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An analysis of coot management options : Shoreline Links, Mountain View, California

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**AN ANALYSIS OF COOT MANAGEMENT OPTIONS:
SHORELINE LINKS,
MOUNTAIN VIEW, CALIFORNIA**

A Thesis

Presented to

**The Faculty of the Department of Geography
and Environmental Studies
San Jose State University**

**In Partial Fulfillment
of the Requirements for the Degree
Master of Science**

by

Gary R. Santos

December 1995

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ABSTRACT

AN ANALYSIS OF COOT MANAGEMENT OPTIONS: SHORELINE LINKS, MOUNTAIN VIEW, CALIFORNIA

by Gary R. Santos

The American coot (*Fulica americana americana*) is one of over 150 species of birds inhabiting Shoreline At Mountain View, a 650-plus acre regional recreational and wildlife area adjacent to San Francisco Bay. Unlike most waterfowl, the coot incessantly eats the grass at Shoreline's golf course which results in significant maintenance costs each year. Shoreline and other golf courses have used many methods, including shooting, to keep the birds off play areas. In this thesis, a comprehensive literature search was undertaken and 45 techniques to deter coots were examined to determine the most effective. No single method was completely effective, although dogs and fences were two of the best. At Shoreline, an integrated program featuring tall vegetative barriers should be used to direct coot movements, or the Course should be redesigned to distance it from the Park's water areas.

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TABLE OF CONTENTS

ACKNOWLEDGMENTS	v
LIST OF TABLES	xii
LIST OF ILLUSTRATIONS	xiii
LIST OF ABBREVIATIONS	xiv
Chapter	
I. INTRODUCTION	1
The Problem	1
The Study Area: Shoreline At Mountain View	6
Methods Used in This Study	11
II. THE SHORELINE PROBLEM: COOTS VERSUS PEOPLE .	14
Human-Coot Interactions	14
Golf Courses: A Brief History	17
Shoreline Golf Links	21
The Research Goal	26
Research Methodology	29
III. COOT ECOLOGY	31
Taxonomy	31
Life Cycle	34
Behavior	43
Population Dynamics	47

Chapter	Page
Community Ecology	65
Ecological Importance of Coots	80
IV. PRELIMINARY RESEARCH	82
V. BARRIERS	83
Fencing: Non-electric	84
Human Blockade	85
Net Exclusion	89
Riprap	90
Wires: Submerged or Suspended	91
Conclusion	93
VI. HABITAT ALTERATIONS	94
Feeding Area	95
Pond Salting	102
Sacrifice Area	106
Synthetic Grass	107
Territoriality	109
Vegetative Enhancement	114
Vegetative Removal	125
Water Removal	128
Conclusion	130

Chapter	Page
VII. POPULATION REDUCTION	131
Anesthetics	132
Chemosterilants	134
Disease and Parasitism	135
Natural Predators	137
Net Capture	139
Poisoning	143
Shotgun Capture	145
Sport Hunting	156
Trapping	165
Conclusion	167
VIII. REPELLENTS	169
Chemical	169
Visual	177
Conclusion	180
IX. SCARE DEVICES	183
Arm-waving	184
Automatic Exploders	185
Balloons	187
Beachball: Tethered	190
Dogs	191

Chapter	Page
Falconry	194
Fencing: Electric	195
Flagging	197
Horns	198
Lights	199
Night Harassment	200
Outboard Motorboat	201
Pyrotechnics	202
Radio-controlled Model Airplane	204
Radio-controlled Model Boats	205
Recorded Alarm and Distress Calls	207
Scarecrows	210
Shooting As a Scare Device	213
Ultrasonics	214
Volunteers	216
Water Sprinklers	219
Other Scare Devices	220
Conclusion	221
X. SHORELINE FIELD RESEARCH	222

Chapter	Page
XI. SHORELINE COOT CENSUS	223
The Problem	223
Methods Used in This Census	225
Census Results	232
Census Analysis	242
Management Implications of Coot Census Analysis	280
Miscellaneous Coot Notes	282
XII. SHORELINE TESTS	287
Arm-waving	287
Dogs	288
Falconry	289
Fencing: Non-electric	290
Outboard Motorboat	292
Radio-controlled Model Airplane	293
Riprap	294
XIII. SHORELINE TEST ANALYSIS	295
Arm-waving	295
Dogs	296
Falconry	301
Fencing: Non-electric	303
Outboard Motorboat	306

Chapter	Page
Radio-controlled Model Airplane	308
Riprap	309
XIV. SUMMARY OF EVALUATIONS AND TESTS	311
Other Tests Which Would Be Useful	317
XV. RECOMMENDATIONS	320
Required Duration of Management Options	320
Coot Ecology Affects Management Options	321
Recommendation No. 1: Integrated Coot Management ..	322
Recommendation No. 2: Remodel Shoreline Golf Links .	331
Conclusion	336
LIST OF REFERENCES	337

LIST OF TABLES

Table	Page
1. Projected Annual Coot Population Cycle	52
2. South Bay Coot Population Trends, 1980-91	58
3. American Coot Food-Habit Studies	72
4. People Needed to Surround Coots on Various-sized Water Areas	87
5. Hours Needed per Volunteer Position	218
6. Comprehensive 1990-91 Shoreline Coot Census Data	233
7. 1990-91 Shoreline Coot Census Two-Count Average	239
8. Effect of Wind on Counting Accuracy	258
9. Coot Migrational Timetable Comparisons	269
10. Peak 1990-91 Shoreline Over-wintering Coot Densities	274
11. Projected Work Schedule for 1 October	299
12. Management Techniques Evaluated According to Constraints	313

LIST OF ILLUSTRATIONS

Figure	Page
1. Coots Wintering at Shoreline Golf Links	4
2. Coots Grazing on Shoreline Park's Turf	5
3. Location of Shoreline At Mountain View	7
4. Shoreline At Mountain View, Mountain View, California . . .	9
5. Graph of 1990-91 Shoreline Coot Census	243
6. Current Extent of Coot Grazing	323
7. Projected Area of Coot Grazing after Completion of Proposed Integrated Management Program	329

LIST OF ABBREVIATIONS

DFG	California Department of Fish and Game
DMA	Dimethyl anthranilate
LACDA	Los Angeles County Department of Agriculture
PG&E®	Pacific Gas and Electric Company®
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
WPA	Work Projects Administration
WVA	Woodbridge Village Association

CHAPTER I

INTRODUCTION

The Problem

North American birds sense the onset of winter when their water areas in the far north start to dry. Soon thereafter, millions of birds will migrate south across the U.S. over four main air routes called "flyways." The most western flyway, the Pacific, is located between the Pacific Ocean and the Rocky Mountains (Williams [1993], 1).

These centuries-old routes follow a chain of wetland stepping stones,¹ each crucial to their journey (Williams [1993], 1). Wetland habitats produce waterfowl in the spring and summer, and sustain them in the fall and winter months.² These water areas also "are among the most fragile and rapidly disappearing of habitat types" (Shaw 1985, 163).

¹A wetland is any area of land covered by water for at least seven consecutive days per year with water loving plant species in soil that has adapted to a wet environment. Therefore, bottomlands, estuaries, marshes, and swamps are all considered wetlands (Trulio 1995c).

²Waterfowl include all swimming and wading birds (Stein 1980, 1486). This group of birds consists of "ducks, geese, swans, coots, and cranes" (Pfeifer 1983, 75[E]).

Originally, the U.S. contained 127 million acres of wetlands. By 1968, all but 75 million had been drained or filled. Of these 75 million, only 9 million are of high quality, while the remaining 66 million acres are "of either low or negligible value" (Shaw 1985, 163). The U.S. has also lost 90 percent of certain freshwater types of wetlands (Shaw 1985, 237).

In California, which is located entirely within the Pacific Flyway, small remnants in the form of wildlife refuges are all that remain of the state's natural wetland ecosystem (Kutilek 1989d). California has lost 90 percent of its original five million acres of wetlands (Tharratt and Lollock 1989, 66-67). Nearly four million of those acres were lost in the state's Central Valley (Miller 1990, 1).

Despite the fact today's Central Valley has only 290,000 acres of wetlands (Miller 1990, 1), 60 percent of all Pacific Flyway birds winter there (Williams [1993], 2).

The American coot (*Fulica americana americana*), hereafter referred to simply as "coot" or "mud hen," can be found year-round in California as approximately fifty thousand birds have established permanent residency in the state (Fredrickson et al. 1977, 133). In the fall and winter months, annual northern migrants cause the Golden State's coot population to increase ten- to twenty-fold (Van Way 1986, 292).

According to California waterfowl biologists, coots make use of all 850,000 acres of wintering habitat left in the state. Of this 850,000 acres,

only 110,000 acres are of high quality (Fredrickson et al. 1977, 134), an area slightly smaller than the city of San Jose, California, which is 112,000 acres (Jacobs 1994). This prime habitat is located in the state's southern Central Valley (Fredrickson et al. 1977, 135). Here, many coots and ducks spend the winter in crowded conditions (Fredrickson et al. 1977, 141).

Mud hens prefer natural wetland ecosystems for wintering, but sometimes must settle for croplands, pastures, and golf courses (fig. 1). When flocks of coots use these human-maintained systems, depredation problems often occur (Fredrickson et al. 1977, 135).

Coot grazing is a common problem on California's golf courses (Salmon, T. P. 1989) (fig. 2). Coots damage grass with their "intense clipping . . . or puddling of . . . turf areas near water." They also can contaminate small bodies of water with their fecal deposits (Van Way 1986, 292).

This paper will focus on the problem of coots depredating golf courses.

Fig. 1. Coots wintering at Shoreline Golf Links. Nearly two hundred mud hens enjoy a respite from the area's March rains on and around one of the Golf Course's ponds. Photo by author.

Fig. 2. Coots grazing on Shoreline Park's turf. Shoreline's coots always grazed within about two hundred feet of the Park's water areas. Here, Shoreline Lake (barely visible through the trees) is just forty feet from the paved trail on the left. Photo by author.

The Research Goal

The goal of this study will be to develop or identify at least one nonlethal solution to the problem of coots depredating golf courses (see "The Research Goal" section in "The Shoreline Problem: Coots versus People"). While this research focuses on Shoreline Golf Links in Mountain View, California, the methods investigated are applicable to other similar areas in the state with coot grazing problems.

The Significance of This Study

Currently, a nonlethal solution to coots depredating golf courses does not exist (Gorenzel 1989; Weddle 1994). Developing a humane solution to this problem will not only help Mountain View's coots, but will also serve as a model for other agencies where a similar depredation problem occurs, hopefully ensuring the long-term survival of another species that might some day be faced with extinction.

The Study Area: Shoreline At Mountain View

In 1968, the City of Mountain View purchased 544 acres of land that was once a junkyard, hog farm, and sanitary treatment plant near southern San Francisco Bay (fig. 3). The land was purchased in order to preserve open space (Shoreline At Mountain View 1987, 2) and make a regional recreational and wildlife area (Volunteer rangers n.d., 2).

Fig. 3. Location of Shoreline At Mountain View. Shoreline Park is near southern San Francisco Bay in Santa Clara County. The small rectangular area (2.2 x 1.6 mm) three miles northeast of "Mountain View" is the area enlarged in Figure 4. Drawing by author.

To eliminate the possibility of flooding during high tide, domestic garbage was imported from San Francisco to raise the area approximately fifteen feet. Revenue from dumping fees was used to design the facility and pay for its landscaping and recreational features (Shoreline At Mountain View 1987, 2-3).

Shoreline At Mountain View, hereafter referred to as "Shoreline Park," "Shoreline," or "the Park," was officially dedicated in 1983. To support its operation, the City receives about \$170,000 annually from Pacific Gas and Electric Company® (PG&E®) for the methane gas recovered from now decomposing refuse buried under the Park (Shoreline At Mountain View 1987, 2-3).

Recreational facilities (fig. 4) include a 187-acre golf course (Collins 1987). Approximately seventy-five thousand rounds of golf are played annually on Shoreline Golf Links (Summer '88 at Shoreline [1988], 2), which in the future will also be referred to as "Shoreline Golf Course," "the Golf Course," "the Course," "Shoreline Links," "the Golf Links," "the Links," or "Shoreline." Boating on the 50-acre saltwater lake has likewise proved popular, as twelve thousand boaters used Shoreline facilities in 1987 (Summer '88 at Shoreline [1988], 3). Windsurfers enjoy the manmade lake too, while a pumping system continually exchanges its waters with those of San Francisco Bay (Shoreline At Mountain View 1987, 6). Avian

Fig. 4. Shoreline At Mountain View, Mountain View, California. Drawing by author.

enthusiasts are attracted by the more than 150 species of birds that inhabit or visit Shoreline Park, including several species that are endangered, threatened, or candidates for listing (Newberry 1986a, 35-36). Seven miles of hiking, biking, and jogging trails inside the Park are linked to adjacent trail systems in the east and west (Shoreline At Mountain View 1987, 4). Other activities include live entertainment at the twenty-thousand-seat Shoreline Amphitheater (Trulio 1995b), and picnicking and playing in the Park's meadow area (Volunteer rangers n.d., 2). Future additions are also planned (Shoreline At Mountain View 1987, 6).

Unlike the Golf Course,³ the wildlife habitats consist mainly of "tidal saltwater, freshwater, and brackish marshes," dikes, and unirrigated grassland and upland areas. Vegetation found in the wildlife areas include salt marsh pickleweed (*Salicornia* spp.), cordgrass (*Spartina* spp.), and natural grasses and shrubs (Newberry 1986b, 1-2). The area along the northeastern shore of Shoreline Lake, hereafter referred to as the "City Park," is made up of a coarse fescue (*Festuca* spp.) (Vaught 1988a), which is regularly mowed and irrigated.

The area studied in this thesis was the Shoreline Golf Links. The Golf Course is bounded on the north by fifty-acre Shoreline Lake (Shoreline

³See the "Shoreline Golf Links" section in "The Shoreline Problem: Coots versus People" for a description of the dominant plant and non-avian aquatic life found in Shoreline Golf Links.

At Mountain View 1987, 6), Rengstorff House, and Shoreline Boulevard.

Shoreline Boulevard is also the Golf Links' eastern neighbor, while Shoreline Amphitheatre and a former sanitary landfill bound the Course on the south. Commercial development marks Shoreline Links' western border. Two Cargill® salt evaporation ponds separate Shoreline Park from San Francisco Bay, one mile to the north (Shoreline map [1988]).

Methods Used in This Study

The methods used in this study were designed to: (1) determine the extent of the coot problem at Shoreline, and (2) gather all relevant information available on coot ecology and wildlife depredation that could be used to develop a possible solution (or number of possible solutions) to Shoreline's coot crisis.

Defining the Coot Problem

Shoreline's mud hen problem was described by several of the agency's field and supervisory staff who were interviewed by the author. These individuals all had previous experience managing and/or observing Shoreline's coot problem.

From these discussions, and from a review of Shoreline's coot-related files, the author obtained a history of previous coot-human interactions at the Mountain View facility, technical information about the Park, and an additional list of knowledgeable individuals to contact. These

data allowed the author to develop a clear understanding of how the coots were negatively impacting Shoreline.

Information Gathering

In order to be able to formulate possible solutions to Shoreline's coot problem, it was necessary to gather all relevant information available on coot ecology and wildlife depredation. One of the ways this was accomplished was through dozens of telephone interviews.

Experts in every imaginable field who may have had experience with bird problems were contacted including airport managers, corporations who produced wildlife management tools, golf course personnel, hunters, parks department personnel, recreational groups, sod farms, university instructors, waste management plant operators, and wildlife agencies. These individuals often suggested other people and organizations to contact. Individuals from all parts of the U.S. were contacted (see "List of References").

The literature reviewed included a vast wealth of information on coot ecology and related wildlife depredation problems. This literary investigation was aided by separate searches on the Biosis® database at Stanford University, Palo Alto, California and San Jose State University, San Jose, California.

All information on avian damage control techniques obtained during this "study phase" was grouped into areas by the type of control technique employed. Keeping Shoreline's unique constraints in mind, all known solutions were evaluated to see if they might have merit (see "The Research Goal" section in "The Shoreline Problem: Coots versus People" for constraints and chapters V through IX for details of this evaluation process).

After evaluating each control technique, the feasibility of employing that particular approach at Shoreline was evaluated.

Even though a potential answer to Shoreline's coot crisis may be eliminated from consideration, the same technique may be practical at other sites where similar constraints do not exist. Conversely, a possible solution selected at Shoreline may not be suited for other locations for various reasons.

CHAPTER II

THE SHORELINE PROBLEM: COOTS VERSUS PEOPLE

Human-Coot Interactions

Coots and people have interacted on this continent for centuries. For example, the coot was always a part of the Native American's diet (Ward 1953, 326). California growers have reported incidents of coot depredation since 1885 (Van Way 1986, 292).

Below are the main interactions, both harmful and beneficial, that occur between humans and coots.

Harmful Interactions

Conflicts between wildlife and people for food and habitat "date back to the beginnings of recorded history." In the past this competition usually centered on food production. But today there are "wildlife-made conflicts in agricultural, industrial, residential, and recreational contexts" (Marley 1987, 26). People and mud hens have had their share of these negative interactions.

Coots prefer natural wetland ecosystems for wintering (Fredrickson et al. 1977, 135). But, when aquatic vegetation on their normal habitat is

limited or nonexistent, the birds may depredate nearby areas to satisfy their hunger (Van Way 1986, 292).

Examples of human-maintained systems used by wintering mud hens include: vegetable and forage croplands, golf courses (Fredrickson et al. 1977, 125), lawns, and pasturage. Coots have also been known to contaminate reservoirs and ponds with their excessive fecal deposits (Van Way 1986, 292).

Needless to say, mud hens are not popular with farmers, ranchers, golfers, gardeners, maintenance, and water quality workers who are on the receiving end of all their "fowl" play.

Coots often eat gun club duck food, which angers duck hunters. The hunters will often kill coots "merely to get them out of the way" (Ward 1953, 326).

Migrating mud hens sometimes collide with airplanes, causing potential human-safety problems (Fredrickson et al. 1977, 126).

Beneficial Interactions

During the last few decades, the California Department of Fish and Game (DFG) began to notice a shift away from the traditional "consumptive" wildlife-related recreational uses like hunting and fishing, to "nonconsumptive" activities like "bird-watching, photography, and general

nature study" on their 400,000 managed acres (Unkel 1989, 6; Unkel and Weisser 1989, 10).

A 1988 DFG survey revealed two-thirds of adult Californians, nearly thirteen million, participated annually in at least one nonconsumptive wildlife-related recreational activity (Unkel 1989, 7).

A 1980 U.S. Fish and Wildlife Service (USFWS) survey discovered that around forty million Americans are bird-watchers (Mallette 1989, 73), while a 1985 USFWS survey found eighteen million Americans photographed wildlife and nature (Galkowski 1989, 76).

Three million Californians take "trips specifically to view birds and other wildlife." A Californian on a bird-watching trip will spend thirteen dollars on food, gas, film, lodging, local guidebooks, and other miscellaneous supplies (Loomis and Unkel 1989, 84).

In 1987, "spending by bird-watchers contributed a total of twenty-seven million dollars in wages and business income to California's economy." This translates to a total of two thousand jobs in the food, lodging, transportation, and retail sectors because of "services demanded by bird-watchers" (Loomis and Unkel 1989, 84-85).

While not all these nonconsumptive users are watching, photographing, or studying coots, some are. The author often witnessed people of all ages feeding coots in the City Park along northeast Shoreline Lake. Both humans and birds appeared to derive great pleasure from this

activity. Mud hens will take a variety of items including bread, fish bait, fruit cores, popcorn (Van Way 1986, 292), marshmallows, orange peels, and watermelon rinds (Eley and Harris 1976, 226).

Coots, like all wildlife, are a part of our natural history. They offer teaching, research, and volunteer opportunities, as well as subjects for artists and poets. Their health, like that of all wild things, also serves as a natural barometer for the environment.

California has 32,800 waterfowl hunters who shoot coots (Fredrickson et al. 1977, 138). On a hunting trip, sportsmen will spend money on food, gas, lodging, ammunition, and other miscellaneous supplies. Like bird-watchers, coot hunters contribute business income and wages to the Golden State's economy.

Consumptive and nonconsumptive coot users would agree that their coot interactions have a beneficial effect on their quality of life.

Finally, on the "positive" side of the coot depredation issue, mud hens also mean income and wages for corporations who make wildlife management tools.

Golf Courses: A Brief History

Golf, as we know it today, got its start in Scotland around the fourteenth century (Cornish and Whitten 1981, 16).

The first golf courses were formed and designed by nature along three river estuaries in southeastern Scotland. These courses, known as "links," consisted of grazed areas of bent grass (*Agrostis* spp.) and some fescue between sand dunes and various-sized bunkers. The fifteenth century links contained no trees or water hazards, while the number of holes varied depending on the amount of available playable land (Cornish and Whitten 1981, 16). It was not until the eighteenth century that people enhanced nature's original design by adding turfed greens to the old links at St. Andrews, Scotland (Cornish and Whitten 1981, 18).

In 1834, King William IV proclaimed St. Andrews "Royal and Ancient." Thus the old links became the standard by which all other courses were measured. Soon all golf courses had eighteen holes, just like St. Andrews (Cornish and Whitten 1981, 22).

As the sport spread out from Scotland's river estuaries, it was not always possible to design new courses around their natural surroundings. Soil and terrain had to be modified to re-create conditions similar to those of the links (Cornish and Whitten 1981, 24).

Around 1900, the first courses built on England's heath land included a new development; some existing trees were incorporated into their designs. These twentieth century courses also featured manmade hazards like artificial ponds (Cornish and Whitten 1981, 36).

The first U.S. golf course was built in the 1880s, and by 1896, there were eighty. In 1900, a course existed in every state with nearly one thousand overall (Cornish and Whitten 1981, 44).

During the late 1890s and early 1900s, two waves of British golfing immigrants deeply influenced U.S. golf course architecture (Cornish and Whitten 1981, 47, 71). One immigrant, Donald J. Ross, was "to become the top name in American course design" before its 1920s "Golden Age" until his death in 1948 (Cornish and Whitten 1981, 74, 211).

Ross's style, no doubt influenced by his Scottish roots, "incorporated naturalness and a links touch" (Cornish and Whitten 1981, 211).

During the period of the Great Depression and World War II (1930-1946), there was a net loss of over one thousand U.S. golf courses, or nearly 18 percent (Cornish and Whitten 1981, 228).

From 1935 to 1943, Ross, and young course architects like Robert Trent Jones, took advantage of the federal Work Projects Administration (WPA) program that allowed communities to hire architects to make public courses (Cornish and Whitten 1981, 93).

By the early 1950s, Jones's style had been "adopted and modified by so any American and British architects," it came to be known as "contemporary style" (Cornish and Whitten 1981, 110). By 1960, he was known worldwide by nongolfers as well as golfers (Cornish and Whitten 1981, 100). By 1980, Jones had over four hundred original and one hundred

remodeled courses around the world (Cornish and Whitten 1981, 116, 190). His influence on golf course architecture was "unparalleled in its history" (Cornish and Whitten 1981, 110).

Jones's two children, Robert Trent Jones, Jr., and Rees, became golf course architects with their own unique styles (Cornish and Whitten 1981, 116). Jones's namesake established his own practice in 1972. By 1980, Robert Trent Jones, Jr., "had designed over sixty courses and remolded many others," not including those done with his famous father (Cornish and Whitten 1981, 116, 191).

By 1960, many new developments "revolutionized golf course construction and design." Among these were: (1) modern earth-moving equipment, (2) new fertilizers, chemicals, and hybrid grasses, (3) a better understanding of turf grass growth and care, (4) automatic irrigation systems, (5) irrigation of fairways as well as greens, and (6) golf cars (Cornish and Whitten 1981, 98, 100-2).

These innovations came just in time, as around 1970, real estate, construction, and financing costs skyrocketed, while new environmental regulations raised costs too (Cornish and Whitten 1981, 114). Therefore, new courses have either been municipally-owned, or part of real estate, resort, or other recreational complexes (Cornish and Whitten 1981, 116, 188). Mushrooming expenses also meant many recent courses would be built on ledge rock, reclaimed lakes, marshes, gravel pits, strip mines, or

landfills (Cornish and Whitten 1981, 116), like the Robert Trent Jones, Jr.-designed, Shoreline municipal course in Mountain View (Shoreline At Mountain View 1987, 5).

Shoreline Golf Links

Open since 1983 (Lyles 1988c), Shoreline Golf Links is part of a 650-plus acre regional recreation and wildlife area adjacent to San Francisco Bay that is owned and operated by the City of Mountain View (Volunteer rangers n.d., 2).

The Golf Links's architect, Robert Trent Jones, Jr., believes a golf course is "a work of art" and should be created so it "blends with the environment" (Cornish and Whitten 1981, 191). As Shoreline is next to several water areas, four ponds were designed into the eighteen-hole, par seventy-two course (Shoreline At Mountain View 1987, 5).

In 1988, Jones assisted Shoreline management in the development of some aesthetic changes. New vegetation was incorporated into the Course to give it more of a linksland look. This included the planting of tall fescue grasses in nonplay areas. These changes helped the young course to be included in "California Golf's Top Twenty-five Public Courses" (Summer '88 at Shoreline [1988], 2).

The Golf Course itself is made up of fine-blade grasses. The fairways and roughs are Kentucky bluegrass (*Poa pratensis*), while the greens and tees are creeping bent (*Agrostis palustris*) (Vaught 1988a).

A true championship course, Shoreline hosted the Mountain View Open (a Golden State Players professional fifty-four-hole event) for the first time in 1987 (Summer '88 at Shoreline [1988], 2).

Water Areas

The Golf Course abuts fifty-acre Shoreline Lake (hereafter also referred to as "the Lake") on the Course's northwestern border. A pumping system continually exchanges the Lake's waters with those of the Bay (Shoreline At Mountain View 1987, 6), while maintaining the saltwater impoundment at a constant level. The bottom of the manmade lake drops off quickly to a depth of twenty to twenty-two feet (Trulio 1995a).

Shoreline Lake's lack of tidal action keeps its vegetation at a low level (Trulio 1991b). Normally, only small amounts of algae are found growing in the Lake. The Lake's non-avian animal life consists of fish as well as several types of gastropods including oysters and Baltic clams (*Malcoma baltica*) (Trulio 1991c).

The Course's freshwater ponds have a combined surface area of sixteen acres (Rafalski 1991a). Their water levels are kept fairly constant, dropping only about a foot in the summer (Bakanoff 1991) from their

normal ten- to fifteen-foot depth (Bakanoff 1995b). When necessary, either fresh or tertiary water is added to the manmade ponds to keep them full (Trulio 1995a).

Some shoreline cattails (*Typha* spp.) grow in the Parks' ponds (McMillan 1991). But since the ponds drop off quickly (Trulio 1995a), other emergents are virtually nonexistent. Tall clusters of pampas grass (*Cortaderia sellona*) grow along the banks of all the freshwater ponds, while algae, as well as small amounts of other aquatic vegetation, are present at or below the surface of the ponds' shallow shores.

Non-avian animal life in the Course's ponds is composed of small fish (Trulio 1991c) and an occasional muskrat (*Ondatra zibethica*).

The Problem

San Francisco Bay wetlands are visited by literally millions of migratory waterfowl each year (Oliver 1989, 1; Steiner 1989). Even during off-peak periods, around 800,000 birds use the Bay Area's marshes (Steiner 1989). Thousands of these birds stop off at Shoreline Park (Shoreline At Mountain View 1987, 4).

Unfortunately, California's coastal bays have suffered the same fate as the rest of the state's water areas. The Humboldt, Newport, and San Francisco Bays have lost most of their wetlands (San Francisco Bay National Wildlife Refuge n.d., 2). In a little more than a century, the San

Francisco Bay's wetland shrank from 200,000 to 25,000 acres (Schurman 1993, 1), while the bay itself lost one-third of its original size (San Francisco Bay National Wildlife Refuge n.d., 2).

Development of much of the San Francisco Bay's wetlands has pushed the American coot onto manmade water areas. A golf course with, or adjacent to, a water area, makes an ideal coot winter habitat (Gullion 1989).

Mountain View is bordered on the east by the Moffett Field Naval Air Station and the City of Sunnyvale, California. Both communities have golf courses southeast of Shoreline's, and both had coot problems until the Shoreline Golf Links opened. Moffett Field Golf Course Superintendent Lee Henderson believes Shoreline is a more attractive site for the coots since it is closer to the San Francisco Bay than Moffett or the Sunnyvale Municipal Golf Course (Katches 1986, 12[A]).

According to Shoreline Manager Glenn Lyles (1988c), the Course has annually attracted several thousand coots since it opened in 1983. Shoreline Golf Links Superintendent Dave Vaught (1988a) observed up to four thousand mud hens on or near the Golf Course every September through March (migratory season).

The coots graze constantly near water in large herds of five hundred or more. Here they dine on the tender grasses of the greens, tees, and

fairways (Lyles 1988c) where their numerous random droppings fertilize the turf and cause uneven growth (Lyles 1988a).

The heaviest concentrations of the birds occur along holes number ten and eleven where they harm both greens as well as the tenth fairway (fig. 4) (Collins 1988).

The mud hens once made it necessary to reseed two to three acres of turf (Lyles 1988a). Their impact is most detrimental to greens, where their regular droppings resemble soil plugs after a turf aeration. The Golf Course maintenance crew must mow and clean these greens twice daily to keep them playable (Vaught 1988a).

It is estimated the coots annually cause twenty thousand dollars in damage to the turf while "inconveniencing and disrupting golf" on the Golf Links (Lyles 1988d).

Previous Management Action

The Shoreline maintenance crew tried several methods to discourage the coots from feeding on their golf course. These techniques included the use of dogs, fencing, flagging, and prey decoys to "guard" the turf (Lyles 1988c); Tabasco® sauce and sticky gels applied on or near the turf (Vaught 1988a); alternate feeding sites (Bakanoff 1988), firing blanks and pyrotechnics (Katches 1986, 1[A]), and even shooting up to several thousand mud hens annually (Lyles 1988c), all with little or no success.

The Research Goal

During the 1984-88 migratory seasons, the City of Mountain View attempted to solve its coot problem by shooting its depredating mud hens (Lyles 1988b). This lethal management action was criticized by the local humane society, the press, and the general public (Lyles 1988a).

Sensitive to any negative publicity and without an effective nonlethal method of mitigating its coot troubles, the City of Mountain View approached San Jose State University's Department of Geography and Environmental Studies for assistance.

The City's goal was to reduce the number of coots at its facility to a more manageable target of four hundred mud hens (Lyles 1988c). This was to be accomplished by developing at least one nonlethal solution to Shoreline Golf Links's coot problem (Lyles 1988d).

After consulting with management from the City of Mountain View, Shoreline Golf Links, and the Humane Society of Santa Clara Valley, it was decided any coot solution must meet the following criteria:

1. Be acceptable to the general public and avoid negative publicity
2. Not adversely impact the environment, especially since Shoreline is part of the San Francisco Bay ecosystem
3. Not adversely affect other wildlife at Shoreline
4. Not be in violation of any federal, state, or local law

5. Not have an impact on Shoreline's golfers that would negatively affect business
6. Not have a negative impact on Shoreline Lake's recreational activities
7. Minimally disrupt maintenance practices
8. Not be too expensive to implement
9. Not be so successful that it shifts the coot problem to a new area at Shoreline
10. Be approved by the Humane Society of Santa Clara Valley, the Shoreline Golf Links, and the City of Mountain View

Shortly before the author's study began, five more conditions were added to the above list.

1. Not attract more coots to Shoreline
2. Not be of only temporary benefit
3. Not be impractical to implement on a large facility like Shoreline
4. Not be too labor intensive for results received
5. Not be aesthetically unacceptable

Questions to Be Answered

The following are some of the questions to be answered during this research project:

1. Is there a coot expert who might be consulted about Shoreline's coot problem?

2. Is there a food coots prefer to grass?
3. Do coots prefer a particular type of grass?
4. Do coots eat constantly or do they have an eating pattern?
5. Do coots drink fresh or salt water?
6. Would salinating Shoreline's ponds affect the coot?
7. What type of habitat do coots prefer?
8. What is the coot's role in the ecosystem?
9. Would the San Francisco Bay's ecology be affected if the coot was eliminated?
10. Is the coot displacing other species at the Park, and if so, should Shoreline resume shooting its mud hens?
11. Have any studies been done on pigeons (*Columba livia*) or other species that might be of help in solving Shoreline's coot problem?
12. Do other golf courses have coot problems?
13. What management approaches have others used previously, and with what results?
14. How intelligent is the coot?
15. Can the coot be trained to associate electric golf carts with danger?
16. Can the coot be trained to eat in specific areas where its defecating would be of benefit?
17. How does the coot get along with other species?
18. What is the coot's role in the food chain?

19. How acute are the coot's senses?
20. Will coots be bothered by noises of variable pitch or intensity?
21. Where do coots go and what do they do at night?
22. What are the coot's distinctive characteristics?
23. Are there any new wildlife management tools?

Research Methodology

After an exhaustive evaluation process conducted during the "study phase" of this project, many potential answers to Shoreline's coot crisis were eliminated (see "Methods Used in This Study" section in "Introduction").

More literature and expert opinions were then sought to help formulate the selected control methods within the constraints of the study area. When possible, the individuals who wrote on these topics were contacted.

Next, preliminary tests were designed and conducted for several selected control techniques (see "Shoreline Tests" chapter). As requested by the City of Mountain View (Lyles 1988e), the City, the Shoreline Golf Links, and the Humane Society of Santa Clara Valley were all contacted for their approval before the author conducted any experiment that was either of a sensitive nature or might impact other recreational activities within the Park.

Finally, a comprehensive coot count was held during the entire 1990-91 migratory season in order to establish baseline data that could be used to help determine the effectiveness of any Shoreline long-term coot control studies.¹

Results of each selected control technique tested at the study site and recommendations regarding its feasibility at Shoreline are presented.

Even though some tested coot control techniques may be rejected for use at Shoreline, the same technique may be practical at other sites where circumstances may be different. Conversely, it is possible a technique deemed appropriate for Shoreline may not be practical at other sites for various reasons.

¹A complete record and analysis of this comprehensive count is in the "Shoreline Coot Census" chapter.

CHAPTER III

COOT ECOLOGY

Taxonomy

The American coot is an aquatic member of the Order Gruiformes. Birds belonging to this order are all long-legged wading birds (Robbins, Bruun, and Zim 1966, 100).

Three families of Gruiformes can be found in North America: (1) Gruidae, (2) Aramidae, and (3) Rallidae (Robbins, Bruun, and Zim 1966, 100).

Cranes make up the Gruidae family, while the Aramidae are composed of limpkins. Rallidae are split into two subfamilies, with the gallinules and rails in one subfamily and coots in the other (Robbins, Bruun, and Zim 1966, 100).

Worldwide, there are 132 species of Rallidae (Peterson 1980, 112). Of these 132 species, 9 are *Fulica* (coots) (Howard and Moore 1991, 64-65), with the *F. americana* the only coot common to North America (Fitzner and Schrickhise 1979, 9).

There are also five subspecies of the *Fulica americana*. Four of these subspecies are found just in South America or Hawaii, while the

Fulica americana americana (the bird studied in this paper) is the only subspecies living in North America (Howard and Moore 1991, 65).

Just five species of Rallidae can be seen at Shoreline. They include the American coot, clapper rail (*Rallus longirostris*), common moorhen or common gallinule (*Gallinula chloropus*), sora rail (*Porzana carolina*), and Virginia rail (*Rallus limicola*) (Newberry 1986a, 4).

Description

The American coot is the most ducklike of the Rallidae in North America (Jones 1940, 1).

Also known as the "mud hen," "poule d'eau," "whitebill" (Kiel and Hawkins 1953, 312), and "blue peter" (Rand 1956, 167), coots, both young and old, are monomorphic. Sometimes, during breeding season, the adult female will have "a conspicuous yellow margin around the leading edge of the frontal shield" (Fitzner and Schrickhise 1979, 11).

It is possible to tell the sexes apart by their calls. The female emits low-pitched nasal tones, while the male has a slightly higher-pitched nasalless voice. The mud hen's guttural calls sound like "puhlk, poonk, kuh-huh-kuk, cack-ka, puhk-uh, cou-ah, and punk-cow-ah" (Fredrickson et al. 1977, 125).

A mature male normally weighs twenty-six ounces, while the female mud hen averages nineteen ounces (Fredrickson et al. 1977, 124).

The male mud hen has an average length of twelve inches and wingspan of twenty-five inches (Robbins, Bruun, and Zim 1966, 105).

The coot's soft plumage stays the same year-round. It undergoes annual full prebasic and wing molts after breeding. About forty-five days prior to molting, the mud hen sheds its leg scutes (Fredrickson et al. 1977, 124).

The adult coot's black body contrasts with its white, chickenlike bill (Jones 1940, 1) and red iris. Two chestnut spots near the apex of its mandibles complement the coot's brown frontal shield (Fitzner and Schrickhise 1979, 9). The mud hen has two white patches under its short tail (Peterson 1980, 64) as well as some white tips on its wings (Peterson 1980, 65). The coot's legs and three-lobed toes are green, while the tarsi on more mature birds can be "yellow lime to scarlet orange" (Fredrickson et al. 1977, 124). It also has clawlike nails and a prominent rear toe (Brown 1973, 2-3).

It is easy to tell coots and ducks apart, as coots have downward-tipped bills, thick necks, rounded backs, and bob their heads back and forth in coordination with their paddling feet when they swim (Rand 1956, 167).

The juvenile coot looks much like the adult except its iris is brown, while its plumage, legs, and feet have more of a grayish cast. The immature's frontal shield is also smaller (Fredrickson et al. 1977, 124) and

duller (Peterson 1980, 64), and does not fully develop until the late summer of its second year (Jones 1940, 1).

The coot chick is a downy blackish gray with white underparts (Fredrickson et al. 1977, 125) and hairlike orange-red head and shoulder feathers (Peterson 1980, 64). The lores are red, while the bill is red with a black tip (Fredrickson et al. 1977, 125).

The coot's smooth, buff-colored eggs are covered with small, dark-brown speckles (Jones 1940, 2).

Life Cycle

Habitat

The coot breeds on any wetland with sufficient water and cover (Allen 1985, 2). Its breeding range generally includes the Bahamas, Cuba, Belize, Guatemala, Mexico, the contiguous U.S., and all of Canada about two hundred miles north of the U.S. border. Coots also breed in nearly all of Alberta and Saskatchewan, central Manitoba, eastern British Columbia, and the Northwest Territory's southern Mackenzie district within three degrees of the Arctic Circle (Jones 1940, 3).

Optimal nest densities occur on inland, deep, freshwater marshes in south-central Canada and the north-central U.S., while at the other extreme, coots have been known to breed on eastern Pacific islands, where they seemed unhealthy with small broods (Fredrickson et al. 1977, 125).

Coots migrating through Oklahoma select areas with ample submergent aquatic vegetation as temporary homes. They also make use of open, deepwater areas "for loafing and escape cover" (Allen 1985, 5).

The coot's winter range in the U.S. roughly includes the Pacific states, southwestern Idaho, western Nevada, northwestern and southern Arizona, southern New Mexico, Texas, southeastern Oklahoma, Arkansas, Louisiana, all states south of the Ohio River and Pennsylvania, and the entire Eastern seaboard. The mud hen also winters in Mexico, Central America west of the Panama Canal Zone, Cuba, and the Bahamas (Jones 1940, 3). Here it stays until its food is depleted, or until the advancing cold pushes it farther south (Allen 1985, 1).

During the U.S. winter, large groups of coots congregate on both fresh and salt water in California, Florida, Louisiana, and Texas (Allen 1985, 1), especially along coastal wetlands (Fredrickson et al. 1977, 125). When available, over-wintering coots seem to prefer areas "with abundant submergent vegetation, and sparse emergent vegetation adjacent to expansive, deep, open-water areas" (Allen 1985, 5). Here the mud hens thrive on marsh and aquatic vegetation (Jones 1940, 12).

But where wetlands have been reclaimed, coots must turn to rice (*Orzya sativa*), barley (*Hordeum* spp.), clover (*Trifolium* spp.), alfalfa (*Medicago sativa*), pasturage (Gullion 1950, 173), golf courses, lawns, and vegetable croplands to survive (Fredrickson et al. 1977, 125).

Migration

Waterfowl generally "winter where their ancestors did" and "home to where they learned to fly" (Heusmann 1987, 20). Although scientists have much to learn about the coot's migratory patterns (Fredrickson et al. 1977, 123-24), it is known that mud hens annually migrate from their northern breeding grounds, south, to warmer locales (Robbins, Bruun, and Zim 1966, 104), and "at least some wintering coots" return to the same areas they occupied the previous winter (Gullion 1950, 47-48).

Mud hen males begin flocking together in Canada in preparation for their annual southern migration by mid-July (Fredrickson et al. 1977, 126). Although Colorado arrivals have been reported as early as July and August (Gorenzel, Ryder, and Braun 1981, 118), most migration begins in mid-September and peaks in early October (Fredrickson et al. 1977, 126). Often coots will wait until ice forms on their northern lakes before beginning their southern journey (Jones 1940, 2).

One late October, around sunset, mud hens were observed individually and in pairs, leaving a large group from the center of a Minnesota marsh. They began slowly spiraling upward to around three hundred feet before eventually disappearing from sight. The scene resembled "a large flock of buzzing mosquitoes" (Schladweiler 1986, 50).

Adult coots arrive in Colorado several weeks before immatures (Gorenzel, Ryder, and Braun 1981, 118). Adult females complete their

southern migration by around 1 November (Eddleman, Knopf, and Patterson 1985, 241) even though females travel farther south than male mud hens (Fitzner and Schrickhise 1979, 11). Adult males and juveniles continue to migrate into December (Eddleman, Knopf, and Patterson 1985, 241) when winter concentrations peak (Fredrickson et al. 1977, 126).

Adult coots begin their northern journey before the juveniles in the spring (Eddleman, Knopf, and Patterson 1985, 241), frequently arriving at still partially-frozen breeding grounds (Jones 1940, 2).

One April evening, concentrations of several hundred restless California coots were observed huddling together at Humboldt Bay before individual coots rose into the wind, circled upward a few hundred feet, and "flew off as scattered single birds" (Yocum, Rogiatto, and Eshleman 1978, 302). By 1 May, most mud hens have reached the Canadian border (Fredrickson et al. 1977, 126).

Since coots are nocturnal migrants, their nighttime movements have not yet been recorded (Yocum, Rogiatto, and Eshelman 1978, 302). Collisions with buildings and towers, and reports of vocalizations during migration, suggest coots migrate at low altitudes (Fredrickson et al. 1977, 126).

But some mud hens fly at higher elevations as evidenced by a reported coot-plane collision at forty-five hundred feet (Fredrickson et al. 1977, 126). Banding records also suggest the birds travel over several large

mountain ranges to reach their northern California wintering grounds (Yocum, Rogiatto, and Eshelman 1978, 302).

Coots make use of a majority of U.S. water areas when they migrate (Fredrickson et al. 1977, 135). Most mud hens apparently end their nocturnal trips on the closest water area or wherever else they can at dawn (Fredrickson et al. 1977, 125).

Mud hen migration appears to be triggered by a change in the weather. One October at dusk, Schladweiler (1986, 50) observed about 95 percent of the coots leave a Minnesota marsh hours before a snowstorm.

Eddleman, Patterson, and Knopf (1985, 470) discovered mud hens migrate nocturnally behind cold fronts in the fall. This is in contrast with other waterfowl that "migrate ahead of cold fronts and often diurnally." By choosing to migrate when they do, coots may be waiting for an assist from rising thermals (Lester 1995).

Ward (1953, 322) also noted "in either season, a bright moon appears to be one of the prime requisites for heavy coot movement."

Fredrickson et al. (1977, 143) observed that coot management could be improved if more information was available on mud hen "migration patterns and differential migration."

Reproduction

Pair formation involves various courtship displays, but as yet, is not well understood. Territories are established before nesting and defended until the fledgling stage (Fredrickson et al. 1977, 126) (see "Behavior" section later in this chapter).

Mud hen populations vary according to water, weather, and marsh conditions (Fredrickson et al. 1977, 128, 131). Ideally, coots nest in semi-permanently flooded, freshwater wetlands. This environment provides fairly shallow, but stable water levels, which means adequate amounts of plant and invertebrate foods through the fledgling period. This wetland type also has ample vegetative cover to protect the nest from predation, wind, and waves, as well as minimal competition with fish for invertebrates (Allen 1985, 2-4, 11).

In Colorado, coots have not shown a nesting preference toward any specific plant species. Instead, they chose sites that were in standing water with vegetation sturdy enough to support a nest and provide cover (Allen 1985, 3-4). By contrast, California coots have been known to nest in rice, and even cotton fields (Fredrickson et al. 1977, 131). Saskatchewan mud hens appear to prefer emergent vegetation in ponds that were not likely to dry up before the fledgling period (Sutherland and Maher 1987, 804). Another Colorado study found 99.7 percent of 354 coot nests were constructed in cattails or tule bulrushes (*Scirpus actus*) (Gorenzel, Ryder,

and Braun 1982, 59). In fact, hardy "persistent, emergent herbaceous vegetation like cattails and bulrushes" (*Scirpus* spp.) give optimal coot cover and nest-building material (Allen 1985, 10).

The coot pair takes turns collecting nest material and nest building. Typically, one coot builds the nest, while its mate gathers material. Once completed, the nest will be used for mating, nesting, and brood rearing (Fredrickson et al. 1977, 126).

The nest is a firmly woven basket, neatly lined with bits of various smooth material, while leaving just enough room for the eggs. Normally, it is securely attached to growing vegetation several inches above the water and built from whatever materials are available (Fitzner and Schrickhise 1979, 13).

A Colorado study found most coot nests were hidden from the top and "at least three sides" while above water of about twenty inches in depth (Allen 1985, 3). A different Colorado study observed that "nest site vegetation height, concealment, water depth, and distance to open water" varied depending on local conditions (Gorenzel, Ryder, and Braun 1982, 59). Allen (1985, 5) noted mud hens sometimes build nests on islands or on muskrat structures.

The most successful nests are those built in "islands of emergent vegetation" as opposed to shoreline strips of emergent vegetation (Allen 1985, 5). Spatial needs dictate that the coot nests in water areas of at least

an acre in size (Gullion 1950, 159). Regardless, mud hens seldom build nests within six feet of the shoreline (Sutherland 1987, 602), choosing instead, sites as far as possible from shore in large emergent zones (Sutherland and Maher 1987, 804).

Gorenzel, Ryder, and Braun (1982, 59) found successful coot nests were as high as 13.4 per acre in Colorado. Nesting densities like these have occurred under ideal conditions where "emergent vegetation and open water were highly interspersed and present at a 50:50 ratio" with "immediate access to open water." A nest in this environment allows the mud hen access to: (1) food, (2) territorial defense, and (3) the nest via water (Allen 1985, 4-5).

Mortality

Nearly a million coots were reported killed annually by U.S. hunters from 1952-72 (Fredrickson et al. 1977, 140), and it is possible at least that many were destroyed each year for various reasons (see "Population Reduction" chapter).

The percentage of North America's coots shot each year is not known (Fredrickson et al. 1977, 141), but it is safe to say shooting is a significant factor in coot mortality.

Lead poisoning, from consuming lead shot, most likely is not a problem for the coot. Unlike ducks, coots' chickenlike bills do not allow

them to sift the soft mud at the bottom when they dive. This probably explains why less than 2 percent of the 792 coot stomachs Jones (1940, 11) examined contained lead shot. When lead shot was found, it was normally just one pellet.

Coots commonly migrate into still-icy breeding grounds in the spring and wait until ice forms on their northern homes before migrating south in the fall (Jones 1940, 2). Therefore, it should be no surprise that many mud hens die of starvation after "snow and ice storms" (Fredrickson et al. 1977, 130).

Since coots migrate at night (Schladweiler 1986, 49), they often crash into objects like "wires, fences, power lines, towers, and buildings" (Fredrickson et al. 1977, 130). Migrating mud hens also have been known to collide with airplanes (Fredrickson et al. 1977, 126).

Coots rarely build nests on land (Allen 1985, 5). Therefore, trampling by livestock, and collisions with farm machinery (Kutilek 1989d) are uncommon occurrences.

Coots nesting in Wisconsin shoreline vegetation were less successful than mud hens nesting in areas surrounded by water. This was due to diminishing water levels during the breeding season, and mammalian predation, especially by raccoons (*Procyon lotor*) (Allen 1985, 5).

Avian predators, along with raccoons, were the suspected cause of nest failures and egg loss in Colorado. Birds believed responsible were

black-billed magpies (*Pica pica*), black-crowned night herons (*Nycticorax nycticorax*), and common crows (*Corvus brachyrhynchos*) (Gorenzel, Ryder, and Braun 1982, 61).

Coots do fall prey to peregrine falcons (*Falco peregrinus*), horned owls (*Bubo virginianus*) (Gullion 1950, 177), bald eagles (*Haliaeetus leucocephalus*) (Grubb 1977, 1066), golden eagles (*Aquila chrysaetos*), northern harriers (*Circus cyaneus*), prairie falcons (*Falco mexicanus*), and red-tailed hawks (*Buteo jamaicensis*) (Priest 1991), although predation generally is not thought to be a problem with large organisms (Kutilek 1989a).

Mud hens are hosts to several varieties of parasites, but these "leeches" generally are not considered "an obvious cause of mortality" (Fredrickson et al. 1977, 129).

