield drainage ditches. Small mammals represented 15.9% of all mammals and included at least 6 mice (4.5%) which could have included the salt marsh harvest mouse (Botti et al., Wertz-Koerner 1997).

The mean animal fatality interval (relative occurrence for all species) on both lanes of Route 37 was 1 road-kill every 2.1 km (2.1 km SD). The mean animal fatality interval for birds was 1 road-kill every 5.0 km (3.5 km SD). Mean animal fatality interval for mammals was 1 road-kill every 4.0 km (3.1 km SD). The westbound lane had an animal fatality interval of 1 road-kill every 1.8 km (1.8 km SD) and the eastbound lane had an animal fatality interval of 1 road-kill every 2.4 km (2.5 km SD). These intervals did not incorporate dead animal removals attributed to scavengers, which removed 38% of all dead birds within 96 hours beneath a 115-kV transmission line in the study area (Hartman et al. 1992). Route 37 experiences an average of 26,000 vehicles per day based on Caltrans daily traffic numbers (C. Morton, pers. comm.).

We assumed the K-rail (Type 50) barrier separating the eastbound and westbound lanes was sufficient to prevent most mammals from crossing the road, although small rectangular holes (scuppers) were present to allow for small mammal migration. Mammal mortality on the highway may have been higher because of the barrier. Road-kill mammals likely were associated with adjacent habi-

Table 1. Habitat types and relative occurrence of birds and mammals observed dead along the westbound and eastbound lanes of State Route 37 (14.7-km stretch), in Solano and Sonoma Counties, California, December 1999-2000.

	Habitat	Birds		Mammals		Total	
Type	%	No.	%	No.	%	No.	%
Westbound lane							
Seasonal wetlands	36	33	34	36	58	69	44
Open water	13	18	19	8	13	26	17
Tidal marsh	25	29	30	7	11	36	23
Bridge	5	6	6	1	2	7	4
Agriculture	20	10	10	10	16	20	13
Total		96	61	62	39	158	100
Eastbound lane							
Open water	13	12	20	17	26	29	23
Tidal marsh	73	37	61	18	28	55	44
Bridge	5	2	30	13	5	5	4
Agriculture	10	10	16	27	42	37	29
Total		61	48	65	52	126	100
Grand total		157	55	127	45	284	100

tats. Bird species may not have been as strongly associated to adjacent habitats as mammals. Caltrans installed 0.4-m tall plywood above the K-rail (Type 50) barrier on Sonoma Creek bridge to reduce headlight glare. This heightened barrier may have caused birds to fly higher resulting in fewer birds killed along this 0.73-km section of road.

It was difficult to identify wildlife to species during crepuscular hours, on cloudy days, and during rain, and therefore surveys were avoided during these conditions. Some animals were crushed beyond recognition and double-counting of these animals was possible.

We compared the relative abundance of road-killed bird and mammal species with the relative abundance of their populations within the study area. Relative abundance of American coot (*Fulica americana*) was 10.1% of all birds in our study, and 14% in Fall 1998 and 39.8% in Spring 1999 (Takekawa et al. 1999). In contrast, we found that barn owls (*Tyto alba*) represented 13.2% of all birds observed dead on the road and red-tailed hawks (*Buteo jamaicensis*) represented 5.0%, whereas Takekawa et al. (1999) found that these species comprised $\leq$ 0.003% of birds in the study area. Our results suggest raptors, especially barn owls, may be particularly vulnerable along this segment of highway.

We counted 21 small mammals dead on the highway in one year. Takekawa et al. (1999) conducted small mammal trappings to ascertain relative abundance of salt marsh harvest mice and caught 10 in seasonal wetlands and 14 in tidal marsh. These data suggest that salt marsh harvest mice likely experienced low mortality associated with the highway.

Our study represents an undetermined underestimate of the actual wildlife mortality associated with transportation on this section of California Route 37, because animals impacted that expired off the pavement went undetected. Future research will attempt to determine the percentage of impacted wildlife not detected by our survey method (i.e., road shoulder searches) to determine a more accurate animal fatality interval. Since the study period ended, an eleventh species of mammal, mink

Table 2. Relative occurrence of bird species observed dead along a 14.7-km stretch of State Route 37 in Solano and Sonoma Counties, California, December 1999-2000.

Species	*n*
Waterfowl	*45*
American coot	16
Mallard	14
Unidentified waterfowl	11
Canvasback	1
Gadwall	1
Green-winged teal	1
Scaup	1
Raptors	*32*
Barn owl	21
Red-tailed hawk	8
Great horned owl	1
American kestrel	1
White-tailed kite	1
Passerines	*28*
Red-winged blackbird	20
Meadowlark	4
Brewers blackbird	3
Unidentified sparrow	2
San Pablos song sparrow	1
European starling	1
Egrets	*12*
Snowy egret	7
Great egret	5
Shorebirds	*6*
Unidentified shorebird	3
Dowitcher	1
Curlew	1
Western sandpiper	1
Gulls	6
California gull	*5*
Bonapart's gull	1
Gamebirds	5
Pheasant	2
Domestic chicken	2
Rock dove	1
Unidentified bird	*21*

Table 3. Relative occurrence of mammal species observed dead along a 14.7-km stretch of State Route 37 in Solano and Sonoma Counties, California, December 1999-2000.

Species	*n*
Rabbits	*51*
Brush rabbit	38
Black-tailed jackrabbit	13
Furbearers	*51*
Muskrat	20
Striped skunk	13
Raccoon	12
Opossum	6
Small mammals	*21*
Mice/rats/voles	15
Unidentifed small mammal	6
Ground Squirrel	1
Feral house cat	*2*
Unidentified mammals	*6*

(*Mustela vison*) was identified dead on the pavement in association with agriculture and another in association with open water.

MANAGEMENT IMPLICATIONS

No California clapper rails and only 6 small mammals (none positively identified as a salt marsh harvest mouse) were detected in 2000. Thus, road mortality may not be a significant factor for these species at this time. However, other species were impacted and strategies to reduce highway-related mortality along this stretch may be warranted. Such strategies could include above ground viaducts and reduced speed limits. Also, native vegetation planted between the lanes or along 1 or more shoulders could reduce the rate of collision for birds by encouraging higher flight paths (K. Gish personal communication). However, plants not suitable as food, cover, or nesting would be necessary so as not to attract birds. However, plantings may increase mortality of mammals, as has been observed in other areas.

ACKNOWLEDGEMENTS

Thanks to L. Vicencio, G. Downard, S. Wainwright-De La Cruz, D. Battaglia, and D. Tsao, U.S. Geological Survey, San Francisco Bay Estuary Field Station, and T. Huffman, J. Swanson, and L. Wyckoff with California Department of Fish and Game for ideas, assistance and support. Many thanks to C. Morton, Caltrans for providing traffic data and openly discussing ways to reduce wildlife mortality in the study area. Thanks to C. Morton, B. Cypher, C. Haas, and L. Spiegel for reviewing earlier versions of this manuscript. L. Vicencio, C. Rejas, S. Miller and C. Hoffman participated in road-kill surveys, and D. Leslie, Jr., K. Gish, P. Baye, M. Bias, and S. Laugtug provided additional ideas, literature, and assistance.

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