Coots are extremely vulnerable to a number of infectious and noninfectious diseases (see "Disease and Parasitism" section in "Population Reduction").

Behavior

The coot is a diurnally active bird, although it may sometimes feed on "calm moonlit nights" (Gullion 1950, 161).

During eleven days in April and May, Gullion (1950, 160) noticed Oakland, California's Lake Temescal coots all ceased their activity by

approximately twenty-five minutes after sunset. The first coot vocalization in the morning occurred an average seventy-four minutes before sunrise, while initial mud hen activity began around twenty-six minutes before sunrise.

On four separate observations from 30 April to 4 July, Gullion (1950, 161) also noted that some coots used the same roosting areas at night.

Coots seem to always be in motion, whether they are feeding, diving, swimming, or squabbling with a neighbor. When repositioning themselves on a pond, they often "skitter across the surface, making a pattering noise with their feet" while flapping their wings (Rand 1956, 167).

The coot has two distinct personalities: (1) a gregarious "wintering behavior" exhibited by migrants, and (2) a strong "territorial behavior" (Allen 1985, 1; Gullion 1989).

Wintering Behavior

It is not unusual to see large flocks of sociable, wintering coots in open water or even feeding near water (Gullion 1989; Jones 1940, 2; Rand 1956, 167; Van Way 1986, 292).

Coots are not often seen flying during the day (Fitzner and Schrickhise 1979, 11), even though they are good fliers. When alarmed, they normally swim from danger rather than fly (Jones 1940, 2). Often, all

mud hens in the vicinity swim together into a tight huddle for protection (Grubb 1977, 1065) in open water (Rand 1956, 167).

Approximately 5 percent of California's wintering coots are year-round residents (Fredrickson et al. 1977, 133). These resident birds, unlike the wintering flocks, defend a nesting territory throughout the year (Gullion 1950, 44).

Territorial Behavior

California has about twenty-five thousand pairs of coots who defend breeding territory (Fredrickson et al. 1977, 129, 133). "Immediately following the hatching period," these pairs will attack "most vertebrates, coot-sized or smaller," that venture inside their territorial waters (Gullion 1950, 71). However, if people disturb a coot family, the entire family will hide in emergent vegetation "and frequently remain hidden despite various efforts to dislodge them" (Kiel and Hawkins 1953, 320).

The coot saves its most intense interactions for other mud hens (Fredrickson et al. 1977, 126). Before a territorial boundary is violated by another coot, the resident mud hen will approach the intruder and "patrol" its border. If the intruder has already violated its territory, the resident will chase the retreating intruder to its border (Gullion 1950, 67-68).

But if force is required to protect its domain, fighting may continue well beyond the territorial boundary, which does not include adjacent

shores. Birds are seldom chased if they go on shore; and if they are, it is only for a few feet (Gullion 1950, 67-68).

In early March, California's resident mud hens begin increasing their territories to meet impending brood-raising needs (Gullion 1950, 49, 52). Nonresident and yearling coots without nesting areas often battle resident mud hens for territory. If the resident coots are successful in their defense, their adversaries will leave the lake (Gullion 1950, 71).

By early June, coot pairs are busy raising chicks and protecting their territories (Gullion 1950, 52) which average around one acre in the Golden State (Gullion 1950, 156-57). But as their offspring begin to obtain winter feathers, they are evicted by their parents (Gullion 1950, 71-72).

Once their offspring have left, resident coots gradually defend less territory, until around mid-October when their domain shrinks to a "winter core area" centered near the previous spring's nesting site (Gullion 1950, 44, 72). This reduced-defended territory, "about one-fifth to one-half" the size of their breeding territory, allows new and migrant pairs the opportunity to establish additional territorial core areas in between resident pairs; at least until early March (Gullion 1950, 44-45, 49, 69).

Gullion (1950, 61) believes California's resident coots defend core areas year-round to maintain their pair bond, as territorial behavior soon disappears when a bond is broken.

Population Dynamics

It is thought that the monogamous mud hen (Gullion 1950, 200) first breeds at age one. The female coot lays a single egg each day (Crawford 1980, 184; Fredrickson et al. 1977, 126) until the clutch reaches its normal size of eight to ten eggs (Fitzner and Schrickhise 1979, 20; Fredrickson et al. 1977, 126; Gorenzel, Ryder, and Braun 1982, 61; Hill 1988, 329; Kiel and Hawkins 1953, 320; Rand 1956, 167).

Combined data from seven different studies in the U.S. and Canada, over a forty-year period, found an impressive 87 percent of 1,730 coot nests were successful (Fitzner and Schrickhise 1979, 20; Fredrickson et al. 1977, 126; Gorenzel, Ryder, and Braun 1982, 59), while successful nests in Iowa, Utah, and Manitoba hatched a high 93 percent of their combined 5,806 eggs (Fredrickson et al. 1977, 128; Kiel and Hawkins 1953, 320).

Researchers also discovered nesting success, hatching success, and clutch size decreased at higher altitudes, while clutch size also declined "at all elevations as the season progressed" (Gorenzel, Ryder, and Braun 1982, 59).

If a pair's first nest fails, they will normally renest (Fredrickson et al. 1977, 127-28), sometimes as many as three times in one season (Hill 1988, 330). Nests in Colorado are started between mid-April and mid-July (Gorenzel, Ryder, and Braun 1982, 59), while nests during an Iowa study were initiated from 8 May to 28 June (Crawford 1980, 184). Eggs in

Colorado normally hatched between mid-May and early-August (Gorenzel, Ryder, and Braun 1982, 59).

Coots sometimes also rear two separate broods in one season. A Utah study found 13 percent of nesting females raised second broods during two different nesting seasons (Fredrickson et al. 1977, 128), while no second broods were found in an Iowa study (Crawford 1980, 184).

Younger coots nested statistically later than older mud hens in Iowa. This may have been the result of the dominant adults securing most of the prime nesting areas. The younger mud hens also hatched smaller eggs from smaller clutches while fledgling fewer and lighter birds (Crawford 1980, 183-88). A Colorado study confirmed that older coots laid more eggs than younger mud hens (Gorenzel, Ryder, and Braun 1982, 63).

Hill (1988, 329) noted it is usually possible to predict a bird's egg size and clutch size by its physical size and family group. But coots as a whole lay smaller eggs and have larger clutches than would be expected for Rallidae.

One can normally also predict a bird's incubation time by the species' body mass, which in the coots' case, should be twenty-seven days (Hill 1988, 330). Since average coot incubation time is around twenty-three days (Crawford 1980, 184; Fitzner and Schrickhise 1979, 13; Fredrickson et al. 1977, 126; Hill 1988, 330; Jones 1940, 2; Rand 1956, 167), Hill (1988, 330) theorizes that because the mud hen breeds in unpredictable conditions,

it has evolved smaller eggs that require a shorter incubation time. Smaller eggs may also "decrease the investment in each clutch," making renesting possible.

When conditions of high food abundance exist, the coot produces larger eggs instead of larger clutches (Hill 1988, 324). Larger eggs mean bigger chicks. Bigger chicks may not only have a better chance of surviving to fledgling, but may "always be at a competitive advantage" over coots from smaller eggs (Hill 1988, 330).

The pair shares incubation, brooding, and feeding duties. Within a few days after hatching, the precocial chicks leave the nest (Fredrickson et al. 1977, 128), swimming and diving "almost as well as their parents" (Jones 1940, 2). Adults feed the young until they are around three weeks old (Hill 1988, 325).

Young coots in Manitoba leave their home territories at about fifty days of age by walking in small flocks, and begin flying in California at around seventy-five days (Fredrickson et al. 1977, 129).

Continental Coot Population Status

In the late 1930s and 1940s, many sportsmen and wildlife managers felt the coot was overabundant and advocated increasing shooting pressure on the mud hen (Ward 1953, 327). Coot hunting was so intense in local areas of the Mississippi Flyway, that a combined forty-two thousand coots

were bagged on one Illinois lake on opening day of the 1942 and 1943 hunting seasons (Kiel and Hawkins 1953, 315).

Manitoba's marshlands are thought to be a major breeding area for Mississippi Flyway coots. After several years of heavy hunting pressure, the Manitoba area experienced a sharp decline in its 1952 coot population. Waterfowl managers in the U.S. and Canada were unable to determine if hunting mortality, a drought, or possibly something else was responsible for the coot's decline (Kiel and Hawkins 1953, 319).

A 1957 study calculated the coot had an average annual 57 percent adult mortality rate in Wisconsin and Illinois (Burton 1959, 207), while in the early 1960s, Ryder found mud hens banded as immatures suffered a mean 83 percent annual mortality rate (Fredrickson et al. 1977, 137). If annual adult mortality averaged 57 percent, and assuming all coots bred once per season beginning at age one, annual "egg-to-first-breeding mortality" could not surpass 85 percent if the population were to remain stable. This would require the survival of 1.14 from each annual brood of eight (Burton 1959, 207).

A presumably stable fall coot population should include around "79 percent young, 12 percent one-year-olds, and the remaining 9 percent older birds" (Burton 1959, 204). Crawford (1980, 183) also estimated 57 percent of coots returning to Iowa in the spring were young birds.

Using Burton, Ryder, and Crawford's aforementioned data, and assuming an annual 57 percent mortality rate for all adult age groups, one can construct a table of the annual coot population cycle (table 1).

But Crawford (1980, 188) discovered only 58 percent of returning juveniles bred, compared to nearly 98 percent of all other coots at the Iowa site. Therefore (all other population variables being equal), if Crawford's low breeding figures are found to be the norm for one-year-olds, mud hen numbers would actually be decreasing.

Ryder also cautioned that "coots have an average annual mortality rate higher than that of dabbling ducks and as high as that of some declining waterfowl species" (Fredrickson et al. 1977, 137).

Wildlife species fall along a reproductive continuum with "rapid reproducers" at one extreme and "low reproducers" at the other. Rapid reproducers have a small body size, begin breeding at an early age, have a rapid dispersal rate, a high juvenile mortality rate, a short life span, and experience rapid population turnover and low population stability (Shaw 1985, 70-71).

The American coot would seem to easily fit the description of a rapid reproducer. Since a rapid reproducer has a high natural mortality rate, the mud hen should be able to sustain some hunting pressure without it affecting coot populations (Shaw 1985, 161). Most U.S. state waterfowl

TABLE 1
PROJECTED ANNUAL COOT POPULATION CYCLE

Sequential Events	Adult Coots	Young Coots	Total Coots	Comments
1. Pre-breeding	2.00	0.00	2.00	57% age 1, 24.5% age 2, 18.5% age 3+
2. Post-breeding	2.00	8.00	10.00	All pairs produce 8 young
3. Fall	.....	.....	.....	79% juvenile, 12% age 1, 9% age 2+
4. Post-wintering	0.86	1.14	2.00	57% juvenile, 24.5% age 1, 18.5% age 2+
5. Pre-breeding	2.00	0.00	2.00	Juveniles now adults, return to step 1

biologists agree, claiming harvests could actually be increased in their states (Fredrickson et al. 1977, 138).

So what is the continental coot population, and how many harvestable mud hens are there? Unfortunately, no one knows (Fredrickson et al. 1977, 138). Fredrickson et al. (1977, 123, 141-43) contend population studies are the top research need for the species since no state conducts an accurate breeding count, just "two of the contiguous forty-eight states" hold satisfactory wintering or migration counts, few states band coots, kill statistics are incomplete, and the USFWS's annual surveys are suspect.

A 1991 mid-winter waterfowl count by thirty-one biologists reported 251,000 coots in California.¹ The biologists, in thirteen airplanes, took sixty-nine hours to conduct the January count. One vehicle also took part, although it traveled only ten miles (Yparraguirre 1991).

Realistically, it is impossible to count all of California's waterfowl. Therefore, the mid-winter counts are actually "indexes" (a method of

¹Mid-winter counts are ideally conducted on one of the last few days before the end of duck hunting season in January when most waterfowl are concentrated on refuges. Therefore, an insignificant number of waterfowl are killed before hunting season ends that were included in the count. Because of bad weather, biologists sometimes are forced to take the mid-winter count after hunting season when waterfowl are more dispersed. Some species are easier to count by airplane than others for various reasons. Long-term trends in mid-winter counts are more valuable than individual counts (Yparraguirre 1993b).

estimating the actual population). In theory, harvest could actually exceed the mid-winter count (Yparraguirre 1991).²

In the 1950s, all waterfowl population trends for the continent were based on the USFWS mid-winter counts. But this information cannot be used in coot management as numerous problems exist with the data. During aerial counts, it is much easier to see a light-colored duck than a dark coot. Also, where coots and ducks are present in large numbers, "observers commonly devote most of their attention to the ducks and only roughly estimate the number of coots" (Kiel and Hawkins 1953, 317).

More recently, mid-winter inventories have been just one of five different censusing tools used to figure continental waterfowl populations (Yparraguirre 1993b). But this tool has still been of little value to coot managers. For example, during the mid-winter counts of 1983-87, coots in the waterfowl-rich Sacramento Valley of California were not even counted (Yparraguirre 1991).

Although other censusing tools are now more sophisticated, similar problems exist with them as well. An example can be found in routine breeding ground surveys. Even though coot habitat is similar to that of dabbling and diving ducks, their habits are very dissimilar (Fredrickson et

²The actual over-wintering coot population in California is thought to be twice the number recorded in a mid-winter count (Van Way 1986, 292).

al. 1977, 135). For instance, "young coots generally go to roost . . . earlier . . . than young ducks" (Kiel and Hawkins 1953, 320). Therefore, it is not known if waterfowl census methods produce very accurate mud hen population estimates. "An additional bias may be introduced by waterfowl biologists who are primarily interested in ducks, and whose collection of information on coots is incidental to their main interest" (Fredrickson et al. 1977, 135-36).

Allen (1985, 1) contends, "the size of the American coot population depends on the availability and quality of breeding habitat." Yet, there is almost no information available on coot breeding population trends (Kiel and Hawkins 1953, 313).

Fredrickson et al. (1977, 143) claims age ratio and age-related productivity studies are necessary to assist in interpreting breeding ground survey data, and annual productivity estimates would benefit if more was known about mud hen productivity in relation to wetland cycles.

Waterfowl managers do not know for certain what effect migration mortality and wintering ground mortality have on any waterfowl species, including a popular species like the mallard (*Anas platyrhynchos*) (Shaw 1985, 161). Kiel and Hawkins (1953, 317) add that "coot population trends for units the size of flyways or larger have not been determined satisfactorily."

California's wildlife faces its greatest threat today from growing habitat loss (Spotts 1989, 89). This decline is due to the ever-increasing human population in the state (Tharratt and Lollock 1989, 65).

The Pacific Flyway coot may be poised for a setback similar to the one that occurred a century ago in northeastern North America, when a growing human population adversely affected coot numbers (Fredrickson et al. 1977, 130). North American coot numbers are already "thought to be slowly declining due to their high annual average mortality rate" (Fredrickson et al. 1977, 137).

South Bay Coot Population Status

At about the same time the USFWS conducts its annual mid-winter counts, the National Audubon Society holds its numerous local Christmas bird counts.³

Audubon members gather at one of over one thousand separate "circles" throughout the country, all of which are fifteen miles in diameter or smaller (Dicandio 1995). Here, at around the end of each year, they count all birds within their respective areas for an entire day. Although these counts are not conducted scientifically, comparing results over a

³All uncited material in this subsection derived from the National Audubon Society's Christmas counts was taken from the fourth issues of each volume of American Birds from 1981-91. Bibliographical information for these eleven issues is in "List of References" under Drennan, S. D., Heilbrun, L. D., LeBaron, G. S., Leukering, T., and Rubega, M. A.

period of several years may help to uncover local avian population trends (Bousman 1995a).

Included below are the results of the three counts held on the west side of southern San Francisco Bay (table 2). These California counts, which include the Crystal Springs, Palo Alto, and San Jose circles, encompass most of San Mateo County south from the city of Millbrae, to Milpitas in Santa Clara County (fig. 4). Shoreline Park is entirely within the Palo Alto circle. The Crystal Springs counting area is centered about 16½ miles west by north of Shoreline, while the middle of the San Jose circle is approximately 11 miles east by south of Shoreline.

The Santa Clara Valley Audubon Society has been conducting biweekly bird counts at Shoreline's Charleston Slough (260 yards west by north of Shoreline Lake's northwestern border) since October 1980 (Bousman 1995a). Results of the Charleston count chronologically closest to that year's Palo Alto Christmas count are also listed in table 2 (Bousman 1995b, 1-2).

Possible population trends. From observing table 2, it would appear the total number of local coots is down since the 1985-86 migratory season. The average combined number of coots recorded at the three local Christmas counts dropped from 15,767 in 1980-86, to 10,354 for 1986-91 (excluding the incomplete 1988-89 count).

TABLE 2

SOUTH BAY COOT POPULATION TRENDS, 1980-91

Migratory Season	San Jose (SJ)	Crystal Springs (CS)	Palo Alto (PA)	Total (SJ, CS, PA)	Charles-ton Slough	Calif. (CA) Mid-winter	Shoreline Notes
80-81	2,876	3,889	10,175	16,940	1,989 ^a	392,000	CA duck nos. beg. decade-long dec.
81-82	3,694	1,809	4,331	9,834	421	257,000	Last "pre-Golf Course habitat" count
82-83	3,385	1,551	9,971	14,907	1,020 ^a	.....	Golf Course turf, water in by end of '82
83-84	2,654	2,653	16,617	21,924	1,880	.....	Park, Golf Course opened summer '83
84-85	4,706	2,015	8,141	14,862	320	.....	Some Golf Course coots shot
85-86	2,385	2,283	11,466	16,134	365	.....	Some Golf Course coots shot
86-87	3,886	2,179	4,975	11,040	580	.....	Some Golf Course coots shot

TABLE 2
SOUTH BAY COOT POPULATION TRENDS, 1980-91 (continued)

Migratory Season	San Jose (SJ)	Crystal Springs (CS)	Palo Alto (PA)	Total (SJ, CS, PA)	Charleston Slough	Calif. (CA) Mid-winter	Shoreline Notes
87-88	5,485	1,883	3,478	10,846	835 ^a	.....	Some Golf Course coots shot
88-89	4,109	.....	3,987	.....	287 ^a	178,000	CA duck nos. flat/slightly incr. thru '91
89-90	8,166	1,892	2,286	12,344	200 ^b	207,000	Slough coots estimated thru '91
90-91	3,104	1,864	2,218	7,186	200 ^b	251,000	3,354 coots at Golf Course

Notes: All San Jose, Crystal Springs, Palo Alto, and Charleston Slough figures were recorded between 8 December and 30 December. None of the Palo Alto and Charleston Slough counts were taken more than 11 days apart with an average of 5.2 days between counts. The most number of days between a Palo Alto and Crystal Springs count was 10, with the average at 4.0 days. The most number of days between a Palo Alto and San Jose count was 11, with the average at 3.0 days. The most number of days between a Crystal Springs and San Jose count was 7, with the average at 2.8 days. According to Yparraguirre (1991), the

California mid-winter count is annually conducted at about the same time, which is (weather permitting) a few days before the end of duck hunting season. For example, the final day of the 1990-91 duck hunting season in most of the state was 5 January (Bontadelli 1990). Therefore, most mid-winter counts are likely held within a few days of 1 January. California mid-winter count figures were supplied by Yparraguirre (1991). Data not provided by sources are represented by ellipsis points. References for "Shoreline Notes" (listed by migratory seasons) are 80-81: Yparraguirre (1991), 81-83: Bakanoff (1995a), 83-84 Park: Shoreline At Mountain View (1987, 2), 83-84 Golf Course: Lyles (1988c), 84-88: Lyles (1988b), 88-89: Yparraguirre (1991), 89-90: Bousman (1995a), 90-91: The Palo Alto Christmas count took place the day before 3,354 coots were counted by the author at Shoreline Golf Links.

^aPeak number of Charleston Slough coots recorded during respective migratory season.

^bEstimated.

According to state mid-winter counts, California' duck numbers dropped in the 1980s. Statewide duck numbers from the 1954-80 migratory seasons annually averaged around 5.1 million birds. During the 1980-91 migratory seasons, the Golden State averaged only 3.6 million ducks, a decline of 29 percent (Yparraguirre 1991).

Drought conditions that existed on waterfowl breeding grounds in the prairie states and Canada were thought to be the cause of this decline. Most of California's ducks come from Alberta, Canada (Yparraguirre 1991).

Yocum, Rogiatto, and Eshelman (1978, 302) found that many overwintering coots in northwestern California bred in Alberta and British Columbia, Canada.

If one compares the number of California coots and ducks at the beginning of the 1980s (1980-82) to those counted around a decade later (1989-91), one finds statewide mud hens decreased 29 percent while California ducks declined 27 percent (Yparraguirre 1991). The local mud hen population also dropped 27 percent during this period.⁴

Although Christmas counts are not conducted scientifically (Chandik 1989) and the accuracy of state mid-winter counts is unknown (Fredrickson et al. 1977, 141), it would appear the same breeding area drought that was

⁴Coot and duck population data from 1980-82 and 1989-91 were used for comparison as they were the only complete figures available from 1980-91.

thought to have affected California duck numbers in the 1980s might have caused state and local coot numbers to suffer similar simultaneous declines.

From observing the coot census data in table 2, several minor trends are worth noting:

1. The Palo Alto and Crystal Springs Christmas counts followed the same population pattern from one year to the next. With the exception of their 1982-83 counts, coot numbers from the two circles always increased together or decreased together from their previous annual counts.
2. The Palo Alto and San Jose Christmas counts followed exactly opposite population trends from year to year, with the only exception being the 1990-91 migratory season. The two circles took their opposition to extremes as Palo Alto recorded its most coots in 1983-84, the same year San Jose counted its least mud hens to that point, and second lowest total overall. In 1985-86, when San Jose saw its lowest number of coots, the Palo Alto circle recorded its second highest total. Conversely, San Jose's highest and second highest numbers were recorded during Palo Alto's lowest totals to that point, 1987-88 and 1989-90. Audubon Society members noted similar variations in local duck numbers and speculated these unexplained population fluctuations might be caused by variations in breeding ground productivity (Dicandio 1995). This is

due to the fact that waterfowl generally "winter where their ancestors did" and "home to where they learned to fly" (Heusmann 1987, 20).

3. Christmas count numbers from Crystal Springs and San Jose were much more stable from year to year than those recorded in Palo Alto. In particular, Palo Alto's numbers dropped drastically from 1986-91. Bill Bousman (1995a) also noted that since around 1988, only two hundred migratory mud hens could be found at Charleston Slough, a wildlife area located within the Palo Alto circle. Previously, Bousman commonly saw seven hundred to fifteen hundred coots at the Slough.
4. Compared to the average number of coots recorded in its 1980-86 counts, Palo Alto experienced a 67 percent coot decline during its 1986-1991 crash period. During Palo Alto's crash period, Crystal Springs coot numbers dropped only 17 percent,⁵ while San Jose's mud hens actually increased 34 percent over their average 1980-86 numbers. If one includes Charleston Slough's two estimated counts, the Slough would have experienced a 58 percent coot drop, which is very close to the decline experienced within the entire Palo Alto Circle.
5. It is not clear whether all or some of the coots from Shoreline Golf Links have ever been included in the annual Palo Alto Christmas count, especially during the circle's recent coot crash. Vaught (1988a), who has

⁵The Crystal Springs percentage does not include missing 1988-89 data.

worked in Shoreline's maintenance department since its golf course opened, estimated mud hen numbers annually peaked at 3,000 to 4,000 birds. The author confirmed Vaught's observation when over 3,000 coots were recorded on the Links during the entire months of December 1990, January 1991, and February 1991 (see "Shoreline Coot Census" chapter), and this in a season in which Shoreline personnel felt mud hen numbers appeared down somewhat from previous years (Lyles 1990). Even so, the author counted 3,354 Shoreline Links coots the day after Palo Alto's December 1990 Christmas count. This is just 35 coots less than the entire Palo Alto circle averaged for their annual 1986-91 Christmas counts.

6. Keeping in mind that waterfowl managers are uncertain what effect wintering ground mortality has on a waterfowl species and that Christmas counts are not conducted scientifically, Golf Links shooting (about twelve hundred mud hens annually per Lyles 1988a, 1988c) did not seem to be the cause of Palo Alto's recent coot decline as the circle's figures did not show serious signs of deterioration until the 1987-88 migratory season. By the fall of 1987, Shoreline had begun to severely restrict its coot shooting (Lyles 1987b), and within a few months, stopped shooting mud hens altogether (Bakanoff 1994). Moreover, Shoreline Golf Links experienced coot "overpopulation" problems before, during, and after its shooting program (Vaught 1988a), as did Moffett

Field Naval Air Station's golf course (Carlton 1994; Katches 1986, 12[A]) (see "Shotgun Capture" section in "Population Reduction").

Moffett Field, also part of the Palo Alto circle, is only one-quarter mile southeast of Shoreline and should be the first non-Shoreline area to be affected by a Golf Links shooting program due to its location along the coots' fall flyway route (fig. 4).

Community Ecology

Coot encounters affect many other species. Both competitive and mutualistic interactions are explored as well as the mud hen's role in the food chain.

Competition with Other Species

Studies in British Columbia and Wisconsin "found no important competition for food between ducks and coots during fall months" (Kiel and Hawkins 1953, 312). In fact, the latter study concluded high coot duckweed (no species identified) consumption was "probably beneficial to the average marsh in Wisconsin" (Stollberg 1949, 424).

A Texas study on fourteen wintering waterfowl species including the coot, discovered "each waterfowl species occupied a unique and realized niche" (White and James 1978, 110).

Wintering coots and northern pintails (*Anas acuta*) in California's Los Banos Wildlife Area have vastly different diets. "It is unlikely serious competition for food exists between these two species" (Ivey 1987, 46).

Coots and ducks seldom interact during migration since "arrivals and departures of coots differed from those of waterfowl for all species" (Eddleman, Patterson, and Knopf 1985, 470).

Coots are well known for their pugnacious territorial defense during the hatching period (Allen 1985, 1; Fredrickson et al. 1977, 129; Gullion 1950, 176), yet only two journal articles were found where its aggressiveness resulted in fatal consequences.

A coot was documented "drowning a downy canvasback" (*Aythya valisineria*) in 1932 (McNicholl 1975, 110). Mud hens were also reported eating Franklin's gull (*Larus pipixcan*), pied-billed grebe (*Podiceps grisegena*), and red-winged blackbird (*Agelaius phoeniceus*) eggs (Burger 1973, 450).

Despite the fact coots interact "with a variety of birds, mammals, and reptiles within their territorial boundaries," no available evidence on competition indicates coot territorial activity "restricts the productivity of other species" (Fredrickson et al. 1977, 126).

One Saskatchewan study found "the presence of American coots did not suppress populations of redhead (*Aythya americana*), canvasback, and lesser scaup (*Aythya affinis*)" (Allen 1985, 6). In Iowa, successful coot and

redhead nests were found within three feet of each other (Kiel and Hawkins 1953, 312). In California, Gullion (1950, 52) witnessed a ruddy duck (*Oxyura jamaicensis*) "bring off a brood" very close to a coot nest with minimal opposition.

Another Saskatchewan study using twenty-six years of duck and coot census data was unable to find any evidence that high coot densities impaired breeding duck densities (Nudds 1981, 19).

In a seven-year study, Kiel and Hawkins (1953, 312) found conflicts between breeding coots and ducks in the Manitoba potholes did not adversely affect the ducks. Coots, unlike mallards and teals (*Anas* spp.), are probably reluctant to breed in farmyard potholes, as they normally require wetland habitat at least an acre in size (Gullion 1950, 173).

Three other investigations were unable to find any evidence that coots adversely affected duck broods, decreased duck pothole use, or evicted blue-winged teal (*Anas discors*) from desirable nesting areas (Kiel and Hawkins 1953, 312).

Finally, a Utah study found duck productivity "in areas . . . with nesting coots" was similar to that "in areas where coots had been removed" (Eddleman, Patterson, and Knopf 1985, 463).

Ryder (1959, 440) offers three possible explanations why the coot has a relatively neutral effect on breeding ducks: (1) female ducks with ducklings usually dominate attacking coots, (2) although some ducks may be

"excluded from nesting habitat" by territorial coots, others are able to nest in areas normally unavailable to them due to the presence of abandoned coot platforms, and (3) ducks that nest and rear young near territorial coots probably benefit from the mud hen's attacks on common enemies.

Mutualistic Interactions

Rand (1956, 167) noted that mud hens "seem to be on good terms" with neighboring ducks even though they rob waterweed (no species identified) from canvasbacks.

Bergen (1986, 307) witnessed coots in South Carolina robbing ring-necked ducks (*Aythya collaris*) of what appeared to be pondweed (*Pontamogeton* spp.). In only about 5 percent of these interactions did a victimized ringneck even briefly chase the marauding mud hen before dropping its food for the coot. Bergen (1986, 306-7) added coots were previously documented robbing redheads as well as canvasbacks.

Wintering coots and ducks had similar diets in Oklahoma where "cooperative feeding and food robbery" were found to be "mostly neutral or beneficial" to the ducks. Cooperative feeding took place between mud hens and mallards, redheads, ring-necked ducks, American wigeons (*Anas americana*), and gadwalls (*Anas strepera*). The latter two were the only waterfowl recorded stealing from coots, while mud hens were not observed

robbing ducks during the Oklahoma study (Eddleman, Patterson, and Knopf 1985, 466, 469-70).

Another researcher reported wigeons often stole aquatic "vegetation directly from the bills" of surfacing coots in Iowa. Some coots mastered "evasive maneuvers," dropping their food in order to secure an immediate unmolested dive, to satisfy both the wigeon's and its own hunger. This food piracy was extremely important to the wigeon as the only vegetation available that spring was located in deep water (Ryan 1981, 275). Knapton and Knudsen (1978, 403) theorized the wigeon's actions allowed it access to a resource either out of its reach or acquired more efficiently by robbing mud hens.

Mud hens have yet to be recorded reacting aggressively toward their kleptoparasites, either in the Ryan article, or in three other journal articles where wigeons and/or gadwalls were described stealing from coots (Ryan 1981, 275).

A study in Manitoba hypothesized coots might purposely nest near Forster's terns (*Sterna forsteri*) and yellow-headed blackbirds (*Xanthocephalus xanthocephalus*) to gain protection from aerial predators. Terns and blackbirds successfully chased off aerial attackers by mobbing them, a skill not practiced by the mud hens (McNicoll 1975, 109).

Finally, in a study at Oakland's Lake Merritt, Gullion (1950, 168) often witnessed coots eating gull (*Larus* spp.), tern (no species identified),

and pigeon (*Columba* spp.) feces, frequently stretching "under the resting birds to pick up fresh material." Gullion speculated the Oakland coots were satisfying a dietary deficiency.

Role in the Food Chain

Although the coot has definite food preferences, it is a fairly opportunistic eater, quick to adapt to whatever foods are available (Gullion 1950, 172).

In the most comprehensive study on coot diet ever conducted, Jones (1940, 8-9, 33-39, 50) examined the stomach contents of 792 coots from every region of the U.S. and Canada. Exactly 219 different types of plant and animal matter were identified of which one-third (73) were present just once in trace amounts. This suggests the mud hen may have consumed many items accidentally or incidentally.

Although the mud hens Jones (1940, 9, 12, 27) studied consumed material from at least one-third more animal than plant families, nearly ninth-tenths of its diet came from the vegetable kingdom. In fact, all six studies uncovered in the literature found by volume, the coot consumed between 86 and 100 percent vegetable material, while the predominant plant family taken varied with location (Eley and Harris 1976, 225-26; Fitzner and Schrickhise 1979, 20, 24; Ivey 1987, 46-47; Jones 1940, 10, 27; Munro 1939, 178).

The table on the following page is based on the sources just mentioned (table 3).

Mud hens are primarily dabblers and grazers, feeding at or near the water's surface or along the shore (Jones 1940, 9). Although coots tip like surface-feeding ducks, only seeds are eaten underwater. Non-seed items are brought to the surface before they are consumed (Gullion 1950, 163).

Coots are fine divers, sometimes descending up to twenty-five feet for food (Jones 1940, 9). But mud hens normally will not stay submerged for more than fifteen seconds (Gullion 1950, 164), which is considerably less time than most diving waterfowl (Dow 1964, 557).

Sago pondweed (*Potamogeton pectinatus*) is the mud hen's preferred food in the San Francisco Bay Area. Gullion (1950, 166) found it to be taken nearly exclusively when available. In fact, Jones's (1940, 13) comprehensive study found the Najadaceae plant family (of which sago pondweed is a member) the predominant family in the mud hen's diet. It was consumed "in every month and in every section" of the U.S., while comprising 42.1 percent of food volume (table 3). However, pondweeds were not taken in a previous British Columbian investigation, where muskgrass (*Chara* spp.) was the dominant growth on the lake studied (Munro 1939, 178).

TABLE 3
AMERICAN COOT FOOD-HABIT STUDIES

Study Number and Site	Study Duration	Stomachs Analyzed	Percent Plant Volume	Percent Volume of Most Commonly Occurring Plant Family with Family Identified
1. U.S. & Canada	Y	792	89.4	42.1 ^a Najadaceae (pondweeds)
2. Lower Colorado R.	F, W	250 ^b	98.9 ^c	36.9 ^d Najadaceae (pondweeds)
3. Washington State	.....	143	86.6 ^e	37.8 ^f Najadaceae (pondweeds)
4. British Columbia	F	45	100.0	97.0 Characeae (muskgrasses)
5. California	F, W	41	99.5	.....
California	F, W	41 ^g	90.2	42.5 ^h Gramineae (grasses)
6. Washington State	.....	.....	98.0 ⁱ	33.9 ^j Cyperaceae (sedges)

Notes: Percent animal volume for each study can be obtained by subtracting its "Percent Plant Volume" from 100.0. All identifiable animal matter consisted of invertebrate material except for 0.02 percent vertebrate matter in study number one. The majority of invertebrates consumed were from the Insecta (insect) class. Abbreviations used are: (F) fall, (R) river, (W) winter, and (Y) year-round. Data not provided by sources are represented by ellipsis points.

^aDoes not include 3.4 percent unknown plant material.

^bIncludes some esophagus material.

^cDoes not include 1.5 percent unknown organic material.

- ^dDoes not include 1.5 percent unknown organic material and 13.7 percent unknown plant material.
- ^eDoes not include 0.7 percent unlisted stomach material.
- ^fDoes not include 0.7 percent unlisted stomach material and 2.1 percent unknown plant material.
- ^gEsophagi analyzed.
- ^hDoes not include 1.1 percent unknown plant material.
- ⁱDoes not include 1.0 percent unlisted stomach material.
- ^jDoes not include 1.0 percent unlisted stomach material and 37.4 percent miscellaneous plant material.

If the local supply of sago pondweed was exhausted, Bay Area coots turned to cattails (*Typha* spp., Typhaceae family) and green algae (no species identified) as staple foods (Gullion 1950, 166-67).

After the pondweeds, other families consumed significantly (at least 5.0 percent by volume) in the Jones (1940, 14) study were the sedges (Cyperaceae family) 14.2 percent, muskgrasses (Characeae, an algal family) 10.3 percent, and grasses (Graminae family), 8.5 percent.⁶

Stomach analyses conducted only in the fall and winter months revealed that coots ate an average of 99.1 percent plant food during migratory season (Eley and Harris 1976, 226; Ivey 1987, 46; Munro 1939, 178). Jones's (1940, 10) study also found coots consumed 97.9 percent vegetable matter from October through February.

More animal food is taken by coots during the breeding season. Jones (1940, 10) found coots took an average of 24.0 percent animal material from April through August, compared to just 2.1 percent from October through February.

Juvenile mud hens consume a higher percentage of animal food (46.6 percent) than adults (22.8 percent) during the spring and summer (Jones 1940, 28, 39).

⁶These volumetric percentages were adjusted to compensate for the 3.4 percent unknown plant material recorded during Jones's (1940, 27) research.

Animal food is also more important to the diet of coot chicks than to older juveniles (Fitzner and Schrickhise 1979, 23). Adults hunt insects (no species identified) to feed to chicks (Gullion 1950, 167) until they are about three weeks old (Hill 1988, 325). However, "adults feeding themselves make no special effort to hunt insects," choosing to take only "those they chance upon" (Gullion 1950, 167).

A Washington study noted juvenile coots ate 21 percent animal matter to just 11 percent in adult gizzards, although there was no mention of the time of year the analysis was conducted. Regardless, higher juvenile animal consumption appears to be due to the growing bird's protein requirements (Fitzner and Schrickhise 1979, 20, 23).

But a North Dakota study found examination of blue-winged teal gizzard contents to be less accurate than esophageal analyses in determining food consumption due to stomach digestion. Soft foods, which broke down within minutes of ingestion, were underrepresented in the stomach exams (Swanson and Bartonek 1970, 739, 745).

Ivey (1987, 46) conducted both stomach and esophagus exams on forty-one coots in California and found just 0.5 percent animal material during gizzard analyses compared to 9.8 percent in esophageal exams.

Esophageal analysis appears to be a more accurate test, not only for ducks, but for coots too. Therefore, the five stomach-based studies above (table 3) probably underestimated the percent of soft-bodied animal material

in the mud hen's diet. But there was no difference in the general types of plant and animal foods found regardless of the analysis technique used (Eley and Harris 1976, 226; Ivey 1987, 46, 47; Jones 1940, 33-39).

Although no animal family made up a significant part of the mud hen's diet in any of the food-habit studies, virtually all its nonplant food consisted of invertebrates, the majority of which were insects (class: Insecta) (table 3). Only two of the food studies found any vertebrate matter. Jones's (1940, 10) research discovered an insignificant 0.02 percent of coot food (0.2 percent of identifiable animal material) was vertebrate material, while Eley and Harris (1976, 226) reported just a trace of fish bones in their study. In fact, incidents of coots taking vertebrates are so rare, only around a dozen examples have been documented.

Other than Eley and Harris's fish bones, Jones (1940, 32-33) found merely traces of fish in 3 of 792 stomachs, although reference was made to an 1882 report of coots diving for minnows (no species identified).

Coots in Oakland were recorded eating floating, dead black crappie (*Pomoxis nigro-maculatus*) (Gullion 1950, 168), while mud hens in Washington have been known to take goldfish (no species identified) (Fitzner and Schrickhise 1979, 23).

The mud hen was one of seventeen species of birds observed feeding on herring (*Clupea pallasii*) eggs in an Oregon estuary, although only a minority of the coots participated in the egg eating (Bayer 1980, 193).

In general, it is unlikely the American coot consumes enough fish to affect fish hatcheries (Jones 1940, 32) or anglers.

A tiger salamander (*Ambystoma tigrinum*) in South Dakota comprised the entire measurable 0.02 percent vertebrate volume found in Jones's (1940, 33) study, while Gullion (1950, 168) reported a coot eating a tadpole (*Rana* sp.) in California. These were the only references made to coots eating amphibians located in the literature.

A coot in California reportedly suffocated trying to consume a blue-bellied swift (*Sceloporus occidentalis*) (McCurdy 1983, 158), while on another occasion, a pair of dead reptiles was offered to a captive flock of mud hens with a much different outcome. The blue-bellied swift and alligator lizard (*Gerrhonotus coeruleus*) were both partially eaten (Gullion 1950, 168).

Only three accounts in the literature were found that described coots feeding on bird or bird eggs.

Jones's (1940, 32) coot stomachs did not include "even a trace" of any bird or bird eggs of any species including their own. Jones does mention an 1894 account of a coot consuming part of a freshly shot duck's breast.

Burger (1973, 450) twice observed a coot eating Franklin Gull eggs in Minnesota, and relayed two other incidents of coots preying on avian eggs

in Montana (in 1961) and Manitoba (around 1970). Paullin (1987, 442) reported coots involved in cannibalism during a severe spring in Oregon.

Jones (1940, 32) concluded mud hens seldom prey on avian nests or nesting birds (see "Life Cycle" section, previously in this chapter, for birds and other animals that prey on mud hens).

No literature was found on coots eating mammals.

The American coot feeds mostly while swimming, and when sufficient food is available in the water, it will not feed on land. Nonterritorial coots are the first to feed on land, but only after their aquatic food is exhausted (Gullion 1950, 160, 163).

The mud hen's lobed feet appear to make its walking effortless on soft and firm soil (Jones 1940, 2) as it grazes on grasses and any other desirable greenery. But most grazing coots acquired "cystlike growths on the soles of their feet, and often in addition, developed swollen joints and malformities of the toes." These foot problems soon disappeared when the affected birds were moved to their normal environment. Aquatic-feeding mud hens did not experience these foot troubles (Gullion 1950, 165).

The mud hen prefers sago pondweed to all agricultural plants but lettuce (*Lactuca* spp.). Gullion (1950, 174) doubts agricultural depredation would be a problem where there was an abundant supply of sago pondweed.

Where the coot's natural foods are in short supply, Gullion (1950, 174) favors increasing hunting pressure on the mud hen. If the coot were

heavily hunted early in hunting season, its existing aquatic foods would go farther as there would be less coots remaining to eat them, thus greatly reducing crop depredation. Also, a healthy supply of coot meat would make it to hunters' tables (Gullion 1950, 175). Unfortunately, most hunters feel the coot is not worth eating (Fredrickson et al. 1977, 143; Kiel and Hawkins 1953, 313). The mud hen's diet probably accounts for its poor taste (Van Way 1986, 292).

But properly prepared, the coot is quite edible (Kiel and Hawkins 1953, 313). Skinning the mud hen must eliminate the cause of its bad taste, as skinned coot tastes "as good as most domestic fowl" (Gullion 1950, 176).

Historically, the coot was more heavily hunted when other sources of protein were in short supply.

A century ago, most Ohioans would not have considered eating the mud hen. But soon after ducks became scarce, the taste of "its flesh was considered as equalling or surpassing that of the lesser scaup." From 1922-1934, more coots were bagged in the Buckeye State than "all other waterfowl species combined" (Gullion 1950, 175).

Coots were commonly used as food by North American settlers (Fredrickson et al. 1977, 130). Mud hens caught in muskrat traps were eaten in Manitoba (Ward 1953, 326).

Native Americans have always used the coot for food. When Indians gathered eggs, they found coot eggs were more abundant, and just as tasty as duck eggs. About 1900, natives along the Mexican Gulf Coast preferred to hunt coots over ducks since they could kill more mud hens with a single shot (Ward 1953, 326).

Ecological Importance of Coots

Every species fills a role in the biotic community and its "activities can help maintain stability and sustain natural diversity" (Shaw 1985, 15). Biologists contend coots stir up microorganisms along lakes and ponds for other birds (Priest 1991).

Duckweed (no species identified) often grows in thick masses on the surface of Wisconsin's sheltered waters. High coot duckweed consumption allows the "more valuable submergents" a chance to grow that would otherwise be seriously reduced by shading. Thus the mud hen's presence "is probably beneficial to the average marsh in Wisconsin" (Stollberg 1949, 424).

Sportsmen appreciate the coot's contribution as a buffer against duck predation. The peregrine falcon, bald eagle, red-tailed hawk, and horned owl all take many coots, "thus releasing pressure on other species" (Gullion 1950, 177). Prairie falcons, northern harriers, and golden eagles also prey on coots (Priest 1991).

Recently, Canada geese (*Branta canadensis*) have become more prevalent on North American golf courses. Like coots, Canada geese graze and defecate on grass (Marley 1987, 20). A large male coot can weigh nearly two pounds (Fredrickson et al. 1977, 124), while a Canada goose can get up to seventeen pounds (Heusmann 1987, 20). Needless to say, one goose can do more damage than several coots.

At no time during the 1990-91 Shoreline coot census were more than thirty-one geese recorded. Although the coots were counted on a regular basis and the geese were not, the author made a special note each time more geese were observed than usual.

It is possible geese might fill any void created by the removal of the coots. Thus a reduction in coot numbers at Shoreline could eventually create an even bigger problem in the presence of more geese.

Regardless, it would be unwise to advocate the complete elimination of the coot. Although we may not be able to totally understand its ecological value, "neither can we predict the long-range consequences of [its] disappearance." Therefore, the coot, like all other wild creatures, "should be conserved to avoid irreversible ecological changes" (Shaw 1985, 15).

CHAPTER IV

PRELIMINARY RESEARCH

Coots have been responsible for depredation problems in California for at least one hundred years (Van Way 1986, 292). During this time, countless management techniques have been tried to control mud hens and other avian pests with varying degrees of success.

Relevant information was collected from many of these previous California management experiences, as well as those of other Americans and Canadians, and organized into five areas according to the type of control method used.

A separate chapter has been devoted to analyzing each area to determine which, if any, of these control techniques, might be effective at Shoreline, keeping the Golf Course's unique constraints in mind. Control methods under analysis include the use of:

1. Barriers
2. Habitat alteration
3. Population reduction
4. Repellents
5. Scare devices

CHAPTER V

BARRIERS

This chapter has information on the use of various nonvegetative barriers as tools of exclusion. For information on the use of vegetative barriers for the purpose of directing the movement of grazing coots, see the "Vegetative Enhancement" section in "Habitat Alterations."

A physical barrier denies access to the target animal (Marley 1987, 20). Barriers are often selected because they are the only wildlife management measure that will eliminate damage in the desired area (Hodge 1990a, 2).

Before selecting a barrier system, one must identify the offending bird species and how long the problem is expected to last. Next, the size of the area to be protected should be considered. Impacts on the public such as aesthetics and recreation should be examined. Finally, the barrier system must be able to withstand exposure to wind, rain, temperature extremes, and ultraviolet radiation, as well as be cost-effective (Salmon, Conte, and Gorenzel 1986, 88-89[E]).

The following barriers are control methods that were considered to discourage coots on the Shoreline Golf Course.

Fencing: Non-electric

Fencing can be erected to deny turf access by its presence alone. For information on fencing that has been electrified to frighten its victims away from protected areas upon contact, see the "Fencing: Electric" section in "Scare Devices."

Many kinds of fences have been suggested for use against coots, from short chicken wire to various taller varieties.

Dias (1994), Duke (1989), and Zahn (1988) thought a fence might help somewhat, while Gorenzel (1989) also suggested a low fence, remembering the coot's general reluctance to fly. Jenni (1988) agreed, noting a barrier with a two-foot vertical face might make it unattractive for the coots to leave the water. Hodge (1990a, 84) supported the use of a light wire fence, if the area to be protected was not very large.

At the other extreme, Van Way (1986, 294) proposed a fence in the form of a barrier net to be erected along lake edges. This fence would not only block turf access, but could also be designed to direct coots into less sensitive areas.

The Links at Spanish Bay, on California's Monterey Peninsula, succeeded in directing its coots away from sensitive areas with the use of low fencing (Fenzke 1994). Another Monterey area course, Pacific Grove Municipal, also successfully protected its facility with fencing (Leech 1994).

On the other hand, Mott and Timbrook (1988, 301) reported perimeter wires were found to be of little value as a barrier against geese, a bird with feeding habits similar to those of the coot. Figeira (1995) had short-lived success against coots with a wire, perimeter fence angled in toward the water.

This barrier technique was one of the methods later attempted at Shoreline (see chapters XII and XIII).

Human Blockade

Doug Weddle (1989), Superintendent of a Santa Barbara, California golf course, used a "human blockade" in an attempt to bar turf access to coots on the club's thirty-acre lake. With limited food in its lake, Weddle hoped the voracious coots would eventually fly off to search for a new wintering area.

Taking advantage of the coots' diurnal feeding habits and their reluctance to fly, volunteers succeeded in keeping the mud hens in the water for five days. Finally, hungry and irritable, the coots flew off, only to return after feeding elsewhere (Weddle 1989).

Coots have a strong attachment to their wintering grounds, as hazed or physically-removed mud hens usually return.

Richardson (1990) observed coots reoccupied their original water areas as soon as radio-controlled boat operators left, while Gullion (1950,

47-48)¹ discovered mud hens trapped and moved to various other California water areas normally returned, even when relocated to a better habitat.

Even if Weddle's plan had succeeded, Shoreline's numerous water areas make a project involving human blockades (without the aid of any management tools) more labor-intensive than at similar facilities with just one water area.

Shoreline has five coot-infested water areas in or adjacent to its golf course (fig. 4). These water areas are in the form of a lake and four ponds totaling 66 acres. Since these 66 acres are divided instead of contained in one lake, they create a shoreline length equivalent in size to a 213-acre lake.¹ Unfortunately, it would be necessary to blockade all five water areas to prevent coots from temporarily feeding in other parts of the Golf Course or Park during this management activity.

It is easy to see how additional shoreline, or "edge," would make Santa Barbara's "Human Blockade" experiment more difficult at Shoreline. If the Santa Barbara group used one person for every three hundred feet of edge, fourteen people would be required. On the other hand, Shoreline would need approximately thirty-five individuals spaced three hundred feet apart to surround its aquatic coots (table 4).

¹Calculations are based on circular-sized water areas. Square-shaped water areas of the same acreage would have about 13 percent more edge. The more a water area deviates from a circular or square shape (e.g., elongates), the greater its edge will be in relation to its acreage.

TABLE 4

PEOPLE NEEDED TO SURROUND COOTS ON VARIOUS-SIZED WATER AREAS

	Size in Acres	Edge in Feet	People Required
Shoreline Lake	50	5,232	17
Pond No. 1	3	1,282	4
Pond No. 2	3 $\frac{3}{4}$	1,417	5
Pond No. 3	1	740	2
Pond No. 4	8 $\frac{1}{4}$	2,136	7
Shoreline Golf Links total	66	10,807	35 ^a
Theoretical sixty-six-acre lake	66	6,011	20
Theoretical lake with similar edge	213	10,798	36 ^a
Santa Barbara Golf Course lake	30	4,053	14

^aDifference due to rounding

California coots have abandoned potential nesting areas due to competition with resident coots (Gullion 1950, 71). It is possible Weddle's migrant birds may have vacated their winter home if his blockade had continued.

Even though this technique is labor-intensive, it would satisfy all of Shoreline's unique constraints and would be worth trying if it were not for one problem. Mud hens annually migrate into Shoreline from late September through mid January (see "Shoreline Coot Census" chapter). Therefore, blockaders would be required for about a four-month period each year in order to keep Shoreline relatively coot-free. Even then, thousands of emigrating mud hens from areas south of Mountain View may temporarily stop off at Shoreline as late as May, thereby necessitating the services of blockaders for an even longer time period.

Any agency considering this technique needs to be aware that when blockading a water area, blockaders will not always be facing the golf course, which can be a very dangerous assignment. Golfers would have to be notified when a blockade was being conducted so they could be on the lookout for individuals on the course, while blockaders should be required to wear helmets and orange vests at all times.

This management method should be well planned so that blockaders are visible to golfers without being a distraction to their game. Planning

should also include a check of all parties' insurance coverage before this technique is attempted.

Net Exclusion

Hodge (1989a) suggests draping a plastic net across the surface of Shoreline's ponds. This technique is used at fish hatcheries. Pearson (1988) recommends covering the ponds with net chicken-wire attached to a raised structure.

Salmon, Conte, and Gorenzel (1986, 89[E]) feel complete exclusion from problem areas with lightweight, low-priced, plastic netting may, in the long run, be cost-effective. They recommend attaching approximately 1½-inch mesh netting to frames, or draping the netting on wires.

Conwed® Corporation of Minneapolis claims its plastic netting is noiseless, nontoxic, and will not harm birds. Based on suggested usage of three to five years, a net enclosure system would have a depreciating cost of \$50 to \$105 per acre (Conwed® plastic netting for bird damage control n.d., 3).

San Jose Water Pollution Control tried a net barrier to keep sea gulls (*Larus* spp.) away from its tanks. Unfortunately, when the gulls were hungry, they were able to find holes in the nets (Beebe 1989).

A permanent exclusion barrier should be considered only when an ongoing, year-round problem exists. A permanent barrier is not possible if aesthetics are important to golf course members and staff (Marley 1987, 20).

A permanent exclusion barrier would not only remove most of the seasonal coots from Shoreline's ponds, it would eliminate all other waterfowl as well.

But about two-thirds of Shoreline's coots are found in or around Shoreline's fifty-acre lake, which is too big for an exclusion barrier (Hodge 1990a, 84). Regardless, the Lake's designation as a recreation and wildlife area eliminates this management option.

Riprap

Riprap, massive rocks used as a water break, could be placed between the shoreline and the Golf Course to separate waterborne coots from the grass.

Lara (1989a) warned coots would fly over a rock ledge to graze on the turf.

Since a riprap barrier was already in place at the Course, this management technique would be observed to see if it protected the turf from nearby aquatic coots (see chapters XII and XIII).

Wires: Submerged or Suspended

Long horizontal wires in one direction can be suspended six inches above the water at intervals across ponds. If aesthetics are a factor, the wires can be submerged a few inches. The presence of plunging feeders like the osprey (*Pandion haliaetus*) or the belted kingfisher (*Megaceryle alcyon*) would preclude submerged wires (Hodge 1989a).

Steel wire or hundred-pound test fishing line can be placed in an overhead grid pattern above ponds or lakes. The grid startles landing birds, as it is invisible until they are nearly on top of it (Marley 1987, 26).

Thin steel wire is preferable to monofilament fishing line as the latter needs more upkeep and decomposes with ultraviolet radiation (Marley 1987, 26).

Line spacing is determined by the depredating birds' habits. Netting is occasionally needed to prevent entrance through vulnerable side edges (Salmon, Conte, and Gorenzel 1986, 90[E]).

Many bird species have been repelled when a grid system is used along with pyrotechnics (Marley 1987, 26).

Mountain View Solid Waste Department strung nylon fishing line in a random pattern over its fill area in an attempt to exclude sea gulls. The line was attached to a circle of poles about 150 feet larger than the fill area. The overhead system kept out the gulls (Bowers 1989).

San Jose Water Pollution Control suspended twine in a crisscross pattern, six feet apart, above its tanks. The twine successfully frustrated the gulls during takeoffs and landings (Corbett 1991).

Although overhead wires are inexpensive compared to complete exclosure systems, they are not effective against all avian species (Salmon, Conte, and Gorenzel (1986, 89[E])). For instance, they generally do not work on geese (Mott and Timbrook 1988, 301).

Shoreline's coots and geese have similar feeding habits. Both are grass grazers that enter water areas from land. An overhead mesh would be generally useless against coots unless attached to shoreline netting.

Coots often die from collisions with wires (Fredrickson et al. 1977, 130). An overhead system would undoubtedly be fatal to non-target birds as well.

A slightly submerged wire system would not be possible as a wide variety of plunging feeders including rare ones such as the brown pelican (*Pelecanus occidentalis*) are year-round visitors to Shoreline's ponds and lake (Trulio 1995b).

Shoreline Lake is designated as a wildlife and recreation area. Therefore, it could not be covered by a wire barrier just above the water.

It may be possible to install a wire system just above the ponds located inside Shoreline Golf Links. But a grid small enough to exclude the

coot would bar most, and possibly injure, other wildlife as well. A grid may also not be in keeping with the aesthetic theme of the Golf Course.

Conclusion

Barriers may offer hope in the fight to protect Shoreline's golf course from coots.

Obstructing turf access by means of a human blockade shows promise, but this technique is too labor-intensive to be used at Shoreline.

Although wires suspended a few inches above the water should keep coots from Shoreline's ponds, this type of barrier may not be practical. Birds are sometimes killed or injured by collisions with Shoreline's power lines. Suspended wires would probably also injure unsuspecting wildlife. On the other hand, mesh netting is a safe, total exclusion system.

But wires and netting would expel most other wildlife from the Golf Course's ponds, and would, therefore, be unacceptable. These management techniques would also not be an option on Shoreline Lake due to the Lake's designation as a wildlife and recreation area.

Non-electric fencing offers some hope as a coot barrier, having successfully stopped coot depredation at two other California golf courses. This method, as well as that of the riprap barrier, will be tested and analyzed in chapters XII and XIII.

CHAPTER VI

HABITAT ALTERATIONS

Managers can change populations indirectly by changing habitat or directly by controlling the population itself (Kutilek 1989b). This chapter will focus on habitat change, while the chapter on "Population Reduction" will concentrate on the latter.

Some of the main factors that control the carrying capacity of any potential habitat are food supply, social behavior, dispersal (Kutilek 1989a), and predators (see "Natural Predators" section in "Population Reduction" for information on predators).

Population size for all animals is determined by the amount of available food and water (Kutilek 1989b). Over-wintering coots specifically choose sites with abundant vegetation and deep open-water areas (Allen 1985, 5).

Food supply, especially for herbivores, is very important (Kutilek 1989a). From October through April, when Shoreline is visited by migratory mud hens, plants make up 97 percent of the coot's diet (Jones 1940, 10).

A species social behavior affects its breeding potential (Kutilek 1989a). While currently less than 1 percent of Shoreline's mud hens breed in the Park (see "Shoreline Coot Census" chapter), these resident coots' territorial instincts require them to procure enough space and cover habitat to meet their reproductive needs (Gullion 1950, 157). On the other hand, the Golf Course's over-wintering mud hens are gregarious (Allen 1985, 1).

Since practically all of Shoreline's winter coots are migrants, dispersal plays a critical role in determining the Park's over-wintering mud hen population.

This chapter looks at how habitat change acts on these three controlling factors to affect the coot carrying capacity at Shoreline Golf Links.

Feeding Area

Any attempt to reduce coot grazing at Shoreline Golf Links would probably be extremely difficult unless the mud hens were provided with an equally attractive area in which to feed (Salmon, V. 1985).

Since the completion of Shoreline Park seemed to solve two other local golf courses' coot problems (Katches 1986, 12[A]), it would appear most marauding mud hens might leave the Park if provided with a better habitat. Priest (1989) agrees, noting alternate feeding areas have been successful in the eastern U.S.

Gilhuly (1989), of the U.S. Golf Association, also felt coot feeding sites were worth a try. Gorenzel (1989), of the University of California at Davis, recommended giving the coots seed, while Lyles (1988c) proposed offering the mud hens grass clippings.

Below are results from three northern California feeding experiments: one with confined coots, and two with unconfined mud hens.

Feeding Experiments

Gullion (1950, 169-70) raised sixty-six captive coots entirely on "commercial scratch feed consisting of cracked corn, wheat, sorghum, and millet." Several of the mud hens lost "one-third to one-half of their weight in a few weeks after capture." When Gullion added greens to their diet, consumption of grain quadrupled, all the coots gained weight, and their runny droppings changed to normal firm pellets.

Hardy (1989) put cracked corn in a feeding trough in an attempt to stop Moffett Field Golf Course coots from grazing on its turf. The mud hens gladly accepted the corn when offered, but soon returned to their grazing.

It is possible Hardy's coots were meeting their dietary need for greens by continuing to graze. It is unknown if Hardy's mud hens would have stopped or reduced their grazing if greens had been provided along with cracked corn. Regardless, it appears a coot diet entirely of grain is not

only unhealthy, but might create an even bigger management problem if defecating coots ever ventured on to Shoreline's golf course.

In an uncontrolled experiment, Shoreline staff placed grass clippings between its golf course and an adjacent water area hoping to satisfy the mud hen's appetite (Hodges 1987, 3[A]). Unfortunately, the coots did not eat the cuttings (Bakanoff 1988).

Coots are not likely to be interested in grass clippings as it is growing grass they find attractive. This is because after mowing, the regenerating grass has a higher nutrient value. The fact Shoreline mows its fairways daily and its greens twice daily, makes its golf course an "absolutely ideal foraging site" (Gullion 1989).

Shoreline Feeding Sites

So judging from the three experiments above, what would a Shoreline feeding program involve?

Shoreline had at least 400 mud hens on or around its golf course from about 29 September through 30 April during its 1990-91 coot census (see "Shoreline Coot Census" chapter). During this 214-day period, it averaged approximately 2,466 mud hens. If the Park's coots could be trained to eat cracked corn instead of the Park's turf, then each mud hen would consume around thirteen cents in corn each day (Garcia 1995), or collectively \$68,600 per season. This means a season's supply of corn would

cost over three times more than the amount of damage the mud hens annually inflict on the Course (Lyles 1988d).

But the above cost of a season's supply of corn assumes no other animals would eat the corn and that none would be wasted. Van Way (1986, 294) was unable to stop ducks from eating food set out for coots. When this happens, additional management time is required to monitor the area (Mason et al. 1985, 637).

As noted earlier, it would be nutritionally unwise for the coots to eliminate grass from their diet since there is no other readily available vegetation near the Golf Course (see "Shoreline Golf Links" section in "The Shoreline Problem: Coots versus People"). Gullion (1950,169) solved this problem by including "green trimmings from a local produce market." Gullion (1950, 170) added coots preferred lettuce-like plants over grasses.

So if the Golf Course could daily replace approximately 71 percent (fifty pounds) of its corn with donated lettuce trimmings, it could provide its coots a healthy alternative to the Course's grass. This corn and lettuce diet would cost Shoreline a more affordable twenty thousand dollars per season.

But the whole point of feeding the Park's coots would be to get them to stop eating and eliminating on its Golf Course. It was apparent from observing the grazing mud hens during Shoreline's 1990-91 coot census, that they would not feed more than about two hundred feet inland from

their aquatic wintering areas. Therefore, all feeding sites would need to be relatively close to the Course's water areas in order to attract the coots.

Unfortunately, placing feeding stations too close to the Course's water areas might cause unhealthy aquatic conditions. On the other hand, if the mud hens needed to cross the Golf Course to reach a feeding site, the birds would continue to graze and puddle on the Course on their way to and from the stations. Hence, it goes without saying, the location of each feeding site would need to be carefully considered.

Finally, time would be involved establishing and then maintaining a feeding program. Some of the areas to be considered include:

(1) researching and preparing each site, (2) researching feed availability and cost, (3) soliciting for donations of green trimmings (and possibly corn), (4) setting up a feed delivery and collection system, (5) determining maintenance needs, (6) deciding staffing needs, and (7) determining a budget.

Feeding Drawbacks

Pearson (1988), Gorenzel (1989), and Gullion (1989) all fear a feeding area may attract more coots. Hodge (1990a, 83) adds supplemental feeding often leads to dependency.

Feeding can concentrate a large number of birds in a small area and create new management problems. If the area is not constantly maintained,

filthy surroundings and poor water quality may result. Unsanitary conditions like these can lead to disease and botulism outbreaks (Don't feed geese n.d., 1).

Even though the Park discourages its visitors from feeding its mud hens, the author occasionally observed people in the City Park, on the northeast end of Shoreline Lake (fig. 4), feeding the coots. Only a few hundred migrant mud hens frequent this area, and these handouts make up a very small part of their diets.

Presumably because of the problems coots cause on the Golf Course, golfers were rarely seen feeding mud hens. Predictably, the Golf Course's coots were far more wary of people than those in the City Park.

As Van Way (1986, 292) noted, coots often accept foods like bread and popcorn when visited by park patrons. Young geese fed these low-protein foods "develop deformed wings and lose the ability to fly throughout life" (Don't feed geese n.d., 1). Fortunately for the Park's coots, none of its seventy-three summer residents was observed venturing across the Lake to the City Park, where developing young mud hens risked malnutrition from handouts.

Perhaps the feeding area's biggest drawback is that it trains its recipients to rely on an unnatural source for their subsistence (Hodge 1990a, 83). The birds soon figure out people mean food, and become a nuisance with their bold demands for handouts (Don't feed geese n.d., 1).

Some golfers might begin to reward begging chicks with bits of bread and other unhealthy treats. Their seemingly innocent acts could contribute to an eventual year-round coot problem, as Shoreline's few summer breeders begin raising young that are unable to fly. Former migrants may also become domesticated and ignore the urge to migrate north.

Fredrickson et al. (1977, 141) support refuge habitat acquisition to relieve pressure on depredated areas. As stated before, coots left two golf courses in adjacent towns when Shoreline's regional recreational and wildlife area was completed in 1983. Perhaps Shoreline's coots would eventually leave if a feeding area next to a large body of water was developed several miles away (Gullion 1989).

But it may be possible Shoreline's creation only temporarily solved its neighbor's mud hen troubles. Henderson, of nearby Moffett Field Golf Course, felt Moffett no longer had a coot problem in 1986 (Katches 1986, 12[A]). Three years later, Moffett Field's Hardy (1989) was involved with management efforts to keep coots from grazing on its grass.

Coots are quick to utilize any new habitat (Jahn and Hunt 1964, 93). Although it is possible most of Moffett Field's mud hens moved to Shoreline in 1983, other coots looking for winter homes probably took their place. After all, there were always new coots to replace the thousands shot previously at Shoreline (Lyles 1988c).

Conclusion

It is unlikely feeding areas will stop Shoreline's nearly thirty-six hundred coots from grazing. An on-site feeding program may also cause new coot problems like increased population, pollution, dependency, and begging. Not only that, the projected cost in bird feed alone exceeds the cost of the Park's coot depredation unless most of the feed is donated. Even if Shoreline's coots moved to a developed feeding site a few miles away, new mud hens would eventually replace the birds that left.

Pond Salting

Would salting the Park's freshwater ponds drive its coots away? It appears a saline environment would affect the Park's breeding and overwintering mud hens differently.

Breeding Coots and Salt Water

Allen (1985, 3) noted a North Dakota study found there was "an inverse relationship between water salinity and the abundance of breeding pairs of American coots" while nesting mud hens completely avoided "subsaline and saline wetlands." The coot's inability to utilize salty environments is likely due to this habitat's "absence of suitable vegetative cover, insufficient food, and the American coot's physiological inability to use saline water for extended periods."

A local, biweekly avian census confirmed the North Dakota study's findings. No coots bred at saltwater Charleston Slough during Bousman's (1995b) ten-year research project despite an annual average of over one thousand mud hen visitors at the 130-acre Shoreline site.

The author also was unable to find any coot nests on saline Shoreline Lake during the 1990-91 Shoreline coot census (see "Shoreline Coot Census" chapter). In fact, during a special July mud hen count, the Lake itself was virtually "cootless." Just two of the summer's seventy-three mud hens were not in or near the Course's freshwater ponds. Even these two "isolated" coots were only about two hundred feet north of Pond No. 2A by the Lake's southwestern island (fig. 4).

The fact breeding American coots are generally limited to non-saline environments in temperate areas makes them "more restricted in habitat than many species of waterfowl" (Gullion 1950, 200).

Over-wintering Coots and Salt Water

During the winter migratory season, the coot's habitat requirements are less restricted as thousands of the birds often cluster on open, brackish water (Gullion 1950, 158). University of Montana's Jenni (1988) agrees, noting mud hens seem to show no preference between freshwater and saltwater habitats.

Pearson (1988), of the U.S. Department of Interior, thinks Shoreline's coots would prefer fresh water, but adds salting the Park's ponds would kill any greenery. McMillan (1991), Shoreline's horticulturist, concurs, asserting nothing but pickleweed will grow in saline Shoreline Lake.

Approximately 60 percent of Shoreline's coots winter on or near the Park's saltwater lake (see "Shoreline Coot Census" chapter) even though they appear to favor fresh water.

Heavy rains and automatic sprinklers sometimes leave puddles of fresh water within a few feet of the Lake. Many of the coots appear to find these puddles more enticing than the Golf Course's grass. On 21 March 1991, over eight hundred mud hens gathered in and around a shallow pond on the Course's rain-soaked tenth fairway.

Grazing coots frightened into the water often take the opportunity to drink from the Park's ponds, but not from its Lake. It was not until the author's ninety-second count, 2 May 1991, a coot was observed, albeit unenthusiastically, possibly drinking from the Lake.

Mud hens often walk between Ponds No. 2, No. 3, and the Lake. Part of their journey is probably motivated by a search for fresh water. Not only that, hundreds of coots appear to "commute" just before dark from the City Park northeast of Shoreline Lake, across the Lake to Pond No. 2. Could this evening swim be partly caused by thirst?

Conclusion

Salting Shoreline's ponds would probably evict its approximately six breeding coot pairs (see "Shoreline Coot Census" chapter), but it would not eliminate its winter mud hen depredation problems.

The saltwater habitat at Charleston Slough averages over one thousand migrant coots each year. Therefore, salting the Golf Course's ponds probably will not reduce the Course's overall number of winter coots to a manageable level. This is especially true since the irrigated grass next to the Course's water areas will still attract thousands of mud hen migrants.

Over-wintering coots have been known to temporarily leave their wintering area after being forced to feed offsite (Weddle 1989). Thirsty birds might also temporarily leave Shoreline to drink elsewhere. For example, if the Lake's coots were no longer able to drink from Pond No. 2, they might relieve their thirst by traveling to the Park's freshwater marshes. Even if some mud hens did not return from their off-site sojourns, new migrants would soon arrive to replace most of the departed birds (see "Shoreline Coot Census" chapter).

But even if pond salting cured the Golf Course's coot troubles, it would negatively impact the Course's aesthetics by killing nearly all its aquatic plants (McMillan 1991). The Golf Links's other animals might also

be adversely affected. Therefore, this management technique would not be an option at Shoreline (Trulio 1990b).

Sacrifice Area

Gullion (1989) thinks a "sacrifice" area may attract the Park's coots if it is watched continually. In this way, Shoreline could encourage its mud hens to graze in areas not normally used by golfers instead of engaging in annual turf battles with its coots.

Lyles (1988d) states Shoreline's ultimate goal is to concentrate its "efforts on scare techniques" while "providing alternate grazing areas." Trained dogs and volunteers could be used to keep coots in surrendered areas although these techniques by themselves or in combination are very labor-intensive (see "Dogs" and "Volunteers" sections in "Scare Devices").

But Shoreline could take advantage of the mud hen's reluctance to fly by directing its grazing coots into sacrificed areas bordered by vegetative barriers (see "Vegetative Enhancement" section later in this chapter). In this way, the number of dogs and volunteers needed could be reduced. Of course, mud hens will only make use of sacrificed areas adjacent to water where they normally congregate.

The Course's maintenance department already sacrificed a non-play area on the southwest shore of Pond No. 4A (fig. 4). The land northwest of Pond No. 2A could also be sacrificed (Vaught 1988a).

If necessary, some parts of Shoreline's actual playing area could be surrendered although any area sacrificed could not have a negative impact on golfing business.

The Course's fairways can tolerate more coot abuse than its sensitive greens and tees. For instance, shoreline areas along the tenth fairway can withstand a typical season's grazing by the Park's over-wintering coots (Vaught 1988a).

It appears sacrificed areas may be of value at Shoreline if they are: (1) established near areas coots normally feed, (2) enhanced with vegetative barriers, (3) supported by trained dogs and volunteers, and (4) above all, not negatively impacting golfing business.

Synthetic Grass

One option might be to replace the most heavily depredated areas of Shoreline Links with a synthetic grass the coots would naturally avoid.

Artificial grass, commonly known as "Astroturf®," was installed on the greens of a Colorado golf course. The synthetic green negatively impacted all golfing skills. A golf ball on the Astroturf® green rolled faster and bounced higher than one on a natural grass green. The Astroturf®'s color also stood out from that of the natural grass on the rest of the course. Because of golfer protest, the synthetic greens were removed from the Colorado course (Benz 1994).

A Florida golf course tried adding sand to the base of its artificial greens to dampen the aforementioned intensified ball action.

Unfortunately, the Florida course's synthetic greens did not perform like grass greens and were removed. Currently, no legitimate U.S. course has artificial greens (Keller 1994).

U.S. Indoor Golf of South San Francisco, California has recently perfected a layered, multi-component artificial grass system called "Tour True®". Tour True®'s makers claim their product's consistently true performance actually plays better than grass. Tour True® is proud of the fact its artificial system outcompeted several bidders in 1991 for the job of installing the putting green at the Washington D.C. White House (Keller 1994).

Astroturf® wears out and must be replaced every ten to fifteen years, while Tour True® is designed to last for maybe fifty to one hundred years (Keller 1994). Tour True® installation would cost around one million dollars per hole or about fifty thousand dollars for a single green (Benz 1994). Since Mountain View is only about twenty miles from Tour True®'s display at the San Francisco Airport, the Company would be willing to designate Shoreline as a "showplace" while installing the synthetic surface at a substantial savings (Keller 1994).

But even if Shoreline was used as a showplace, will installing Tour True® on Shoreline Golf Links's most seriously depredated areas make financial sense?

If a Tour True® system were to replace a coot-depredated green, it would not require anywhere near the amount of upkeep the coot-soiled grass demands, thus reducing maintenance costs (The finest bent grass putting surface in the world isn't made of bent grass, n.d., 2). Not only that, if the Tour True® surface plays as advertised, new business may be attracted to Shoreline as local golfers come to try the Course's synthetic grass areas (Priest 1994). So if, for example, a Tour True® system can be installed on a heavily-depredated green for substantially less than its fifty-thousand-dollar retail price, it may pay for itself in the long run.

Unfortunately, the coots would continue to graze on all the Course's naturally turfed areas, including along the edge of all fairways adjacent to an artificial green. Therefore, coot puddling would continue on the Golf Course, including on the outside edge of any synthetic green unless the fake green was constantly supervised.

Territoriality

This section discusses a proposal to attract more breeding coots and take advantage of their territorial nature by enhancing Shoreline's aquatic vegetation. For information on enhancing the Golf Course's vegetation to

control the movements of its over-wintering coots both in and out of its water areas, see the "Vegetative Enhancement" section later in this chapter.

A resident mud hen pair will attack "most vertebrates, coot-sized or smaller," in defense of their breeding territory, which averages around one acre in Northern California (Gullion 1950, 71, 156-57). The coot does, however, save its most intense interactions for other mud hens (Fredrickson et al. 1977, 126), an example of which can be seen in its determination to drive migrant coots from its territorial waters (Gullion 1950, 149). It should be noted that the breeding coot's aggressive nature does not restrict "the productivity of other species" (Fredrickson et al. 1977, 126). Therefore, if Shoreline's water areas were altered to make them more desirable as coot nesting sites, it is possible the natural territorial instincts of the Park's subsequently enlarged number of breeding pairs would compel these resident birds to drive off the Golf Course's mud hen migrants, thus reducing the size of the Course's winter coot population.

According to Gullion (1989), the Park must undergo the following habitat alterations in order to attract more breeding mud hens: (1) decrease its water depth, and (2) increase its aquatic vegetation.

Decrease Water Depth

Coots nest above water no deeper than three to four feet (Gullion 1989), while vegetation needs to be in water of "four feet or less to have

emergence" (Gorenzel 1989). Submerged aquatic vegetation is the mud hen's main food (Allen 1985, 4), with most of it acquired at a maximum depth of four to eight feet (Gullion 1950, 164). But all the Park's water areas drop off quickly, with the Lake twenty to twenty-two feet deep (Trulio 1995a), and Shoreline's ponds about ten to fifteen feet in depth (Bakanoff 1995b). Therefore, the depth of the Park's aquatic impoundments would need to be dramatically decreased to attract more nesting coots.

Increase Aquatic Vegetation

Shoreline Lake currently has no emergent vegetation while its submergent vegetation is almost nonexistent. Normally, coot nests are securely attached to growing plants several inches above the water and seldom located within six feet of the shore (see "Life Cycle" section in "Coot Ecology"). Assuming the depth of the Park's water areas was decreased, Gullion (1989) favors creating numerous coot core breeding territories (see "Behavior" section in "Coot Ecology") by heavily seeding with rushes (*Juncus* spp.), tules (*Scirpus lacustris* or *S. californicus*), and cattails. For instance, if fifty-acre Shoreline Lake was dotted with underwater islands (each supporting robust stands of emergent vegetation), the redesigned Lake would only need to attract about forty to fifty coot pairs, one per territory, in order for the entire water area to be defended.

Narrow bands of emergent vegetation are present along about one-fourth of Shoreline's ponds which also contain small amounts of submergent vegetation. Reconstructing the Park's four ponds along the same lines as its Lake would accommodate about fourteen to seventeen coot pairs, or about eight to eleven more pairs than currently reside on these combined sixteen acres of water area.

Jahn and Hunt (1964, 154) recommend a summer water drawdown of the Park's lake and ponds to improve the quantity and quality of Shoreline's aquatic vegetation (see "Vegetative Enhancement" section later in this chapter). Permanently decreasing the Park's winter water depths would put this improved aquatic vegetation within reach of feeding mud hens, thereby making it possible for coots to establish and maintain nests in areas where it is now impossible.

Gullion (1989) estimates it might take two to three years before a plan based on the coot's territorial instincts was successful (i.e., until new vegetation matured, core areas were occupied). But after that, the plan would be "self-sustaining." That is, as long as the "water levels, rough fish populations, sedimentation, and pollution" were controlled in the Park's lake and ponds (Jahn and Hunt 1964, 18).

If Shoreline's revamped water areas were to support enough breeding pairs to chase off all the Course's over-wintering coots, based on an interpolation of the author's 16 July 1991 resident census figures in chapter

XI, this would give the Park's approximately 122 resident coots and a population of around 742 by the end of breeding season. This figure is well above the 400 mud hens considered manageable by Shoreline's staff (Lyles 1988c), although these 742 residents, unlike the Course's over-wintering coots, should feed in the water of the Park's redesigned aquatic habitat and not on its golf course (Gullion 1950, 163).

Unfortunately, there are several reasons why a program using the coot's territorial instincts would not be appropriate for either Shoreline Lake or the Park's ponds.

A North Dakota study found nesting mud hens completely avoided "subsaline and saline wetlands" (Allen 1985, 3), so it is unlikely any coots will nest in saline Shoreline Lake. McMillan (1991) agrees, claiming nothing but pickleweed will grow in the Lake. Hence, ample aquatic vegetation for feeding and breeding coots is not possible as long as the Lake remains salty.

Regardless, the Lake is designated as a recreational area for boaters and sailboarders. Therefore, its water level and vegetation could not be manipulated to encourage more breeding coots even if it was not salty.

Although it may be possible to alter Shoreline's ponds to meet the needs of resident mud hens, these breeding birds would only defend the Course's freshwater areas from about early March through the summer breeding season. This is because Northern California resident coots reduce

the size of the territory they defend to a winter core area by mid-October, while their territorial activity drops to a low level throughout the overwintering period. This reduced-defended area is only about "one-fifth to one-half" the size of their breeding territory (Gullion 1950, 44, 69).

It is also possible breeding mud hens, like their European relative the black coot (*Fulica atra*), would be "overwhelmed by an invasion of migrant coots," and give "up all attempts to defend [their] territory" (Gullion 1950, 58).

In any event, at least 50 to 80 percent of the surface area of Shoreline's ponds, plus all of Shoreline Lake, would be undefended by territorial coots. In other words, the Park's migrant coot numbers would be virtually the same as they were in previous years until March, when the increased number of resident mud hens in the Course's ponds might hasten the departure of some migrant coots by a few weeks.

Vegetative Enhancement

This section looks at plans to enhance Shoreline Golf Course's vegetation for the purpose of controlling the movements of its overwintering coots, both in and out of its water areas. For information on the use of non-vegetative obstructions to exclude nuisance coots, see the previous chapter "Barriers." For information on enhancing the Park's aquatic vegetation to attract more breeding coots and take advantage of

their territorial nature, see the "Territoriality" section earlier in this chapter.

Enhance Submergent Vegetation

It is possible over-wintering coots would stop grazing on the Golf Course if its water areas were turned into prime wintering habitat.

Gullion (1950, 163-65) observed over-wintering coots only resorted to grazing when aquatic foods were in short supply. To illustrate "the unnaturalness of grazing," coots forced to eat in this manner usually developed physical injuries to their joints and feet. Gullion added that "during the sixteen months of watching birds at [Berkeley's] Lake Jewel, where an abundant food supply was always available, I never observed a coot on land."

One of the best ways to make Shoreline's water areas more attractive to coots would be to purposefully manipulate their water levels. This would encourage the "establishment of volunteer or seeded crops of preferred moist soil food plants" (Jahn and Hunt 1964, 154) each spring after migratory waterfowl leave (Kutilek 1989d).¹ Once the plants are mature (around "late summer or early fall"), they are flooded to place them

¹If, in an attempt to encourage submergent vegetation, Shoreline's water areas are drawn down to the point where they recede considerably or go dry, the Park's breeding mud hens will abandon the area (Gorenzel, Ryder, and Braun 1981, 118).

"in a favored shallow water feeding condition" (Jahn and Hunt 1964, 154), which, in the coot's case, would be at a maximum depth of four to eight feet (Gullion 1950, 164). This process attempts to re-create the bird's natural, shallow marshland habitat that existed before it was altered by European settlers (Beam 1989).

Shoreline's water areas would need to be managed to encourage annual growth since food production declines when vegetation is allowed to succeed to perennials (Beam 1989). As noted in the previous section, managers would also need to control "rough fish populations, sedimentation, and pollution" (Jahn and Hunt 1964, 18).

Vegetation makes up about 97 percent of the coot's diet during migratory season (Jones 1940, 10). Gullion (1950, 166), following Aldo Leopold's classification system for game foods, found Bay Area coots took sago pondweed nearly exclusively when available, while Jones's (1940, 13) study on mud hens' continental feeding habits found the *Najadaceae* (or pondweed) plant family to be the predominant family in the coot's diet. On the Pacific Coast, Jones (1940, 48) noted a majority of the pondweeds consumed were from the *Potamogeton* genus (of which sago pondweed is a member). If Shoreline's water areas were seeded, they would obviously need to include plants the coot naturally preferred to the Course's grass. Therefore, generous amounts of seeds from the *Potamogeton* genus should be included in any restoration program.

Although most species of pondweeds the coot consumes on the West Coast "grow in ponds and quiet streams" (Stein 1980, 1031), it may be possible to increase the amount of green algae (a staple food in the coot's diet [Gullion 1950, 167]) in saline Shoreline Lake.

It is important to note that government funds may be available to assist with a Shoreline wetlands restoration program (Priest 1991).

Unfortunately, Pearson (1988) fears creating an ideal over-wintering habitat at Shoreline will attract even more waterfowl to the Park. Shaw (1985, 158) agrees, noting the most reliable way to increase a wild animal's population is to improve its habitat.

Oakland's saltwater Lake Merritt, which is designated as a wildfowl refuge (Smith-Hansgen [1993], 45), at times has been clogged with copious amounts of green algae. Lake Merritt also happens to be surrounded by irrigated lawn. Gullion (1950, 165) concedes "grazing is also necessary at Lake Merritt" due to the "excessive number of birds" wintering there.

So if the Golf Course enhanced the aquatic vegetation in its water areas, it would very likely attract even more ducks and coots than it does now. Therefore, despite an increased aquatic food supply, Shoreline's over-wintering coots would probably be forced to graze by avian overcrowding.

Regardless, the Lake's submergent vegetation could not be enhanced if the increased plant life interfered with recreational use.

Enhance Shoreline Vegetation

The Park's shoreline vegetation could be enhanced by growing:

- (1) forage crops next to coot-infested water areas in non-play areas,
- (2) vegetative barriers along the perimeter of its water areas, or (3) a combination of the two.

Growing ideal coot forage. Gullion (1950, 174) thinks it might be possible to grow a preferred coot plant on the Course's water banks to satisfy its grazing mud hens. Since the Park's coots tend to do nearly all their grazing within two hundred feet of Shoreline's water areas (see "Shoreline Coot Census" chapter), new vegetation planted in non-play areas near the water might keep its mud hens content.

Large areas of young, germinating grass (three to four weeks old at most) or heavily fertilized grass could be grown right next to the water to intercept the coots. Gullion (1989) suspects these new grass areas would be more attractive than the Course's established turf.

The seed alone for ten acres of Kentucky bluegrass, the same grass used for the Course's fairways (Vaught 1988a), would cost \$7,840.80 (Snethen 1995). But if the mud hens were found to accept less expensive perennial ryegrass (*Lolium perenne*), a common forage crop (Stein 1980, 1157), the same acreage could be planted for only \$3,665.57 (Snethen 1995).

Lettuce could be grown year-round to appease the hungry mud hens (Lazzerini 1995). Gullion (1950, 170) noticed (of the plants he provided) lettuce-like plants were the only foods captive coots preferred over grass.

While the seed to produce ten acres of most varieties of lettuce (at one seed per square foot) would only be around \$545.00, coots and other animals would most likely devour the seedlings well before the sixty days it took for them to reach maturity. Therefore, it would make more sense to purchase greenhouse-grown lettuce for transplant at \$9,147.60 (Lazzerini 1995).

It should be noted that while each potential enhancement program is well below the twenty thousand dollars in turf damage annually caused by the coots (Lyles 1988d), these seeding and transplanting prices do not include any overseeding or maintenance costs.

Again, as in the subsection above, creating an ideal situation will probably just attract more birds. Not only that, the Course's turf often grows within five or ten feet of the Park's water areas. Therefore, a deterrent would be needed to stop the coots from wandering back to the Golf Course to graze.

Growing vegetative barriers. Vegetative barriers can be used to conceal the Park's grass from its grazing coots as well as direct its mud hens into less sensitive turfed areas (see "Sacrifice Area" previously in this

chapter). Priest (1991) adds the barriers also serve as good windbreaks for golfers.

Hodge (1990a, 84) noted waterfowl may abandon a water area if vegetative barriers are planted between the water and their nearby feedings grounds. Shoreline officials considered planting "large shrubs and trees" between its lake and golf course to hide its tasty turf from waterborne coots (Griswold 1986, 10[A]). Vegetative barriers could be used for the same purpose between the Course's ponds and turf.

Geese, like coots, graze on golf courses. This may be partly due to the fact "geese like to be able to see around [themselves]." That is why they do not forage in tall grass or in wooded areas (Heusmann 1987, 20-21).

During the author's coot census, it became apparent the Park's coots always grazed in open areas within a short run or glide of their aquatic wintering areas. Sometimes they would graze in clear view behind tall, thick stands of shoreline vegetation. For instance, the Golf Course along the north shore of Pond No. 4B (figs. 1, 4) has become cut off from the Pond by a ten-foot tall wall of pampas grass. The author often witnessed coots slipping through small openings or running around this organic wall the moment they sensed danger. Occasionally, they even flew over this formidable obstacle. But despite the author's observations, Hodge (1990c) is confident the pampas grass can become an impenetrable coot barrier if it is reinforced with galvanized wire.

Even when a flock of coots grazed behind a vegetative barrier, it appeared at least a few coots to the back of the flock always kept the group's water area in view. This was also true when they grazed up and over the side of a long mound of irrigated grass. In this way, the entire flock never lost sight of its aquatic safety zone.

Since planting a row of bushes or allowing a wide patch of weeds to remain between a water area and mowed lawn can serve as a goose barrier (Heusmann 1987, 21), it is possible these same techniques might be of value against coots.

But in Gullion's (1989) opinion, the mud hens would just fly over a vegetative barrier. Although, as noted above, the author sometimes observed coots flying over vegetative barriers, this behavior was only recorded in coots frantically returning to the water. Similar behavior was also noted in coots feeding behind a fifteen-foot high mesh fence next to the Course's driving range.

Only Weddle (1989) actually saw mud hens fly from water to land over a tall barrier to feed. But this was not until after the birds had been deprived of food for five days (see "Human Blockade" section in "Barriers").

Therefore, it would appear coots only fly over barriers when they are desperate.

Either pampas grass or cattails currently exist along the shore of about one-half of the Park's ponds. If the Golf Course chose to add

bulrushes to their vegetative barriers, the hardstem bulrush (*Scirpus actus*) would be the best choice since it grows to six feet in its first year. The hardstem's maximum height is around eight feet (Robinson 1991).

The broadleaf cattail (*Typha latifolia*) also grows quickly, reaching five feet in its first year before topping out at seven feet. Although slightly shorter than the hardstem bulrush, the cattail is generally a more vigorous and faster spreading plant. Therefore, a wall of bulrushes would require three rows of seed (planted in a diamond pattern about one inch apart) while only two (triangular-shaped rows planted the same distance apart) would be needed for cattails (Robinson 1991).

Unfortunately, Shoreline Biologist Trulio (1991a) feels the Park's cattails may die back in the winter. Robinson (1991) agrees, adding bulrushes also go dormant at a time when the Course's over-wintering coot numbers peak.

On the other hand, nearly all of Shoreline's pampas grass still had a robust appearance during the author's 22 January and 14 March 1991 coot counts (fig. 1). Pampas grass seed could be planted in quite a large shoreline area for just two hundred dollars (Rafalski 1991a).

But pampas grass cannot handle raising water levels and thus requires some dead areas to be cut back. The flower-topped plant can also

grow too high, so blossoms may need to be trimmed in areas where they obstruct fairway views (McMillan 1991).²

Therefore, if the Course's water levels were maintained at a fairly constant level, and fairway plants were occasionally topped, pampas grass (reinforced along the bottom few feet with galvanized wire) should be able to provide an adequate barrier against the Park's grazing coots.

Unfortunately, pampas grass will only grow next to the Course's freshwater ponds. Other than algae, McMillan (1991) notes just pickleweed will grow in saline Shoreline Lake.

The *Photinia fraseri*, a member of the rose family, could be used as a vegetative barrier on the banks above Shoreline Lake. Although not native, it is commonly used as an ornamental plant in the Bay Area (Bell 1991).

The *P. fraseri* has nice foliage and remains attractive year-round. Although it grows thick over its entire length, it may have some leaf loss near the ground. Either an opaque screen on the Lake side of the hedge or early pruning (since its shape is flexible) should solve this leaf loss problem (Bell 1991).

²Pampas grass has sharp edges that can cut an unsuspecting golfer reaching for an errant ball (McMillan 1991). Therefore, everyone on the Course should be made aware of this potential hazard.

The *P. fraseri* is inexpensive and requires little maintenance (Bell 1991). The plant costs about twenty-eight dollars wholesale for a four-foot bush. If planted five feet apart, it will form a solid wall by its second growing season (McKinney 1991).

P. fraseri normally grow eight to ten feet tall with a maximum of fifteen feet (Bell 1991). It should increase in height by about two feet per year (McKinney 1991).

Since the *P. fraseri* does not require much water, adjustments in irrigation practices would be necessary in areas where Shoreline's turf grows near proposed barrier sites (Villa-Scott 1995).

San Jose State's Bell (1991) notes willows (*Salix* spp.) growing near the Lake are healthy despite being deep-rooted and intolerant of salt. Therefore, *P. fraseri* should not have any salt problems. Regardless, Nurseryperson McKinney (1991) recommends testing Shoreline's soil for salinity before a lakeside planting program is undertaken.

But since all of Shoreline's water areas have inadequate food supplies, its over-wintering coots would fly over any barriers if their aquatic homes were cut off from the Park's turf.

Combination of the two. By planting ideal coot forage in areas accessible to hungry coots via openings in vegetative barriers, it should be possible to direct the Park's grazing mud hens into areas where their

presence will be less destructive. This option is discussed later in the "Recommendations" chapter.

Vegetative Removal

This section includes the use of chemical herbicides. For information on chemicals applied to vegetation to produce an aversive reaction in waterfowl, see the "Chemicals" section in "Repellents."

Coots make use of most U.S. water areas during migration. Especially attractive are areas with ample aquatic food supplies where flocks of mud hens may stay until either the weather deteriorates or all food is depleted (Fredrickson et al. 1977, 135). Since vegetable matter makes up about 97 percent of the coot's diet during migratory season (Jones 1940, 10), and since mud hens normally feed while swimming (Gullion 1950, 163), Shoreline's mud hens should not find the Course's water areas as enticing if all their aquatic vegetation was removed.

Several experts note that removing the Course's water plants should also eliminate Shoreline's breeding coots since vegetation serves the dual role of food and shelter for the Park's resident mud hens. Lara (1989a) recommends the removal of all vegetation from the Course's ponds while Hodge (1989a) favors keeping Shoreline Lake devoid of any vegetative cover. Sutherland (1987, 602) agrees, stating "nesting cover rather than food limits nesting destiny" in coots.

Richardson (1990) reported coots inhabited Campbell, California's percolation ponds until the ponds' weeds were sprayed with a herbicide. But chemicals diffuse into the environment, and therefore must be reapplied to be effective (Hodge 1990c). Richardson (1990) would agree, noting coots eventually returned to the Campbell ponds.

Despite the fact Shoreline's Pond No. 1 (fig. 4) has some plant-eating fish, its gilled inhabitants are not cumulatively eating enough to keep its algae under control. Therefore, copper sulfate had been used in the past against the algae in Pond No. 1 as well as in the Park's three fishless ponds, although none of the herbicide was used during the author's 1990-91 Shoreline coot census (Rafalski 1991b).

There is no tidal action in saline Shoreline Lake so it has very little vegetation. But if it ever were to develop a plant problem, chemicals like copper sulfate (which kills fish) are not allowed in the Lake since it is connected to San Francisco Bay (Trulio 1991b, 1991c).

Therefore, for the reasons noted above, algae were present in all the Park's water areas during the author's qualitative aquatic examinations of 2 May and 16 July 1991, although they were present to a far lesser extent in the Park's saltwater Lake.

Shoreline Lake and the Golf Course's ponds drop off very quickly (Trulio 1995a). Consequently, no non-algal vegetation was noted by the author during the aforementioned aquatic examinations of the Lake, while

nearly all of the ponds' non-algal aquatic vegetation consisted of scattered shoreline strips of cattails. Since it is probably easier to physically or mechanically remove these reeds, using herbicides to eliminate the negligible amount of remaining aquatic vegetation would likely be a waste of time and money. In any event, removing the Golf Course's cattails should rid the Course of its approximately six breeding coot pairs, resulting in the elimination of no more than 2 percent of Shoreline's overall coot numbers (see "Shoreline Coot Census" chapter).

But even if chemicals were used to control the aquatic plants in relatively closed systems like Shoreline's ponds, Jahn and Hunt (1964, 16) warn the chemicals could become concentrated in the food chain and therefore "their effects on waterfowl ingesting them should be determined." Balgooyen (1989) adds all chemical labels would need to be checked thoroughly before any substances were used.

But eliminating Shoreline's aquatic vegetation would be counterproductive. This is because coots only graze when there are a lack of aquatic plants (Gullion 1950, 163; Van Way 1986, 292). Therefore, if Shoreline denuded its golf course ponds, it would still attract thousands of grazing migratory mud hens "as long as the grass was there" (Gullion 1989). Van Way (1986, 294) agrees, stating "vegetation management . . . would not be possible . . . in a golf course water hazard."

It should also be noted that even if an aquatic vegetation denuding program was successful, the Course's aquatic plants would undoubtedly grow back again since they were originally self-seeded (Trulio 1995b). Hence the Park's aquatic vegetation would need to be taken out on a regular basis.

Regardless, Shoreline Horticulturist McMillan (1991) likes the natural look the Park's water areas have developed.

Finally, other Shoreline wildlife would be adversely affected by an aquatic denuding program.

Water Removal

Mud hens are the most aquatic of all the birds in the Rallidae family (Fredrickson et al. 1977, 123). They winter on water and nest over water (Allen 1985, 5). Under normal food conditions, "mud hens feed exclusively in the water" (Gullion 1950, 163). They also seek escape cover on water in both winter (Kiel and Hawkins 1953, 320) and during breeding season (Allen 1985, 5). Therefore, it appears Shoreline Golf Links may be able to rid itself of its menacing mud hens by isolating its course from the Park's water areas.

Henderson believes Shoreline experiences coot troubles because it is too close to the San Francisco Bay (Katches 1986, 12[A]). Gorenzel (1989)

agrees, stating it is important to put more distance between the Golf Links and all water areas, which would include draining the Park's marshes.

Others have similar suggestions. Pearson (1988) recommends emptying Shoreline's freshwater ponds while Jenni (1988) thinks draining the Park's large lake might do the trick.

But eliminating part of the Park's water areas will not solve the Course's coot problems. In times of aquatic food shortage, hundreds, sometimes thousands of the wintering birds, feed by spreading out over mud flats or wandering over pastures (Gullion 1950, 158, 163-65). Therefore, as Gorenzel noted above, a substantial buffer area would be required between the Golf Course and any water areas. Gullion (1989) feels the only way to put the Golf Course out of grazing range is to dry up all water sources within "one-half mile or so."

While a quarter-mile buffer between Shoreline Golf Links and nearby water areas is probably more than enough to oust the annoying coot, a buffer this large may not be possible. This is because draining Shoreline Lake, or any of the Park's marshlands, is not an option since they are part of Shoreline's regional recreational and wildlife area, and as such, are regulated by wildlife agencies (Trulio 1995b). Although the Golf Course can change its design to be more like the original Scottish links courses (by removing its four ponds), this will not stop coots from depredating sensitive areas of the Course located near Shoreline Lake.

Conclusion

The Park will always attract migratory mud hens as long as it has irrigated grass near its Lake and ponds. Therefore, it would appear Shoreline will not receive relief from its depredating coots until its water areas and at least the most sensitive parts of its Course are physically separated from each other.

By incorporating different concepts from the "Sacrifice Area," "Vegetative Enhancement," and "Water Removal" sections (and possibly even the "Synthetic Grass" segment), as well as some ideas from the chapter on "Scare Devices," it might be possible to devise a few plans that allow the Park's golfers and mud hens to peacefully coexist. These potential coot depredation solutions will be explored in the "Recommendations" chapter.

CHAPTER VII

POPULATION REDUCTION

While the goal of all the techniques proposed in this paper is to reduce the coot's impact on Shoreline Golf Links's turf, other methods concentrate on attempting to make the Golf Course unattractive or unavailable to the mud hen. Population reduction programs rely on more aggressive approaches, like capturing and killing, to meet management goals.

There are four basic ways to reduce the population density of a species: (1) reduce natality, (2) increase mortality, (3) reduce immigration, or (4) increase emigration (Kutilek 1989a).

There are also four strategies employed to reduce populations, all of which have differing effects on one or more of the above population-density regulators: (1) encourage natural predators, (2) capture and translocate excess animals, (3) cull using trained professionals, and (4) birth control (Kutilek 1989d).

The federal Migratory Bird Treaty Act protects all waterfowl. Permits must be obtained from a state office of the USFWS before one

attempts to kill or capture coots (Hodge 1990a, 83). State and local permits may also be required (Marley 1978, 20).

It is important to consider public opinion and one's personal feelings about killing and trapping animals before a population reduction plan is formulated (Marley 1987, 20).

Anesthetics

Shoreline's coots can be anesthetized and relocated. The exiled birds could have their wings clipped so they would not return (Mason 1990c).

The Woodbridge Village Association (WVA), a private residential complex in Irvine, California, was invaded by nearly three thousand waterfowl every fall migration. These unwanted migrants were mainly coots (Van Way 1986, 293). The WVA decided to anesthetize the mud hens for capture and not shoot them, since the coot problem existed in an area of "high public exposure" (Van Way 1986, 294).

Several chemicals were explored. Alpha-chloralose and tribromoethanol had been successfully used as immobilizing agents against some waterfowl in the past. Methoxymol was eliminated from consideration since it was not registered for use on coots (Van Way 1986, 293). Sodium amobarbital was selected by the veterinarian hired to comply with regulations regarding the handling of immobilizing agents. The chosen

drug was changed to sodium pentothal when it turned out to be less expensive. Tribromoethanol was also used after one pound was donated by an interested California Department of Food and Agriculture. The veterinarian also handled the disposal of the captured birds (Van Way 1986, 294).

The chemicals were presented to the birds after being soaked in chicken scratch and one-inch cubes of white bread. Unfortunately, ducks often scared off the coots and ate all the bait. Sometimes, the ducks overdosed and had to be euthanized (Van Way 1986, 294).

Results were inconsistent when the coots were finally allowed to eat. Drugged coots per application varied from two to eighty, with no pattern evident (Van Way 1986, 294).

The aforementioned chemicals cost approximately \$375 to \$400 per pound in 1984, although the amount needed per application was not stated. This expense did not include veterinarianial costs (Van Way 1986, 294). WVA officials estimated it cost \$23 to dispose of each drugged coot (Figueira 1995).

Even if this method had succeeded, public sentiment might have nixed this approach since the captured coots were euthanized, and many non-target waterfowl were also affected (Van Way 1986, 294).

Clipping the captured coots' wings and translocating them would be a temporary solution at best, as other migrating coots would soon replace the evicted mud hens.

Chemosterilants

Oral contraceptives have been used in specific cases on wildlife, but this management option is very expensive (Kutilek 1989d).

Ornitrol® is a chemosterilant registered for use on pigeons. In order to be effective, Ornitrol® "must be administered at all locations in the city where pigeons gather in large numbers." The chemical causes illness and even death in some birds (Hodge 1990a, 28-29).

Coots are migratory, while pigeons are not (Robbins, Bruun, and Zim 1966, 104, 154). If an oral contraceptive was registered to use on coots, the treated mud hens would remain a local nuisance until they migrated in the spring.

Since waterfowl have up to a 40 percent return rate on migration (Hodge 1990b), the unwanted coots could reappear at the treatment area for several years. An Ornitrol®-produced sterility is temporary (Hodge 1990a, 28), so coots ingesting a similar drug may reproduce before returning in the fall.

There is only one sure way to reduce coot numbers at a winter-depredated area in California with chemosterilants: administering the drug to a large percentage of the Pacific Flyway's approximately 717,000 coots on their summer breeding grounds (Fredrickson et al. 1977, 135). Obviously, this is not practical.

Even if a massive summer coot chemosterilant program was attempted, ducks might steal most of the baited coot food (Van Way 1986, 294).

Disease and Parasitism

Disease and parasitism are known to be natural regulators of population (Kutilek 1989a).

As natural habitat disappears, wildlife refuges like Shoreline (Shaw 1985, 233) will become home to an increasing number of coots (Jahn and Hunt 1964, 93) and other animals. Heavy waterfowl concentrations increase the likelihood of avian illnesses. Since management techniques often "concentrate waterfowl, disease problems will very likely become more severe" (Shaw 1985, 234).

Being extremely social animals, migratory waterfowl are particularly prone to infectious disease. Two of the most virulent infectious diseases in North American waterfowl are fowl cholera and duck virus enteritis. New World birds have almost no resistance to these diseases as both were introduced from Europe (Shaw 1985, 233).

Coots are especially vulnerable to fowl cholera (Fredrickson et al. 1977, 129). The disease is caused by the *Pasteurella multocida* bacterium which is sometimes responsible for locally high fatalities (Shaw 1985, 234).

Shoreline's coots suffered a die off from fowl cholera in March 1990 (Trulio 1990a).

Other diseases that affect mud hens are aspergillosis, pullorum, and botulism (Fredrickson et al. 1977, 129).

Botulism has been responsible for the most waterfowl deaths among non-infectious diseases. It has been especially deadly in the Western U.S. (Shaw 1985, 236).

Another bacterium, *Clostridium botulinum*, causes the botulin toxin to form (Stein 1980, 158). Outbreaks can occur when waterfowl droppings accumulate. This often happens when birds are present in large numbers (Hodge 1990a, 83).

Botulism can usually be avoided by removing animal wastes (Hodge 1990a, 83), and by managing water levels to minimize stagnation (Shaw 1985, 236).

A small number of coots died during an autumn outbreak of botulism in Saskatchewan. In this case, it was thought "live maggots present in carcasses despite subfreezing temperatures" caused the intoxication (Wobeser et al. 1983, 90).

Although many types of parasites are common to coots, these "leeches" generally are not considered "an obvious cause of mortality" (Fredrickson et al. 1977, 129).

It is possible that through natural selection and evolution of the introduced disease or parasite, coots could reach a new natural balance at Shoreline (Kutilek 1989b). But introducing a disease or parasite to kill mud hens would not be a humane or acceptable solution. It would also be impossible to target just the coot, as other waterfowl species would undoubtedly be affected.

Natural Predators

This section discusses the use of natural predators as a coot population reduction technique at Shoreline. Information on birds of prey as frightening tools is in the "Falconry" section of "Scare Devices."

In general, predators are not thought to control prey numbers (Kutilek 1989a). The golden eagle, northern harrier, prairie falcon, and red-tailed hawk, all take coots (Priest 1991). All normally can be seen at Shoreline sometime during the year (Newberry 1986a, 3; Trulio 1993). Peregrine falcons (Gullion 1950, 177), bald eagles (Grubb 1977, 1066), and great horned owls (Fredrickson et al. 1977, 130) also prey on coots, but these birds are not often found at Shoreline (Trulio 1993).

Golden eagles are occasionally seen at Shoreline during the fall and winter (Trulio 1993). A resident pair of golden eagles may take one coot per day per pair (Priest 1991), although they usually prey on rodents (Robbins,

Bruun, and Zim 1966, 76) and rabbits (Trulio 1995b). A golden eagle's home territory can be up to sixty square miles (Priest 1991).

The northern harrier can be seen year-round at Shoreline (Newberry 1986a, 3). Also known as the marsh hawk, it preys on amphibians, birds, carrion, crayfish, insects, and rodents (Newberry 1986b, 27), although it mainly feeds on rodents (Robbins, Bruun, and Zim 1966, 68).

The prairie falcon is an extremely rare guest at Shoreline, visiting only in the spring and fall (Newberry 1986a, 3). It naturally takes coots (Priest 1991). A falconer could train a bird to prey on Shoreline's coots, but if there already was a resident prairie falcon at Shoreline, the two would clash (Priest 1989). Regardless, the encouragement of natural predators often does not work (Kutilek 1989d).

The red-tailed hawk is fairly common at Shoreline year-round (Newberry 1986a, 3). The red-tail is not apt to prey on birds unless it has been so trained. It usually takes squirrels or rabbits (Priest 1989). Lyles (1988c) has noticed red-tails frequent the PG&E® right-of-way corridor south of the main golf course, as opposed to the Lake area where most coots reside.

A resident red-tail will fight any other red-tail hawk that invades its territory (Priest 1991). Therefore, introducing other trained red-tails to take coots would not be a good idea.

Conclusion

Although birds of prey take coots, the number of coots taken is insignificant compared to the thirty-five hundred mud hens that winter at Shoreline. Introduced raptors might also have territorial fights with resident birds of the same species. Regardless, the encouragement of natural predators as a population reduction method is usually not successful.

Net Capture

Cannon, butterfly-type, and mist nets, can all be used to capture birds (Van Way 1986, 293).

Zahn (1989) recommended capturing Shoreline's coots with cannon nets and transporting them to another refuge on the San Francisco Bay.

The Los Angeles County Department of Agriculture (LACDA) purchased a weighted 30-by-60-foot, 1¼-inch mesh cannon net (cost not indicated), an ignition device (\$350.00), three rocket tubes (\$75.00 each), and mortar charges (\$2.75 each), in an attempt to remove coots from a recreational reservoir with minimal public disruption. But LACDA's best effort produced only twenty-five mud hens, as the coots were reluctant to return to the vicinity after each explosion. The experimenters discovered cannon netting was too expensive, too time-consuming, and as noisy and hazardous as shotgun capture. Van Way (1986, 293) suggested a

cannon-type net might be more successful if dropped horizontally from a predetermined area onto herded coots.

The WVA used a butterfly-type net to capture coots. The daylight attempt ended when only one coot was caught in 2½ hours (Van Way 1986, 293). Hand netting at night has been successfully used outside of California with the aid of high-intensity lights (Van Way 1986, 294). Shoreline's coots would probably be difficult to hand net at night, as most rest in the middle of one of the Golf Links's large ponds.

Mist nets are designed to catch smaller, lighter birds in flight. Even if a stronger mist net existed, it would be of little value against a coot, since it seldom flies (Van Way 1986, 293).

Once coots are captured, they can be either: (1) relocated or (2) killed.

Relocate after Capture

State and federal permits are required if any coots are handled and relocated. The USFWS must first sanction a relocation request before the DFG can be contacted for its approval (Lara 1989a).

The DFG generally does not approve a request to relocate captured wild animals. The animals must be quarantined for a specific number of days to make sure they are not infected with a disease. During this period,

the animals must be housed and fed. No money is currently available to board quarantined animals (Lara 1991).

If the DFG did approve a relocation request, it would then have to select a relocation site (Lara 1989a).

Relocating captured animals is extremely difficult. Most wild places are already occupied by other animals, and there probably would not be enough food and shelter to go around (Lara 1991; Hodge 1990a, 6).

When handling wild animals, care must be taken to work "as safely and quickly as possible," as most will be terrified and uncooperative. Trained help should be used to decrease the risk of injury to the handler and to the animal (Hodge 1990a, 103).

Translocation is usually only a temporary solution. New coots soon arrive to take the place of the evicted birds (Beam 1989). There is also a chance the ousted coots will come back (Yparraguirre 1991). It might even be necessary to remove the mud hens two or three times each year (Beam 1989).

A homing study found most relocated coots soon returned to their old homes. Gullion (1950, 46) tagged and relocated thirteen first-year coots at four different sites within thirty-one miles of their winter home, Oakland's Lake Merritt. At least nine of the ten birds released north of Lake Merritt left their new homes, even though some of the coots were placed in locations "much more suitable than their preferred wintering area

at Lake Merritt." At least seven of the northern-released birds returned to Lake Merritt and remained there for the rest of the winter. The three mud hens released on San Francisco's Stow Lake, southwest of Lake Merritt, remained in San Francisco for the winter.

It is hard to generalize from Gullion's homing experiment, since only birds that migrated once previously were used, but it would appear unfamiliarity with their new surroundings prevented the southwest-released birds from returning to Oakland. In fact, Gullion (1950, 48) cites another homing study done with gannets (*Morus bassanus*) where previous knowledge of the terrain was found to be important.

Even if coots were translocated to areas south of Shoreline, this might not prevent them from returning the following winter. It would also be impossible to capture all of Shoreline's coots (Yparraguirre 1991). With an estimated 90 to 95 percent of Pacific Flyway birds stopping along the San Francisco Bay (Steiner 1989), the remaining coots would probably attract other migrating mud hens (Heusmann 1987, 20).

Animal relocation is very costly. The larger the animal, the more expensive the move becomes. This is especially true if the problem is a continual one (Kutilek 1989e). The cost of capturing the coots would depend on the amount of volunteer help Shoreline could muster (Yparraguirre 1991). Relocation is only recommended for geese when other control methods are used to discourage their return (Don't feed geese n.d., 1).

Another possible problem with relocation is negative publicity.

Coots annually congested the artificial lakes at Spring Valley Lake, a planned community near Hesperia, California. Around 1990, Spring Valley Lake attempted to capture and move the coots, but received strong opposition from animal rights advocates (Alves 1992).

Kill after Capture

An option to moving captured coots would be to kill the birds. Additional licenses and permits are required if one chooses this lethal alternative (Marley 1987, 20).

Killing the coots solves the problem of captured birds returning. It would not stop new coots from taking their place or animal lovers from protesting.

Poisoning

One option would be to poison Shoreline's nuisance coots. Avitrol® is a chemical registered for use against herring gulls (*Larus argentatus*) and blackbirds (no species identified). Avitrol® is offered to the aforementioned birds on baited bread and tainted grains, respectively. Few birds actually die from the deadly Avitrol®, as the first bird(s) to consume the bait scare off others with their unusual behavior and calls of alarm and distress. Both federal and state permits must be obtained before Avitrol® can be administered to herring gulls (Salmon, Conte, and Gorenzel 1986, 92[E]).

Before the Environmental Protection Agency will register a chemical for use on coots, it must undergo expensive testing specifically on coots (Conover 1989).¹ Even then, poisons are prohibited in some states and municipalities for use as bird control agents. Therefore, one must first determine the local legal status of any management plan that includes the use of toxicants (Zajanc 1962, 207).

Often when toxicants like starlicide are used, non-target animals become unintended victims, and target animals learn to avoid bait. When this happens, more time is spent pre-baiting, baiting, and monitoring, which means higher costs (Mason et al. 1985, 637).

Another problem with some lethal agents is the risk of secondary poisoning. All poisoned coots would need to be retrieved promptly before local raptors, cats, dogs, foxes, or other carnivores had a chance to come in contact with them (Zajanc 1962, 207).

Past attempts at poisoning (Jones 1940, 50) and anesthetizing coots (Van Way 1986, 294) (see "Anesthetics" section earlier in this chapter) have not been effective.

But poison programs often fail due to the inexperience of those administering the toxicants. The main reasons for these failures include

¹Chemical registration is covered in more detail in the chapter on "Repellents."

the use of: (1) inappropriate baiting sites, (2) incorrect bait, (3) insufficient poison, and (4) ineffective poison (Zajanc 1962, 206).

Regardless, a poison-based solution to Shoreline's coot problem was eliminated from consideration since it is not humane.

Shotgun Capture

This section discusses shooting as a coot population reduction tool. Information on coot shooting for sport is covered later in this chapter in the "Sport Hunting" section.

The USFWS considers shooting the most cost-effective way to deal with unwanted coots (Lara 1989a). The fact many coot characteristics make it particularly vulnerable to being shot probably accounts for the technique's cost-effectiveness.

During its southern migration, the coot is less selective when choosing a winter home. Thousands of mud hens often cluster on open water unprotected (Gullion 1950, 158).

Coots are generally docile and trusting around people (Jahn and Hunt 1964, 117). Mud hens commonly swim among hunters' decoys and are not very bothered by shotgun blasts (Jahn and Hunt 1964, 93).

When alarmed, a centripetal scramble takes place, as coots in the vicinity furiously dart "across the water surface toward the flock center . . . to form a tight huddle" (Grubb 1977, 1065) in the open (Rand 1956, 167).

The coot alarm response is known as the "selfish herd phenomenon." Individuals attempt to hide out in a group of the same species. This gives single group members a better chance of survival as hundreds, often thousands, flock together (Rogers 1987). But when this happens, a gunner can often kill twenty or more coots with one shot (Ward 1953, 327).

Coots seldom fly during the day (Fitzner and Schrickhise 1979, 11). But if frightened into the air, the mud hens usually mill around above the water, low enough to stay in shotgun range (Kiel and Hawkins 1953, 316).

Waterfowl generally will return to "where they learned to fly, and winter where their ancestors did" (Heusmann 1987, 20). Therefore, if a local population is shot out, it will take a long time to repopulate (Kutilek 1989c).

Another advantage of a shooting program is the waterfowl often vacate the depredated area even when they are not shot (Heusmann 1987, 21).

Coots and all other waterfowl are protected by the 1918 Migratory Bird Treaty Act (Marley 1987, 22). A permit must be obtained from the state branch of the USFWS to shoot or capture bothersome waterfowl (Hodge 1990a, 83). State and local permits also may be required. Federal permits usually are only approved after nonlethal management practices have failed (Salmon, Conte, and Gorenzel 1986, 92[E]). In extreme cases,

normally "involving human health or safety, a [federal] kill permit may be issued" (Pfeifer 1983, 76[E]).

A coot eradication program can be conducted under the authority of a depredation permit (Tate-Hall 1991) or, where regulations allow, by a controlled hunt during hunting season (Marley 1987, 22). Tate-Hall (1991), a member of the USFWS law enforcement division, notes coots are the only species of waterfowl that can be shot with a depredation permit. All other waterfowl must be trapped.

Wright (1991), another USFWS employee, will often make a kill recommendation, stating the coot is "not a preferred game bird. It's considered a trash bird."

The USFWS receives numerous calls about problem coots. Lara (1989b) favors eliminating the pests, declaring they are "not in danger of extinction." Jenni (1988) agrees, noting there is "basically a bottomless population [of coots] in North America." Regardless, complete extermination at the depredation site is necessary as any remaining coots will attract others (Salmon, V. 1985).

Following are some examples of how simple and successful this population reduction method can be.

Exterminate Depredators

In 1984, the LACDA obtained a depredation permit and killed three thousand mud hens using just fifteen man-hours and about five hundred dollars in ammunition (Van Way 1986, 293).

A Mission Viejo, California golf course was issued a permit to shoot its unwanted coots. When the management action was completed, only two coots remained out of the thousands that once occupied the course (Gilhuly 1989).

Another option, the aforementioned "coot shoot," is a possibility during duck hunting season. All participants must have a current federal duck stamp and a hunting license. Coot shooters should not be allowed to discharge their guns near roads or buildings before local laws and state hunting regulations are investigated. A state duck stamp may also be required (Salmon, Conte, and Gorenzel 1986, 92[E]).

Members of a Santa Barbara, California golf course enjoyed the "coot shoots" at their country club. Course Superintendent Weddle (1989) supports shooting as the only effective coot population reduction tool.

Coot shoots are also popular on some California gun club preserves where mud hens are shot simply to "get them out of the way." Around five thousand coots were killed in one day at a Merced County gun club shoot (Ward 1953, 326).

As attractive as this management approach might sound, it should be noted a coot shoot or depredation shoot must be held periodically if one is to realize any long-term success as new coots will eventually repopulate the area. The aforementioned Santa Barbara golf course soon found itself reinfested with mud hens after a local law prohibited its coot shoots (Weddle 1989).

Limited Shooting

Many coot management strategies include shooting along with other control techniques.

When depredation is a problem, Fredrickson et al. (1977, 141) support limited shooting or habitat acquisition. Lara (1989a) recommends hazing and pyrotechnics reinforced with shooting. Gullion (1950, 174) suggests herding, artificial feeding, and shooting to decrease depredation until appropriate habitat can be provided.

Shoreline Golf Links has annually attracted up to four thousand wintering coots since it opened in 1983 (Vaught 1988a). Shoreline's staff attempted numerous alternative techniques prior to and during their limited shooting program of 1984-87. Some of these methods included hazing and pyrotechnics (Katches 1986, 1[A]), herding with dogs (Lyles 1988c), and artificial feeding (Bakanoff 1988). The Golf Course

maintenance staff also unsuccessfully sacrificed specific areas of their course to the coots (Vaught 1988a).

Shoreline first obtained a USFWS permit to shoot its coots in 1984 (Lyles 1988b). All shooting was conducted during morning twilight before golfers were allowed on the Golf Links (Hodges 1987, 3[A]). Only steel shot was used during the operation while a trained dog retrieved coots killed on water (Lyles 1987a).

In 1985, seven hundred Golf Course coots were taken under the now annually-renewed depredation permit (Lyles 1988c). Nearby Moffett Field Golf Course experienced an invasion of about two thousand mud hens that year and felt its coot increase was related to Shoreline's shooting northwest of Moffett Field (Katches 1986, 12[A]).

Despite the shooting, the mud hens returned to Shoreline the following year. This time, about twenty-five hundred coots were killed (Hodges 1987, 3[A]).

Shoreline Golf Links had a different management plan ready when the coots arrived in 1987. Live ammunition would only be fired around two days each week while blanks would be used daily. Lyles (1988a) felt as many as one hundred blanks were shot for each live shell. It was hoped this new approach would reduce Shoreline's mud hens to a manageable number without killing as many as in past years (Lyles 1987b).

An estimated five hundred coots were taken in 1987, about 80 percent less than were shot the previous year (Collins 1988). Unfortunately, the coots continued to depredate the Links (Lyles 1988c).

Nearly all live shooting was handled by Shoreline maintenance workers from gas-powered Cushman® industrial cars,² while course marshalls fired blanks from their quiet electric carts. Coots were soon able to distinguish between vehicles, and would run for safety when they heard a Cushman® approaching (Lyles 1988e).

The observation spawned another management plan for 1988. If all live ammunition was discharged from electric golf carts, maybe the coots could be trained to flee every time an electric cart approached. Since golfers and course marshalls also use electric carts, the coots would end up spending less time grazing and more time running for safety (Lyles 1988e).

But coots are not permanently bothered by shooting (Jahn and Hunt 1964, 123), and soon return to graze. Also, a limited shooting program would be in conflict with Shoreline's ultimate goal to end all shooting (Lyles 1988c), so the new plan was never implemented.

Another unattempted limited shooting plan involved directing Shoreline's firepower at one sex versus the other. Wildlife populations are sometimes managed by maintaining uneven sex ratios (Kutilek 1989b).

²Cushmans® are about the same width as golf cars, only longer.

Waterfowl species tend to have an uneven sex ratio. Normally, there are more males than females. Females suffer a higher mortality rate since they spend much of their time on the nest. Therefore, females are susceptible to predation, trampling by livestock, and collisions with farm machinery. Females also migrate later, so they tend to be shot more. Sometimes, males will outnumber females by more than four to one (Kutilek 1989d).

Since waterfowl are generally monogamous, the number of broods each spring is limited to the number of mated pairs (Kutilek 1989d). Therefore, if this large gender disparity appeared in Shoreline's thirty-five hundred coots, only seven hundred would be females. Since the same coots should return to winter at Shoreline each year (Yocum, Rogiatto, and Eshelman 1978, 302), managers could concentrate their shooting on female coots.

Annual adult coot mortality is around 57 percent (Burton 1959, 207). Therefore, assuming dead coots are not replaced by new arrivals, Shoreline could reduce its coot population to 324 males within two years by just shooting female mud hens. This figure is less than Shoreline's stated goal of 400 coots.

But coot habits are very different from other waterfowl (Fredrickson et al. 1977, 135). Although mud hens are monogamous (Gullion 1950, 200) like most other waterfowl, they differ in that they share incubation duty

(Jones 1940, 2). Coots normally are not affected by nest predation (Fredrickson et al. 1977, 130) or farm machinery as they nest over water. Adult females complete their migration before all other coots, so they often arrive at their wintering grounds before hunting season (Eddleman, Knopf, and Patterson 1985, 241).

The previous paragraphs imply that male mud hens do not outnumber female mud hens, but there is no data on the sex ratio of coots. This is because the "most pressing management need for coots is adequate inventories" (Fredrickson et al. 1977, 141).

Even if a greater disparity existed, managers would be unable to use it to their advantage. Coots, young and old, male and female, are indistinguishable during hunting season (Fitzner and Schrickhise 1979, 11).

Discourage Shooting

Not everyone agrees that shooting coots to reduce their population is a good idea. Van Way (1986, 293) discourages the use of shooting in areas near homes or recreation facilities for safety and possible public relation reasons while Pfeifer (1983, 76[E]) believes wildlife managers should use firearms not to shoot, but to scare waterfowl (see "Shooting As a Scare Tactic" section in "Scare Devices" for nonlethal applications of shooting versus coots).

Hodge (1989a) concluded shooting has no long-term effect on coot numbers in a nuisance area. Gullion (1989) agrees, adding shooting will not stop coots from coming to Shoreline's golf course, as it is an "ecological trap." In fact, Shoreline shot nearly three thousand coots in one season, and it did not seem to help (Lyles 1988c).

Moffett Field Naval Air Station, just one-quarter mile southeast of Shoreline, is the next suitable habitat along the coots' southern migrational route. Like Shoreline, Moffett Field has a golf course next to San Francisco Bay that includes several water areas.

Moffett Field's golf course experienced coot problems until Shoreline opened in 1983. Course Superintendent Lee Henderson feels "Shoreline offers the birds a more suitable environment because it is closer to the Bay" (Katches 1986, 12[A]). Gullion (1989) agrees, adding it is rare in the Bay Area to have turf so close to water. Gullion also notes coot numbers may not be endless if some left nearby Moffett Field.

Conclusion

The coots' habits make them extremely vulnerable to shooting. Although complete extermination via a shotgun capture program is the most cost-effective way to handle nuisance coot problems, it is only a temporary solution.

Henderson felt Shoreline's limited shooting plan may have done little more than shift Shoreline's coot troubles to nearby Moffett Field in 1985. But Kiel and Hawkins (1953, 316) observed mud hens would not leave a Wisconsin lake despite being under heavy shotgun attack. Lyles (1987b) also noted Shoreline's limited shooting scheme merely kept its coots dispersed so that the nearly one thousand grazing birds near Shoreline Lake were more manageable. The fact that Moffett Field personnel reported continuing coot problems after Shoreline's shooting program ended makes it even more unlikely that Shoreline's shooting was responsible for Moffett Field's mud hen reinfestation (Carlton 1994, Hardy 1989). Instead, Moffett Field's reinfestation was probably caused by an inadequate supply of coot wintering habitat along the Pacific Flyway (Fredrickson et al. 1977, 141).

Steiner (1989) estimates as many as 95 percent of the birds that use the Pacific Flyway stop along San Francisco Bay. Since Shoreline Golf Links is next to the Bay, it will always attract new mud hens to the area. To annually shoot several thousand coots just makes previously-occupied habitat available for the waves of new migrants seeking winter homes, not to mention the public relations nightmare such a policy would undoubtedly create. Even if it were possible to eliminate the pesky coot, it might be replaced by something even less desirable like the Canada goose (see "Ecological Importance of Coots" section in "Coot Ecology").

Waterfowl management is a complicated process that includes nesting, wintering, and connecting flyway programs. It requires cooperation between state and federal agencies as well as private organizations (Shaw 1985, 159). If all managers were to advocate exterminating entire flocks of depredating coots, it is not known what effect it would have in the long run.

In the early 1800s, a single flock of passenger pigeons (*Ectopistes migratorius*) in North America contained up to two billion birds. These flocks were often 1 mile wide and as much as 240 miles long. Hunting of the passenger pigeon reduced its flock size to the point where it could not recover (Kutilek 1989c). A century later, it was extinct.

It would not be fair to suggest the coot awaits the same fate as the passenger pigeon, as the two come from entirely different, biological families (Peterson 1980, 64, 180). But it is fair to say more information is needed on the coot if it is to be managed wisely (Kiel and Hawkins 1953, 311).

Sport Hunting

This section discusses how hunter attitudes toward the coot as a sporting bird affect the number of mud hens harvested. Information on shooting as a population reduction tool was covered previously in the "Shotgun Capture" section in this chapter.

A logical solution to coot depredation would be to increase hunting pressure.

Gullion (1950, 174-75) recommended increasing coot sport shooting early in hunting season so "existing natural foods would not only last longer, but the number of birds left to cause crop depredation would be greatly reduced."

Practically all of northern and central California hold a split hunting season for ducks and coots. In 1990, the year the author conducted Shoreline's coot census, the first split season began 27 October and ran for twenty-three days. The second split season started 1 December and continued for thirty-six days (Bontadelli 1990, 5).

But before the first split season began, nearly half of Shoreline's eventual 1990-91 migrants had already reached their winter destination (see "Shoreline Coot Census" chapter). If increased hunting pressure is to be of value, it would need to start before the current hunting season.

In previous years, there actually was a longer hunting season for coots than for other California waterfowl. Hunters did not take advantage of the extended season, so it was discontinued (Connelly 1991).

It is interesting to note that the graph of the 1990-91 Shoreline coot migration looks very much like that of a normal curve (see "Shoreline Coot Census" chapter). One would expect a noticeable change in the graph, one way or the other, to coincide with hunting season. Surprisingly, no change is detectable. This was apparently because only 6,367 out of approximately

257,000 California coots, or about 2 percent,³ were reported as retrieved kills during this period. Compared to 31 percent for the mallard, the highest percentage killed for any waterfowl species, this amount is negligible (Yparraguirre 1993a).

Fredrickson et al. (1977, 130) report more coots are killed during a special two-day depredation shoot in California than the state's 175,000 waterfowl hunters take in an entire season. It is believed less than 20 percent of California waterfowl hunters kill coots.

The coot's bag limit of twenty-five is about seven times greater than that of ducks or geese (Bontadelli 1990, 4), yet the mud hen comprised less than 1 percent of California waterfowl reported killed in 1990-91 (Yparraguirre 1993a). About 6 percent of California's waterfowl are coots (Yparraguirre 1991).

The coot has never been heavily hunted in the Pacific Flyway. Kiel and Hawkins (1953, 315) stated the coot made up around 1 percent of the hunters' bags during the 1949-52 waterfowl seasons. During the 1972-73 season, 1.3 percent of the retrieved kill were coots (Fitzner and Schrickhise 1979, 23). The average coot harvest from the twenty seasons between 1953-1972 was approximately 169,400 (Fredrickson et al. 1977, 140). This is

³The percent kill statistic is that of the author. Percent kill is derived by dividing the sum of the same season's final federal retrieved kill and mid-winter count numbers by the final federal retrieved kill.

slightly above the 1951-52 total when 119,017 comprised 1.4 percent of the total waterfowl kill (Kiel and Hawkins 1953, 315).

Nationally, small bag limits for ducks and geese, and large bag limits for coots are the rule. Even where duck and goose populations are low, hunters generally will not shoot coots (Fredrickson et al. 1977, 141).

Reasons for Low Hunter Interest

Waterfowl hunters give two reasons why they typically do not shoot coots: (1) duck hunting is more exciting and (2) coots are unpalatable (Fredrickson et al. 1977, 138).

According to Kiel and Hawkins (1953, 313), shooting coots does not offer hunters the same thrill as shooting ducks.

When alarmed, the coot will swim to open water. "Hunters find little sport in a bird that seldom flies or hides" (Rand 1956, 167).

But Gullion (1950, 175) contends once coots start being shot, they soon become a sporting bird, and uses the eastern U.S. as an example.

In the 1950s, the coot generally surpassed all waterfowl species in Mississippi-Flyway hunters' bags except for the mallard (Burton 1959, 203). During the combined 1949-52 waterfowl seasons, 80 percent of all coots killed were shot in the Mississippi Flyway, while 14 percent were bagged in the Atlantic Flyway. The remaining 6 percent were divided among hunters in the Central and Pacific Flyways (Kiel and Hawkins 1953, 315).

Most hunters feel the coot is not worth eating (Fredrickson et al. 1977, 143; Kiel and Hawkins 1953, 313). The mud hen's diet probably accounts for its poor taste (Van Way 1986, 292).

But properly prepared, the coot is quite edible (Kiel and Hawkins 1953, 313). Skinning the mud hen must eliminate the cause of its bad taste, as skinned coot tastes "as good as most domestic fowl" (Gullion 1950, 176).

But Why Shoot Coots?

In the eastern U.S., sportsmen turned to the coot when ducks were scarce (Gullion 1950, 175). But Yparraguirre (1991), a DFG wildlife biologist, sees little reason for the Golden State's waterfowl hunters to shoot coots, stating, "The [California] Central Valley has the highest concentration of ducks in North America behind only the Texas Gulf Coast and possibly Louisiana."

In part, because of California's geographic good fortune, the coot has become known as "one of the most . . . unwanted of the migratory birds" (Lyles 1988d); "a trash bird" (Wright 1991). Therefore, California coots usually succumb to: (1) waste, (2) depredation shoots, and (3) accidental shootings.

Waste. Despite a federal hunting regulation prohibiting wanton waste (Bontadelli 1990, 7), federal game management agents regularly find

large numbers of unretrieved coots (Kiel and Hawkins 1953, 316). The main reason coots are indiscriminately killed seems to be that many sportsmen believe the coot competes with the more-valued duck for habitat.

A drought in the early 1930s (Kiel and Hawkins 1953, 313), along with the destruction of marshes and the draining of prairie potholes for agriculture, reduced waterfowl numbers in North America from hundreds of millions to only twenty-seven million in the late 1930s (Kutilek 1989d).

Some claimed the coot outcompeted several duck species on their breeding and wintering grounds. These conflicts were supposedly partly to blame for the large duck decline (Kiel and Hawkins 1953, 312) and theoretical coot overabundance of the thirties (Ward 1953, 326). It is more likely coots do better during a drought, and recover faster afterwards, because they are apparently able to travel farther than ducks to avoid dry conditions (Kiel and Hawkins 1953, 319).

Because of the management efforts of private groups and public agencies, duck numbers have been in good shape since the fifties (Kutilek 1989d). Despite this, anti-coot sentiment persists. Many still feel the "overabundant" coot deprives ducks of food (Ward 1953, 325).

When wintering coots help themselves to duck food on California gun club preserves, club members shoot them by the thousands "to get them out of the way" (Ward 1953, 325, 326).

Another example of this anti-coot philosophy can be seen when hunters, impatient from waiting for ducks, often perform "a service" for their webfooted friends by "warming up" on coots. Mud hens taken in this manner are seldom retrieved (Ward 1953, 325).

Even some naturalists urged bird lovers to remove the coot from all protective legislation, stating action was needed to "mitigate or abolish the menace of the mud hen" (Kiel and Hawkins 1953, 312).

Despite an exhaustive investigation, no literature was found to support the coot haters' charges, only articles to the contrary (see "Community Ecology" section in "Coot Ecology").

Coots are often wasted for reasons other than to relieve possible resource competition with ducks.

Some hunters shot mud hens "just to see how many they could kill with a single shot" (Fredrickson et al. 1977, 130). Other sportsmen use coots for target practice without bothering to retrieve their kills (Jahn and Hunt 1964, 124).

Crippling losses for coots are consistently higher than those for ducks.⁴ During the 1959-60 waterfowl season, 36 percent of coots shot in the four U.S. flyways were crippling losses, compared to 16 percent for ducks (Jahn and Hunt 1964, 120).

⁴A crippling loss is a wounded or killed bird that is unretrievable, while "wasted" birds are retrievable birds that are not retrieved.

It seems unlikely, slow, low-flying coots would be lost more than twice as often as ducks. Jahn and Hunt (1964, 123) think "hunters are apparently willing to report these unretrieved birds because they want credit for having shot them."

Depredation shoots. Many hunters participate in coot depredation shoots. Fredrickson et al. (1977, 130) reported "650 hunters normally take about 7,500 coots" in a two-day California depredation shoot.

Depredation permit holders must give the USFWS an annual summary of all birds taken under the permit (Van Way 1986, 293). Despite this, the USFWS in California does not know how many mud hens are killed in this manner (Wright 1991).

Tate-Hall (1991) in the USFWS's Portland, Oregon regional office, estimates at least as many coots are taken with depredation permits as are retrieved by sportsmen during a typical California hunting season.

Accidental shootings. Sometimes coots are killed when they are mistaken for ducks.

Hunters may have trouble distinguishing one species of waterfowl from another when visibility is poor. This occasionally occurs "in the early morning of a dull, overcast day" (Kiel and Hawkins, 1953, 316).

Conclusion

While most U.S. waterfowl biologists agree the coot harvest could be increased, proper management of this resource would be difficult without accurate population and harvest data (Fredrickson et al. 1977, 138). This data should also include depredation shoots. More coots are killed annually in California with depredation permits than are retrieved by hunters, yet no records are kept on depredation shoots.

Even if accurate coot data were available, American sportsmen generally believe mud hens are not challenging or worth eating (Fredrickson et al. 1977, 143). Currently, coots are only seriously hunted locally in five states (Fredrickson et al. 1977, 123). Some still destroy coots for competing with the more-favored duck despite conclusive evidence to the contrary (Kiel and Hawkins 1953, 320). A concerted educational campaign would be required to change hunter attitude toward the coot (Fredrickson et al. 1977, 143).

Coots are extremely vulnerable to the shotgun. Since they rarely attempt to escape from gunfire, it is estimated up to 95 percent of mud hens in some areas of the Mississippi Flyway have been killed on the opening day of hunting season (Ward 1953, 326).

Hunting deaths are usually compensatory to a species's natural mortality up to a certain point. Whenever that point is surpassed, hunting kills become additive (Shaw 1985, 171). Before more hunters are persuaded

to take coots, it is critical that precise inventorying methods are developed. Then it will be possible to properly monitor and set realistic bag limits for the species (Fredrickson et al. 1977, 144). This will insure a minimum number of breeders survive each year (Jahn and Hunt 1964, 106). In the meantime, it would be sensible to advocate less liberal daily bag limits for the coot (Shaw 1985, 148).

But even if it was proven safe to increase coot sport hunting, the public and some environmental groups in California have balked at a similar lethal solution to a much more serious habitat conflict between humans and cougars (*Felis concolor*).

Regardless, coot sport hunting would probably have to be added to the recreational activities offered at Shoreline in order for there to be a noticeable reduction in the Golf Links's coot population (Connelly 1991), as coots annually return to the same wintering area (Gullion 1950, 48).

Trapping

Gilhuly (1989) and Gorenzel (1989) both felt Shoreline's coots could be trapped and released in another area. Balgooyen (1989) recommended baited traps as a safe and effective way to remove the coots from the Golf Course. Van Way (1986, 294) suggested modifying a baited waterfowl trap to exploit the coot's flocking behavior.

If Shoreline decided to trap its coots, it would first need to contact the USFWS Department of Animal Damage Control in Fresno, California. The USFWS would then send a representative to investigate the complaint and offer technical assistance on trapping (Lara 1989a).

Shoreline staff would next be required to complete an application to trap the coots. The application would then be forwarded to the USFWS in Sacramento (Lara 1989a). State and local permits may also be required (Salmon, Conte, and Gorenzel 1986, 92[E]).

Trapping permits usually are not approved unless nonlethal control methods have failed (Salmon, Conte, and Gorenzel 1986, 92[E]).

Weddle (1989) found trapping coots does not work on a golf course. Golfers using the course would invariably pass by and accidentally scare the mud hens away from the trapping area.

Mason, Adams, and Clark (1989, 55) found trapping expensive and added that "birds often return when control measures are relaxed."

Hobson (1989) stated that trapping the coots would be hard to do every year.

But even if a trapping program was successful, an acceptable method of coot disposal would need to be found. Current disposal

techniques are either inhumane or too costly to make trapping a viable option.⁵

Conclusion

Most population reduction methods give only temporary relief from depredating coots, since other mud hens eventually replace the removed or destroyed birds. It is also difficult to target only coots with more permanent population thinning techniques like natural predators, disease, and parasitism. When targeting is possible, the reduction tool is ineffective.

All the techniques in this chapter cause stress, injury, or death to the coot, and would not be considered humane by the general public. It is possible there might be less opposition to the use of chemosterilants or natural predators, but both these techniques would be of little benefit at Shoreline.

Shotgun capture may be the most cost-effective method of resolving nuisance coot problems, but it too is temporary and prone to public criticism. There also is an inherent danger in this approach.

With natural habitat continuing to disappear, more and more coots are forced onto manmade "islands" like golf courses and artificial lakes. Biologists do not understand enough about coot population dynamics to

⁵The topic of how to dispose of the captured coots was discussed previously in the "Net Capture" section of this chapter.

know the long-term effect shotgun capture would have if it was adopted as a tool of choice for resolving nuisance coot problems.

CHAPTER VIII

REPELLENTS

A repellent is a substance that triggers an aversive reaction after a taste, touch, or smell by the target animal. Repellents do not solve animal nuisance problems. They are used to quickly, but temporarily, expel pests from nuisance areas (Hodge 1990a, 3-4).

Repellents are commonly used when a crop is ripening, a time when a pest's presence is least welcome (Hodge 1990a, 4).

There are over one hundred chemical repellents registered for sale in the U.S. (Hodge 1990a, 4). The chemicals are either applied to a bait, or directly on the greenery being consumed. Some chemicals just make the animal ill, while others are lethal (see "Poisoning" section in "Population Reduction" for information on lethal chemicals as bird control tools).

This chapter includes a section on "visual" repellents. Although the target species is not repelled by physical contact, as is the case with chemical repellents, the end result is much the same.

Chemical

It is a common belief that birds have virtually no sense of smell (Hodge 1989a). This belief may exist because of differences in avian and

mammalian trigeminal systems (nerves that control mastication).

Therefore, substances that are inoffensive to birds, sometimes bother humans, and vice versa. For instance, ammonia, gingerol, and zingerone were found inoffensive to red-winged blackbirds and European starlings (*Sturnus vulgaris*) while the same birds were repelled by allyl isothiocyanate, piperine, and mercaptobenzoic acid. The latter three substances warrant further testing as possible avian repellents (Mason and Otis 1990, 319).

Several nonlethal compounds that have been recommended as avian repellents are listed below.

Anthranilate Derivatives

Dimethyl anthranilate (DMA), a human food flavoring, has been successfully tested as an avian repellent on European starlings, red-winged blackbirds, Japanese quail (*Coturnix japonica*), pigeons, jungle fowl (*Gallus gallus*), herring gulls, ring-necked pheasants (*Phasianus colchicus*), mallard ducks, and Canada geese (Mason, Adams, and Clark 1989, 55). DMA does not pose a hazard to non-target animals that might ingest the compound (Mason et al. 1985, 641).

The Monell Chemical Senses Center in Philadelphia tested DMA and eight other anthranilate derivatives on starlings. Of the eight, ethyl, isobutyl, isobutyl methyl, and methyl anthranilate were all found to be as aversive as DMA (Mason, Adams, and Clark 1989, 55).

The Philadelphia researchers were encouraged by the results of their anthranilate testing and speculated that any of the four aforementioned anthranilates might potentially be useful as a bird control tool (Mason, Adams, and Clark 1989, 62).

Of the four, methyl anthranilate was most encouraging since it can be obtained for about 20 percent the cost of DMA (Mason, Adams, and Clark 1989, 62). Four pounds of methyl anthranilate are needed per acre of turf (Mason 1990c). Methyl anthranilate currently is not registered for use on birds (Mason 1990a, 130) or grass (Cummings 1990).

Capsaicin

Capsaicin, a compound found in capsicum peppers (*Capsicum* spp.), had no effect on parrots (*Amazona* spp.), pigeons, and red-winged blackbirds (Mason and Otis 1990, 310).

Shoreline coots continued to graze on turf treated with capsaicin-containing Tabasco® sauce (Vaught 1988a). Moffett Field Golf Course briefly sprayed its turf with a solution containing Tabasco® sauce, but stopped when they noticed the mixture did not survive seasonal rains (Hardy 1989).

Sold under the name Savannah®, capsaicin is ineffective as an avian repellent despite manufacturer claims to the contrary (Salmon, T. P. 1989).

D-pulegone

D-pulegone is another human food flavoring. When tested on European starlings, its avian repellent qualities were found to be ten times greater than those of methyl and dimethyl anthranilate (Mason 1990a, 133).

The chemical costs only around eleven dollars per pound (Mason 1990a, 133). Since it elicits avoidance at such minute concentrations, d-pulegone could be applied for less than five dollars per acre.

D-pulegone also is not yet registered for use on birds (Mason 1990a, 130) or grass (Cummings 1990).

Fungicides

In an unscientific experiment, Dias (1989) noticed coots seemed to stay off areas of a Palo Alto, California golf course that had been sprayed with a fungicide.

The Florida Research Center is considering testing fungicides as avian repellents (Mason 1990b). Currently, fungicides are not registered for use on waterfowl (Cummings 1990).

Herbicides

Herbicides are used to kill unwanted plants. But if successful in their intended purpose, herbicides may also expel herbivorous animals that relied on the chemically removed plants for sustenance. Regardless, the mechanism employed against the Park's coot depredation problem in this

case would be different from that of repellents. Therefore, herbicides are included in the "Vegetative Removal" section in "Habitat Alterations."

Methiocarb

Marketed under the name Mesurol®, methiocarb is the only effective nonlethal substance registered as an avian repellent. Unfortunately, it is quite expensive at twenty-five dollars per pound (Mason 1990a, 130).

Birds that ingest methiocarb become ill, but do not die (Conover 1985, 631; Hodge 1989a). It also has been found stored in small amounts in some birds' fat (Conover 1985, 635).

About 2.7 pounds of methiocarb are needed to cover an acre of turf. After an application, Conover (1985, 634) noticed it significantly reduced Canada goose grazing time on the study area.

Another study found methiocarb-treated seed stopped goose sprout pulling, but was ineffective against grazing (Marley 1987, 26).

Tests have shown methiocarb must be reapplied after normal watering and mowing (Conover 1985, 632).

Ro-pel®

Ro-pel® is promoted as an "animal, rodent, and bird repellent" by its maker, Burlington Bio-Medical and Scientific Corporation of Farmingdale, New York. Burlington claims Ro-pel®'s bitter taste "can keep animals away for a year or longer." The manufacturer contends Ro-pel® was successfully

tested on numerous animals including crows (*Corvus* spp.), sea gulls (no species identified), and woodpeckers (no species identified) (Ro-pel®. Animal, rodent, and bird repellent [1985], 1).

The U.S. Department of Agriculture (USDA) tested Ro-pel®'s claims on red-winged blackbirds. Compared to other passerines, red-winged blackbirds have a good sense of taste (Mason 1987, 2).

Mason (1987, 1) found no evidence Ro-pel®'s active ingredients, denatonium saccharide and thymol, repelled blackbirds. This was true even when much higher concentrations than those found in Ro-pel® were used.

Discussion

Although it may be possible to find a substance that will keep the coots from grazing on golf course grass, there are many inherent problems with this procedure:

1. A chemical must be approved by the USDA for use against each specific target animal. For instance, Mesurol® is approved for use on Canadian geese. It is not approved for use on coots. It is possible to test Mesurol® on coots if one were to get a permit as an agricultural experimental station. But even if the product were to be effective against coots, it is unlikely it would ever be approved for use on coots. In this case, Mobay Chemical Corporation, the company that markets Mesurol®, would have to decide if there was a large enough market for its product as a coot

repellent before it conducted the tests required by the Environmental Protection Agency for coot registration. Unfortunately, the market probably does not warrant the use of Mesurol® or any other product as a coot repellent (Conover 1989). An unapproved coot repellent could not be used at Shoreline.

2. The avian repellent must be registered for use on grass. To be registered, the chemical must be tested on a minimum of six different study sites of one to twenty acres at a cost of about five thousand dollars per site (Cummings 1990). Again, it is unlikely the market is large enough to justify this expense. An unregistered repellent could not be used at Shoreline.
3. State regulations may differ. The repellent must be registered in each state where it is used. Therefore, a repellent must be registered in California if it is to be used at Shoreline.
4. Is the chemical environmentally safe? Mesurol®, for instance, is toxic to fish (Conover 1989). Mud hens prefer to graze on shoreline grass. Any chemicals applied to Shoreline's golf course would end up in the San Francisco Bay (Balgooyen 1989).
5. The Shoreline fairways are mowed daily, while the greens are mowed twice per day (Vaught 1988a). Cummings (1990) claims a methyl anthranilate treatment would not be affected by mowing, as the chemical should penetrate the grass roots. On the other hand, Mason

(1990c) contends mowing after a methyl anthranilate application would be a problem. Methiocarb must be reapplied after normal mowing (Conover 1985, 632). The cost of daily and twice-daily applications in labor and repellent would preclude this option at Shoreline.

6. The San Francisco Bay Area receives all its rainfall from September through June (Carpenter 1966, 109). This coincides with Shoreline's coot season. Shoreline's golf course also receives a daily watering (Bakanoff 1994). Rain and irrigation would be a problem if one used methyl anthranilate unless the chemical was attached to the grass with a spreader sticker. Regardless, methyl anthranilate still would not survive a mowing (Mason 1990c). Methiocarb would need to be reapplied after watering (Conover 1985, 632). Any repellent applied to Shoreline's turf must be able to withstand the Golf Course's daily watering.
7. It is not known how most repellents will hold up under normal golf course conditions. Some chemicals will affect the visual appearance of the grass. For instance, methyl anthranilate will burn the grass if it is applied without being encapsulated (Mason 1990b). Some chemicals might come off on golf cart tires, golfing equipment, or golfers' clothing with unknown consequences. Any repellent with damaging side effects could not be used at Shoreline.

8. Repellents must be in place before Shoreline's migrating coots start arriving in September. If not, there could be a reduction in avoidance learning (Mason 1989, 840).
9. Anthranilates will be less effective on "highly preferred foods and sole food sources" (Mason, Adams, and Clark 1989, 63). Grass is not only a highly preferred coot food (Gullion 1989), it is taken by the mud hen because its normal aquatic foods are in short supply at Shoreline (Gullion 1950, 164).
10. When DMA was added to livestock feed, it was discovered the offending birds returned to the feed once the compound was no longer present (Glahn, Mason, and Woods 1989, 319). Thus, Shoreline's treatments would likely need to continue as long as it had a coot problem.

Visual

It seems coots find the appearance of food is as important as taste or smell (Gullion 1989). Mud hens eat green cabbage while refusing purple cabbage (Gullion 1950, 171).

Research has shown animals use visual cues to avoid unpalatable foods. Often "multiple signals are used, perhaps to decrease ambiguity, or perhaps to affect different sensory capacities in different types of predators" (Mason 1989, 839).

Red-winged blackbirds were repelled by methiocarb-poisoned apples. When methiocarb was used in combination with a visual or chemical cue, repulsion usually increased. Best results were recorded when multiple cues were paired with methiocarb (Mason 1989, 839).

Natural warning colors such as red or orange are more likely to repel nuisance animals than other infrequently occurring warning colors (Mason 1989, 840). Redundant use of unpalatable chemicals and warning colors could allow managers to reduce the rate of chemical application without suffering increased depredation (Mason 1989, 836).

Loblolly pine seeds were sown after being dyed or covered with colored sawdust. Aluminum, blue, bronze, green bronze, yellow, untreated, and two shades of red seeds were used. The sown lots were checked four months later. Only about 2.0 percent of the seeds were left by birds in the non-red treated areas, while 12.9 percent and 14.4 percent remained in the two red spots (Williston 1954, 2).

Although red-treated seed survived significantly better, at least 85 percent was still consumed.

Gorenzel (1989) pointed out dyeing the turf blue would make it unattractive to birds. Unfortunately, dyeing the grass blue would block the sun's blue wavelength and disrupt the turf's natural photosynthesis. This would kill the grass. Pitts (1989) suspects the coots would eat the turf anyway.

Most turf dyes only slightly change the appearance of grass and they wash off after a few waterings (Erickson 1993). If a dye actually changed the turf's appearance sufficiently to repel coots, enough sunlight might be blocked to affect photosynthesis, regardless of the color used.

Approximately four gallons of dye per acre are needed to stain turf green at a cost of up to two hundred dollars per acre (Erickson 1993). If cost and amount required were similar in an anti-coot dye, the procedure would not be cost-effective, as daily and twice-daily mowings would require repeated applications.

Shoreline, like most golf courses, has creeping bent grass on its greens and tees. Bent grass is very sensitive. If the turf were irrigated with colored water, it would absorb enough dye internally to probably change color. Unfortunately, this procedure could also lead to disease problems in the bent grass (Erickson 1993).

Even if the bent grass remained healthy after a colored water irrigation, it is not known if the grass would remain dyed long enough to make this technique cost-effective. Of course, there is always the possibility coots repelled by dyed turf might just shift their grazing and depredating to untreated areas of the Course.

Many dyes are approved for use on grass (Erickson 1993), but it is not known what physical effects an ingested dye would have on coots and

other wildlife. Therefore, tests on coots and environmental approval may be required.

Golf courses are built to meet specific soil and sand content requirements. Although it may not be precisely stated, it probably is assumed that a golf course must consist of green-colored grass (Erickson 1993). Regardless, golfers would be uncomfortable with any dyed turf that stood out from the natural grass on the rest of the course (Benz 1994).

Maybe a variety of grass exists, or can be developed, that coots naturally avoid and that golfers would accept. Exploring this option would be more feasible than any turf-dyeing program.

Conclusion

There are two problems inherent with chemical repellents that make their use impractical at Shoreline: (1) rainfall and turf irrigation and (2) the Course's daily and twice daily grass mowing routines. Even if a water-sensitive repellent could be attached to the grass, its effect would be lost during mowing.

If a repellent could be absorbed systemically by the turf, watering and cutting would no longer be a problem.

Preliminary tests have found d-pulegone to be an effective, safe, and inexpensive avian repellent (Mason 1990a, 133). It is not yet known to what extent d-pulegone would be internally absorbed by the grass.

Chemicals like d-pulegone are continually diffusing into the environment. Assuming d-pulegone is systemically absorbed, it is not known how many applications would be required each coot season to maintain the desired effect (Hodge 1990c). Numerous applications might make even this inexpensive repellent economically prohibitive as the aforementioned cost does not include labor.

Grass is a preferred coot food (Gullion 1989). It would be harder to keep the coots from eating chemically-treated grass than it would a less preferred food, especially since sufficient alternatives do not exist in the Park. Not only that, the availability of untreated grass on other areas of the Golf Course would make avoidance learning even more difficult.

Marley (1987, 18) warns the success of taste aversion products varies depending on the species. Gilhuly (1989), of the U.S. Golf Association's Western Regional Greens Section, has yet to find a chemical that will stop coot grazing. Terry Salmon (1989) contends there is no turf-sprayed repellent that will ward off coots.

But if an effective coot repellent was found, it would still need to be registered in California to use both against coots and on grass. This is not likely to happen since there is little commercial interest in a coot repellent.

Even if registration obstacles were overcome, any repellent used at Shoreline must be safe for all organisms in the San Francisco Bay ecosystem.

Finally, if a safe repellent was found, turf treatment would be required from the time the first migrating coots arrived in September until most mud hens left the following May.

Many of the same drawbacks inherent in chemicals exist in dyes as well, especially the problems of watering and mowing.

Contact with wet grass could also result in chemicals or dye on shoes, pant cuffs, golf balls, and hands.

A dyed turf may succeed in repelling coots, but it may also bother golfers and kill the lawn. Regardless, repelled coots would likely just shift their grazing and depredating to undyed areas of the Course.

Time might be better spent searching for or developing a turf that is naturally undesirable to coots and other grazers.

CHAPTER IX

SCARE DEVICES

Almost anything that makes an area unpleasant for the intended victim can be used as a scare device (Marley 1987, 20). Animals are often frightened by an unnatural sound or movement. "Noisemaking devices are designed to convey messages of stress, alarm, or imminent danger to animals and should prompt animals to flee" (Hodge 1990a, 4).

An important problem with scare devices is that they lose their effectiveness once the target animal adapts to them. The more often an animal is exposed to a scare device without negative reinforcement, the sooner it will ignore the stimulus. Animals do have a harder time habituating to variably occurring or more intense stimuli (Shaw 1985, 112).

Seldom are nuisance incidents solved using only one scare tactic (Salmon, Conte, and Gorenzel 1986, 91[E]). To avoid habituation, it is suggested different types of frightening devices be used at the same time, and frequently repositioned (Pfeifer 1983, 76[E]; Salmon, Conte, and Gorenzel 1986, 91[E]).

A frightening program must be well planned to specifically target the depredating bird species. Once scare tools are chosen, labor and

equipment costs, as well as possible conflicts with golf course operations and neighbors, should be identified. If the program is still feasible, it must be aggressively conducted (Salmon, Conte, and Gorenzel 1986, 91[E]).

Once an animal has established itself in an area, it will be almost impossible to remove it with scare devices (Hodge 1990a, 5). Therefore, all devices should be in place when the first coots arrive from their migration (Hodge 1989a).

Waterfowl harassment activities should begin early in the morning when the birds are hungry and irritable (Hodge 1989b).

No permit is required to haze or harass problem coots (Lara 1989b), although it is recommended "local, state, and federal fish and game agencies" be kept abreast of one's plans and status (Marley 1987, 22).

Most of the scare devices in this chapter are targeted at the coot's sense of hearing or sight. Hodge (1989c) feels scare devices are most effective when at least two senses are bombarded at once.

Arm-waving

Shoreline maintenance personnel discovered coots could be coaxed from a depredated area by simply moving their arms "up and down" in a "flying" motion (Vaught 1988b).

It is possible coots may sense danger when confronted by a flapping episode, as "geese struggle and flap their wings when caught by a predator"

(Heusmann 1987, 21). A flapping exhibition could also be interpreted by the coots as an aggressive territorial display.

This scare tactic was one of the methods tested at Shoreline (see chapters XII and XIII).

Automatic Exploders

Takekawa (1988) recommended hazing Shoreline's coots with automatic exploders. Automatic exploders, also known as "scare cannons," "propane exploders" (Marley 1987, 20), "propane cannons" (Marley 1987, 22), "sonic guns" (Swanson 1994), "zon guns" (Takekawa 1988), and "gas boomers" (Gullion 1989), actually look like miniature cannons. The devices normally run on propane or acetylene (Salmon, Conte, and Gorenzel 1986, 91[E]) and must be placed in such a way as to minimize any fire danger (Pfeifer 1983, 77[E]).

Exploders give out loud blasts and can be fitted with automatic directional adjusters and timers (Salmon, Conte, and Gorenzel 1986, 91[E]). Blast intensity, which is louder than that of a shotgun, can also be adjusted (Pfeifer 1983, 77[E]).

Explosions intensify and often reverberate when used near buildings or water (Marley 1987, 22). Salmon, Conte, and Gorenzel (1986, 91[E]) noted elevation may be required to avoid potential sound muffling.

Optimally, one exploder may protect up to fifty acres (Pfeifer 1983, 77[E]). More commonly, an exploder will protect three to five acres when used in conjunction with other scare devices (Salmon, Conte, and Gorenzel 1986, 91[E]).

Small time intervals between explosions make it more likely the birds will become conditioned to the exploders (Salmon, Conte, and Gorenzel 1986, 91[E]). To be effective, exploders should discharge about every fifteen minutes. They should also be moved every few days around the infested area (Pfeifer 1983, 77[E]).

Reports from actual field applications of exploders were mixed. The USFWS used exploders to scare birds away from polluted areas of Kesterson National Wildlife Refuge in California (Benson 1993, 16[A]) and found the devices were more beneficial when their placement and blast intervals were routinely changed (Woolington 1995). Severson's (1988) experience was that exploders worked when used on ducks and geese. Marley (1987, 22) found combining exploders with pyrotechnics and scarecrows increased their effectiveness against geese. Salmon, Conte, and Gorenzel (1986, 91[E]) felt exploders were especially beneficial when used against great blue herons (*Ardea herodias*), black-crowned night-herons (*Nycticorax nycticorax*), blackbirds (no species identified), and diving ducks.

On the other hand, Mott and Timbrook (1988, 301) noted exploders were "generally ineffective" versus geese, while Pearson (1988) believed

coots did not respond to the devices. Vincent Salmon (1985) concluded intense audible sound soon lost its effectiveness against starlings unless it was supported by a negative reinforcer. Gullion (1989), Swanson (1994), and Figeira (1995) all felt mud hens quickly adapted to automatic exploders. In fact, according to Figeira, it was not long before coots were eating below and sitting on the scare cannons.

Sonic discharges would not be possible while golfers were using Shoreline Golf Links. Since golfing activity begins daily shortly after sunrise, explosions would be limited to a few blasts during morning twilight.

Exploders also could not be operated in coot-infested areas along the northern shore of Shoreline Lake as these sonic interruptions would disturb anyone recreating on or adjacent to the Lake, including golfers near the Lake's southern boundary (Pfeifer 1983, 77[E]).

Even if Shoreline's visitors were not bothered by the explosions, it would be impossible to avoid disturbing non-target wildlife species.

Balloons

Balloons of various types have been successfully tested against depredating birds (Avery et al. 1988, 277). They can be suspended from posts or tree branches (Hodge 1990b), or staked above water and in open

fields (wherever adjacent objects are unlikely to puncture them) (Pfeifer 1983, 77[E]).

It has been known for some time insects use eyespot patterns as protection against birds. An "eyespot" balloon features an eye spot similar to that of a raptor. As many as one-half dozen eye spots are evenly spaced around the circumference of the balloon (Avery et al. 1988, 277).

A few years ago, the USDA made the eyespot balloon its tool of choice (Hodge 1989a).

Also known as the "hawkeye", the eye spot is inflated with either air or helium. A pair of twenty-inch ribbons of mylar reflective tape can be suspended from the balloon to increase its effectiveness (Avery et al. 1988, 277).

In Japan, scientists floated an 8½-foot diameter balloon with five eye spots nearly 50 feet above the ground (Avery et al. 1988, 277). The scientists discovered their helium-filled vinyl balloon reduced gray starling (*Sturnus cineraceus*) damage to grapes, cherries, and peaches over an area of roughly 8½ acres.

Smaller eyespot balloons are made commercially in the U.S. One domestic product is a heavy-duty, two-foot diameter, vinyl balloon with three-dimensional moving, holographic eyes (Hodge 1989a).

In another field trial, the hawkeye had mixed results when used on the boat-tailed grackle (*Quiscalus major*) (Avery et al. 1988, 277). The

authors warned of common habituation to the balloons during longer exposures and recommended concurrent use with audio scare devices (Avery et al. 1988, 280). Pfeifer (1983, 77[E]) advised that balloons be moved often to insure their effectiveness.

Non-scientific tests with balloons were conducted by city officials in San Jose, Palo Alto, and San Mateo, California. San Jose has a problem with sea gulls (*Larus* spp.) on their water pollution control tanks. A few dozen hawk-eye balloons were positioned around two of San Jose's several hundred tanks. Beebe (1989) estimated there were one-third as many gulls on the ballooned tanks. Unfortunately, the gulls ignored the balloons when they were hungry. Two years later, San Jose's Corbett (1991) said, "The balloons worked at first against the gulls, and then we gave up on them."

Palo Alto Golf Course unsuccessfully tried three eyespot balloons on barn swallows (*Hirundo rustica*) and pigeons (White, 1989). Durbia (1991) reported the hawk-eyes did not keep pigeons out of San Mateo Golf Course parking lots.

DFG Biologist Jim Swanson (1994) is not convinced the hawk-eye has any practical value. It has been the agency's experience that similar scare devices generally only work a short time. The DFG does not supply or recommend hawk-eyes.

Like most scare devices, habituation is a big problem with the eyespot balloon. Unfortunately, it would not be possible to use the balloons

with audio scare devices at Shoreline, as the noise would interfere with normal golf course play.

Although the hawkeye was never tested against coots, the mud hen is not apt to fall for this ruse. Coots, and probably other waterfowl, can discriminate minute details between flying predators well enough to distinguish bald eagles from red-shouldered hawks (*Buteo lineatus*) and ospreys (Grubb 1977, 1066). Therefore, it is unlikely a balloon, even one with eye spots, would have much, if any, frightening effect against coots unless it was used with a negative reinforcer.

Beachball: Tethered

Geese can be kept from shoreline property by the use of a tethered beachball (Hodge 1990a, 84). The natural action of the wind maintains ball movement on both land and water (Hodge 1989a).

Although this scare tactic was not attempted at Shoreline, it seems unlikely an eighteen-hole golf course, next to a fifty-acre lake, would receive much protection from these bouncing devices unless there were literally dozens of them scattered strategically around the Park.

But without some other scare device(s) to reinforce their "danger," and constant repositioning, the coots would soon ignore the beachballs. Even then, the mud hens would probably just avoid the balls by swimming and grazing between them.

Fluttering beachballs would not only be aesthetically out of place at a golf course, but would be distracting to golfers as well. This scare device would also be a nuisance to Shoreline Lake's boaters and sailboarders, as well as to Shoreline's non-target animals.

Finally, unattended beachballs would be prone to theft and vandalism, thus adding to normal replacement costs.

Dogs

Dogs (*Canis familiaris*) have been successfully trained to control waterfowl. A dog can be free-ranging, slip-wired, or tethered. To be effective, tethered dogs should be periodically moved (Pfeifer 1983, 77[E]).

Marley (1987, 26) recommends the use of "well-trained, free-ranging dogs" to harass golf course geese. Although a dog would not be able to catch a "full-flighted" goose, dogs enjoy chasing the birds, and their persistent barking has driven off geese (Heusmann 1987, 21). The dogs are most successful when they patrol preferred goose locations (Marley 1987, 26).

Levens (1995) felt a free-ranging pooch with a handler could be trained to control birds on a golf course.

Larry Gilhuly (1989), of the U.S. Golf Association, has found dogs to be very good at keeping birds off golf courses as long as one persists with the harassment. Gorenzel (1989) suggests using a dog all day to harass Shoreline's coots. Lyles (1988c) mentioned dogs were used to herd

waterfowl on duck farms. He felt a dog had been the best management tool to date at Shoreline when used with a handler.

California's Spanish Bay Golf Links used a dog to chase coots off its course. Course Superintendent Mike Phillips noted the dog was his most effective coot deterrent (Tyler 1988, 22).

Almost any breed of dog could be trained to chase birds as long as it was prey-drive oriented and had a lot of energy. If trained and socialized to people properly, German short-haired pointers, golden retrievers, Labrador retrievers, and shepherds would all make good bird chasers (Levens 1995).

On 11 June 1993, nearly one hundred sea gulls (no species identified) interfered with a professional baseball game in Milwaukee, Wisconsin by hunting for moths in the stadium's turf. Sirens, factory whistles, and thousands of screaming spectators failed to deter the gulls (Feeding frenzy 1993, 5[D]). The following day, a retriever from a local waterfowl club chased the gulls between innings of the game. By the time the game was one-third complete, the dog had encouraged the gulls to fly away. This event was recorded in the San Jose Mercury News dated 13 June 1993.

Besides being prey-drive oriented, Shoreline would want an animal that was controllable, friendly, and off-leash trained (Levens 1995). The Golf Course could either use a pooch of its own, or hire an owner-handler to harass the coots.

It costs around three thousand dollars and takes three to four months to train a dog to chase birds. The animal must be at least one year of age, and not much older, when training begins. A trained pooch should give about six to ten years of service depending on its breed. The larger the breed, the less time it can be expected to live (Levens 1995).

An experienced handler would charge twelve to fifteen dollars for every hour the owner-animal team worked. Hiring a handler would eliminate dog-maintenance expenses (e.g., veterinary costs, shots, food, etc.) (Levens 1995).

The amount of daily time a dog could work would depend on the pooch and on the number of coots that needed to be chased, but three to four hours of fairly continuous activity should be possible before a complete break is needed (Levens 1995).

All parties involved with this harassment activity should have adequate insurance coverage to protect them against potential golf course- and dog-related accidents. All golfers should be alerted to the presence of harassment activity before they begin their round of golf. Regardless, all dogs and handlers should wear appropriate safety equipment during this operation.

To increase the frightening effect of a dog on Shoreline's golf course, Priest (1989) suggested using a dog on the Course along with a boat in the Lake.

The author conducted preliminary tests with dogs, alone, and in conjunction with an outboard motorboat. Information on these tests can be found in chapters XII and XIII.

Falconry

This section discusses the use of birds of prey as scare devices at Shoreline. Information on raptors as population reduction tools can be found in the "Natural Predators" section of "Population Reduction."

Falcons (*Falco* spp.) are used to keep airports free of birds in England (Becota 1993).

With swelling urbanization, it has become increasingly difficult for falconers to find places to exercise their birds. The falcon is a bird of prey that naturally takes coots (Priest 1991). These raptors could be exercised at Shoreline Golf Links while they exorcised the coots.

Grubb (1977, 1066) was able to show coots easily discriminate between species of raptors that prey on them and those that do not, even though there are only subtle differences between their potential killers. Therefore, once Shoreline's mud hens perceive a threat from a raptor, it should trigger their alarm response.

Weddle (1994) tried a falcon against the coots on the LaCumbre Country Club golf course. The raptor's presence caused the mud hens to seek the safety of LaCumbre's lake, but the coots did not leave the area.

Despite taking an occasional coot, WVA's falcon was unable to evict its mud hens (Figueira 1995).

This is one scare tactic that was attempted by the author against Shoreline's coots (see chapters XII and XIII).

Fencing: Electric

This section is on the use of fencing that has been electrified to frighten its victims away from protected areas upon contact. For information on the use of fencing erected to deny turf access by its presence alone, see the "Fencing: Non-electric" section in "Barriers."

It has been suggested an electric fence system be used to protect Shoreline's golf course from coots (Jenni 1988). This technique has been used successfully on geese (Marley 1987, 22).

An electric fence can consist of single threads of high-visibility wire, baited wire, or a combination of the two (Marley 1987, 18). It is simple, easy to install, and inexpensive. The fence can be plugged into an existing outlet, or charged from a battery equipped with a solar panel (Marley 1987, 22).

Marley (1987, 26) cautions that "only UL- or CSA-approved units" be used. Marley adds that an ongoing hazing program is needed, in combination with electric fencing, to discourage waterfowl from landing on golf courses.

In areas where waterfowl venture onto land, electric hot wire can be used. A shoreline wire suspended just above the ground would shock waterborne coots as they walked onto green vegetation (Marley 1987, 22, 26).

But this system would jolt damp, non-target animals as well (Marley 1987, 22, 26). Although the electric shock should not injure its recipients (Hodge 1990a, 5), it is not a particularly humane scare tactic. A careless golfer could also receive an unexpected penalty while retrieving a submerged ball near an electric wire.

This method does have its detractors. Salmon, Conte, and Gorenzel (1986, 90[E]) claim the devices are of limited value, while Lara (1989a) predicts coots would fly over an electric fence.

Greenwich, Connecticut residents installed an electric fence in an attempt to prevent Canada geese from visiting the town's popular beach. The fence succeeded in keeping their beach "practically goose-free" for about three weeks before several geese began hopping over it (Strohm 1986, 30).

After observing coots solving Shoreline's low non-electric fencing (see "Fencing: Non-electric" section in "Shoreline Tests"), it is doubtful an electrified version would perform any better. For this reason, as well as the certain negative public criticism this method would draw, electric fencing should not be used at Shoreline.

Flagging

Waterfowl managers usually favor flagging as it is inexpensive and often effective. Pfeifer (1983, 76[E]) recommends two-by-three-foot pieces of three-mil thick plastic be flown from four-foot tall stakes.

Research seems to indicate waterfowl were more frightened of black-colored flags than flags of other colors. Larger flags did not move as easily in light winds, while lighter-colored or smaller flags were more difficult to see (Pfeifer 1983, 77[E]).

Depredated areas can be protected by the placement of approximately one flag per acre in a grid pattern. Unmolested areas may need only one flag for every five acres. Plastic flags are most effective when used along with other scare devices, especially automatic exploders (Pfeifer 1983, 77[E]).

Others share Pfeifer's support of flags. Hodge (1990a, 84) calls a plastic flag system "one of the most effective frightening techniques for waterfowl." Hodge (1989a) adds that black or red vinyl flags should be used. It is Severson's (1988) experience that flags work to deter ducks and geese, while Lara (1989a) recommends the ongoing use of black or silver plastic flags reinforced with killing. Erickson (1993) suggests metallic strips, but admits coots will probably become accustomed to them.

In an uncontrolled experiment, Shoreline's flag system did not work against its mud hens (Lyles 1988c). It is also interesting to note Golf

Course greens near Shoreline's water areas are some of the most heavily used areas by coots. This, despite the fact all are naturally "protected" by a fluttering flag flying above their cups.

Flags are very similar to another scare tactic discussed later in this chapter: scarecrows. Both usually rely on noise or wind-aided movement, and both soon lose their effectiveness without the support of negative reinforcers like exploders and killing.

Since Shoreline cannot support a flag system with loud or lethal management techniques, its coots would soon habituate to the waving flags. Regardless, the flags may have more of a frightening effect against non-target waterfowl than against Shoreline's coots.

Horns

Although this method was not tried on Shoreline's coots, birds soon ignore intense audible sound unless it is accompanied by a negative event (Salmon, V. 1985).

Sea gulls (no species identified) apparently searching for food in the turf during a professional baseball game, were only briefly upset by a siren and a factory whistle (Feeding frenzy 1993, 5[D]). Heusmann (1987, 21) noted geese can also habituate to loud noises.

The San Jose Water Pollution Control Department failed to scare gulls from its facility when it used automatic random horns. The noise did,

however, have an unsettling effect on the Department's staff. According to a supervisor, it "drove the employees crazy" (Corbett 1991).

Obviously, this scare technique would be unsatisfactory at a golf course.

Lights

Many types of lights have been used as nocturnal frightening devices. Most birds soon habituate to flashing barricades and revolving or moving lights, but aircraft-type strobe lights, with their blinding, flashing beams, are often effective. Reflective tape can be added to protect sensitive areas the lights might otherwise miss (Salmon, Conte, and Gorenzel 1986, 92[E]).

Jones (1940, 50) reported ducks were successfully driven off with searchlights. However, coots will not leave when illuminated by high-intensity lights. In fact, mud hens have been successfully hand-netted at night using high-intensity light (Van Way 1986, 294).

Lights are used to scare night-feeding birds. Shoreline's coots begin feeding in the morning twilight and continue into the evening twilight. By one hour after sunset, most can be seen entering the water and swimming to the middle of a pond. Here they quietly mass together in safety.

Weddle (1989) also observed coots at a Santa Barbara golf course did not feed at night. This supports the common belief that coots are

diurnally active (Gullion 1950, 161). Hodge (1990b) concurs, noting waterfowl stay put once they settle in for the evening.

Although non-target, night-feeding birds might be affected, nighttime harassment of coots with lights would likely be a waste of time.

Night Harassment

Coots prefer diurnal activity (Gullion 1950, 161). They can usually be found roosting soon after sunset (Kiel and Hawkins 1953, 319). By the end of evening twilight, most of Shoreline's coots are quietly grouped together in the middle of a pond. Some choose to roost on logs or islands of vegetation along the shore.

Conceivably, this would seem like an ideal time to harass the coot. One could take advantage of the resting mud hen's flocking behavior, thus bothering a minimal number of non-target species.

But Hodge (1990b) recommended against harassing coots at night. Mud hens, like most waterfowl, stay put once they have settled in for the evening.

When the diurnally active aquatic coot is harassed in the daytime, it normally repositions itself by skittering over the water's surface (Rand 1956, 167). But the coot is so inactive at night, it can be successfully captured with hand nets (Van Way 1986, 292). Weddle (1989) notes overwintering coots in Santa Barbara will not feed at night.

Nighttime would be an excellent time to capture, not harass coots.

Outboard Motorboat

Hodge (1989c) felt the coots' aquatic flocking behavior might make bothering them with an outboard motorboat preferable to harassment with a radio-controlled model boat. Hodge also believed an outboard motorboat should have an especially unsettling effect on the mud hens since it would aggressively attack two of their senses simultaneously: sight and hearing.

The coots' tendency to segregate themselves from other avian species would allow the boat to discriminate against the mud hen. Therefore, non-target species would be disturbed to a lesser extent as only the coot should have more than one sense attacked by the tormenting boat. Thus, other animals in the area should return soon after harassment activities ended (Hodge 1989c).

The mud hens should be disturbed soon after sunrise when they are hungry and irritable. Motorboat harassment might be required two or three times before all the coots left Shoreline (Hodge 1990b).

To increase the scaring effect of a motorboat harassment program, Priest (1989) suggested combining a dog on land with the boater in the water (see "Dogs" section previously in this chapter).

At any one time, a majority of Shoreline's coots can be found on or near fifty-acre Shoreline Lake. Most of the Golf Course's turf damage

occurs on areas adjacent to this lake. Therefore, it was decided to try a combined motorboat-dog harassment in this area of high coot depredation.

For the results and an analysis of this test, see chapters XII and XIII respectively.

Pyrotechnics

Pyrotechnic devices have been highly successful when used to drive off ducks (Jones 1940, 50). These devices consist of bird control shells and racket bombs.

Bird control shells, also known as "cracker shells," actually contain firecrackers. The shells are fired from a twelve-gauge shotgun and travel fifty to one hundred yards before exploding (Salmon, Conte, and Gorenzel 1986, 91[E]).

The gun barrel must be checked after each shot, and the firearm cleaned regularly, as remnants of spent shells may stay in the gun (Salmon, Conte, and Gorenzel 1986, 91[E]).

The Mountain View Solid Waste Department assigned an individual full-time to fire screeching and exploding cracker shells at nuisance sea gulls and clean up the area. Mountain View quickly discovered the gulls were more difficult to frighten if allowed to land. After several months of harassment, the sea gulls finally left (Bowers 1989).

Unlike gulls, Mott and Timbrook (1988, 301) noted firecrackers were generally of little value against geese.

Racket bombs, although their range is 25 percent less than cracker shells, are easier to use and less expensive. These scare devices, also called "bird bombs," "bird whistles," "clow bombs," "noise bombs," "noise rockets," and "whistle bombs," use a six-millimeter blank pistol (Salmon, Conte, and Gorenzel 1986, 91[E]). Racket bombs are also made for fifteen-millimeter pistol launchers. These bombs travel up to 125 yards and make a steady whistling noise while in the air (Mott and Timbrook 1988, 302).

Pyrotechnics are most effective when shot to explode just above their intended victims. Aerial detonations also reduce the risk of pyrotechnics-induced fires (Pfeifer 1983, 77[E]). A fire marshal's permit is sometimes required to use or possess pyrotechnics (Salmon, Conte, and Gorenzel 1986, 91[E]).

But pyrotechnics lose their effectiveness after just a few exposures unless they are used along with something birds perceive as dangerous (Salmon V. 1985). Scarecrows (Marley 1987, 22), balloons (Avery et al. 1988, 280), and overhead wires (Marley 1987, 26) are some of the tools recommended for use with pyrotechnics.

Shoreline tried shooting fireworks and blanks while using a sour-tasting chemical on its turf in an unsuccessful, month-long attempt to evict its coots in 1986 (Katches 1986, 1[A]).

Pearson (1988), a senior resident agent for the U.S. Department of Interior in Sacramento, reported that coots do not respond to pyrotechnics.

Although it would be easier to avoid bothering recreators and non-target wildlife than with automatic exploders, pyrotechnics would still upset golfers playing in the vicinity. Therefore, any Shoreline harassment program including fireworks would need to be limited to a daily dawn assault before golfing activity began.

Regardless, it is unlikely pyrotechnics could permanently chase off mud hens, as coots would not even abandon a Wisconsin lake despite the steady rumble of hunters' lethal guns (Kiel and Hawkins 1953, 316).

Radio-controlled Model Airplane

It was possible coots harassed by a radio-controlled model airplane might be frightened enough to leave Shoreline Park.

Although a radio-controlled toy plane might be noisier than a radio-controlled model boat (Hodge 1989a), remote-controlled planes are actually more appropriate for pigeons than waterfowl (Hodge 1989b). Regardless, a model plane harassment program could be successful against coots, especially since it attacks more than one of the mud hens' senses at the same time (Hodge 1989a).

In order to frighten off the coots, they should be harassed early in the morning (Hodge 1989b) or about one-half hour before they begin to roost

(Hodge 1989a). A three- or four-foot streamer could be attached to a noisy plane to enhance the effect on its victims' sense of sight and sound (Hodge 1989b). Gas-powered radio-controlled model planes are preferred since they are noisy, while similar electric-powered and free-fly¹ devices are much quieter (Graffia 1995).

For information on Shoreline's radio-controlled model airplane experiment, see chapters XII and XIII.

Radio-controlled Model Boats

In Hodge's (1989b) opinion, it would be more appropriate to harass waterfowl with radio-controlled model boats than with radio-controlled model airplanes. Shoreline could contact a local radio-controlled model boat club to help with the harassment (Hodge 1989a).

Toy boats have experienced some success in evicting waterfowl from ponds and lakes (Hodge 1990a, 84). Hodge (1989b) cites an instance at an industrial office park in Massachusetts where a single radio-controlled model boat was used to harass Canada geese. The boat chased the geese constantly for three days whenever they appeared until the gaggle left. The geese have not returned for two years.

¹Free-fly radio-controlled model airplanes are powered by rubber bands or by the initial thrust of a start-up engine (Graffia 1995).

Model boats are powered by either electricity or gas. An electric boat is not as effective at scaring waterfowl since it makes very little noise (Graffia 1993).

Gas-powered toy boats can run on gasoline or nitromethane. High-performance boats use nitromethane, which leaves an oil residue on surface water. Depending on the fuel mixture, nitromethane can cost twelve to twenty-five dollars per gallon (Graffia 1993). A nitromethane-powered boat would need to be refueled every two to five minutes (Richardson 1990).

A custom-made, nitromethane-powered boat could be built to run an hour or longer. Construction costs would range between one and two thousand dollars (Richardson 1990).

Sheldon's Hobbies in San Jose has an assembled forty-six-inch, gasoline-powered toy boat for around seven hundred dollars. A gasoline-powered boat would not leave an oil residue on the water. Although a nitromethane-powered boat performs better, a gasoline-powered boat should be adequate to scare coots (Graffia 1993).

A model-boat harassment program would require continuous participation from boat owners until the coot problem was resolved. Most volunteer hobbyists are only available on a limited basis (Richardson 1990).

If a private individual was to operate a model boat at Shoreline, the individual's insurance would exclude all other boats from operating in the

area. Shoreline could solve its potential insurance and operator problems by building and operating its own toy boat (Richardson 1990).

Richardson (1990) noted coots inhabit the percolation ponds in Campbell where his club operates its boats. The Campbell coots simply move to the nearest boatless pond when the hobbyists arrive, and return to their original pond when the hobbyists leave.

The coots only abandoned the percolation ponds, albeit temporarily, after the application of an herbicide affected their food supply (Richardson 1990).

Shoreline is too big to use a toy boat successfully. One boat could not possibly cover its fifty-acre lake. Besides, lake-borne harassment activities would also disrupt aquatic recreation. Toy-boat harassment on one of Shoreline's ponds would do little more than temporarily move mud hens to a part of the wildlife area where a boat was not being used.

It would be difficult to involve additional model boats or enhance this technique with other control methods without affecting non-target animals. The continual noise from the boat's gasoline engine would also bother golfers.

Recorded Alarm and Distress Calls

Numerous avian species convey alarm or distress calls to fellow birds (Salmon, Conte, and Gorenzel 1986, 91[E]). An alarm call warns other

birds away, while a distress call is a cry for help (Hodge 1989a). Broadcast recordings of selected bird calls can scare and remove some target bird species (Salmon, Conte, and Gorenzel 1986, 91[E]).

Calls can be broadcast at set intervals with a timing device (Salmon, Conte, and Gorenzel 1986, 91[E]), or in larger areas, played from a moving vehicle (Mott and Timbrook 1988, 302).

Results vary depending on the species, place, size of affected area, and time of year. Success is greatest when calls are played at the first sight of the target species. This scare tactic usually must continue indefinitely, as the birds normally reappear (Salmon, Conte, and Gorenzel 1986, 91[E]).

Distress calls may soon need the support of other frightening devices to be of any value. Positive results have been achieved using alarm calls on black-crowned night herons, blackbirds (no species identified), and gulls (no species identified) (Salmon, Conte, and Gorenzel 1986, 91-92[E]).

Alarm and distress calls were tested on Canadian geese at two campgrounds in Tennessee. Goose calls were recorded and later broadcast at the unwanted visitors for ten to fifteen minutes about five times per day (Mott and Timbrook 1988, 302).

Goose numbers decreased 71 percent during the five-day experiment when calls were the only frightening device used. When racket bombs were used along with calls, goose numbers decreased 96 percent. Unfortunately,

as soon as the experiment ended, the geese returned (Mott and Timbrook 1988, 301).

The researchers felt the lack of other local loafing and feeding areas may have added to their inability to permanently evict the geese. It appeared an ongoing harassment program would be required to make their campgrounds "goose-free" (Mott and Timbrook 1988, 301).

It was suggested that Shoreline record and broadcast a coot distress call to scare its mud hens away from nuisance areas. A coot would need to be terrified into making the required call. The call would also need to be reconditioned by occasional coot kills or mock kills (Salmon, V. 1989).

Unfortunately, it is unlikely many coots would be scared off by broadcast calls. When threatened, wintering mud hens normally swim from danger rather than fly (Jones 1940, 2). Often, all mud hens in the vicinity swim together in a tight huddle for protection (Grubb 1977, 1065).

Coots would not even leave a Wisconsin lake when they were under heavy shotgun attack (Kiel and Hawkins 1953, 316). It should be safe to assume the targeted mud hens made many alarm and/or distress calls during this shooting event. Evidentially, the Wisconsin coots were not "programmed" to interpret their fellow birds' frantic calls as "abandon the area."

But even if mud hens were frightened by broadcast calls, this plan has several drawbacks at Shoreline: (1) it would be very labor-intensive

locating and harassing all of Shoreline's coots several times a day during their annual four-month long immigration period (see "Shoreline Coot Census" chapter), (2) the immense size of the recreation and wildlife areas would make it easy for scared birds to fly to another area within the Park, (3) the harassment would have little effect on coots that sought refuge in the middle of fifty-acre Shoreline Lake, and (4) since most coot-depredated areas are on the Golf Course, this management program could not be supported by pyrotechnics, shooting, a barking dog, or any other annoying noises.

Regardless, this plan is not humane, as it requires terrifying, and most likely, killing coots.

Scarecrows

Scarecrows do not need to be expensive or elaborate. Crossed sticks supporting fertilizer or plastic garbage bags are often adequate. An old tire, attached on the inside to a post, will also make a good scarecrow when its sides are enhanced by several dangling, dark-colored plastic strips (Marley 1987, 22).

Other examples of scarecrows include "wind chimes, mirrors, portable radios, foil strips, kites" (Hodge 1990a, 4), "old cars, farm machinery, pinwheels, streamers, fluorescent traffic cones, and dangling aluminum pie plates." Any object that makes a frightening noise or

wind-aided movement will be particularly useful as a scarecrow, especially if repositioned often (Pfeifer 1983, 77[E]).

Pfeifer (1983, 76[E]) recommends there be a scarecrow for every five acres that need protection.

Unfortunately, any audibly or visually disturbing scarecrows (e.g., portable radios, old tires, etc.) could not be used on Shoreline's golf course.

Geese are sometimes frightened by full-sized swan (no species identified) decoys since geese see swans as threats. But the geese soon learn to ignore the motionless "swans" (Heusmann 1987, 21).

Mountain View Solid Waste Department's Mark Bowers (1989) reported fake pigeon hawks (*Falco columbarius*) had no effect on sea gulls.

San Jose's Water Pollution Control Department constantly repositioned a simulated owl around its tanks in an attempt to frighten gulls. After a few successful weeks, the gulls ignored the fake owl (Beebe 1989).

Pollution Control employees experienced similar results when they tried using a dead sea gull to "protect" their facility. After some initial success, the bothersome gulls returned (Corbett 1991).

Lyles (1988a) noted many coots die naturally at Shoreline. The presence of these dead mud hens did not affect the living coots' normal activity.

Takekawa (1988) recommended scarecrows for use versus coots, but warned mud hens are bold. As suspected, Shoreline's coots ignored hawk (*Buteo* spp.) and owl decoys during previous uncontrolled experiments (Lyles 1988c).

Depredating coots are also not likely to abandon an area because of a threatening raptor-mimicking kite, as mud hens are able to distinguish the difference between various avian and manmade aerial objects (Grubb 1977, 1066).

San Jose Airport's Wildlife Hazard Management Plan Coordinator Dave Becota (1993) claims it takes birds only about twenty minutes to acclimate to a fake owl. Swanson (1994) agrees, stating it was the DFG's experience that scarecrow-type devices generally work only temporarily.

Some scarecrows are also subject to theft and vandalism, as Shoreline maintenance workers discovered when their owl decoy was stolen (Lyles 1989).

Marley (1987, 22) found combining scarecrows with automatic exploders and pyrotechnics increased their effectiveness against geese. But any harassment program including exploders and pyrotechnics would not be possible on a golf course. In fact, there are probably no potentially successful methods with a strong negative reinforcer that would be suitable for use with scarecrows on a golf course against coots.

Shooting As a Scare Tactic

Shooting can be used strictly as a scare tactic as opposed to a means of destroying the mud hens (see "Shotgun Capture" and "Sport Hunting" sections in "Population Reduction" for lethal applications of shooting versus coots).

Coots are not frightened by the sound of shooting (Jahn and Hunt 1964, 93) and rarely leave an area where shooting occurs (Jones 1940, 50). Zahn (1988) was unable to scare the coots off of selenium-contaminated Kesterson National Wildlife Refuge in California with guns. Shoreline's maintenance crew had only minor success using a shotgun with blanks against its coots (Vaught 1988a). Mott and Timbrook (1988, 301) also reported little success using this method of harassment against geese.

Pfeifer (1983, 76[E]) recommends employing other devices like flags or scarecrows along with firearms to frighten off nuisance waterfowl. Shoreline shot blanks and pyrotechnics while using a sour-tasting chemical on its turf in an unsuccessful attempt to remove its coots (Katches 1986, 1[A]).

Since Shoreline's golf course is occupied by people during daylight hours, shooting can only take place for a limited time each day before golfers arrive. Extreme care must be observed if any hazing with live ammunition is conducted near buildings or anywhere else for that matter

(Pfeifer 1983, 76[E]), since individuals could be in Shoreline Park even during pre-dawn hours.

It would be impossible to isolate only coots for firearm hazing. Other non-target animals within the Park would also be adversely affected.

Because of its inherent limitations and previous failure at Shoreline, it is doubtful shooting as a scare technique would be of any value.

Ultrasonics

It has been suggested Shoreline try using intense audible and ultrasonic frequency sound to drive off its coots (Becota 1993) (see "Automatic Exploders," "Horns," and "Pyrotechnics" in this chapter for information on audible scare devices).²

Vincent Salmon (1985) noted starlings soon ignored ultrasonic harassment unless it was associated with danger, while in separate tests, Zajanc (1962, 201) was unable to detect any visible reaction from starlings or English sparrows (*Passer domesticus*) when a device emitting twenty thousand cycles per second was used against the avian pests.

²The range of normal human audible sound is from 20 to 16,000 cycles per second (Zajanc 1962, 201), while anything above the normal human audible range is considered ultrasonic. High-frequency sound is 3,000,000 to 30,000,000 cycles, and ultrahigh-frequency sound is 300,000,000 to 3,000,000,000 cycles per second (Stein 1980, 625, 1425).

Ultrahigh-frequency sound initially kept sea gulls away from water pollution control tanks in San Jose. However, the gulls eventually returned (Corbett 1991).

A member of a Santa Barbara, California golf course built a high-frequency device with low, medium, and high settings for use against the course's coots. Their mud hens were unaffected at both the low and medium sound levels. The experiment ended when activation of the medium setting brought complaints from nearby homeowners (Weddle 1989).

But even if an ultrasonic harassment program was successful against the Park's coots, it would probably also evict non-target birds from Shoreline's golf course and wildlife area.

Regardless, Marley (1987, 26) states, "The USFWS and other agencies have not found this technology to be effective on birds in an outside environment." This is probably due to the fact scientific research found several common avian species including the pigeon, sparrow (no species identified), and starling, had normal hearing ranges "more restricted than that of humans" (Zajanc 1962, 200-1).

Therefore, if sound was used as part of a bird control program, it would likely need "to be within the range audible to humans" (Zajanc 1962, 201). This, of course, would be unacceptable at a golf course.

Volunteers

Many have suggested enlisting the help of volunteers to assist in Shoreline's annual coot harassment effort. Volunteers could also be used in possible barrier construction, habitat alteration, and population reduction programs (see chapters V through VII respectively for information on these other management programs).

Jenni (1988) supports making someone an "official coot chaser," while others recommend a more intensive show of force. Weddle (1989) proposes an ongoing, "around-the-clock effort of several volunteers" to keep Shoreline's golf course free of coots (see "Human Blockade" section in "Barriers" for information on a volunteer-based coot-exclusion plan). Gorenzel (1989) advocates placing someone on the payroll to work all day harassing mud hens.

By taking advantage of the coots' flocking behavior, it might be possible for a few volunteers to herd large numbers of mud hens. In order to be effective at Shoreline, a volunteer-based coot-harassment program would require at least six volunteer stations. This program might be successful if run by a paid coordinator.

A volunteer would be needed at Pond No. 1, at the southern end of Pond No. 2, between Pond No. 2 and Shoreline Lake, between Pond No. 3 and Shoreline Lake, at the northern end of Pond No. 4, and at the southeastern end of Pond No. 4 (fig. 4). Volunteers at all locations, except

Pond No. 1 and northern Pond No. 4, should be assisted by a trained dog (see "Dogs" section previously in this chapter). Since mud hens are diurnally active (Gullion 1950, 160), the volunteer positions would need to be staffed continuously from morning twilight to evening twilight, seven days per week.

The goal of a Shoreline harassment program would be to reduce its coot population to a manageable number of around four hundred (Lyles 1988c). By the first of October, migration has raised Shoreline's coot population to around four hundred (see "Shoreline Coot Census" chapter). Even if Shoreline's coots tired of being herded and abandoned the Park, new migrants would still need to be harassed until mud hen immigration ceased in December.

But it is more likely volunteer activities would only temporarily keep coots off sensitive turfed areas. Since coot numbers remain above the four hundred level until about the first of May, a seven-month harassment program would be required.

The volunteer hours needed for just one position are calculated in table 5. Over fifteen thousand volunteer hours are required to staff six positions.

Volunteer activities would need to be well planned so as not to adversely affect ongoing golfing games. All volunteers would wear orange vests and helmets to help protect them from the potential risk associated

TABLE 5
HOURS NEEDED PER VOLUNTEER POSITION

Month	Days in Month	Average Daily Hours	Total Hours in Month
October	31	12.25	379.75
November	30	11.25	337.50
December	31	10.50	325.50
January	31	10.75	333.25
February	28	11.75	331.94
March	31	13.00	403.00
April	30	14.25	427.50
Total	212	11.96	2,538.44

Notes: "Average Daily Hours" were determined by rounding the amount of daylight on the fifteenth of each month to the nearest quarter hour, plus one hour for twilight time. Days used in "February" and "Total" calculations were 28.25 and 212.25, respectively.

with working on a golf course. Companion dogs should also be required to wear appropriate safety equipment.

People and animals share approximately 150 diseases (Hodge 1990a, 91). Volunteers would need to be informed about the possible health risks involved with working around any animals in their particular area (Arnstein 1962, 316-17) as well as the proper use of sensible preventive measures (Hodge 1990a, 91). All volunteers should also sign liability insurance waivers.

Trained volunteers could help reduce coot depredation problems at Shoreline, but it is unlikely they would be able to annually fill the over fifteen thousand hours required in the previously described control program. Even if they could, volunteers and dogs would not be able to keep Shoreline's coot population at around four hundred coots. They would probably only be able to keep the existing number of coots in areas of the Golf Course where the mud hens would be less destructive. Under this plan, coot depredation to the grass along northeastern Shoreline Lake would probably increase unless this area was also patrolled. Regardless, unless the number of volunteer hours needed could be lowered, this plan is probably not realistic.

Water Sprinklers

Some birds avoid areas being sprayed by rotating sprinklers. This scare device is most effective when the water pressure is intense enough to bother the target bird. Sprinklers could be aimed at sensitive areas from either in or near Shoreline Golf Links's ponds and lake. Sprinklers could also be set to operate frequently for short intervals to take advantage of the startling effect of their sudden startup noise (Salmon, Conte, and Gorenzel 1986, 92[E]). During the day, sprinklers could be directed at shoreline turf, thereby singling out grazing coots for harassment.

But golfers may not appreciate a sprinkler unexpectedly starting in the middle of their game, and the water sprays probably will not bother the coots since they often graze between the jets of water. In fact, grazing coots adjacent to Shoreline Lake's north shore seem to be attracted by water sprinklers. It is not uncommon to see ten or more mud hens crowd around puddles left by the sprinklers. The coots appear to prefer drinking the unsalted puddle water over the salt water in Shoreline Lake.

When dark, water sprays would need to be directed across Shoreline's ponds and lake since most of its wintering coots spend the night on the water. But even if a nighttime spraying program bothered the Park's coots, it would disturb all other aquatic-roosting waterfowl as well.

Other Scare Devices

Hodge (1990a, 4) also suggested flares, lanterns, and recorded predator calls be used as frightening devices. These techniques were not investigated because they used much the same scaring concepts as other devices already discussed. Refer to the sections noted for these three scare tactics:

1. Flares: "Night Harassment" or "Pyrotechnics"
2. Lanterns: "Lights" or "Night Harassment"
3. Recorded Predator Calls: "Recorded Alarm and Distress Calls"

Conclusion

Coots are not driven off by frightening devices. Tactics that appear to work soon lose their effectiveness when the mud hens adapt or habituate to the control measure.

The USFWS's Pearson (1985) said, "Scaring, herding, and hazing techniques which work for ducks and geese are ineffective for coots."

After viewing Shoreline's golf course and wildlife area, Hodge (1990c) believed any harassment activity at the Park would be ineffective due to the immense size of the facility. The use of volunteers and dogs may offer some hope as part of an integrated management program. This alternative will be discussed in the "Recommendations" chapter.

CHAPTER X

SHORELINE FIELD RESEARCH

Despite Shoreline's numerous constraints, the literature research summarized in the previous five chapters revealed several methods which showed potential as possible solutions to the Course's coot depredation problem.

Before any of these promising management tools could be thoroughly tested, it was necessary to conduct a comprehensive coot census at Shoreline to determine the magnitude, timing, and location of the Course's mud hen mischief. Results of this census can be found in the next chapter.

Following the census, accounts and analyses of the author's preliminary tests are recorded in chapters XII and XIII.

The author's research is summarized in chapter XIV.

CHAPTER XI

SHORELINE COOT CENSUS

The Problem

During the author's analysis of different avian control techniques (see chapters V through IX), the main focus was on the best way to manage the Golf Course's coots, given Shoreline's unique constraints.

But for any Shoreline mud hen management program to be successful, there must be a significant, verifiable, coot population decrease on the sensitive areas of its golf course. Although several management techniques deserved consideration as possible solutions, without reliable information on Shoreline's coot population, it would be difficult to draw valid conclusions from any tests.

No Shoreline personnel had ever censused the Park's coots (Rafalski 1990). Vaught (1988a) estimated Shoreline had "about a dozen" resident coots and an over-wintering population that peaked at three thousand to four thousand mud hens. Lyles (1988a) believed there were around one hundred resident coots with several thousand mud hens on the Course by mid-January.

Shoreline staff also held differing opinions on local coot migration patterns. Bakanoff (1989) felt the mud hens began arriving in late August, while Vaught (1988a) estimated the coots first reached Shoreline in September or October and stayed through March. Vaught added that the coots' migration appeared to be weather related, observing the birds seemed to stay with a majority of the area's rains. Lyles (1988c) thought a storm or duck hunting on San Francisco Bay brought many coots to the Golf Course looking for sanctuary.

Chandik (1989), a naturalist at Palo Alto's Baylands Nature Interpretive Center, noted the mud hen was not a bird of great interest and admitted the Center had not kept track of its local population.

The Santa Clara Valley Audubon Society conducts an ongoing, biweekly bird count at Shoreline's Charleston Slough (Bousman 1995a), an area of the Park that was not censused by the author. But Charleston Slough and Shoreline Golf Links represent very different habitat types, and as far as Bousman knew, no one ever counted the Golf Course's or the Lake's coots. Bousman's (1995b) data did show that the first mud hens annually arrived at Charleston Slough around 2 September, while the season's last coots left the Slough about 2 June.

Since no wildlife agencies or individuals had ever conducted a comprehensive coot census on Shoreline's golf course or lake, it would be impossible to compare pre-test and post-test counts to previous baseline

data as none existed. Therefore, it was essential a comprehensive coot census be conducted at Shoreline in order to properly evaluate any planned research activities.

The goal of the Shoreline coot census was to accurately count all the American coots on Shoreline Lake and Golf Links throughout an entire mud hen migratory season. A comprehensive coot census had never been conducted on Shoreline Lake and Golf Links. A census of this magnitude would represent valuable baseline data that could be used during future counts and studies.

The census was limited to the coots on Shoreline Lake and the four Golf Course ponds (fig. 4). Mud hens on land adjacent to the ponds and Lake were also included. Since Shoreline's mud hens appeared to maintain general winter territories and did not venture on land more than about two hundred feet from the Park's water areas, this census should represent a complete record of the coots that resided at Shoreline Lake and Golf Links during the 1990-91 migratory season.

Methods Used in This Census

Census Composition

A twice-weekly census of all coots in the vicinity of Shoreline's ponds and lake began 27 September 1990 and continued until most of the migratory mud hens left 2 May 1991. These censuses were conducted each

Tuesday and Thursday until they changed to Thursday-only events on 31 January 1991.

Each census day consisted of two separate comprehensive counts. The first comprehensive count was conducted at dawn. The second comprehensive count started an average of eighty minutes before sunset.

The only exceptions to the above were as follows:

1. Due to the author's participation in Shoreline coot harassment activities, no morning count was held on 16 October 1990.
2. Due to heavy Golf Links usage on Thanksgiving, 22 November 1990, no afternoon count was held on this Thursday.
3. No morning or afternoon counts were held on 25 December 1990, 1 January, and 3 January 1991.
4. For comparative purposes, non-migratory morning and evening comprehensive counts were conducted 16 July 1991.

There were ninety-four separate comprehensive coot counts made between 27 September 1990 and 16 July 1991. For statistical purposes, the Shoreline coot census consisted of the ninety comprehensive counts, taken two per day, on forty-five days between 27 September 1990 and 2 May 1991.

Census Procedures

In an attempt to duplicate the same conditions for each individual count, the following procedures were kept throughout the entire 1990-91 Shoreline coot census.

1. All counts were conducted by the author.
2. The census route was changed only once during the entire census when increasing coot numbers necessitated a route addition on 30 October 1990 (see "The Census Route" below).
3. The census route was covered entirely by foot.
4. When magnification was required, 8x30 binoculars were used.
5. Whenever possible, all coots were counted one by one.
6. When any uncertainty existed regarding the accuracy of a counted group of coots, when feasible, the entire group was recounted.
7. When unsure if a handful of coots within a larger group of mud hens had been counted, and it was impractical to recount the entire group, then half the coots in question were included in the group's count.
8. When it was impossible to individually count several coots in a large group of mud hens, any remaining birds were counted by groups of ten or fifteen. Any error thought possible due to this estimating technique was noted in table 6 (p. 233).

The Census Route

The census route, which was the same for morning and afternoon counts, was chosen after observing the terrain, location of the sun, and coot behavioral tendencies in the study area. Since it was noted that Shoreline's coots never grazed more than about two hundred feet from the nearest water area and never lost sight of the water, the route generally consisted of the shoreline sections of the Park's water areas with the best viewing sites.

The route (fig. 4) started at the southwest corner of Pond No. 4 and proceeded clockwise along its entire northern length. Next, the census route moved south across the Pond at the footbridge between Ponds No. 4B and No. 4C. Here, the Pond No. 4 count was completed by following the interior shores of Ponds No. 4C and No. 4D clockwise to the western edge of Pond No. 4D.

The average starting time of the forty-five morning counts was about three minutes after sunrise. Since the vegetation around Pond No. 4 required that much of this water area be counted facing east, it was censused first to avoid looking into the sun once it rose above the hills on the eastern horizon.

The author then traveled west to Pond No. 3 where it was counted from its northern shore in a counterclockwise direction.

Next, the author proceeded to the southern tip of Shoreline Lake's beach. Because of its lack of plants, this location was normally uninhabited by coots and therefore made an ideal starting point for the Lake's census.

The Shoreline Lake count ran in a clockwise direction along its southern shore until all landscaping ended just southeast of the Lake's small island. This spot was very sparsely populated by mud hens and made a good place to begin the Pond No. 2 count. The author quickly backtracked to the area between Pond No. 2B's northeastern corner and Shoreline Lake before the uncounted Pond No. 2 coots mixed with the counted coots in the Lake. Pond No. 2 was then counted clockwise along its southern and western edges. The census route was now back at the small island ready to resume the Shoreline Lake count.

The census continued in a clockwise direction around the Lake until it completed its circuit at the southern tip of the Shoreline Lake beach. This second half of the Lake count was added 30 October 1990 when the coot population on its northern shore became too large to count from its southern shore with binoculars.

Finally, the author traveled southwest to Pond No. 1, where the count was conducted entirely from the Pond's southeastern shore. This concluded the census route.

Strategies Developed

The following strategies were developed to minimize counting error during the coot census:

1. For various reasons, large groups of coots were more difficult to count when on land than when in the water. Therefore, most grazing mud hens were approached with waving arms. This menacing greeting almost always sent them to the safety of the nearest water area.
2. The count was often delayed several minutes after scaring very large groups of grazing coots into the water. Initially, the mud hens massed in a dense flock of up to eight hundred birds. By simply standing where the coots had just grazed, it was possible to physically block their return to the Golf Course. Within minutes, the large group would form a line four or five abreast and swim for another nearby turfed area. It was normally possible to count nearly all of this aquatic procession one by one before they reached the shore, thereby nearly eliminating the need for estimation.
3. Coots from Pond No. 2 and Pond No. 3 wander back and forth between Shoreline Lake and their respective ponds. Before counting in either area, special care was taken to scare the pond coots as far from Shoreline Lake as possible, and vice versa. If this was not done, coots from these areas could intermingle during counting.

4. Counting was not conducted when part of a group of coots was on land and part was in water since they usually would not stay that way for long. Therefore, all the mud hens were scared into the water before a count was attempted.
5. Whether an uncounted coot flock was on land or in the water, its group configuration was analyzed with respect to its immediate surroundings before a decision was made regarding how it would be counted. In this way, escape routes and areas where mixing with other counted and uncounted groups could normally be anticipated and eliminated.
6. Although coots normally fly to escape danger as a last resort, great care was taken when approaching coots on very windy days when flights of up to one hundred yards to safety were common.
7. Coots in close proximity to one another will instinctively seek safety in numbers when they feel threatened. Therefore, it was necessary to delay counting frightened birds until all merging and mixing had stopped.
8. When feeding, most diving waterfowl stay submerged much longer than coots. If an unidentified bird remained underwater after about fifteen seconds, there was no need to wait for it to surface. It was not a coot.
9. Whenever possible, counts were timed to avoid conflicts with golfers.
10. Knowledge of distinctive coot markings, calls, habits, and silhouettes, were used to enhance census accuracy during overcast, fog, rain, and twilight.

Census Results

The Shoreline coot census began 27 September 1990 with about 325 coots spotted on and around the Golf Course. The number of mud hens in the study area for all forty-five counting days was determined by averaging that day's morning and evening counts (tables 6-7). The mud hen population grew by approximately 42 birds per night during the next five nights, so that by 2 October, there were over 500 coots within the Shoreline Park census area.

Mud hen numbers continued to increase at a rate of just over forty-two per night through the entire month of October. By 1 November, more than eighteen hundred coots were counted at Shoreline.

From 1 November to 15 November, mud hen numbers rose at a rate of 65 per night. During this two-week period, the Park's coot population increased nearly 50 percent to 2,745 birds.

The rate of increase fell to twenty-eight per night for the remainder of November, while the first two weeks of December saw an even slower nightly increase of nineteen coots.

On 13 December, migration into Shoreline virtually stopped. Up to this point, coot numbers had grown with each new count. Now with 3,406 coots present, the mud hen population fluctuated up and down through 21 February 1991, and except for the 14 February count, never strayed more than 5 percent from the 13 December total.

TABLE 6

COMPREHENSIVE 1990-91 SHORELINE COOT CENSUS DATA

Date	Sun- rise	Sun- set	Count Began	Count Ended	Pond N. 4	Pond N. 3	Lake	Pond N. 2	Pond N. 1	Total Coots	Est. Error	(°F)	Weather (Sky) (Wind)
09/27	0659	.....	0710	0808	125	0	214	3	2	344	0	58	CR 0
09/27	.....	1857	1805	1933	119	0	185	3	0	307	0	74	CR 18NW ^c
10/02	0704	.....	0701	0845	212	0	314	7	3	536	0	58	CR 0
10/02	.....	1849	1758	1920	212	0	255	63	3	533	0	79	CR 9NW ^c
10/04	0705	.....	0712	0814	226	5	355	15	4	605	0	63	CR 0
10/04	.....	1846	1750	1845	236	4	247	142	4	633	0	79	CR 11NW ^c
10/09	0710	.....	0705	0821	316	5	490	73	8	892	0	54	CR 0
10/09	.....	1839	1743	1848	211	5	509	41	8	774	0	85	CR 9NW ^c
10/11	0712	.....	0716	0821	331	8	517	41	10	907	0	53	CR 0
10/11	.....	1836	1736	1848	314	8	554	27	11	914	0	81	CR 15NW ^c
10/16	0716	.....	.....	.....	.....	....	.....	.....	....	.....	...	59	PC 5N
10/16	.....	1829	1723	1851	340	16	651	99	9	1115	0	77	CR 11NW
10/18	0718	.....	0737	0849	387	31	619	122	13	1172	0	60	OC 0
10/18	.....	1827	1742	1844	428	15	660	58	14	1175	0	71	OC 9NW ^c
10/23	0723	.....	0718	0839	446	9	825	115	20	1415	0	54	OC 0
10/23	.....	1820	1737	1838	468	52	740	17	12	1289	0	75	CR 8NW
10/25	0725	.....	0720	0839	480	11	917	99	15	1522	0	53	CR 0
10/25	.....	1818	1725	1827	494	5	1023	7	25	1554	0	74	SO 6NW ^c
10/30	0630	.....	0635	0803	525	8	1020	158	30	1741	0	56	PC 0
10/30	.....	1712	1554	1713	552	51	1106	32	25	1766	0	68	PC 17N
11/01	0632	.....	0645	0801	595	47	1013	132	39	1826	0	47	CR 0
11/01	.....	1710	1557	1717	574	64	1111	66	37	1852	0	64	CR 12NW ^c

TABLE 6

COMPREHENSIVE 1990-91 SHORELINE COOT CENSUS DATA (continued)

Date	Sun- rise	Sun- set	Count Began	Count Ended	Pond N. 4	Pond N. 3	Lake	Pond N. 2	Pond N. 1	Total Coots	Est. Error	(°F)	Weather (Sky)	(Wind)
11/06	0637	.....	0635	0813	665	118	1110	282	56	2231	0	56	CR	13N
11/06	.....	1705	1546	1709	721	26	1355	56	55	2213	0	71	CR	18NW
11/08	0639	.....	0653	0805	734	66	1273	218	68	2359	0	48	CR	0
11/08	.....	1703	1544	1702	681	128	1394	31	71	2305	0	77	CR	11NW
11/13	0645	.....	0639	0811	794	12	1546	270	85	2707	0	48	PC	0
11/13	.....	1658	1536	1703	745	126	1294	279	87	2531	0	62	OC	12NW
11/15	0647	.....	0650	0817	830	156	1356	314	90	2746	0	50	CR	5W ^c
11/15	.....	1657	1528	1701	764	198	1635	60	86	2743	0	69	CR	7NW ^c
11/20	0652	.....	0648	0817	828	264	1465	297	95	2949	0	45	PC	0
11/20	.....	1654	1540	1657	888	178	1736	34	89	2925	0	57	PC	7NW ^c
11/22	0654	.....	0652	0848	843	89	1577	223	96	2828	0	41	CR	5S ^c
11/22	.....	1653	.....	.....	.....	.....	.....	.....	.....	.....	...	...	....	.....
11/27	0659	.....	0649	0829	872	170	1559	344	100	3045	0	36	CR	0
11/27	.....	1651	1531	1705	898	50	2024	30	103	3105	0	57	CR	9NW
11/29	0701	.....	0651	0834	879	183	1786	210	105	3163	0	38	PC	0
11/29	.....	1650	1524	1652	886	128	1960	36	106	3116	0	61	OC	9NW
12/04	0706	.....	0652	0844	946	389	1289	539	112	3275	0	35	CR	0
12/04	.....	1650	1458	1636	954	81	1926	172	111	3244	0	58	OC	0
12/06	0707	.....	0702	0842	945	278	1583	397	110	3313	0	38	CR	0
12/06	.....	1650	1525	1638	950	186	1836	165	110	3247	0	64	OC	4NW ^c
12/11	0712	.....	0704	0839	1026	148	1710	374	120	3378	0	52	OC	0
12/11	.....	1650	1528	1647	1008	141	2033	68	124	3374	0	55	PC	0

TABLE 6

COMPREHENSIVE 1990-91 SHORELINE COOT CENSUS DATA (continued)

Date	Sun- rise	Sun- set	Count Began	Count Ended	Pond N. 4	Pond N. 3	Lake	Pond N. 2	Pond N. 1	Total Coots	Est. Error	(°F)	Weather (Sky)	(Wind)
12/13	0713	.....	0719	0838	1025	251	1547	457	126	3406	0	38	CR	0
12/13	.....	1650	1526	1645	1012	170	1771	327	125	3405	0	54	CR	7NW ^c
12/18	0716	.....	0715	0848	1060	51	1691	413	126	3341	0	38	PO	0
12/18	.....	1652	1540	1657	1077	304	1360	498	128	3367	0	56	PC	17NW
12/20	0718	.....	0710	0841	1078	0	1635	512	128	3353	0	34	PC	0 ^b
12/20	.....	1653	1513	1645	1064	242	1412	402	128	3248	0	41	PC	18N
12/27	0721	.....	0713	0847	1160	238	1241	636	141	3416	0	32	CR	0
12/27	.....	1657	1510	1659	1178	138	1739	192	137	3384	0	54	CR	12N ^c
01/08	0722	.....	0714	0836	1189	205	1072	906	144	3516	0	50	OC	0
01/08	.....	1707	1541	1728	1182	71	2090	5	143	3491	0	58	PC	9N
01/10	0722	.....	0727	0848	1207	0	1430	652	144	3433	0	42	CF	0
01/10	.....	1708	1546	1652	1178	199	1208	727	145	3457	0	60	CR	6NW ^c
01/15	0721	.....	0711	0831	1237	20	1405	768	145	3575	+50	53	OC	0
01/15	.....	1713	1521	1655	1205	234	1386	568	144	3537	+50	61	PC	11NW
01/17	0720	.....	0726	0845	1136	156	1250	794	142	3478	+70	53	CR	6E ^c
01/17	.....	1715	1519	1712	1189	244	1357	474	136	3400	0	71	CR	8NW
01/22	0718	.....	0723	0845	1160	89	1271	743	145	3408	0	36	CR	0
01/22	.....	1721	1538	1658	1183	194	1515	430	143	3465	0	62	CR	9NW ^c
01/24	0717	.....	0717	0828	1210	76	1204	848	144	3482	+100	38	OC	0
01/24	.....	1723	1543	1701	1168	183	1868	148	144	3511	0	58	CR	0
01/29	0713	.....	0710	0831	1174	107	955	855	140	3231	+55	36	CR	0
01/29	.....	1728	1550	1716	1043	140	1884	38	143	3248	+50	65	CR	6NW

TABLE 6

COMPREHENSIVE 1990-91 SHORELINE COOT CENSUS DATA (continued)

Date	Sun- rise	Sun- set	Count Began	Count Ended	Pond N. 4	Pond N. 3	Lake	Pond N. 2	Pond N. 1	Total Coots	Est. Error	(°F)	Weather (Sky)	(Wind)
01/31	0712	.....	0721	0832	1107	119	1047	839	150	3262	0	42	OC	0
01/31	.....	1731	1557	1703	1119	218	1489	397	147	3370	0	58	CR	7NW
02/07	0706	.....	0711	0818	1105	1	1332	768	145	3351	0	45	PC	0
02/07	.....	1738	1521	1654	1080	165	1171	743	147	3306	0	69	PC	0
02/14	0658	.....	0652	0808	1007	2	1374	682	142	3207	+50	49	CR	0
02/14	.....	1746	1611	1723	1003	67	1643	276	148	3137	0	73	OC	8NW
02/21	0650	.....	0702	0812	1016	31	1311	746	149	3253	+40	49	PC	0
02/21	.....	1753	1634	1746	1000	164	1811	92	149	3216	0	62	OC	9NW
02/28	0641	.....	0712	0837	1024	154	1069	753	146	3146	+20	55	PC	5S
02/28	.....	1800	1724	1839	1001	139	1817	11	145	3113	0	60	OR	7SE
03/07	0631	.....	0627	0752	1026	10	1063	756	150	3005	0	44	CR	0
03/07	.....	1807	1658	1817	1053	109	1265	561	149	3137	0	62	CR	10NW
03/14	0621	.....	0630	0747	1024	7	1087	763	142	3023	+25	42	CR	0
03/14	.....	1814	1651	1814	1038	142	928	720	143	2971	+25	50	CS	21W
03/21	0610	.....	0626	0758	1035	143	973	611	140	2902	+15	48	OS	6W
03/21	.....	1820	1734	1854	1002	163	1497	18	143	2823	+15	54	PC	9NW
03/28	0600	.....	0612	0749	1013	122	1006	396	128	2665	+5	43	CR	0
03/28	.....	1826	1718	1848	1013	137	1165	93	125	2533	+5	61	CR	12NW
04/04	0549	.....	0601	0734	772	60	635	405	104	1976	0	46	CR	0
04/04	.....	1833	1649	1807	792	113	481	409	102	1897	0	67	PO	17NW
04/11	0639	.....	0653	0822	686	106	250	390	105	1537	+30	50	CR	 ^a
04/11	.....	1939	1752	1918	687	129	423	285	107	1631	0	64	CR	13NW

TABLE 6

COMPREHENSIVE 1990-91 SHORELINE COOT CENSUS DATA (continued)

Date	Sun- rise	Sun- set	Count Began	Count Ended	Pond N. 4	Pond N. 3	Lake	Pond N. 2	Pond N. 1	Total Coots	Est. Error	(°F)	Weather (Sky) (Wind)
04/18	0629	.....	0643	0746	438	56	317	181	88	1080	0	50	OC 0
04/18	.....	1945	1821	1926	438	97	134	297	82	1048	0	62	SO 12NW
04/25	0620	.....	0626	0726	260	1	178	192	63	694	0	48	PC 6W ^c
04/25	.....	1951	1833	1933	259	59	140	176	61	695	0	60	PC 4S
05/02	0612	.....	0616	0723	100	0	142	63	35	340	0	51	OC 0
05/02	.....	1958	1914	2014	99	33	145	26	34	337	0	58	CY 11NW
07/16	0559	.....	0559	0712	23	0	34	12	4	73	0	63	OC 0
07/16	.....	2028	1934	2103	23	2	5	38	5	73	0	70	CR 11NW ^c

Notes: Sunrise and sunset times, as well as all counting times, from 28 October 1990 through 6 April 1991 were in Pacific Standard Time. All other times during the census were Pacific Daylight Time. The sunrise and sunset times were taken from various 1990 and 1991 issues of the San Jose Mercury News. The column entitled "Estimation Error" represents what the author perceived to be possible counting error when estimation was required during part of a comprehensive count. This "error" was not figured into any coot census calculations. Temperature and wind readings on the hour closest to the author's census starting times were obtained from an hourly weather summary in various 1990 and 1991 issues of the San Jose Mercury News. All San Jose Mercury News weather readings were recorded at San Jose International Airport, ten miles southeast by east of Shoreline. Abbreviations used for the sky conditions observed by the author are: CF (partly cloudy, turned foggy), CR (clear), CS (cloudy with showers), CY (cloudy), OC (overcast), OR (overcast with light rain), OS (overcast with showers), PC (partly cloudy), PO (partly overcast), and SO (slightly overcast). If the author noticed a change from San Jose Mercury News wind listings during a count, the listed wind information was followed by a superscript letter and an

accompanying explanation. All posted wind speeds were in miles per hour. Figures from the partial 16 October and 22 November 1990 counts, and the non-migratory 16 July 1991 count, were listed above even though they were not included in any Shoreline coot census calculations.

^aWind information for 0700 was not reported. Recorded wind data for 0600 and 0800 indicate the 0700 wind may have been from the north or northwest at twenty to thirty miles per hour.

^bTurned breezy.

^cTurned calm.

TABLE 7

1990-91 SHORELINE COOT CENSUS TWO-COUNT AVERAGE

Date	Total Avg. Coots	Daily Avg. Chg.	Two- count Diff.	Pct. Count Diff.	Pond N. 4 Avg.	N. 4 Pct. Coots	Lake, Ponds N. 2 & N. 3 Comb. Avg.	Lake, N. 2, N. 3 Comb. Pct. Coots	Pond N. 1 Avg.	N. 1 Pct. Coots
09/27	325.5	.....	37	11.37	122.0	37.5	202.5	62.2	1.0	0.3
10/02	534.5	+41.8	3	0.56	212.0	39.7	319.5	59.8	3.0	0.6
10/04	619.0	+42.3	28	4.52	231.0	37.3	384.0	62.0	4.0	0.6
10/09	833.0	+42.8	118	14.17	263.5	31.6	561.5	67.4	8.0	1.0
10/11	910.5	+38.8	7	0.77	322.5	35.4	577.5	63.4	10.5	1.2
10/18	1173.5	+37.6	3	0.26	407.5	34.7	752.5	64.1	13.5	1.2
10/23	1352.0	+35.7	126	9.32	457.0	33.8	879.0	65.0	16.0	1.2
10/25	1538.0	+93.0	32	2.08	487.0	31.7	1031.0	67.0	20.0	1.3
10/30	1753.5	+43.1	25	1.43	538.5	30.7	1187.5	67.7	27.5	1.6
11/01	1839.0	+42.8	26	1.41	584.5	31.8	1216.5	66.2	38.0	2.1
11/06	2222.0	+76.6	18	0.81	693.0	31.2	1473.5	66.3	55.5	2.5
11/08	2332.0	+55.0	54	2.42	707.5	30.3	1555.0	66.7	69.5	3.0
11/13	2619.0	+57.4	176	6.72	769.5	29.4	1764.5	67.4	86.0	3.3
11/15	2744.5	+62.8	3	0.11	797.0	29.0	1859.5	67.8	88.0	3.2
11/20	2937.0	+38.5	24	0.82	858.0	29.2	1987.0	67.7	92.0	3.1
11/27	3075.0	+19.7	60	1.95	885.0	28.8	2088.5	67.9	101.5	3.3
11/29	3139.5	+32.3	47	1.50	882.5	28.1	2151.5	68.5	105.5	3.4
12/04	3259.5	+24.0	31	0.95	950.0	29.1	2198.0	67.4	111.5	3.4
12/06	3280.0	+10.3	66	2.01	947.5	28.9	2222.5	67.8	110.0	3.4
12/11	3376.0	+19.2	4	0.12	1017.0	30.1	2237.0	66.3	122.0	3.6

TABLE 7

1990-91 SHORELINE COOT CENSUS TWO-COUNT AVERAGE (continued)

Date	Total Avg. Coots	Daily Avg. Chg.	Two- count Diff.	Pct. Count Diff.	Pond N. 4 Avg.	N. 4 Pct. Coots	Lake, Ponds N. 2 & N. 3 Comb. Avg.	Lake, N. 2, N. 3 Comb. Pct. Coots	Pond N. 1 Avg.	N. 1 Pct. Coots
12/13	3405.5	+14.8	1	0.03	1018.5	29.9	2261.5	66.4	125.5	3.7
12/18	3354.0	-10.3	26	0.78	1068.5	31.9	2158.5	64.4	127.0	3.8
12/20	3300.5	-26.8	105	3.18	1071.0	32.4	2101.5	63.7	128.0	3.9
12/27	3400.0	+14.2	32	0.94	1169.0	34.4	2092.0	61.5	139.0	4.1
01/08	3503.5	+8.6	25	0.71	1185.5	33.8	2174.5	62.1	143.5	4.1
01/10	3445.0	-29.3	24	0.70	1192.5	34.6	2108.0	61.2	144.5	4.2
01/15	3556.0	+22.2	38	1.07	1221.0	34.3	2190.5	61.6	144.5	4.1
01/17	3439.0	-58.5	78	2.27	1162.5	33.8	2137.5	62.2	139.0	4.0
01/22	3436.5	-0.5	57	1.66	1171.5	34.1	2121.0	61.7	144.0	4.2
01/24	3496.5	+30.0	29	0.83	1189.0	34.0	2163.5	61.9	144.0	4.1
01/29	3239.5	-51.4	17	0.52	1108.5	34.2	1989.5	61.4	141.5	4.4
01/31	3316.0	+38.3	108	3.26	1113.0	33.6	2054.5	62.0	148.5	4.5
02/07	3328.5	+1.8	45	1.35	1092.5	32.8	2090.0	62.8	146.0	4.4
02/14	3172.0	-22.4	70	2.21	1005.0	31.7	2022.0	63.7	145.0	4.6
02/21	3234.5	+8.9	37	1.14	1008.0	31.2	2077.5	64.2	149.0	4.6
02/28	3129.5	-15.0	33	1.05	1012.5	32.4	1971.5	63.0	145.5	4.6
03/07	3071.0	-8.4	132	4.30	1039.5	33.8	1882.0	61.3	149.5	4.9
03/14	2997.0	-10.6	52	1.74	1031.0	34.4	1823.5	60.8	142.5	4.8
03/21	2862.5	-19.2	79	2.76	1018.5	35.6	1702.5	59.5	141.5	4.9
03/28	2599.0	-37.6	132	5.08	1013.0	39.0	1459.5	56.2	126.5	4.9

TABLE 7

1990-91 SHORELINE COOT CENSUS TWO-COUNT AVERAGE (continued)

Date	Total Avg. Coots	Daily Avg. Chg.	Two- count Diff.	Pct. Count Diff.	Pond N. 4 Avg.	N. 4 Pct. Coots	Lake, Ponds N. 2 & N. 3 Comb. Avg.	Lake, N. 2, N. 3 Comb. Pct. Coots	Pond N. 1 Avg.	N. 1 Pct. Coots
04/04	1936.5	-94.6	79	4.08	782.0	40.4	1051.5	54.3	103.0	5.3
04/11	1584.0	-50.4	94	5.93	686.5	43.3	791.5	50.0	106.0	6.7
04/18	1064.0	-74.3	32	3.01	438.0	41.2	541.0	50.8	85.0	8.0
04/25	694.5	-52.8	1	0.14	259.5	37.4	373.0	53.7	62.0	8.9
05/02	338.5	-50.9	3	0.89	99.5	29.4	204.5	60.4	34.5	10.2
07/16	73.0	.....	0	0.00	23.0	31.5	45.5	62.3	4.5	6.2

Notes: This table gives the average of the dawn and dusk counts taken each day. "Daily Average Change" was the average daily increase or decrease in coot numbers since the previous count was conducted. "Two-count Difference" was the difference between that day's morning and afternoon counts. "Percent Count Difference" represents the percent difference between that day's two counts ("Total Average Coots" divided by "Two-count Difference"). Since coots from Shoreline Lake, Pond No. 2, and Pond No. 3 moved freely between these three water areas, they were grouped together above. The percentages of the census population that this combined group, the Pond No. 4 group, and the Pond No. 1 group comprised, are listed in the column immediately to the right of each respective group's averaged population. These three percentages may not always add up to 100.0 due to rounding. Figures from the non-migratory 16 July 1991 count are listed above even though they were not included in any Shoreline coot census calculations.

After 21 February, coot numbers decreased with each count for the remainder of the census. Mud hen numbers dropped by about thirteen per night at Shoreline from 21 February through 21 March.

The Park's coot presence shrank by over twenty-five hundred coots, an average of sixty per night, from 21 March until 2 May. The weekly counts ended on 2 May when the coot population returned to pre-count levels.

The average number of coots from each of Shoreline's forty-five counts (table 7) is plotted in figure 5. When connected, the data points formed a graph similar to that of a Gaussian or normal curve.

For comparative purposes, a Gaussian function was created using the Shoreline data with the curve-fitting feature of the Igor® data analysis computer program, even though just two daily counts were conducted and not the three required for standard error calculations (Gasser 1991).

Although the data cannot be statistically related to the estimated curve (Gasser 1991), the Gaussian curve helps depict the migratory dynamics of Shoreline's coots.

Census Analysis

By analyzing the Shoreline coot census data, it should be possible to determine if: (1) the Park's coots present in the morning and evening are

Fig. 5. Graph of 1990-91 Shoreline Coot Census. "Avecount" is a line graph of the average number of coots recorded from each of Shoreline's forty-five morning and evening counts plotted against its counting date. "Gaussfit" depicts the graph of a normal curve that was fitted to the Shoreline census data. Graph courtesy of Tim Gasser.

likely to be a single population, and (2) subgroup populations existed around Shoreline's individual water areas.

Analysis of these two suppositions may show that most of the Park's mud hens over-wintered in general territorial areas around its golf course. If this is the case, subtle differences in the census data could ultimately reveal coot behavioral tendencies with mud hen management implications.

Are Shoreline's Coots Diurnally One Population?

By comparing the same day's morning and afternoon count totals (table 6), it would appear Shoreline's coots generally stayed within the census area during the course of a day. Although no coots were marked or tagged, it should be possible to test the validity of this observation by subjecting the census data to a few statistical tests.

First, the Pearson product-moment correlation was used to see the strength of the relationship between the set of forty-five paired morning and afternoon count numbers (Bruning and Kintz 1977, 171-74). Possible r values ranged from +1, for a perfect positive correlation, to a -1, for a perfect negative correlation. The calculated correlation between the morning and evening coot counts was +0.998. This score represents an almost perfect positive correlation. The fact that morning and evening numbers were so closely related suggest the Course's mud hens were not randomly moving in and out of the study area.

Next, a t-test for related measures was used on the Shoreline census data (Bruning and Kintz 1977, 13-16). This time, the census figures were divided into the three observed phases of migration.¹

1. Fall migration. This phase extended from 27 September to 13 December 1990 and represents a time during which Shoreline's total coot numbers increased with each succeeding count.
2. Winter intermigration. This phase lasted from 18 December 1990 to 21 February 1991. It depicts the period when mud hen numbers fluctuated up and down from one count to the next.
3. Spring migration. This final phase stretched from 28 February to 2 May 1991. It comprises a period when coot numbers decreased with each new count.

Separate t-tests were conducted for the three phases. In each case, the difference between the phase's morning and afternoon count means was calculated with the resulting t value compared to its corresponding t-table value at the 5 percent significance level for two-tailed tests.

The calculated t values for Shoreline's fall, winter, and spring migrational phases were 1.986, 0.779, and 0.723, respectively. None of these values was significant.

¹Although an argument can be made to include 13 December 1990 in the "winter intermigration" phase and 21 February 1991 in the "spring migration" phase, the author decided not to use data from a phase's terminal date in the succeeding phase's calculations.

The results of these two statistical tests show that morning and evening counts were not significantly different and this suggests the same mud hens were found at Shoreline on both counts. The author suspects the coot's reluctance to graze or fly more than a few hundred feet from the safety of a water area, along with an absence of enticing vegetation on neighboring lands, likely kept Shoreline's mud hens diurnally isolated within the census area.

Do Shoreline's Individual Water
Areas Support Separate Diurnal
Subgroup Populations?

The number of mud hens recorded on Shoreline Lake, Pond No. 2, and Pond No. 3, during their individual morning and evening counts, oscillated from one count to the next (table 6). But when the census figures from these three water areas were combined (table 7), it appeared their coots might actually comprise a major subgroup within Shoreline's overall coot population. The fact the author often witnessed mud hens shuttling freely between these three water areas must have accounted for most of their individual population fluctuations.

Furthermore, the coots on Pond No. 1 and Pond No. 4 also appeared to represent separate, minor subgroup populations.

To test these observations, census figures from each of the three theoretical subgroups were analyzed using the Pearson product-moment correlation (Bruning and Kintz 1977, 171-74).

The Shoreline Lake-Pond No. 2-Pond No. 3 subgroup recorded a +0.996 correlation between its morning and evening counts, while the Pond No. 1 and Pond No. 4 subgroups registered +0.998 and +0.994 correlations, respectively. Therefore, all three subgroup areas scored nearly perfect positive correlations.

So it appears Shoreline's coots make up three distinct subgroups within the Park's overall group population. If this is the case, then subgroup members do not travel outside of their respective boundaries during the course of the day. This behavior would coincide with the fact that the author never observed a coot from any of the aforementioned subgroup areas traveling to another subgroup area (or completely out of the census area) during the entire Shoreline coot count. This apparent attachment of the Park's migratory mud hens to a particular water area(s) is similar to that noted in Oakland's wintering coots where, according to Gullion (1950, 46), "once these tagged birds returned to Lake Merritt they remained in a certain general area."

Since Shoreline's mud hens apparently do not diurnally shuttle between neighboring wildlife areas, or even between their own Shoreline subgroup areas, can one assume the Park's coots: (1) over-winter at

Shoreline or (2) maintain winter territories at the Park? If not, is it possible Shoreline's mud hen migrants simply trade places with new migrants every few nights?

Do Migratory Coots Over-winter at Shoreline?

Over-wintering mud hens prefer areas "with abundant submergent vegetation and sparse emergent vegetation adjacent to expansive, deep, open-water areas" (Allen 1985, 5). Although the coot's winter habitat requirements are less stringent than during the breeding season (Fredrickson et al. 1977, 125), mud hens are restricted to temperate areas year-round (Gullion 1950, 200).

Eddleman, Knopf, and Patterson (1985, 242, 244) noted despite the fact Oklahoma's 5,357-acre Sooner Lake had ample aquatic vegetation, only a very small part of the coots that migrated there actually wintered there. Sooner Lake's wintering population vacillated depending on the weather, with peak numbers of coots "on days immediately following the passage of cold fronts." The birds stayed only a few days before continuing their journey with the next prevailing northerlies.

But Sooner Lake, located twenty-five miles north of Stillwater, Oklahoma, experiences more severe winters than the coastal region of California (Carpenter 1966, 108), and over-wintering coots require mild winter weather (Gorenzel, Ryder, and Braun 1981, 116).

Nearby Charleston Slough, "with over 130 acres of . . . tidal salt marsh and slough," like Sooner Lake, has large amounts of aquatic vegetation (Newberry 1986a, 1, 3). It also shares the same mild winter climate as Shoreline's golf course. One might expect a seasonal graph of its migratory coot numbers to follow a bell-curve pattern similar to that of the author's Shoreline coot census. Yet during ten years of census data, the Slough's mud hen population routinely oscillated during the migratory season (Bousman 1995b).

Unlike Shoreline Golf Links, Charleston Slough has no breeding coots (Bousman 1995b). Since none of Charleston Slough's mud hens were tagged (Bousman 1995a), no one can say for sure how long individual coots remain within the Slough. From its oscillating census data, it would appear a majority of the Slough's birds are transients.

But how can Shoreline Golf Links and Charleston Slough, both located within Shoreline At Mountain View, have such different coot population dynamics? The answer lies in the types of aquatic vegetation found in the Mountain View habitats.

Although the coot is almost exclusively a vegetarian in the fall and winter, plants growing in "brackish and alkaline habitats" have limited value as coot foods (Jones 1940, 12, 23), and Charleston Slough contains primarily *Salicornia* and *Spartina* (halophytes) (Newberry 1986b, 1-2). On the other hand, Oklahoma's Sooner Lake (Eddleman, Knopf, and Patterson

1985, 242) and Shoreline Golf Links's water areas have an ample supply of plants, including algae and grasses, that are a part of the mud hen's normal diet (Jones 1940, 10).

Gullion (1950, 167) reported the coots at Oakland's Lake Merritt and Lake Temescal, and Berkeley's Aquatic Park, fed heavily on algae. When all acceptable aquatic vegetation was gone, the San Francisco Bay Area mud hens went on shore and principally grazed on grasses. These three California water areas are each about thirty miles north-northwest of Shoreline and share Mountain View's mild winters.

Gullion (1950, 46-49) also noted "banding returns have shown that individual coots return to Lake Merritt year after year," while coot numbers on Aquatic Park and Lake Temescal "remained very stable throughout the winter," and added this "would not have been the case had shuttling of birds from one lake to another occurred to any considerable extent." Therefore, the American coot appears to possess "a strong attachment to its chosen winter quarters."

Shoreline Golf Links also experienced a very stable winter coot population. In fact, the Golf Course was home to nearly 90 percent of its peak 1990-91 coot census figure for 79 consecutive days (4 December 1990-21 February 1991), and 80 percent of its peak number for 121 straight days (20 November 1990-21 March 1991).

In summary, although initially attracted by expansive, open-water areas, most migratory mud hens will not establish a winter home in areas that have either (1) severe weather or (2) brackish or alkaline habitats. Sites with either of these limiting factors will support mainly transient coots whose numbers oscillate with the weather. Stable numbers of over-wintering mud hens are capable of being supported in areas with both mild weather and ample plant foods.

Since Shoreline Golf Links has suitable weather and habitat to support over-wintering coots, and it shares similar coot population characteristics with Gullion's over-wintering mud hens, it should be fairly safe to assume most of the Golf Course's individual coots over-winter at the Park.

But assuming most migrant coots over-winter at Shoreline, what type of seasonal feeding patterns do they typically display? Do individual migrants forage aimlessly from one day to the next, or do they stay in specific areas of the Park throughout the winter?

Do Shoreline's Migratory Coots Keep Winter Territories?

Banded coots wintering in Arcata, California apparently return "to the exact area they . . . occupied the preceding winter" (Yocum, Rogiatto, and Eshleman 1978, 302), while each coot Gullion (1950, 46) tagged at Lake

Merritt was found "within a few hundred feet of where it had been on the previous visit."

During peak December 1990 and January 1991 concentrations, approximately 3,535 coots made Shoreline their home. At this time, the author noted a relatively constant number of mud hens were found clustered in the same general areas whenever time a count was conducted. This behavior is consistent with a winter territorial pattern.

The locations (fig. 4), followed by the approximate number of coots discovered at each, were:

1. In and around Pond No. 4A: 150
2. Traveling around and under the bridge between Ponds No. 4A and 4B:
140
3. In and around Ponds No. 4B, 4C, and 4D: 930
4. In or near the water from the lakeshore south of Shoreline Lake's beach, clockwise to the shoreline just north of Pond No. 2A and just southeast of the Lake's island. This includes the entire area in, around, and between Pond No. 2, Pond No. 3, and the southeastern portion of the Lake: 1550
5. In or near Shoreline Lake from the lakeshore just north of Pond No. 2A and just southeast of the Lake's island, clockwise to the Lake's northwestern pier (just off fig. 4): 115

6. In or near the water from the pier at the northwestern corner of Shoreline Lake, clockwise along the Lake's northern shore to its northeastern pier: 250
7. On or near the beach on Shoreline Lake's eastern shore: 50
8. Swimming between the northeast and southeast shores of Shoreline Lake: 200
9. In and around Pond No. 1: 150

The consistent number of birds in various areas around Shoreline is also consistent with winter territoriality. If this is the case, most of the Park's coots should restrict their feeding to areas within their general territories even though they may appear to forage aimlessly.

It is also possible some of Shoreline's migrants only stay in the Park a few days and that some turnover in individual birds occurs. Regardless (as noted in the previous subsection), the number of transient coots at Shoreline at any one time is probably small. But even if this is not the case, the fact that the Course's coots apparently do not travel outside their respective water areas during the day means that any transient mud hens, due to the bird's highly social wintering behavior (see "Behavior" section in "Coot Ecology"), probably accompany a flock of Shoreline's over-wintering coots and thus observe the same territorial feeding behavior as their more permanent peers.

Counting Differences

The mean average of the difference (by percent) between all forty-five same-day counts was 2.51 percent, while the median average was even lower at 1.43 percent (table 7). Although morning and evening counts taken on the same day did not differ significantly, a difference of at least 5 percent occurred during six of the forty-five counting days. These differences, listed chronologically, were:

1. 11.37 percent on 27 September 1990
2. 14.17 percent on 9 October 1990
3. 9.32 percent on 23 October 1990
4. 6.72 percent on 13 November 1990
5. 5.08 percent on 28 March 1991
6. 5.93 percent on 11 April 1991

After reviewing the sequence of significant counts, it was obvious the days with the greatest difference between their counts occurred early in the study. Not only that, the only counts differing by more than 10 percent were two of the first four overall counts conducted, while a day with a 9.32 percent disparity was recorded on the author's seventh count.

Although differences between morning and evening counts could be due to counting error or bird activity, it would appear most of the study's early counting differences were due to the initial inexperience of the census taker.

The most conspicuous example of possible counting inexperience was noted on 9 October. That day's morning count found 316 mud hens at Pond No. 4, while the afternoon count of the identical isolated water area could only account for 211 coots, a decrease of 33.23 percent. Coots around the Park's other four water areas declined just 2.26 percent during the same period.

The author suspects one hundred Pond No. 4 coots went accidentally unrecorded on the 9 October afternoon count. If one accepts this scenario, there would have been only five Pond No. 4 mud hens less during the day's later count, a coot reduction of just 1.58 percent. This "adjusted" decrease would have been nearly identical to the decline experienced that day on the rest of the census area.

Assuming counting error was the main cause behind Shoreline's early counting differences, what other factor(s) could have been responsible for the listed counting differences later in the study?

Wind-influenced Counts

Kiel and Hawkins (1953, 319) warned that "coots appear somewhat more sensitive to wind than ducks, and velocities above twelve miles an hour probably reduce the accuracy of the count sharply." According to the Beaufort wind scale (Stein 1980, 119), this would be any wind of force four (moderate breeze) or stronger.

The author previously noted that although coots tend to fly as a last resort, flights of up to a few hundred feet to safety were common on windy days. Therefore, extra care was taken when counts were conducted under windy conditions. But despite increased care, additional scrutiny of census results appeared to uncover a relationship between wind velocity and Shoreline's count accuracy.

A list of all counts held when San Jose International Airport wind readings were above twelve miles per hour was compiled. Any count held when the author perceived the force of the air to be "breezy" or stronger was also included if its respective airport wind reading was at least eleven miles per hour. Therefore, two counts, 4 October and 13 November 1990, were added despite only recording eleven- and twelve-mile-per-hour readings, respectively, as a "windy" state of the air was noted at Shoreline. Two other counts, 28 March and 18 April 1991, were also added with twelve-mile-per-hour winds and "breezy" Shoreline airs. Finally, the 11 October 1990 count was deleted from the list despite a fifteen-mile-per-hour reading since only a "slight breeze" was noted during the Golf Links count.

Following, is a chronological list of the calculated differences noted between morning and evening wind-influenced counts:

1. 11.37 percent on 27 September 1990
2. 4.52 percent on 4 October 1990
3. 1.43 percent on 30 October 1990

4. 0.81 percent on 6 November 1990
5. 6.72 percent on 13 November 1990
6. 0.78 percent on 18 December 1990
7. 3.18 percent on 20 December 1990
8. 1.74 percent on 14 March 1991
9. 5.08 percent on 28 March 1991
10. 4.08 percent on 4 April 1991
11. 5.93 percent on 11 April 1991
12. 3.01 percent on 18 April 1991

Two days above, 6 November and 11 April, experienced windy conditions on both their morning and evening counts, while the other ten listed dates recorded excessive winds only during their evening counts.

It should be immediately apparent that four of the six days from the prior list in "Counting Differences" can be found in the wind-influenced list including the former list's last three dates (13 November, 28 March, 11 April) with previously "unexplainable" differences.

Upon comparing the mean average of all the differences from the twelve wind-influenced morning and evening counts above with the remaining thirty-three non-windy count differences (table 8), one finds the counting difference during a typical wind-influenced counting day is more than twice that of a non-windy day. Not only that, the median average of the counting differences on windy days is almost four times that of

TABLE 8
EFFECT OF WIND ON COUNTING ACCURACY

		Mean Average Per- cent Difference between Morning Days and Evening Counts	Median Average Per- cent Difference between Morning and Evening Counts
Strong winds during count	12	4.05	3.63
No strong winds during count	33	1.95	0.95
All counts	45	2.51	1.43

non-windy days. Therefore, it would appear Shoreline's coot counts were less accurate on days with excessive winds than on relatively calm days.

It is possible strong winds may also cause an undercount, as during wind-influenced counts, the windier of the day's two counts recorded less coots nine of twelve times. Since wind-influenced counts were six times more likely to be evening counts, it should be no surprise that wind-influenced counting days resulted in evening undercounts twice as often as morning undercounts.

But is this evening undercount something unique to wind-influenced counts or is it found consistently throughout the study? It turns out non-wind-influenced counts experienced evening undercounts at about the same rate (63.6 percent) as wind-influenced counts (66.7 percent). Therefore,

some factor(s) other than wind velocity must be consistently affecting Shoreline count numbers.

What Caused Shoreline's Evening Undercounts?

Fewer total coots were counted in the evenings than in the mornings during almost 90 percent (fourteen of sixteen) of the study's group and subgroup migrational phase and overall numbers. All told, 879 fewer mud hens were spotted in the evening during Shoreline's coot census. Aside from counting error, it is possible these "missing" mud hens died, migrated, roosted, or were scattered by strong winds between the times morning and evening counts were conducted.

Died. The author was the first person on the Golf Course and one of the last to leave it on counting days. Hence, the author would have noticed if large numbers of coots were dying within the census area. But the author can only remember spotting a dead coot in the Park on a few occasions. Therefore, it is unlikely many over-wintering coots died at Shoreline between morning and evening counts.

Migrated. Coots begin their migration around sunset. Even though over half of Shoreline's forty-five evening counts were completed after sunset, the author never witnessed any coots emigrating from the Park. It is unlikely this event would have gone unnoticed as it takes a great deal of

time to initiate and is quite conspicuous (see "Life Cycle" section in "Coot Ecology").

Roosted. Shoreline's morning counts averaged about a three-minute post-sunrise start, but only one of its forty-five counts began over ten minutes before sunrise. This is long after coots normally become active in the morning (see "Behavior" section in "Coot Ecology").

Although the average Shoreline evening count finished a few seconds before sunset, the five latest-finishing (non-wind-influenced) counts averaged a twenty-nine minute post-sunset finish. Kiel and Hawkins (1953, 319) noted "most coots go to roost shortly after sunset." Even so, an evening undercount of only 2.34 percent was recorded during these five late-finishing counts.

It is possible roosting did not have a more noticeable effect on counting accuracy because most of the Park's over-wintering coots spend the night in the middle of one of the Course's ponds. It is not known if this is because resident birds control many of the Park's few concealed roosting sites or because the migrant mud hens simply prefer to roost together on the water.

Wind. As noted in the previous "Wind-influenced Counts" subsection, strong winds appeared to negatively impact counting accuracy, and excessive winds were six times more likely to occur during evening

counts. But when the morning and evening numbers from dates with strong winds were compared, these days produced an average evening undercount of only 1.88 percent.

Conclusion. No one variable by itself appeared responsible for most of Shoreline's overall evening undercount, although roosting, especially very early or very late in the migratory season (when a lower proportion of the Park's coots might be required to roost in the open), combined with excessive winds, may have a detrimental effect on counting accuracy. Other factors such as mortality and migration, as well as recreational and maintenance activities, may also contribute slightly to the Park's evening undercount since all these factors tend to increase either bird activity and/or counting error. Regardless, the 879-bird difference between Shoreline's forty-five dawn and dusk counts represents only a 0.79 percent evening undercount, which is not significant.

Subgroup Population Dynamics

Each of Shoreline's three over-wintering subgroups had its own slightly different coot population dynamics. By using the census data in table 7, these dynamics will be explored in hopes of gleaning new behavioral insights about the Park's coots.

Immigration phase. If one disregards the 9 October 1990 count (in which counting error likely played a significant role), it is interesting to note which areas of the Park initially proved most attractive to Shoreline's early immigrants. Pond No. 4 began the month of October with approximately 40 percent of the Park's mud hens, while the Pond No. 2-Pond No. 3-Shoreline Lake subgroup (hereafter known as the "Lake area" or "Lake subgroup") started at around 60 percent.

But new arrivals found the Lake area even more appealing, and its population grew steadily until it contained two-thirds of all the Park's coots on 25 October. The Lake area maintained a two-thirds share of Shoreline's mud hens until the end of the Park's immigration period when its coot total peaked at 2,262.

By the end of October, Pond No. 4's proportion of the Course's coots gradually declined to about 30 percent and stayed near that level throughout the remainder of Shoreline's mud hen immigration phase.

Tiny Pond No. 1, the farthest water area from the Bay and its Shoreline neighbors, appeared to be more attractive to the coots as the Park's other water areas became more crowded. Assuming the two coots spotted 27 September 1990 at Pond No. 1 were residents,² this water area did not see its first migrants until around 1 October. Judging by the rate of

²The author found Pond No. 1 had a breeding resident pair in 1991.

immigration into the Golf Course, and from previous Charleston Slough records (Bousman 1995b), Shoreline's other water areas probably were first occupied by migrants sometime between 20 August and 21 September.

Pond No. 1's population continued to lag behind during the entire month of October, reaching 10 percent, and then 25 percent, of its 1990-91 peak numbers at least three weeks after Shoreline's other subgroup areas.

But despite its slow start, isolated Pond No. 1's proportion of the Park's coots increased steadily from less than 1 percent during the author's initial count, to nearly 4 percent at the end of the immigration phase.

Intermigration phase. Shoreline's overall intermigration period was estimated to be from 18 December 1990 to 21 February 1991. When this migrational phase was over, the Park's two largest subgroups had almost the same proportion of coots as they did when the period started. Pond No. 4 dropped from 32 to 31 percent while the Lake area retained its 64 percent portion of the Park's mud hens. Tiny Pond No. 1's share increased from 4 to 5 percent of Shoreline's coots.

A closer look at the Park's coot census figures revealed this relatively stable period actually varied in duration depending on the overwintering subgroup.

The Lake subgroup had an intermigration period identical to that of the census area as a whole, while Ponds No. 1 and No. 4's intermigration phases started about mid-January and ended around 7 March.

The dynamics within each over-wintering subgroup varied too. As noted in the previous subsection, the Lake area began its intermigration phase with its peak number of birds. Pond No. 4 also started its intermigration period with its most mud hens, having attracted 1,221 coots on 15 January. Pond No. 1 continued to lure coots until 7 March, the last day of its intermigration phase, when its numbers peaked at 150.

It is interesting to note Pond No. 1's apex occurred twelve weeks after the Lake area's high number mark and more than seven weeks after Pond No. 4 hit its zenith.

Emigration phase. Late February saw the beginning of a seven-week decline in the Lake subgroup's share of coots. The Lake area, which was the most appealing initially, the first to peak, and the first to experience a mid-winter stable period, now would be the first subgroup area to lose its mud hens to emigration. From 21 February through 28 March, the Lake subgroup lost 615 coots while the rest of the Park only lost 18 mud hens.

By mid-April, the Lake area's share of mud hens dipped below 50 percent for the first and only time during the entire 1990-91 census.³ The Lake subgroup now possessed only 35 percent of its peak number of coots compared to 56 percent for Pond No. 4 and 71 percent for Pond No. 1. It would appear the Lake area's early appeal had predisposed this fifty-acre magnet to its early desertion.

The Lake subgroup's migration slowed during the last three weeks of the study until its proportion of mud hens once again reached 60 percent.

Compared to the Lake area, Pond No. 4's coots initially left the Park at a much slower rate, as its share of mud hens peaked at 43 percent on 11 April. But between 11 April and 2 May, Pond No. 4 lost 86 percent of its remaining coots to drop its share of mud hens to 29 percent.

Pond No. 1 contained 95 percent of its peak number of coots as late as 21 March, although these 142 birds comprised only about 5 percent of all the Park's mud hens. No. 1's share of coots reached its zenith on the author's last regular count at just over 10 percent.

By 2 May, only a few hundred migrants remained at Shoreline. Both the Lake area and Pond No. 4 now had less than 10 percent of their peak numbers while Pond No. 1 still supported 23 percent of its high number of coots.

³The Lake subgroup contained 49.97 percent of the census area's coots on 11 April.

Conclusion. First arriving birds preferred to over-winter near the Park's fifty-acre lake. Not surprisingly, the Lake subgroup's mud hens consistently emigrated in large numbers about a month before Shoreline's other water areas. Pond No. 1, which was the last subgroup to attract migrants, was also the last to lose them.

Comparative Migrational Dynamics

So how do Shoreline's coot migrational dynamics compare to that of other research?

A study conducted on transient coots in Colorado found "fall migration occurred over a more widespread period, with less dramatic changes in numbers and with less consistency in timing" than spring migration (Gorenzel, Ryder, and Braun 1981, 118). Although similar migrational dynamics were noted among Shoreline's mud hens, the degree of resemblance to the Colorado study varied depending on the Park's overwintering subgroup.

Like Colorado, Pond No. 4 and Pond No. 1 experienced longer fall than spring migrations. The two Shoreline water areas had 116- (21 September 1990-15 January 1991) and 101-day (1 October 1990-10 January 1991) immigration and only 60- (7 March-5 May 1991) and 65-day (7 March-10 May 1991) emigration periods, respectively. In contrast, the Park's lake subgroup and Shoreline as a whole had nearly equal

84- (20 September-13 December 1990) and 83-day (21 September-13 December 1990) immigration and 77- (21 February-9 May 1991) and 75-day (21 February-7 May 1991) emigration phases, respectively.⁴

The graph of the results of Shoreline's overall coot census (fig. 5) appeared to maintain a fairly uniform rate of increase in relation to the superimposed normal curve, deviating no more than five days on either side of the curve throughout its eleven-week period of ascension.

Again, similar to the Colorado study, the Park's coot numbers displayed more dramatic change in the spring. By 7 March, Shoreline's emigration curve was already six days behind its corresponding normal curve. By 14 March, the Park was about ten days behind the curve. Shoreline's emigration then fell to an average twelve days "behind schedule" from 21 March to 28 March.

The period from 28 March to 4 April marked the most dramatic change of the entire census, as a typical sixteen days worth of emigration

⁴Coot numbers increased from the previous count's numbers during the entire immigration phase and decreased from the previous count's numbers during the emigration phase except for the 6 December 1990 and 11 April 1991 counts on Pond No. 1, and the 29 November and 6 December 1990 counts on Pond No. 4. The immigrational starting dates for Shoreline and its subgroup water areas were based on the rates of daily coot increase between their respective first two 1990 counts while the emigrational ending dates for the Park and its subgroup areas were based on the rates of daily coot decrease between their respective last two regular 1991 counts. All eight migrational calculations assumed the Course's 16 July 1991 coots remained at the Park throughout the year except for Pond No. 1, which was assumed to have just two resident coots.

took place within seven days. After 4 April, Shoreline maintained an uneventful final month of emigration.

The Colorado study used coots with similar wintering behavior at four separate sites from two consecutive migratory seasons when it determined the timing of its fall migration was less consistent than its spring migration (Gorenzel, Ryder, and Braun 1981, 118). Unfortunately, it would be impossible to draw any conclusions about the timing of Shoreline's migrational dynamics since the author's census represented only one site during one migratory season and no other comprehensive count of local over-wintering coots was available for comparison.

Eddleman, Knopf, and Patterson (1985, 241, 244) investigated coot migration chronology on several large Oklahoma reservoirs. Their three-year study was of "virtually all" transient coots, as no mud hens bred, and only a small number wintered in the research area.

Table 9 below compares Shoreline's 1990-91 coot migrational dynamics with Colorado (Gorenzel, Ryder, and Braun 1981, 118) and Oklahoma's (Eddleman, Knopf, and Patterson 1985, 241) earlier findings.

Two things are worth noting: (1) the length of each site's migrational seasons and (2) the timing of the same migrational events at each site.

TABLE 9
COOT MIGRATIONAL TIMETABLE COMPARISONS

Migrational Event	State of Colorado	Stillwater, Oklahoma	Mountain View, California
Fall migration began	Late July	Mid-Sept.	1 Sept.
Migration peaked	Late Sept.	Mid-Oct.	Early Nov.
A few migrants seen after	November	1 Nov.	1 Dec.
Some late migrants appeared	November	Mid-Dec.	Mid-Jan.
Spring migration began	Early March	Late Feb.	Mid-Feb.
Migration peaked	Mid-April	Mid-April	Early April
Last migrants seen	Mid-May	Mid-May	1 June

Note: Since the author's census was conducted from 27 September through 2 May, beginning and ending migrational dates for Mountain View were derived from Bousman's (1995b) Charleston Slough records.

While coot migration at all three sites was more protracted in the fall than in the spring, Shoreline's migrational seasons were slightly longer than those of Colorado and Oklahoma.

The same migrational events began a month or two apart at the three sites in the fall. In the spring, continental migration seemed to be fairly well synchronized as the same events occurred only a week or two apart at the different sites.

Of course, Shoreline (37.4° north) is in a different flyway and has milder winter weather, even though it is located on approximately the same degree of latitude as the Colorado (average, 39.0° north) and north-central Oklahoma (average, 36.3° north) studies (Carpenter 1966, 108, 118-19).

Over-wintering Habitat Preferences

Now that the coot's local territorial habits and migratory dynamics have been investigated, is it possible to explain why the Park's immigrants distributed themselves around Shoreline where they did, in the numbers they did?

Earlier research by Allen (1985, 5) found over-wintering coots preferred habitat "with abundant submergent vegetation, and sparse emergent vegetation adjacent to expansive, deep, open-water areas." In order to see if Allen's habitat model applied to Shoreline, the condition of

the Park's water, vegetation, and cover at its saltwater lake and freshwater ponds was examined.

Water. The water within Shoreline's manmade impoundments is checked often and is all of high quality (Trulio 1995a). Although coots may be better suited for freshwater environments (see "Pond Salting" section in "Habitat Alterations"), the Lake's mud hens are able to obtain ample drinking water from Ponds No. 2 and No. 3 as well as from puddles left by irrigation and rain adjacent to the Lake. Therefore, potable water is not a problem for any of the Park's coots.

Vegetation. Plant food is extremely important to the coot, making up virtually its entire winter diet (see "Community Ecology" section in "Coot Ecology"). But the Lake's lack of tidal action keeps its vegetation at a low level (Trulio 1991b). Some shoreline cattails and pampas grass grow, respectively, in and around the Park's ponds. These same plants will not grow at Shoreline Lake due to its salinity (McMillan 1991).

Since all of the Park's aquatic impoundments tend to drop off rather quickly (Trulio 1995a) to at least ten feet in depth (Bakanoff 1995b, Trulio 1995a), emergents other than cattails are virtually nonexistent. Small amounts of algae are present in all of Shoreline's water areas, although to a lesser extent in its lake.

Based on a previous study, Gullion (1950, 164) felt Bay Area coots accomplished most of their aquatic feeding at a maximum depth of "four to eight feet." Therefore, a great deal of Shoreline's limited submergent vegetation might be too much work for the coots to retrieve, especially with a ready supply of grass nearby.

Cultivated grass was easily accessible along about half of the shore of all four Shoreline ponds and about 40 percent of its lake. Non-turfed areas adjacent to the water were usually disked or paved and thus provided little in the way of an alternative food source.

Therefore, the area in and around the Park's lake and ponds did not offer much easily obtainable vegetation other than cultivated grass.

Cover. Since over-wintering coots typically huddle together for protection in open water (see "Behavior" section in "Coot Ecology"), deep, open-water areas are necessary for the bird's cover requirements.

The water level on the Park's ponds is fairly constant, dropping only about a foot in the summer (Bakanoff 1991). When necessary, either fresh or tertiary water is added to Shoreline's ponds to keep them full (Trulio 1995a).

A pumping system continually exchanges Shoreline Lake's water with that of the Bay (Shoreline At Mountain View 1987, 6) while maintaining the Lake at a constant level (Trulio 1995a).

As noted previously, the Park's water areas are all fairly deep and free of most emergent vegetation. Along with the fact water levels are maintained year-round, adequate escape cover is available on all of the Park's water areas.

So while Shoreline's water areas meet Allen's latter two habitat requirements above, they do not possess ample submergent vegetation for the hordes of mud hens that travel to the Park each winter. Therefore, the Park's most important over-wintering territory would appear to be located near its cultivated grass. Gullion (1989) concurred, stating coots are attracted to Shoreline because its turf and water areas are so close together, which is rare in the Bay Area.

Coot Density

Although Shoreline's water areas share nearly identical over-wintering habitat characteristics, calculating the coot density around each might help one determine which, if any, are favored, and why.

Table 10 compares Shoreline Golf Links's peak number of coots per acre of water surface area to those calculated for the Course's individual water areas as well as its Lake subgroup area (Shoreline Lake-Pond No. 2-Pond No. 3). Since many of the coots in Shoreline Lake traveled freely between Ponds No. 2 and No. 3, the peak numbers used for these three

TABLE 10
PEAK 1990-91 SHORELINE OVER-WINTERING COOT DENSITIES

Water Area	Acres (Approx.)	Peak Pop.	Peak Pop. Date	Coots per Acre
Pond No. 3	1	149	.....	149
Pond No. 4	8 $\frac{1}{2}$	1,221	15 Jan.	147
Pond No. 2	3 $\frac{2}{3}$	458	.....	125
Entire Golf Course	66	3,556	15 Jan.	54
Pond No. 1	3	150	7 Mar.	50
Lake subgroup	54 $\frac{2}{3}$	2,262	13 Dec.	41
Shoreline Lake	50	1,655	.....	33

aquatic impoundments represented a percentage of this subgroup's peak number of 2,262 mud hens.⁵

At first glance, Shoreline's coot preference (by density) seemed to be fairly obvious. Mud hens appeared to choose the freshwater ponds closest to the Bay (and Lake) about 4 times as often as saline Shoreline Lake. In addition, the most isolated and last-inhabited water area, Pond No. 1, attracted only about 1½ times more mud hens than the Lake. Therefore, one might conclude Shoreline's over-wintering coots preferred freshwater habitat closest to the Bay.

An alternative explanation for the distribution of the Park's coots could be pond/lake shape. Pond No. 1, as well as the "A" section of Pond No. 4 (fig. 4), each supported about 50 coots per acre. Both water areas are somewhat circular with open-water areas about two hundred feet across. In contrast, narrow ponds like No. 3 and the remaining portion of No. 4 contained about 150 or more coots per acre.⁶

⁵The coots counted at these three water areas during all ninety individual counts were summed to determine the proportion of birds that wintered at each area. These proportions were then multiplied by the subgroup's 2,261.5 peak number of mud hens counted during the 13 December 1990 averaged count to arrive at each area's peak population. The most mud hens actually recorded on and around these three aquatic impoundments were: 2,090 at Shoreline Lake the evening of 8 January 1991; 906 at Pond No. 2 the morning of 8 January, and 389 at Pond No. 3 the morning of 4 December 1990.

⁶Pond No. 4A is approximately 3 acres and supported about 150 mud hens while Ponds No. 4B, 4C, and 4D combined comprise about 5½

Finally, Shoreline Lake has more of a rounded shape, measuring roughly one-third mile long and one-quarter mile wide. It supported only about thirty-three coots per acre.

Conclusion. Unlike Allen's model (where over-wintering coots thrived on aquatic plants), the Golf Course's migratory mud hens seemed to obtain nearly all their food by grazing on cultivated grass. Therefore, a narrow open-water area that was still wide enough to provide sufficient aquatic escape cover appeared to be preferred by the Park's mud hens over a circular open-water area of approximately the same surface area since it provided greater grass access. However, further research is needed to determine which Shoreline factor exerts the greatest influence on coot habitat choice: distance from the Bay, salinity, water area shape, or its amount of emergent vegetation.

acres and sustained about 1,070 coots (see "Do Shoreline's Migratory Coots Keep Wintering Territories?" subsection previously in this chapter). Also, a smaller proportion of the coots in Pond No. 4's eastern portion wintered in its "B" section since this part was generally too narrow to provide sufficient aquatic escape cover.

Carrying Capacity

Since Shoreline's 1990-91 coot immigration virtually stopped about 13 December, does this mean the Course had reached its carrying capacity? If so, do the densities noted above represent the carrying capacity of Shoreline's individual water areas? Probably not, to both questions.

Fredrickson et al. (1977, 126) noted wintering coot numbers peak in December and that is what Shoreline's coot numbers did. The Park also experienced its heaviest immigration from October through mid-November when nearly two-thirds of its migrants reached Shoreline (table 7). These numerous arrivals follow the main southern movements of mud hens from their Canadian breeding grounds by about two to four weeks, which is about how long one would expect the birds to complete their one thousand- to twelve hundred-mile journeys (see "Life Cycle" section in "Coot Ecology").

But is it possible southern migration may have stopped in December about the same time the Park reached its capacity?

According to wildlife managers, if Shoreline was at capacity, its individual coots would be generally lighter, in poor nutritional condition, and afflicted more often with parasites and diseases than coots found in a habitat below its carrying capacity (Shaw 1985, 34). Although none of the Course's mud hens were examined or weighed, virtually all the Park's coots appeared to be in good health. Not only that, space, food, and water are not a problem at Shoreline. The Course's wintering mud hens are quite

comfortable in their large flocks (see "Behavior" section in "Coot Ecology"), and a bountiful supply of grass and fresh water is available at the Golf Course year-round.

Is there any way of determining the Park's coot carrying capacity even though its mud hens appear healthy?

An area's carrying capacity can be defined in different ways. For example, population ecologists have determined this capacity to be an "upper limit beyond which no further population increase can be sustained by the habitat." Yet habitat conditions are hardly ever static. Natural and manmade influences can change a particular habitat at any time. Therefore, the average number of animals supported "over a period of years" might be a better measure of a given area's carrying capacity (Shaw 1985, 34).

Although the 1990-91 census was the first comprehensive coot count conducted on or around the Golf Course, Shoreline personnel felt mud hen numbers were unexplainably down somewhat from previous years. Likewise, local Audubon Society members have, on occasion, discovered puzzling differences in their annual duck count numbers. Some Audubon members speculated these population fluctuations might have been caused by variations in breeding ground productivity (see "Population Dynamics" section in "Coot Ecology").

Since waterfowl generally "winter where their ancestors did" and "home to where they learned to fly" (Heusmann 1987, 20), and coots apparently return "to the exact area that they had occupied the preceding winter" (Yocum, Rogiatto, and Eshelman 1978, 302), could low breeding ground productivity be responsible for Shoreline's supposed 1990-91 migratory coot decline?

California's duck and coot numbers, as well as South Bay coot figures, all dropped approximately 28 percent from those recorded about ten years prior to Shoreline's coot census. These simultaneous declines were thought to be caused by a protracted drought on waterfowl breeding grounds in Canada (see "Population Dynamics" section in "Coot Ecology"). Therefore, during more productive coot breeding seasons in the past, the Golf Course probably supported more mud hens than it did in the 1990-91 migratory season.

But current management practices usually concentrate waterfowl on habitat islands, increasing the likelihood and severity of infectious diseases (Shaw 1985, 233-34). An example of this was seen in March 1990 when the Park's coots suffered a die off from fowl cholera (see "Disease and Parasitism" section in "Population Reduction").

Coots normally do all their feeding while in the water. A closer examination of the Park's grazing coots likely would have shown the birds to have malformations on their soles and toes as well as swollen joints.

These afflictions are not found in aquatic-feeding mud hens (see "Community Ecology" section in "Coot Ecology").

Conclusion. Based on state and local population estimates, as well as those of long-time Shoreline staff, the Golf Course is probably capable of sustaining more over-wintering coots than it did during the 1990-91 migratory season. On the other hand, wildlife managers would argue irregularities affecting grazing coots, as well as a recent outbreak of fowl cholera, show the Course (as it is currently designed) will probably always attract more migratory mud hens than it can properly support.

Management Implications of Coot Census Analysis

Unquestionably the most important fact uncovered during Shoreline's coot census analysis from a management perspective was that over-wintering mud hens maintained general territorial areas during the day. If the coots had moved freely in and out of the study area, the number of mud hens recorded during different counts conducted on the same day most likely would have fluctuated erratically to reflect this movement. This fluctuation would have made evaluation of harassment activities via pre- and post-test counts extremely difficult, if not impossible. The fact that the Park's over-wintering coots maintain three major subgroup territories even makes evaluation of localized harassment programs possible.

Since an average of forty coots per night migrate into the Park during the fall migration, any mud hens frightened from, blocked access to, or removed from Shoreline, would soon be replaced by new arrivals. So, even if a coot management program was developed that rid the Golf Course of all its coots, the program would need to be repeated about once every ten days throughout the autumn, every autumn, and in all the Park's water areas, to maintain a coot population of under four hundred.

Census figures suggested Shoreline's over-wintering coots chose water areas based on their relationship to the Park's turf. Hence, the mud hens may prefer oblong-shaped water areas over circular ones. Therefore, altering the design of, and/or the vegetation around, Shoreline's water areas (so they were less desirable as coot over-wintering areas), might be a more permanent coot management technique.

Census results also found that a coot management program involving habitat alterations or repellents would need to be in place for about seven months (October through April) in order to keep Golf Course depredation at a manageable level.⁷

⁷Any management technique relying on a scare device that did not permanently evict the coots it was targeted at would also need to be in place from October through April.

Miscellaneous Coot Notes

Several coot behavioral characteristics were observed that are worth noting.

Unusual Feeding

On 27 December 1990, the air temperature at the start of the morning count was 32° F. Normally, around sunrise, Shoreline's mud hens could be found on shore, feeding on the Golf Course's turf. But on this day, Pond No. 4's coots chose to graze from the water. The mud hens formed one long line at the Pond's edge and nibbled the frosty turf like cows feeding at a trough.

On 14 March 1991, the author witnessed coots in the City Park adjoining northeastern Shoreline Lake jumping up to browse from weeping willow (*Salix babylonica*) branches. Gullion (1950, 165) had previously attributed the coots' taste for willows to a food shortage at Oakland's Lake Temescal. But there was plenty of grass available for Shoreline's willow-eating mud hens. Therefore, the birds must have been consuming the willows for some other reason.

Probably the most humorous trait witnessed was that of "tummy" grazing. Occasionally, some birds in a group of grazing coots would actually eat grass while lying flat on their stomachs. Initially, it looked as if injured

coots used this method of eating out of necessity. But upon closer observation, it appeared healthy coots sometimes ate from this position too.

Spring Rains

By the 21 March 1991 count, several weeks of rain had produced numerous young shoots in previously barren lands near the Park's water areas. The coots took advantage of this nutritious vegetation by heavily grazing in these new areas.

Falsely Accused

Shoreline officials generally believe the coot's constant grazing can cause turf damage, which in one case was allegedly responsible for the reseeded of two to three acres of Golf Course grass (Lyles 1988a). Van Way (1986, 292) supports Shoreline's contention, stating the birds are capable of "pulling up sprouting vegetation."

But it is possible the mud hen may not actually be denuding large areas of the Golf Course. As early as 1886 it was reported that the coot actually "bites off only the young shoot instead of pulling up the grain" while grazing (Jones 1940, 49).

On 11 December 1990, approximately three months after the arrival of Shoreline's first mud hen migrants, and with nearly thirty-four hundred coots now in the Park, the author noted areas of the Course where coots frequently grazed had not developed any bare spots. This was probably

because the mud hens appeared to clip the grass as they ate their way across the landscape.

These observations were confirmed by a Shoreline maintenance worker, who noted that areas which were heavily grazed did not require mowing (Dawson 1990).

Therefore, the coots may not be responsible for as much economic damage to the Golf Course as was previously thought and the Course's turf loss may be caused by other factors.

But even if the mud hens are not responsible for most of Shoreline's turf loss, the large quantities of droppings on coot-frequented greens are a major golfing problem.

Herding Reactions

Immediately after a group of grazing mud hens was chased into the water, the birds tended to do a lot of diving, although it did not appear they were feeding. It was possible they were displaying their annoyance at being disturbed, as there was also a great deal of squawking heard during this time. A few coots also used this opportunity to chase other coots in the water.

Other Interesting Behavior

The coot is notorious for the pugnacious defense of its aquatic territory (which does not include nearby grazing areas). The mud hen is

also well-known for its gregarious wintering behavior (see "Behavior" section in "Coot Ecology"). But the author occasionally witnessed single coots chasing nearby grazing mud hens, although these brief pugnacious displays never escalated into fighting. This action was similar to that described in the previous subsection when coots on nestless and undefended Shoreline Lake sometimes chased other coots. It is unclear why the gregarious wintering coot sometimes chases its peers in these two situations or if only particular mud hens engage in this behavior.

General Activity Level

Shoreline's coots generally appeared to be more energetic during afternoon counts than during morning counts. This may have been due to the near freezing temperatures often recorded around sunrise (table 6). The author also noticed the mud hens seemed more apt to fly when hazed and were more pugnacious when it was windy. The coots also appeared to fly more in the afternoons.

No Accessible Aquatic Food

Gullion (1950, 163) noted territorial birds only left the water to feed when their normal feeding areas were inaccessible. On 16 July 1991, the author spotted three chicks among the Lake subgroup's forty-three grazing coots. Obviously, the chicks's territorial parents must have been among the grazers.

Shoreline Lake and City Park Abandoned

During the 16 July 1991 resident counts, not one coot was found in the west and northwest areas of Shoreline Lake where just a small amount of dried vegetation dotted the shore. Not only that, no mud hens were on or near the Lake's east or northeastern areas despite the irrigated turf in the City Park.

It is possible the heavy summer recreational activity on the saltwater Lake, and the lack of fresh water in the City Park, discouraged the coots from venturing far from the Golf Course since there was now little competition for the Course's freshwater habitat.

Summer Population Composition

Approximately six coot breeding pairs and seven chicks (from three or four "successful" broods) were counted among the Park's seventy-three mud hens on 16 July 1991. It was possible some or all of the remaining fifty-four coots might have been from first broods, with the aforementioned seven chicks from second broods or renesters.

CHAPTER XII

SHORELINE TESTS

After reviewing the literature and expert opinions, several management techniques appeared to be possible solutions to Shoreline's coot depredation problem. Qualitative observations were conducted on seven of these promising methods:

1. Arm-waving
2. Dogs
3. Falconry
4. Fencing: Non-electric
5. Outboard Motorboat
6. Radio-controlled Model Airplane
7. Riprap

This chapter gives an account of all these methods tested at Shoreline. The following chapter analyzes these observations.

Arm-waving

By 4 October 1990, coot numbers had grown to the point where it was often difficult to census Shoreline's grazing flocks of mud hens (see "Shoreline Coot Census" chapter). It had now become necessary to find a

way to herd the depredating coots into the water where counting them was a much simpler task. Arm-waving was found to be an effective way to direct grazing mud hens toward the water.

However, this scare technique did not keep the coots waterborne long. After a short time in the water, the hazed coots massed together, eventually forming an elongated circular cluster parallel to the shore. The mud hens then swam a short distance downshore before reappearing on the Course to resume their grazing.

While the Golf Course's mud hens always responded to this hazing technique, coots in the City Park on the northern side of Shoreline Lake sometimes ignored arm-waving (fig. 4). On 29 November 1990, despite repeated attempts to herd about sixty City Park coots into the Lake, most would not budge.

Dogs

One day during the 1990-91 Shoreline coot census, the author observed a lone, free-ranging dog busily engaged in chasing coots from the Golf Course into Shoreline Lake.

But as the pooch patrolled down the approximately five-hundred-yard, coot-infested shoreline adjacent to the Course's turf (fig. 4), the mud hens simply retreated to the safety of the water. The birds soon reappeared onshore in a procession once the dog had passed.

On 16 October 1990, the author used three large, prey-driven, free-ranging dogs with owners (recruited by Shoreline At Mountain View staff), to move all of the approximately six hundred mud hens along the aforementioned, five-hundred-yard stretch of turf into Shoreline Lake. The dogs then denied the waterborne coots turf access as an outboard motorboat chased the birds for an hour on the water (see "Outboard Motorboat" section in this chapter).

Although the harassing motorboat was unable to persuade any mud hens to leave Shoreline Park, the dogs, spaced evenly along the shore, succeeded in keeping the birds in the Lake during the entire experiment.

Falconry

On 7 December 1989, a falconer was invited to Shoreline Golf Links to see what effect his bird would have on Shoreline's grazing coots. A prairie falcon, which had been trained to attack mud hens, was used for the experiment.

The falcon was initially uninterested in the group of around eighty grazing coots it spotted near Shoreline Lake. After flying around for several minutes, the falcon finally swooped over the mud hens.

The coots did not respond to the raptor's first few passes. Once danger was perceived, the alarmed coots headed for safety in the nearby Lake and dove when the falcon tried to attack.

But the coots stayed in the water, even after one was hit on the head by the flying raptor. The experiment was halted after about twenty minutes to avoid harming any coots.

Immediately after the falcon attacks stopped, the mud hens left the Lake and resumed grazing as if nothing had happened.

Fencing: Non-electric

As stated previously in the chapter on "Barriers," many wildlife professionals supported the use of barrier fencing. California golf courses in Pacific Grove and Spanish Bay had also experienced success using this simple technique. Therefore, it was worth a try at Shoreline.

A low, chicken-wire fence was erected along the east side of three-acre Pond No. 1 around 1 December 1990. This two-foot high fence, along with existing cattails and pampas grass, made a formidable one-hundred-yard barrier between the Pond and the turf. A similar fence was also erected between southeastern Shoreline Lake and the Golf Course (fig. 4).

Initially, the fence at Pond No. 1 appeared to work, as coots avoided the more sensitive turfed areas. But within a few weeks, mud hens easily walked around the fence to eat and defecate in the sensitive areas again. When danger approached, the birds simply flew over the fence and into the safety of the Pond. A chicken-wire fence had been tried previously in this area with the same results (Bakanoff 1988).

The fence next to Shoreline Lake did little to discourage the fifteen hundred coots that frequented the area. Most gained access to the turf by walking from other unprotected areas. Without a vegetative barrier to complement the chicken wire, frightened grazers simply ran straight into the fence until their large numbers overwhelmed it. This enabled them to run under or over the fence. Some stragglers kept running straight into the chicken wire until they reached the end of the fence and then ran around it. Others stopped fleeing once the danger passed and resumed grazing.

Initially, there was concern coots might be hurt from their collisions with the chicken-wire fence. But no more injured mud hens than usual were observed.

Within a few weeks, startled grazers near the Lake all flew over the fence and into the water to escape. Coots from the Lake soon flew over both a three-foot-high retaining wall and the fence to reach the Golf Course turf. This confirmed what both Lyles (1988c) and Lara (1989a) had predicted.

A few weeks after the fence experiment ended, grazing coots were observed walking around and flying over the fifteen-foot-high mesh fence that protects Pond No. 3 from the driving range. Here they dined despite the occasional golf ball that fell in their vicinity. This barrier-net fence was similar to the one proposed by Van Way (see "Fencing: Non-electric" in "Barriers").

Outboard Motorboat

Shoreline's coots were harassed for several days beginning 16 October 1990 by an outboard motorboat in the water and dogs on shore. A coot count was taken on 18 October to determine if there was a significant decrease in Shoreline's coots from pre-harassment numbers. If a significant decrease existed, harassment activities would continue. If post-harassment figures found no significant change in Shoreline's coot population, the combined boat and dog harassment program would be terminated.

On 16 October, about six hundred coots on Shoreline Lake were harassed for one hour beginning at 7:30 A.M., just fourteen minutes after sunrise. Three large dogs, spaced along the shore, chased any lakeside coots into the water and then kept the birds in the Lake while a ten-foot outboard motorboat (with a nine-and-a-half-horsepower Johnson® engine) relentlessly pursued them. Not only were the coots harassed on two fronts, they endured bombardment of two senses, as the boat's whining gasoline engine and the barking dogs were visual and auditory affronts.

On 17 October, the same procedure was repeated, although the day's harassment ended after about fifty minutes when the motorboat experienced mechanical difficulties.

On both days, the coots often waited until the last possible moment to escape the onrushing motorboat. Even then, they simply avoided the

boat by flying a short distance to another part of the fifty-acre lake. Here they resumed what they were doing before they had been interrupted.

Radio-Controlled Model Airplane

Shoreline Maintenance Supervisor Mike Bakanoff, a skilled radio-controlled model airplane operator, harassed a group of about four hundred coots on a fairway next to the southern end of Shoreline Lake. A noisy, black, gas-powered, 2½-horsepower plane was used. The streamerless plane had been used to successfully scare off sea gulls (Bakanoff 1991).

The experiment was conducted during the windless sunrise of 3 November 1989. The early morning time was chosen so as not to conflict with any Shoreline recreation activities.

The coots did not respond after a few plane passes about five feet above where they were grazing. Bakanoff crashed his plane near the coots while attempting to make an even closer flight over the birds. The mud hen group began to run away from the crash, but soon stopped and began grazing again.

Bakanoff then waved his arms in frustration and the coots responded by moving to another grazing area.

Riprap

A five-foot tall, riprap barrier was designed into the Golf Course on the northeastern end of Pond No. 2B (fig. 4), most likely to support the edge of the Golf Course which was considerably higher than the Pond. This area would make an ideal place to observe the riprap to see if it protected the turf from mud hens in the Pond.

On 4 December 1990, the author viewed the riprap barrier from a distance with binoculars so as not to disturb any coots near the rock retaining wall. Soon several waterborne coots were witnessed climbing and flying over the riprap. Once above the wall, the mud hens dined on the Golf Course green.

CHAPTER XIII

SHORELINE TEST ANALYSIS

This chapter assesses the effectiveness of each method preliminarily tested at Shoreline.

Arm-waving

Arm-waving was used as a harassment tool during nearly all of the author's ninety-four 1990-91 Shoreline coot counts. Although this technique was normally quite effective at scaring grazing coots into the water, it was only of temporary value.

Not once during the entire Shoreline census were any coots observed abandoning the Park after being hazed by arm-waving. Reduction in depredation following an arm-waving display was limited to the time it took herded coots to reappear downshore, which was a few minutes at best.

Gullion (1950, 46, 47) and Weddle (1994) noted that individual migratory coots could be found in the same general area during their entire over-wintering period. The author also noticed this to be the case at Shoreline during the 1990-91 coot count (see "Shoreline Coot Census" chapter) despite almost ritual arm-waving exhibitions performed during the entire census. Therefore, it is unlikely that many coots were ever

persuaded to permanently shift their depredating inside Shoreline by arm-waving events.

This technique offers only very temporary relief from coot depredation as the previously herded coots or other nearby mud hens move into the depredated area as soon as the arm-waver leaves. Therefore, constant arm-waving would be needed to keep the birds from grazing on Shoreline's turf.

Dogs

Although no turf measurements were taken before or after Shoreline's dog experiments, it was obvious that one dog was able to temporarily halt coot grazing, while multiple dogs totally stopped coot grazing when they patrolled the Golf Course turf adjacent to Shoreline Lake. In fact, in the 16 October 1990 experiment, it would appear the coots decided to take their chances with the motorboat in the water rather than return to the land where the three dogs waited.

If Shoreline decided to utilize trained dogs to harass its coots, it would be imperative that supervised dogs be used for these reasons:

1. An unsupervised dog would chase coots, mallards, snowy egrets (*Leucophoyx thula*), in short, whatever bird it saw. A handler would train the dog to chase on command, sending it only after coots while calling it off any other birds.

2. An unsupervised dog might catch a sick or injured bird. A handler would instruct the dog not to seize these animals.
3. An unsupervised dog would be all over the Golf Course. It would soon become fatigued or lose interest in chasing birds. Hence, it would not be long before it was resting in the shade, chasing other wild animals, visiting golfers, disrupting play, and adding to the coots' turf destruction with its digging and fecal deposits. A handler would keep the pooch on the task at hand, while making sure coot-chasing events did not interfere with golfing activities. The handler would also collect and properly dispose of all dog fecal deposits.
4. An unsupervised dog might react unpredictably around people it perceived as unfriendly. A handler would call the bird dog off before it could possibly injure any hostile individuals (Levens 1995).

Dogs would be required at four different locations within Shoreline in order to eliminate most coot depredation on its golf course (see "Volunteers" section in "Scare Devices").

Since the goal of Shoreline's harassment program is to keep the number of coots around its golf course below four hundred (Lyles 1988c), canine harassment would be needed from 1 October to 1 May each migratory season, as coot numbers stay above four hundred during this seven-month stretch (see "Shoreline Coot Census" chapter).

Since coots are diurnally active (Gullion 1950, 160), dogs would be required from morning twilight until evening twilight. Therefore, each harassment station would need to be filled by a dog and handler for about 2,538 hours per season (see "Volunteers" section in "Scare Devices").

Although a handler would be able to motivate a trained dog to work the entire seven-month period, the animal would require a few days off per week. A trained dog would also tire after three to four hours of fairly continuous action without a break period (Levens 1995). For these reasons, a rotating fifth station (table 11), as well as seven dogs, would be needed for this project.

It should be noted the execution of this plan would probably increase coot depredation to the City Park along northeastern Shoreline Lake (fig. 4) unless this area was also patrolled.

The cost of hiring a trained dog with handler (see "Dogs" section in "Scare Devices") for 2,538 hours would be between \$28,463.82 and \$35,579.78 per season.¹ A seven-month, seven-dog program would run from \$199,246.75 to \$249,058.44 annually, depending on the hourly rate each handler charged. Obviously, the Golf Course could not afford nearly \$250,000.00 to run an annual harassment program.

¹These figures have been adjusted to include the daily rotating position which requires about 30 percent less time than the other four stations.

TABLE 11
PROJECTED WORK SCHEDULE FOR 1 OCTOBER

Station	Dog	Shift 1	Shift 2	Shift 3	Shift 4	Shift 5
One	A	06:30-09:00	09:30-11:30	12:00-14:00	14:30-16:30	17:00-19:30
Two	B	06:30-09:30	10:00-12:00	12:30-14:30	15:00-17:00	17:30-19:30
Three	C	06:30-10:00	10:30-12:30	13:00-15:00	15:30-17:30	18:00-19:30
Four	D	06:30-10:30	11:00-13:00	13:30-15:30	16:00-19:30	.....
Rotating	E	09:00-11:00	11:30-13:30	14:00-16:00	16:30-18:00	.....

However, if Shoreline owned seven dogs and hired someone to train them (at a cost of approximately \$21,000.00 once every eight years), it would still need to pay seven people at least the \$4.25 per hour minimum wage (Zaldivar 1995, 1[F]) to handle the dogs. Even then, this program would annually cost around \$70,566.56 (see footnote 1, p. 298), not including training fees and dog maintenance.

It would appear a dog-based, coot harassment program would be economically impractical at Shoreline due to the immense size of its depredated area unless the number of dogs and the area to be patrolled could be reduced. Even then, the program might only be "affordable" if dog-owning individuals volunteered their services (see "Volunteers" section in "Scare Devices").

But if the over-wintering, waterborne coots exhausted their natural aquatic food supply, they might vacate the area if the trained dogs were fairly successful at denying coot access to Shoreline's turf, and the mud hens were unable to sufficiently feed at other nearby areas. In that case, the desired results could be realized much faster and cheaper than projected above.

Unfortunately, no incidents of dogs forcing coots to abandon an area were found in the literature, although there have been successful evictions of geese and gulls by dogs.

Regardless, new mud hens arrive nightly at Shoreline from late-September through mid-January during their annual four-month immigration (see "Shoreline Coot Census" chapter). Thousands of emigrating mud hens from areas south of Mountain View also probably temporarily stop off at Shoreline as late as May. Thus the services of trained dogs might be required during the entire migratory season even if the animals were successful at evicting some hungry mud hens from the area.

Falconry

Although the experiment ended after only around twenty minutes, it is very doubtful the outcome would have been any different had it continued. Once in the water, the coots seemed relatively unconcerned by the prairie falcon's presence.

This lackadaisical behavior supports Grubb's previous findings on over-wintering coots. In a study on coot response to aerial objects, Grubb (1977, 1065-66) documented the mud hen's reactions to twenty-six separate overflights by bald eagles. Even though the coots responded by huddling together in the water during each overflight, and even though they were sometimes attacked by the eagles, there was no mention of any coots leaving their Florida wintering grounds.

Even if falcons were able to frighten off Shoreline's coots, Hodge (1990c) predicted the raptors probably would be needed about three times per week for an indefinite period. Even then, Hodge was skeptical the raptors could cure Shoreline's mud hen troubles.

Many bird-eating raptors including the golden eagle, northern harrier, red-tailed hawk, and the aforementioned prairie falcon, can be found at Shoreline sometime during the year (see "Natural Predators" section in "Population Reduction"). But the presence of these potential predators has never caused the mud hens to vacate their Golf Course feeding grounds, as the coots have been a nuisance at Shoreline since the facility opened (Lyles 1988c).

One potential problem with using trained raptors against Shoreline's coots is that the visiting raptors might become the targets of resident birds of the same species, aggressively defending their Shoreline territories. Regardless, it would appear reduction in coot depredation using falconry is limited to the time when the raptor is engaged in its anti-coot activity. Coot numbers remain unaffected, unless the prey bird happens to take a coot during its aerial assault.

Since Shoreline's attempt to evict some of its over-wintering coots with falconry was not promising, and since no literature was found to support its use as a coot deterrent, falconry as a coot harassment tool is not recommended.

Fencing: Non-electric

Although no actual physical measurements were made on the turf before or after the installation of the low fences adjacent to Pond No. 1 and Shoreline Lake, it is unlikely either area realized a reduction in depredation as coots at both locations generally ignored the fences.

But was it possible the low fencing may have motivated some birds to move to new feeding areas, thereby reducing the number of mud hens left to depredate turf near the fences?

Pond No. 1 is about six hundred feet from the nearest water area at Shoreline. At no time during the seven-month coot census (see "Shoreline Coot Census" chapter) were any mud hens spotted shuffling back and forth between Pond No. 1 and any other water areas. In fact, Pond No. 1's coots appeared to be a separate subgroup within the overall Shoreline Golf Course population.

"Unfenced" Pond No. 4's mud hens also comprised a separate Shoreline subgroup, and therefore, will be used as a "control" population below.

If the low fencing caused some coots to vacate Pond No. 1 (all other variables being equal), the Pond's population, during the time the fence was in place, should reflect this exodus when compared to: (1) its pre-fence numbers or (2) Pond No. 4's coot numbers.

First, no fluctuation in Pond No. 1's population was noted before, during, or after the experimental period. Except for an insignificant one coot decline on 6 December 1990, Pond No. 1's coots increased from the author's first count until Shoreline numbers peaked on 15 January 1991.

Second, no negative population trend was evident when Pond No. 1's coots were compared to Pond No. 4's mud hens. From 29 November 1990 (the last census conducted prior to fence erection) until 20 December 1990 (when most coots had solved the fencing problem), coot numbers on Ponds No. 1 and No. 4 rose an identical 21 percent.

Therefore, it appears unlikely any mud hens vacated Pond No. 1 because of its low fence barrier. But if they did, any birds that departed must have been quickly replaced by new migrants.

Unlike Pond No. 1, the fenced area of Shoreline Lake did not represent an isolated population, so no comparative census figures are available for Shoreline Lake.

Likewise, no comparative population data are available for the area around Pond No. 3 and the driving range. Regardless, it should be safe to conclude that fencing, used by itself, was not successful as a coot management tool at the aforementioned three Shoreline locations.

But why did fencing work at other California golf courses and not at Shoreline? Spanish Bay's water area is a one-third acre, freshwater marsh,

inhabited by about ten mud hens (Fenzke 1994), while Pacific Grove attracts less than one hundred wintering coots to its course (Leech 1994).

Gullion (1950, 163, 167) noted as long as aquatic food is available, coots will not go ashore to feed. It is possible Pacific Grove's and Spanish Bay's coots were never hungry enough to wander onto adjacent land to graze and therefore never tested the barriers.

Shoreline has over two thousand coots along Shoreline Lake from late November to late February, a saline lake with very little vegetation (Trulio 1991).

Three-acre Pond No. 1 has over one hundred mud hen inhabitants from late November to early April. Although coots have been known to dive up to twenty-five feet (Jones 1940, 9), it is unlikely they do much feeding at depths of more than four to eight feet (Gullion 1950, 164), putting most of deep, freshwater Pond No. 1's vegetation out of their reach.

Up to four hundred wintering coots can be found in and around deep, freshwater Pond No. 3. But Pond No. 3 is only an acre in size, much smaller than less-crowded Pond No. 1.

It appears Shoreline's coots were motivated enough by hunger to overcome their various fence barriers. Since all of Shoreline's coots winter in overcrowded conditions, it would appear fencing, unassisted by any other management tools, would be a very temporary coot deterrent.

Outboard Motorboat

A coot census was taken at Shoreline on 18 October 1990 to determine what effect, if any, the previous two days' harassment activities had on the Golf Course's coots.

Results of the 18 October count found a 29 percent increase in coot numbers, from 911 to 1174, since the final pre-harassment count on 11 October 1990. In fact, the harassment had not even made Shoreline less attractive to newly arriving mud hens, as the author recorded an average daily increase of 38 coots since the 11 October count. This daily increase was only slightly (3 percent) less than the 39-bird per day increase recorded between 9 October and 11 October (table 7). This small decrease in the rate of Shoreline's coot increase could have been the result of many different factors independent of the harassment program (e.g., migratory patterns, mortality, weather conditions, counting error, etc.).

The mud hens in the vicinity of Shoreline Lake were found to be a separate subgroup within the overall Golf Course coot population. Mud hens wintering around Pond No. 1 and those found near Pond No. 4 comprised two more Golf Course subgroup populations.

Since the coots in the Pond No. 2-Pond No. 3-Shoreline Lake subgroup were the only birds harassed by the motorboat, is it possible some tormented coots relocated to boat-free Ponds No. 1 or No. 4?

The 11 October count found 63 percent of all Shoreline coots were in or around the future harassment area. The first count following the complete cessation of hazing (18 October) noted mud hen numbers actually increased slightly around the testing site to 64 percent of the census area's coots (table 7). Therefore, there was also no shift of coots within Shoreline due to the boat-and-dog harassment.

Shoreline Lake was just too big for one boat to effectively cover. But even with more than one boat, it is unlikely the result would have been much different, as expansive Shoreline Park offers many sanctuaries for beleaguered coots. Not only that, it would be difficult to use additional motorboats in the Lake without adversely affecting non-target animals. A motorboat also would not be appropriate for use in the Golf Course's ponds.

The dogs appeared to be a much more effective coot management tool than the motorboat. While the dogs kept the mud hens from grazing, an unaided motorboat probably would have been useless as a coot scare device. The depredating mud hens would have undoubtedly gone ashore and ignored the circling boat if the dogs had not been present.

It is interesting to note that breeding coots seem to be one of "the last species to abandon attractive habitat as disturbance becomes excessive," having been observed in boat channels (Jahn and Hunt 1964, 56).

Not long after the experiment, the author watched as sailboarders on Shoreline Lake routinely passed through groups of mud hens with much the same result as the motorboat experienced. With the wind loudly rippling through their sails, the recreators only briefly disturbed the birds.

Radio-controlled Model Airplane

Although no turf measurements or precise coot counts were taken at Shoreline before or after the 3 November 1989 preliminary test, it would appear no reduction in coot depredation or coot numbers could be expected from a model airplane harassment program as the mud hens completely ignored the attacking plane. In fact, the voracious coots were more frightened by the "arm-waver" than they were by the crashing plane, although both events only interrupted their grazing for a short time (see "Arm-waving" section in "Scare Devices").

A Florida study discovered coots were able to distinguish the difference between various raptors and a small airplane. The overflight of bald eagles stimulated a coot alarm response 100 percent of the time while an airplane failed to elicit a response from the birds. Prior eagle attacks on the coots were believed responsible for their differing responses (Grubb 1977, 1066).

Therefore, the coots are not likely to be frightened by a radio-controlled model airplane overflight unless the birds can associate a negative consequence with the attacking plane.

Riprap

When aquatic food is in short supply, coots routinely wander ashore to graze on whatever greenery strikes their fancy (Gullion 1950, 164). Although coots have been reported to meander up to a mile inland (Jones 1940, 49), the author has never observed Shoreline's coots more than two hundred feet from a water area.

Although the riprap-protected green is adjacent to the northeastern end of Pond No. 2 (Pond No. 2B), it is also coot-accessible from the northwestern extension of the Pond (Pond No. 2A) about 190 feet away (fig. 4). Mud hens in Pond No. 2A often scale the Pond's steep western and eastern banks to feed. Some of these climbing coots occasionally graze on the elevated green. The green is also visible to coots on Shoreline Lake 120 feet to the north.

It is possible coots originally gained access to the elevated green in other ways than by traveling over the riprap barrier. If so, the barrier may have initially discouraged coot access.

Regardless, Shoreline's over-wintering mud hens have an insufficient aquatic food supply (see "Fencing: Non-electric" section earlier

in this chapter). Therefore, a riprap barrier alone offers temporary protection at best from grazing and defecating coots.

CHAPTER XIV

SUMMARY OF EVALUATIONS AND TESTS

Forty-five different coot management techniques were evaluated in chapters V through IX for use at Shoreline. Qualitative observations were described and analyzed for seven of these methods in the previous two chapters.

During this investigation, a technique could not:

1. Have an adverse effect on golfing business
2. Have an adverse effect on Shoreline Lake recreation
3. Have an adverse effect on other wildlife
4. Have an adverse environmental impact
5. Be aesthetically unacceptable
6. Disrupt maintenance practices
7. Be illegal
8. Attract more coots
9. Be of only temporary benefit
10. Shift the coot problem inside Shoreline
11. Be impractical on a large facility like Shoreline
12. Be too costly

13. Be too labor-intensive for results received
14. Be unacceptable to the Humane Society of Santa Clara Valley, Shoreline Golf Links, or the City of Mountain View
15. Be unacceptable to the public

If a proposed technique did not satisfy all fifteen of the above constraints, it was eliminated during the evaluation and testing process. But even though "Sacrifice Area," "Lights," "Night Harassment," and "Radio-controlled Model Airplane" passed all fifteen Shoreline constraints, the four were rejected because they did not work against coots (table 12).

No one of the forty-five techniques can be recommended to deter the Course's coots, although some showed promise when used in combination with other methods (see "Recommendations" chapter).

During this investigation, "Net Capture" as well as "Trapping" (both using translocation), "Radio-controlled Model Boats," and "Human Blockade" were found to be successful in actually evicting mud hens from their respective water areas. Unfortunately, nearly all of these forced departures were temporary. Only territorial coots (see "Territoriality" section in "Habitat Alterations") are capable of ousting other coots from the Park for any length of time, although these breeding mud hens are of little help during winter migratory season when Shoreline has its coot population problem.

TABLE 12

MANAGEMENT TECHNIQUES EVALUATED ACCORDING TO CONSTRAINTS

Technique	Evaluation	Constraint													
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14) (15)
Fencing: Non-electric*	D								x						
Human Blockade	C								x				x		
Net Exclusion	A			x		x					x			x	x
Riprap*	F								x						
Wires: Submerged or Suspended	I		x	x										x	x
Feeding Area*	F							x					x		
Pond Salting	I			x		x								x	
Sacrifice Area*	F														
Synthetic Grass	A											x			
Territoriality	F		x											x	x
Vegetative Enhancement	F		x					x						x	x
Vegetative Removal	F			x		x									
Water Removal	A		x	x										x	x
Anesthetics	D			x					x					x	x
Chemosterilants	F			x					x						
Disease and Parasitism	B			x					x					x	x
Natural Predators*	D			x							x				
Net Capture	D								x				x	x	x
Poisoning	D			x					x					x	x
Shotgun Capture*	B								x					x	x
Sport Hunting	C								x					x	x
Trapping	D								x			x		x	x

TABLE 12

MANAGEMENT TECHNIQUES EVALUATED ACCORDING TO CONSTRAINTS

Technique	Evaluation	Constraint												
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13) (14) (15)
Chemical*	I							x						
Visual	F	x				x				x		x		x
Arm-waving*	D									x		x		
Automatic Exploders	D	x	x	x						x			x	x
Balloons	D									x				
Beachball: Tethered	D	x	x	x		x				x		x		x
Dogs*	C									x				
Falconry*	C									x		x		
Fencing: Electric	D			x						x			x	x
Flagging*	D			x						x				
Horns	D									x				
Lights	F													
Night Harassment	F													
Outboard Motorboat*	F											x		
Pyrotechnics*	D									x				
Radio-controlled Model Airplane*	F													
Radio-controlled Model Boats	C	x	x							x		x	x	x
Recorded Alarm and Distress Calls	D									x		x		
Scarecrows*	D									x				
Shooting as a Scare Tactic*	D			x						x				
Ultrasonics	F									x				
Volunteers	D									x		x		

TABLE 12
MANAGEMENT TECHNIQUES EVALUATED ACCORDING TO CONSTRAINTS

Technique	Constraint														
	Evaluation	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14) (15)
Water Sprinklers	D	x		x						x					x

Notes: Each numbered column corresponds to the enumerated constraint of the same number appearing at the beginning of this chapter. An "X" in any of the fifteen columns removed a technique from consideration. Methods were evaluated as follows: Permanent elimination of coots from sensitive areas (A); Effective, but not permanent. Must be repeated periodically to maintain desired result (B); Temporary effect on coot depredation or significant (greater than approximately 5 percent) yet still small reduction in coot numbers (C); Very temporary effect on coot depredation or insignificant (less than approximately 5 percent) reduction in coot numbers (D); No noticeable effect on coot depredation or numbers (F); Unknown effect on coot depredation and numbers (I).

*Attempted at Shoreline.

Several techniques were able to temporarily halt coot grazing. "Arm-waving," "Falconry," "Natural Predators," and "Dogs" all compelled depredating mud hens to seek safety in the water as long as the stress-producing agent was present.

There are several potential successful but unacceptable approaches. "Net Exclusion" or "Water Removal" could each solve Shoreline's coot problem, although both techniques would also eliminate the Park's other waterfowl as well as its boaters and sailboarders. "Synthetic Turf" would obviously stop mud hen grazing where it was installed. However, the artificial grass is too expensive to place in all the Course's coot-frequented areas. "Shotgun Capture" can immediately reduce nuisance coot numbers to manageable levels. But surviving mud hens do not abandon the area. Instead, they choose to mill around in the air over their aquatic homes until all shooting has ended. Not only that, new migrants soon replace those that were killed.

Non-electric fencing seemed to be the most effective nonlethal technique attempted at Shoreline as it usually worked against the coots for a few days. Therefore, a non-electric fence, supported by dog-owning volunteers, might be used to guard the Links from unwanted mud hens during special golfing events. This technique should temporarily keep the coots off the Course's sensitive spots as long as they were still able to feed in unfenced areas.

Other Tests Which Would Be Useful

The following are a few management techniques that might help reduce Shoreline's coot problem.

Golf course vacuum. Cushman® recently developed a vacuum to collect material off golf course playing surfaces. It might be worth testing this new device to see if it is capable of removing both firm and runny coot droppings.

Since the surfaces most soiled by mud hens are greens within a few hundred feet of the Course's water areas, it should be possible to test the vacuum on the five greens in the coot's normal grazing area. Of course, this mechanical cleanup would need to be repeated periodically during the day to be effective.

If the Cushman® was successful in cleaning the Course's playing surfaces, it is possible the material collected (like guano, the avian-based manure) might be useful as a fertilizer. But if frequent vacuuming was necessary to keep the Links playable, and the material collected was of little value, this practice might be too labor-intensive for the benefit received as well as too disruptive to other maintenance needs.

New repellents. It is possible the Golf Course might some day find a safe chemical solution to its coot grazing problem, especially since a few substances have recently shown promise as bird repellents (Hodge 1990c).

In order to test the anti-coot potential of any currently unregistered substance, Shoreline would need to be designated an agricultural experimental station. Although it would cost five thousand dollars to test each new chemical (Cummings 1990), Hodge (1990c) offered to help fund part of the study expense. D-pulegone might be one such chemical Shoreline could test in the future.

Unappealing grass. Several different types of turf could be grown in test plots next to the Course's water areas to see if any grass species was avoided by the coot. It is hoped a specific variety can be found that: (1) meets golf course grass requirements and (2) is unappealing to the coot.

Actual coot damage. A study to assess the actual damage to turf caused by coots should be conducted. Perhaps mud hens are less of a problem than suspected. But even if the birds are found to be less destructive than previously thought, Lyles (1988c) feels the coots' droppings have been negatively impacting golfing business for some time. Benz (1995) agrees, adding the droppings are not only a nuisance, they also stain shoes and pant cuffs. Therefore, if a study is undertaken, it should include an investigation into the possible negative effect coots have on golfing business.

Integrated approach. A preliminary test should be conducted on the author's recommended "Integrated Coot Management" plan before a

definitive decision is made on its implementation (see "Recommendations" chapter).

Importance of different variables in site selection by over-wintering coots. Allen (1985, 5) noted over-wintering coots preferred expansive, open-water sites. A study could be undertaken to determine how the shape of a golf course pond, as well as its salinity, proximity to the Bay, and amount of emergent vegetation, effected its attractiveness to over-wintering coots. Results of this study would be especially valuable to Shoreline if, in an attempt to solve its coot depredation problem, it was considering incorporating water areas into a remodeled Course (see "Recommendations" chapter).

CHAPTER XV

RECOMMENDATIONS

Required Duration of Management

The literature and experts agree that only a very small amount of the Pacific Flyway's natural wetlands have survived the last few centuries of human activity. Due to this shortage of over-wintering habitat, coots are often forced to spend their southern migratory season crowded onto human-maintained water areas.

Shoreline is home to migratory mud hens for about nine months (2 September-2 June) of the year, with unmanageable numbers (more than four hundred birds) present for about seven months (1 October-1 May) of this time. Therefore, a coot management program using scare devices (that temporarily removed targeted coots), repellents, or habitat alterations would generally need to be in place during this entire seven-month period.

Shoreline's coot numbers steadily increase from September through mid-December before leveling off at around thirty-five hundred. This means management programs based on scare devices (that permanently removed targeted coots), barriers, or population reduction techniques would generally

need to be in place during this entire period if the Course was to be kept relatively free of migratory mud hens.

Since Shoreline has only a limited amount of breeding habitat, all but about 2 percent of these thirty-five hundred birds depart the Park for their northern nests in the spring. Therefore, no management action is required versus the Course's summer coots since less than one hundred of the birds reside year-round at Shoreline.

Coot Ecology Affects Management Options

The over-wintering coot has several characteristics that influence its management. The most important of these are as follows:

1. It returns to the same water area every migratory season, yet if necessary, is quick to take advantage of new habitat.
2. It usually selects a large open-water area with copious amounts of submergent vegetation or nearby forage.
3. It is very site tenacious.
4. It maintains a general winter territory.
5. It is diurnally active.
6. It feeds in, or within sight of, its home water area.
7. It consumes virtually an all-vegetarian diet.
8. It is gregarious and comfortable in large flocks of several hundred.
9. It flies as a last resort.

Therefore, as long as the Course maintains water areas next to its turf and requires a nonlethal coot solution, Shoreline will need to figure out the best way to peacefully coexist with its depredating mud hens.

Seldom are wildlife conflicts solved using only one management technique (Marley 1987, 16). In Shoreline's case, two different plans are proposed, each utilizing several different methods to achieve their desired goals.

Recommendation No. 1: Integrated Coot Management

Since over-wintering coots seldom wander more than two hundred feet from the Park's water areas, and fly only as a last resort, the Course's mud hens could be made to graze in less sensitive areas through a combination of management techniques.

The shaded areas in figure 6 represent the extent of the coot's present grazing range at Shoreline. The five completely shaded "islands" near the Course's ponds are the greens depredated by the Park's mud hens. Shoreline's greens are the most "coot-sensitive" part of its course. The three bridges dividing Pond No. 4 into its four sections are shown as "breaks" in the water area. Since no turf exists west of Pond No. 1, north or east of Pond No. 2A, and south of Pond No. 4B, these areas are relatively untouched by mud hens.

Coots seldom feed on the turf one hundred feet to either side of Pond No. 4's northernmost bridge just north of the Pond. This is because the pampas grass along Pond No. 4's north shore is so thick for three hundred feet to either side of the bridge, coot access is virtually eliminated.

Since a vegetative screen appears to reduce coot depredation so dramatically, could one be grown between all the Course's grass and water areas?

Since Shoreline's aquatic vegetation is not adequate to sustain its thousands of over-wintering mud hens, it would not be long before the hungry birds flew over any shoreline barrier to feed. Therefore, only the Course's most sensitive areas would be protected. By allowing the coots easy access to fairways and non-play areas, the mud hens would have no need to graze behind any protective barriers.

The following different management techniques would need to be integrated to achieve this goal.

Vegetative Enhancement

Shoreline's non-aquatic vegetation would be enhanced by growing vegetative barriers and forage crops.

Vegetative barriers. Barriers would be grown along the shore between the Golf Course's water areas and its depredated greens. These

barriers would consist of pampas grass, next to the Course's freshwater ponds, and *Photinia fraseri*, above saline Shoreline Lake.

New pampas grass would be planted next to approximately three thousand feet of Ponds No. 1, 2, and 4 that were slated for protection. Along with existing pampas grass, this would create about four thousand feet of shoreline barriers. An additional two hundred feet of the vegetative barriers would be required on the east side of Pond No. 3 to fill in with the Pond's current one hundred feet of pampas grass if Course officials chose to protect the tenth tee. Banks not slated to be protected with pampas grass should be thinned of their existing vegetative barriers, thus insuring easy access to fairways and non-play areas from all points on the water while maintaining the Course's natural look. This could be done by transplanting pampas grass from along proposed "non-protected" banks into openings in areas scheduled for vegetative barriers (Rose 1995).

It should be noted that pampas grass is an invasive, non-native species. Its use as a barrier at Shoreline is "recommended" only because the pampas grass is already established, and therefore, a barrier utilizing the plant could be in place immediately after a transplanting program was completed. It is strongly recommended that Shoreline choose a native or non-invasive, non-native species similar to pampas grass as a vegetative barrier for its ponds.

Around one thousand feet of *Photinia fraseri* would be planted along the southern tip of Shoreline Lake. This would put a solid wall of *P. fraseri* at least three hundred feet to the north on either side of the Course's tenth and eleventh greens. It would cost fifty-six hundred dollars to create this vegetative wall out of two hundred *Photinia fraseri*.

Forage crops. The ground immediately south of Pond No. 4B would be planted with perennial ryegrass. This 2¾-acre area could be seeded for \$1,008. This would give No. 4B's coots a grazing alternative to the green to its north. The bank above the west side of Pond No. 2A would be similarly seeded for \$672 to improve its forage value and help keep the Lake area's coots satisfied. But if depredation near Pond No. 2 continued, a small area on the Lake's southwestern shore (where coots currently forage) could also be seeded. Although ryegrass requires no special care, it would need watering between rains (Rose 1995). The grass should also be mowed at least once per week to maintain its nutrient value (Gullion 1989).

Fencing: Non-electric

Once the vegetative blocks were in place, chicken wire would be used to cover any holes in the barriers until they completely filled in. Shoreline's maintenance department could utilize the chicken wire left from its non-electric fencing experiment for this job.

Sacrifice Area

The non-play area west and south of Pond No. 4A will continue to be sacrificed as will the fairways south of Ponds No. 1 and No. 2B, southeast of the Lake, and east of Pond No. 4.

Volunteers and Dogs

Volunteers could be recruited from local scout groups to help organize and implement the Course's plan. After planting and fencing were complete, dog-owning volunteers would be recruited to patrol the previously depredated areas, checking the condition of its barriers and turf, as well as monitoring and controlling coot movements. Retired people with dogs could be contacted through local seniors groups to assist with the patrol effort. Once all vegetation matured, and all sensitive areas were adequately protected, the dog-owning volunteers could probably be discontinued.

Synthetic Grass

The tenth and possibly the eleventh greens, located near the southern tip of Shoreline Lake, might be more difficult to conceal and protect from hungry coots. Therefore, Shoreline may want to consider installing artificial grass on one or both of these greens if it can serve as a synthetic turf showplace. A showplace designation would substantially reduce the cost of the artificial turf.

Figure 7 shows the results of this integrated management approach. Although the number of coots wintering at Shoreline would remain the same, the five greens near the Course's ponds should now be free of coot depredation.

The author recommends that Pond No. 1, because of its small size and isolation from the Course's other water areas, serve as a preliminary test of the integrated management plan. The vacant area immediately west of Pond No. 1 could also be used to test the coot palatability of perennial ryegrass.

Pros and Cons

Listed below are some of the advantages and disadvantages of Recommendation No. 1.

Advantages. An integrated management plan at Shoreline has several positive points. These include the fact this proposal:

1. Can be tested in advance, thus allowing the opportunity to evaluate and, if necessary, adjust the plan before it is implemented
2. Is inexpensive, involving only a one-time cost of about seventy-five hundred dollars for grass and *P. fraseri* plants
3. Keeps down construction costs by using volunteers as well as many existing plant and materials

Fig. 7. Projected Area of Coot Grazing after Completion of Proposed Integrated Management Program. Solid lines next to the Park's water areas are the suggested sites of vegetative barriers, while shading represents the projected location of grazing coots once the integrated program is in place. Drawing by author.

4. Rearranges the Course's pampas grass around its ponds, thus producing immediate results
5. Involves little risk since the amount of physical change to the Course and the cost of the plan are both small
6. Offers an excellent service opportunity for the area's scouts
7. Through their involvement, gives community volunteers a chance to see and appreciate the Park's coot problems first hand
8. Minimally effects golfing activity during its implementation since only minor changes are required
9. Minimally effects Shoreline's other wildlife
10. Should not require volunteers or dogs once all vegetation is in place and any flaws in the system are corrected
11. Should require less time to maintain than was needed previously to clean and repair coot-depredated areas of the Course
12. Should benefit golfing business since coots should no longer be depredating the Course's greens

Disadvantages. This proposal also has several drawbacks:

1. Pampas grass and *P. fraseri* are non-native plants.
2. Pampas grass is an invasive plant. Therefore, it should be used as a barrier only until a non-invasive species similar to pampas grass can be found to replace it.

3. A soil salinity test may find that no vegetative barriers can be grown next to Shoreline Lake.
4. *P. fraseri* will not form a solid wall until its second growing year.
5. Pond water levels would need to be maintained at a fairly constant level to avoid damaging the pampas grass.
6. Pampas grass has sharp edges.
7. Pampas grass needs to be topped in areas where it obstructs fairway views.
8. Coots may fly over vegetative barriers, especially next to Shoreline Lake.
9. Sensitive areas of the Course would probably be reinfested by coots if any of the following were not maintained: barrier integrity, free access to alternative grazing areas, or the alternative grazing areas themselves.
10. Since the *P. fraseri* requires little water, it cannot tolerate lawn irrigation.

If Recommendation No. 1 is rejected for any reason, Shoreline officials may decide to redesign the Links instead.

Recommendation No. 2: Remodel Shoreline Golf Links

The physical location and design of a golf course influence its susceptibility to depredation. Therefore, "locations away from obvious bird

concentrations should . . . be considered" (Salmon, Conte, and Gorenzel 1986, 92[E]). Gullion (1989) agrees, calling Shoreline's current design (which places much of its course next to water) an "ecological trap."

Shoreline might decide to redesign its golf course to be more like that of a true links. Since the original Scottish links contained no water areas, this remodeling would include drying up and filling in the Course's ponds.¹

Once Shoreline's ponds were removed, the vacant spots created could be made into new playing areas. This could be done by:

1. Relocating the driving range to the east onto the previous sites of Ponds No. 4A and 4B
2. Replacing Pond No. 3 and the old driving range with a new tenth hole
3. Making a new eleventh hole in the area left by the removal of Pond No. 2

These changes would leave at least a three-hundred-foot-wide turfed strip (about ten acres) adjacent to southeastern Shoreline Lake. The turfed strip would be slightly wider than the corresponding shaded area appearing in figure 6. This irrigated and weekly mowed turf, along with the grasses of the City Park, should satisfy the Lake's thousands of migratory mud hens, that would therefore have no reason to venture into the now pondless Golf

¹Eliminating Shoreline's ponds would also solve the drainage problems that have developed there (Koh 1994, 18[A]).

Course to feed. Weddle (1994) agrees, noting their Santa Barbara golf course had no coots during years when its lake was dry.

The cost to fill in the Course's ponds; install irrigation, grade, seed, and landscape the new tenth and eleventh holes; and grade a new driving range, would be between \$1.2 and \$1.3 million. This price includes architectural fees (Benz 1995).

If someone other than the Course's original architect, Robert Trent Jones, Jr., was hired to remodel Shoreline, it would be important that the new designer understood and respected "the philosophy and aims of his predecessor." In this way, the Course's principal theme would not be harmed. This would include appreciating the shot value of holes, influence of weather, purpose of features, and anything else that might "effect the playability of the course" (Cornish and Whitten 1981, 160).

The Park might decide to keep some water areas in its redesigned course. But it is not known which characteristic of the Park's water areas exerts greatest influence on the coot's winter habitat choice: distance from the Bay, salinity, water area shape, or its amount of emergent vegetation.

No site selection pattern emerges from similar California coot wintering sites. Shoreline's 130-acre, saltwater Charleston Slough often had over one thousand migrant mud hens (Bousman 1995b). Despite the fact California City, California's course is in the Mojave Desert, its water areas still attract unmanageable numbers of coots (Carlton 1994).

Shoreline's southeastern neighbor, Sunnyvale Municipal Golf Course, has only about fifty coots on its several freshwater lakes, although none of its water areas are more than an acre in size (Black 1994). Spanish Bay's course, which is next to the Pacific Ocean, had hundreds of mud hens before its one-half-acre, freshwater pond turned into a very reedy marsh. Now it has only about ten coots (Fenzke 1994). Therefore, a study should be conducted to better understand the influence of these different variables before Shoreline decides to place any water areas inside its redesigned course.

But regardless how Shoreline is redesigned, it should have no trouble making up for the loss of 10 acres of playing area next to the Lake. This is because at 187 acres, it is much larger than the typical golf course (Stein 1980, 567). However, it is not known if the Park's mud hens would travel farther inland (as Jones [1940, 49] reported) and depredate its course if Shoreline decided to denude this 300-foot-wide turfed strip, even if it were sloped down toward its Lake (to hide the remodeled playing surface). Although the winter coots in a pondless Shoreline would probably be mostly transients, it is not known if the turf on the Lake's north shore would be enough to satisfy all of its migrant mud hens.

Pros and Cons

Listed below are some advantages and disadvantages of Recommendation No. 2.

Advantages. Recommendation No. 2 has several positive points.

These include the fact this proposal:

1. Should eliminate the Golf Course's coots completely while Recommendation No. 1 only protects the Course's greens
2. Would eliminate Shoreline's ponds, thus solving the drainage problems that have developed there
3. Requires only two holes and the driving range be moved
4. Would benefit golfing business since coots would no longer be depredating the Course
5. Should eliminate virtually all coot-related maintenance practices

Disadvantages. This proposal also has several drawbacks.

1. Recommendation No. 2 would cost at least \$1,200,000 while Recommendation No. 1 should only be around \$7,500.
2. Draining the Course's ponds would displace other wildlife.
3. Golfing activities would be disrupted during remodeling.
4. Coot depredation might increase along the Lake's north shore.
5. A ten-acre patch of turf would need to be maintained along southern Shoreline Lake as a buffer against possible coot depredation.

Conclusion

"The effectiveness of control programs is directly proportional to the availability of alternative sources of food and range" (Marley 1987, 26).

Although many of the management techniques investigated worked initially, once the coots ran low on food and space, desperation drove them to solve whatever control method they faced. As long as Shoreline Golf Links has, or is next to water areas, it will have coots. By leaving the mud hens easy access to food and loafing sites, the birds should not be forced to travel away from their normal haunts (and into the Course's sensitive areas) if either of the recommended management programs is followed.

LIST OF REFERENCES

- Allen, A. W. 1985. Habitat suitability index models: American coot. Fort Collins, CO: U.S. Fish & Wildlife Service Biological Report. USFWS, 82 (10.115).
- Alves, W. R. 1992. All-Star Realty. Letter from Hesperia, CA, to author, San Jose, CA, 8 September.
- Arnstein, P. 1962. Infectious disease hazards to pest control operators. In Proceedings of the Vertebrate Pest Conference, Sacramento, CA, February 6-7, 1962, by the National Pest Control Assn., Elizabeth, NJ, 308-26.
- Avery, M. L., D. E. Daneke, D. G. Decker, P. W. Lefebvre, R. E. Matteson, and C. O. Nelms. 1988. Flight pen evaluation of eyespot balloons to protect citrus from bird depredations. In Proceedings of the thirteenth Vertebrate Pest Conference, edited by A. C. Crabb and R. E. Marsh, 277-80.
- Bakanoff, M. Shoreline At Mountain View, Mountain View, CA. 1988. Telephone interview by author, 14 November.
- _____. Shoreline At Mountain View, Mountain View, CA. 1989. Telephone interview by author, 31 August.
- _____. Shoreline At Mountain View, Mountain View, CA. 1991. Telephone interview by author, 27 March.
- _____. Shoreline At Mountain View, Mountain View, CA. 1994. Personal interview by author, Mountain View, CA, 27 September.
- _____. Shoreline At Mountain View, Mountain View, CA. 1995a. Telephone interview by author, 28 February.
- _____. Shoreline At Mountain View, Mountain View, CA. 1995b. Telephone interview by author, 1 June.

- Balgooyen, T. G. San Jose St. Univ., San Jose, CA. 1989. Telephone interview by author, 23 February.
- Bayer, R. D. 1980. Birds feeding on herring eggs at Yaquina Estuary. Condor 82(2): 193-98.
- Beam, J. 1989. California Dept. of Fish & Game, Los Banos, CA. Guest lecture presented to San Jose St. Univ. Zoology 151 class, Los Banos, CA, 24 February.
- Becota, D. San Jose Intl. Airport, San Jose, CA. 1993. Telephone interview by author, 7 September.
- Beebe, R. San Jose Water Pollution Control, San Jose, CA. 1989. Telephone interview by author, 25 January.
- Bell, E. San Jose St. Univ., San Jose, CA. 1991. Telephone interview by author, 9 April.
- Benson, M. 1993. Kesterson's human toll. San Jose Mercury News, 5 July, 1(A) & 16(A).
- Benz, B. Bradford Benz Golf Course Architects, Los Gatos, CA. 1994. Telephone interview by author, 18 October.
- _____. Bradford Benz Golf Course Architects, San Jose, CA. 1995. Telephone interview by author, 29 September.
- Bergen, J. F. 1986. Food robbery of wintering ring-necked ducks by American coots. Wilson Bulletin 98(2): 306-8.
- Black, C. Sunnyvale Municipal Golf Course, Sunnyvale, CA. 1994. Telephone interview by author, 28 September.
- Bontadelli, P. 1990. California hunting regulations: Part III (Waterfowl). Sacramento, CA: California Office of State Printing.
- Bousman, B. Santa Clara Valley Audubon Society, Palo Alto, CA. 1995a. Telephone interview by author, 11 February.
- _____. 1995b. Charleston Slough project. Palo Alto, CA. Santa Clara Valley Audubon Society. Photocopied.

- Bowers, M. Mountain View Solid Waste Dept., Mountain View, CA. 1989. Telephone interview by author, 6 February.
- Brown, V. 1973. Handbook of California birds. Healdsburg, CA: Naturegraph Publishers.
- Bruning, J. L., and B. L. Kintz. 1977. Computational handbook of statistics. 2d ed. Glenview, IL: Scott, Foresman & Co.
- Burger, J. 1973. Competition between American coots and Franklin's gulls for nest sites and egg predation by the coot. Wilson Bulletin 85(4): 449-51.
- Burton, J. H. 1959. Some population mechanics of the American coot. Journal of Wildlife Management 23(2): 203-10.
- Carlton, D. Moffett Field Golf Course, Moffett Field, CA. 1994. Telephone interview by author, 27 September.
- Carpenter, S., ed. 1966. Panoramic world atlas. Maplewood, NJ: Hammond.
- Chandik, T. Baylands Nature Interpretive Center, Palo Alto, CA. 1989. Telephone interview by author, 16 August.
- Collins, D. L. 1987. Shoreline Golf Links. Letter from Mountain View, CA, to M. Cassaretta, Redwood City, CA, 10 November.
- _____. 1988. Shoreline Golf Links. Letter from Mountain View, CA, to R. L. Jaeck, City of Mountain View, Mountain View, CA, 6 October.
- Connelly, D. California Dept. of Fish & Game, Sacramento, CA. 1991. Telephone interview by author, 11 April.
- Conover, M. 1985. Alleviating nuisance goose problems through methiocarb adverting conditions. Journal of Wildlife Management 49(3): 631-36.
- _____. Connecticut Agricultural Experimental Station, New Haven, CT. 1989. Telephone interview by author, 23 January.
- Conwed® plastic netting and bird damage control. n.d. Minneapolis, MN. Privately printed.

- Corbett, D. San Jose Water Pollution Control, San Jose, CA. 1991. Telephone interview by author, 11 April.
- Cornish, G. S., and R. E. Whitten. 1981. The Golf Course. New York: Rutledge Press.
- Crawford, R. D. 1980. Effects on age on reproduction in American coots. Journal of Wildlife Management 44(1): 183-89.
- Cummings, J. Denver Wildlife Research Center, Denver, CO. 1990. Telephone interview by author, 26 September.
- Dawson, K. Shoreline Golf Links, Mountain View, CA. 1990. Personal interview by author, Mountain View, CA, 11 December.
- Dias, P. Palo Alto Golf Course, Palo Alto, CA. 1989. Telephone interview by author, 3 January.
- _____. 1994. Palo Alto Golf Course, Palo Alto, CA. Personal communication to author, San Jose, CA, 27 September.
- Dicandio, J. Santa Clara Valley Audubon Society, Cupertino, CA. 1995. Telephone interview by author, 21 February.
- Don't feed geese. n.d. Annapolis, MD: U.S. Dept. of Agriculture.
- Dow, D. D. 1964. Diving times of wintering water birds. Auk 81(4): 556-58.
- Drennan, S. D., ed. 1985. The eighty-fifth Christmas bird count. American Birds 39(4): 383-826.
- Duke, R. Harvey & Associates, San Jose, CA. 1989. Telephone interview by author, 25 January.
- Dubria, D. San Mateo Golf Course, San Mateo, CA. 1991. Telephone interview by author, 11 April.
- Eddleman, W. R., F. L. Knopf, and C. T. Patterson. 1985. Chronology of migration by American coots in Oklahoma. Journal of Wildlife Management 49(1): 241-46.

- Eddleman, W. R., C. T. Patterson, and F. L. Knopf. 1985. Interspecific relationships between American coots and waterfowl during fall migration. Wilson Bulletin 97(4): 463-72.
- Eley, T. J., and S. W. Harris. 1976. Fall and winter foods of the American coot along the lower Colorado River. California Fish and Game. 62(3): 225-27.
- Erickson, R. A-G Sod Farms, Hollister, CA. 1993. Telephone interview by author, 30 August.
- Feeding frenzy. 1993. San Jose Mercury News, 12 June, 5[D].
- Fenzke, G. The Links at Spanish Bay, Spanish Bay, CA. 1994. Telephone interview by author, 27 September.
- Figeira, B. Woodbridge Village Assn., Irvine, CA. 1995. Telephone interview by author, 7 November.
- Fitzner, R. E., and R. G. Schrickhise. 1979. The American coot (*Fulica Americana*) on the Hanford site. Richland, WA: Dept. of Energy, Pacific Northwest Laboratory. NTIS, E 1.28: PNL-2462.
- Fredrickson, L. H., J. M. Anderson, F. M. Kozlik, and R. A. Ryder. 1977. American coot. In Management of migratory shore and upland game birds in North America, edited by G. C. Sanderson, 122-47. Washington, DC: International Assn. of Fish and Wildlife Agencies.
- Galkowski, J. J. 1989. Capturing California's wildlife on film. Outdoor California 50(1): 76-78.
- Garcia, R. Andy's Pet Shop, San Jose, CA. 1995. Telephone interview by author, 29 July.
- Gasser, T. 1991. Palo Alto, CA. Letter to author, San Jose, CA, 11 September.
- Gilhuly, L. W. U.S. Golf Assn., Santa Ana, CA. 1989. Telephone interview by author, 12 January.
- Glahn, J. F., J. R. Mason, and D. R. Woods. 1989. Dimethyl anthranilate as a bird repellent in livestock feed. Wildlife Society Bulletin 17(3): 313-20.

- Gorenzel, W. P. Univ. of California, Davis, CA. 1989. Telephone interview by author, 9 January.
- Gorenzel, W. P., R. A. Ryder, and C. E. Braun. 1981. American coot distribution and migration in Colorado. Wilson Bulletin 93(1): 115-18.
- _____. 1982. Reproduction and nest site characteristics of American coots at different altitudes in Colorado. Condor 84(1): 59-65.
- Graffia, R. Sheldon's Hobbies, San Jose, CA. 1993. Telephone interview by author, 17 August.
- _____. Sheldon's Hobbies, San Jose, CA. 1995. Telephone interview by author, 9 February.
- Griswold, J. G. 1986. Mountain View coots pulling out. Palo Alto (Calif.) Peninsula Times Tribune, 3 January, 1(A) & 10(A).
- Grubb, T. C. 1977. Discrimination of aerial predators by American coots in nature. Animal Behaviour 25(4): 1065-66.
- Gullion, G. W. 1950. The breeding behavior of the American coot (*Fulica americana*) in the San Francisco Bay Area, California. M. A. Thesis, Univ. of California, Berkeley, CA.
- _____. University of Minnesota, Cloquet, MN. 1989. Telephone interview by author, 6 January.
- Hardy, J. Moffett Field Golf Course, Moffett Field, CA. 1989. Telephone interview by author, 11 January.
- Heilbrun, L. H., ed. 1981. The eighty-first Audubon Christmas bird count. American Birds 35(4): 351-749.
- _____, ed. 1982. The eighty-second Audubon Christmas bird count. American Birds 36(4): 369-778.
- _____, ed. 1983. The eighty-third Audubon Christmas bird count. American Birds 37(4): 369-792.
- Heusmann, H. W. 1987. Living with Canada geese. Sanctuary (February/March): 20-21.

- Hill, W. L. 1988. The effect of food abundance on the reproductive patterns of coots. Condor 90(2): 324-31.
- Hobson, K. San Francisco Bay Bird Observatory, San Jose, CA. 1989. Telephone interview by author, 5 February.
- Hodge, G. R. Humane Society of the U.S., Washington, DC. 1989a. Telephone interview by author, 13 January.
- _____. Humane Society of the U.S., Washington, DC. 1989b. Telephone interview by author, 31 August.
- _____. Humane Society of the U.S., Washington, DC. 1989c. Telephone interview by author, 13 September.
- _____, ed. 1990a. The humane control of wildlife in cities and towns. Washington, DC: The Humane Society of the U.S.
- _____. Humane Society of the U.S., Washington, DC. 1990b. Telephone interview by author, 21 September.
- _____. Humane Society of the U.S., Washington, DC. 1990c. Personal interview by author, Mountain View, CA, 29 October.
- Hodges, A. 1987. Coots return to Shoreline Golf Course. Palo Alto (Calif.) Peninsula Times Tribune, 29 October, 3(A).
- Howard, R., and A. Moore. 1991. A complete checklist of the birds of the world. 2d ed. London: Academic Press.
- Ivey, G. L. 1987. Winter foods of American coots in the northern San Joaquin Valley, California. California Fish and Game 73(1): 45-48.
- Jacobs, T. City of San Jose, CA. 1994. Telephone interview by author, 1 September.
- Jahn, L. R., and R. A. Hunt. 1964. Duck and coot ecology and management in Wisconsin. Wisconsin State Conservation Dept. technical bulletin thirty-three. Madison, WI: Wisconsin Conservation Dept.
- Jenni, D. A. University of Montana, Missoula, MT. 1988. Telephone interview by author, 22 December.

- Jones, J. C. 1940. Food habits of the American coot with notes on distribution. Washington, DC: U.S. Govt. Printing Office.
- Katches, M. 1986. A rude welcome for coots. Palo Alto (Calif.) Peninsula Times Tribune, 24 October, 1(A) & 12(A).
- Keller, S. U.S. Indoor Golf, South San Francisco, CA. 1994. Telephone interview by author, 18 October.
- Kiel, W. H., and A. S. Hawkins. 1953. Status of the coot in the Mississippi Flyway. In Transactions of the eighteenth North American Wildlife Conference, edited by J. B. Trefethen, 311-21. Washington, DC: Wildlife Mgt. Institute.
- Koh, B. 1994. City blamed in links' demise. San Jose Mercury News, 28 December, 1(A) & 18(A).
- Knapton, R. W., and B. Knudsen. 1978. Food piracy by American wigeons on American coots. The Canadian Field-Naturalist 92(4): 403-4.
- Kutilek, M. J. 1989a. San Jose St. Univ., San Jose, CA. Zoology 151 lecture notes, 27 January.
- _____. 1989b. San Jose St. Univ., San Jose, CA. Zoology 151 lecture notes, 3 February.
- _____. 1989c. San Jose St. Univ., San Jose, CA. Zoology 151 lecture notes, 10 February.
- _____. 1989d. San Jose St. Univ., San Jose, CA. Zoology 151 lecture notes, 17 February.
- _____. 1989e. San Jose St. Univ., San Jose, CA. Zoology 151 lecture notes, 31 March.
- Lara, A. U.S. Fish & Wildlife Service, Oakdale, CA. 1989a. Telephone interview by author, 3 January.
- _____. U.S. Fish & Wildlife Service, Oakdale, CA. 1989b. Telephone interview by author, 31 August.
- _____. U.S. Fish & Wildlife Service, Oakdale, CA. 1991. Telephone interview by author, 4 April.

- Lazzerini, K. Dominic's Farm-Fresh Produce, Watsonville, CA. 1995. Telephone interview by author, 20 August.
- LeBaron, G. S., ed. 1987. The eighty-seventh Christmas bird count. American Birds 41(4): 519-1321.
- _____, ed. 1988. The eighty-eighth Christmas bird count. American Birds 42(4): 504-1198.
- _____, ed. 1989. The eighty-ninth Christmas bird count. American Birds 43(4): 551-1222.
- _____, ed. 1990. The ninetieth Christmas bird count. American Birds 44(4): 516-1046.
- _____, ed. 1991. The ninety-first Christmas bird count. American Birds 45(4): 523-1022.
- Leech, M. 1994. Pacific Grove Municipal Golf Course, Pacific Grove, CA. Personal communication to author, San Jose, CA, 27 September.
- Lester, P. San Jose St. Univ., San Jose, CA. 1995. Telephone interview by author, 13 April.
- Leukering, T., ed. 1986. The eighty-sixth Christmas bird count. American Birds 40(4): 589-1071.
- Levens, A. American Canine Institute & Kennel, Mountain View, CA. 1995. Telephone interview by author, 5 January.
- Loomis J., and C. Unkel. 1989. The economic contribution of wildlife viewers. Outdoor California 50(1): 84-85.
- Lyles, G. 1987a. Shoreline At Mountain View, Mountain View, CA. Letter to D. L. Collins, Shoreline Golf Links, Mountain View, CA, 28 October.
- _____. 1987b. Shoreline At Mountain View, Mountain View, CA. Letter to T. C. Gallagher, Sunnyvale, CA, 30 November.
- _____. Shoreline At Mountain View, Mountain View, CA. 1988a. Telephone interview by author, 10 October.

- _____. 1988b. Shoreline At Mountain View, Mountain View, CA. Interoffice memo to R. L. Jaeck, City of Mountain View, Mountain View, CA, 3 November.
- _____. Shoreline At Mountain View, Mountain View, CA. 1988c. Personal interview by author, Mountain View, CA, 8 November.
- _____. 1988d. Shoreline At Mountain View, Mountain View, CA. Letter to Dept. of Environmental Studies, San Jose St. Univ., San Jose, CA, 29 November.
- _____. Shoreline At Mountain View, Mountain View, CA. 1988e. Personal interview by author, Mountain View, CA, 20 December.
- _____. Shoreline At Mountain View, Mountain View, CA. 1989. Telephone interview by author, 28 April.
- _____. Shoreline At Mountain View, Mountain View, CA. 1990. Personal interview by author, Mountain View, CA, 15 November.
- Mallette, E. 1989. The fastest growing outdoor activity. Outdoor California 50(1): 73-75.
- Marley, J. 1987. Controlling wildlife on and around the course. Golf Course Management (April): 14-26.
- Mason, J. R. 1987. Ro-pel® efficacy: Evaluation of active ingredients under optimal conditions with red-winged blackbirds (*Agelaius phoeniceus*). Philadelphia, PA: By the author, 3500 Market St.
- _____. 1989. Avoidance of methiocarb-poisoned apples by red-winged blackbirds. Journal of Wildlife Management 53(3): 836-40.
- _____. 1990a. Evaluation of d-pulegone as an avian repellent. Journal of Wildlife Management 54(1): 130-35.
- _____. Monell Chemical Senses Center, Philadelphia, PA. 1990b. Telephone interview by author, 18 April.
- _____. Monell Chemical Senses Center, Philadelphia, PA. 1990c. Telephone interview by author, 21 September.

- Mason, J. R., M. A. Adams, and L. Clark. 1989. Anthranilate repellency to starlings: Chemical correlates and sensory perception. Journal of Wildlife Management 53(1): 55-64.
- Mason, J. R., J. F. Glahn, R. A. Dolbeer, and R. F. Reidinger, Jr. 1985. Field evaluation of dimethyl anthranilate as a bird repellent livestock feed additive. Journal of Wildlife Management 49(3): 636-42.
- Mason, J. R., and D. L. Otis. 1990. Chemical senses. Publication of Monell Chemical Senses Center. Eds. B. G. Green, J. R. Mason, and M. R. Kare, no. 2. New York: Marcel Dekker.
- McCurdy, G. F. 1983. American coot apparently suffocates while attempting to swallow lizard. Wilson Bulletin 95(1): 158.
- McKinney, S. Boething Treeland Nursery, Portola Valley, CA. 1991. Telephone interview by author, 25 April.
- McMillan, D. Shoreline At Mountain View, Mountain View, CA. 1991. Personal interview by author, Mountain View, CA, 31 March.
- McNicholl, M. K. 1975. Interactions between Forster's terns and American coots. Wilson Bulletin 87(1): 109-10.
- Miller, G. 1990. Rep. Miller's initiative to restore fish and wildlife. Congressman George Miller Reports to Contra Costa (April): 1-2.
- Mott, D. F. and S. K. Timbrook. 1988. Alleviating nuisance Canada goose problems with acoustical stimuli. In Proceedings of the thirteenth Vertebrate Pest Conference, edited by A. C. Crabb and R. E. Marsh, 301-5. Davis, CA: Univ. of California.
- Munro, J. A. 1939. Food of ducks and coots at Swan Lake, British Columbia. Canadian Journal of Research 17(8): 178-86.
- Newberry, L. 1986a. Birds of Shoreline. Mountain View, CA: Privately printed.
- _____. 1986b. Checklist of the birds of Shoreline At Mountain View. Mountain View, CA: Privately printed.
- Nudds, T. D. 1981. Effects of coots on duck densities in Saskatchewan parkland. Wildfowl 32: 19-22.

- Oliver, L. 1989. TNC and Ducks Unlimited undertake \$7.5-million wetlands rescue. California Nature Conservancy Newsletter (Summer): 1-2.
- Paullin, D. G. 1987. Cannibalism in American coots induced by severe spring weather and avian cholera. Condor 89(2): 442-43.
- Pearson, S. 1985. U.S. Dept. on Interior. Letter from Sacramento, CA, to G. Lyles, Shoreline At Mountain View, Mountain View, CA, 14 November.
- _____. U.S. Dept. of Interior, Sacramento, CA. 1988. Telephone interview by author, 27 December.
- Peterson, R. T. 1980. A field guide to the birds. 4th ed. Boston, MA: Houghton Mifflin.
- Pfeifer, W. K. 1983. Waterfowl. In Prevention and control of wildlife damage, 75-78(E). Lincoln, NE: Univ. of Nebraska.
- Pitts, W. D. San Jose St. Univ., San Jose, CA. 1989. Telephone interview by author, 10 March.
- Priest, J. Humane Society of Santa Clara Valley, Santa Clara, CA. 1989. Telephone interview by author, 20 November.
- _____. Humane Society of Santa Clara Valley, Santa Clara, CA. 1991. Telephone interview by author, 15 March.
- _____. Humane Society of Santa Clara Valley, Santa Clara, CA. 1994. Telephone interview by author, 1 November.
- Rafalski, A. Shoreline Golf Links, Mountain View, CA. 1990. Telephone interview by author, 6 November.
- _____. Shoreline Golf Links, Mountain View, CA. 1991a. Telephone interview by author, 28 March.
- _____. Shoreline Golf Links, Mountain View, CA. 1991b. Telephone interview by author, 11 April.
- Rand, A. L. 1956. American water and game birds. New York: Dutton.

- Richardson, D. Marine Modelers of Santa Clara, Santa Clara, CA. 1990. Personal interview by author, San Jose, CA, 16 October.
- Robbins, C. S., B. Bruun, and H. S. Zim. 1966. Birds of North America. New York: Golden Press.
- Robinson, R. Balance Restoration Nursery, Scottsburg, OR. 1991. Telephone interview by author, 25 April.
- Rogers, W. 1987. Univ. of California, Berkeley, CA. Zoology S10 lecture notes, 31 July.
- Ro-pel®. Animal, rodent, and bird repellent. [1985]. Farmingdale, NY: Privately printed.
- Rose, V. Yamagami's Nursery, Cupertino, CA. 1995. Telephone interview by author, 8 October.
- Rubega, M. A., ed. 1984. The eighty-fourth Audubon Christmas bird count. American Birds 38(4): 396-828.
- Ryan, M. R. 1981. Evasive behavior of American coots to kleptoparasitism by waterfowl. Wilson Bulletin 93(2): 274-75.
- Ryder, R. A. 1959. Interspecific intolerance of the American coot in Utah. Auk 76(4): 424-42.
- Salmon, T. P. Univ. of California, Davis, CA. 1989. Telephone interview by author, 9 January.
- Salmon, T. P., F. S. Conte, and W. P. Gorenzel. 1986. Bird damage at aquaculture facilities. Supplement in Prevention and control of wildlife damage, 85-92(E). Lincoln, NE: Univ. of Nebraska.
- Salmon, V. 1985. Acoustical consultant, Menlo Park, CA. Letter to G. Lyles, Shoreline At Mountain View, Mountain View, CA, 27 November.
- _____. Acoustical consultant, Menlo Park, CA. 1989. Telephone interview by author, 3 January.
- San Francisco Bay National Wildlife Refuge. n.d. Newark, CA: Privately printed.

- San Jose Mercury News. 1990. 27 September-31 December.
- _____. 1991. 1 January-17 July.
- _____. 1993. 13 June, 6[D].
- Schladweiler, J. 1986. Weather-induced migration of coots. Loon 58(1): 49-50.
- Schurman, D. 1993. Sonoma Land Trust. Santa Rosa, CA: Privately printed.
- Severson, K. U.S. Fish & Wildlife Service, Bismarck, ND. 1988. Telephone interview by author, 22 December.
- Shaw, J. H. 1985. Introduction to wildlife management. New York: McGraw-Hill.
- Shoreline At Mountain View. 1987. Mountain View, CA: Privately printed.
- Shoreline map. [1988]. Mountain View, CA: Privately printed.
- Smith-Hansgen, S., ed. [1993]. Golden California. Van Nuys, CA: MH West.
- Snethen, K. Sierra Pacific Turf Supply, Campbell, CA. 1995. Telephone interview by author, 22 August.
- Spotts, R. 1989. What others say. Outdoor California 50(1): 88-91.
- Stein, J., ed. 1980. Random House college dictionary. New York: Random House. S. v. "Beaufort scale," "botulinus," "golf course," "high frequency," "pondweed," "ryegrass," "ultrahigh frequency," "ultrasonic," "waterfowl."
- Steiner, J. 1989. San Francisco Bay National Wildlife Refuge, Newark, CA. Guest lecture presented to San Jose St. Univ. Zoology 151 class, Newark, CA, 27 January.
- Stollberg, B. P. 1949. Competition of American coots and shoalwater ducks for food. Journal of Wildlife Management 13(4): 423-24.

- Strohm, J., ed. 1986. Pesky geese prodded to leave town beach. International Wildlife 16(5): 30.
- Summer '88 at Shoreline. [1988]. Mountain View, CA: Privately printed.
- Sutherland, J. M. 1987. Territorial displacement in the American coot in response to pond drying. The Canadian Field-Naturalist 101(4): 601-3.
- Sutherland, J. M., and W. J. Maher. 1987. Site selection of the American coot in the aspen parklands of Saskatchewan. Condor 89(4): 804-10.
- Swanson, G. A., and J. C. Bartonek. 1970. Bias associated with food analysis in gizzards of blue-winged teal. Journal of Wildlife Management 34(4): 739-46.
- Swanson, J. California Dept. of Fish & Game, Yountville, CA. 1994. Telephone interview by author, 27 September.
- Takekawa, G. San Francisco Bay National Wildlife Refuge, Newark, CA. 1988. Telephone interview by author, 20 December.
- Tate-Hall, T. U.S. Fish & Wildlife Service, Portland, OR. 1991. Telephone interview by author, 11 April.
- Tharratt, B., and D. Lollock. 1989. Habitat: The key to California's fish and wildlife future. Outdoor California 50(1): 65-69.
- The finest bent grass putting surface in the world isn't made of bent grass. n.d. South San Francisco, CA: Privately printed.
- Trulio, L. Shoreline At Mountain View, Mountain View, CA. 1990a. Personal interview by author, Mountain View, CA, 26 March.
- _____. Shoreline At Mountain View, Mountain View, CA. 1990b. Personal interview by author, Mountain View, CA, 19 September.
- _____. Shoreline At Mountain View, Mountain View, CA. 1991a. Personal interview by author, Mountain View, CA, 1 April.
- _____. Shoreline At Mountain View, Mountain View, CA. 1991b. Personal interview by author, Mountain View, CA, 11 April.

- _____. Shoreline At Mountain View, Mountain View, CA. 1991c. Personal interview by author, Mountain View, CA, 25 April.
- _____. 1993. San Jose St. Univ., San Jose, CA. Personal communication to author, San Jose, CA, 2 December.
- _____. San Jose St. Univ., San Jose, CA. 1995. Personal interview by author, San Jose, CA, 24 May.
- _____. 1995b. San Jose St. Univ., San Jose, CA. Personal communication to author, San Jose, CA, 12 October.
- _____. San Jose St. Univ., San Jose, CA. 1995c. Personal interview by author, San Jose, CA, 12 November.
- Tyler, L. 1988. The Links at Spanish Bay, California. Southern Golf-Landscape and Resort (September/October): 21-22.
- Unkel, C. 1989. California wildlands program. Outdoor California 50(1): 6-9.
- Unkel, C., and P. Weissner. 1989. The change in DFG funding. Outdoor California 50(1): 10-11.
- Van Way, V. 1986. Approaches to coot management in California. In Proceedings of the twelfth Vertebrate Pest Conference, San Diego, CA, March 4-6, 1986, edited by T. P. Salmon, 292-94. Davis, CA: Univ. of California.
- Vaught, D. Shoreline Golf Links, Mountain View, CA. 1988a. Personal interview by author, Mountain View, CA, 16 November.
- _____. Shoreline Golf Links, Mountain View, CA. 1988b. Personal interview by author, Mountain View, CA, 21 November.
- Villa-Scott, C. Yamagami's Nursery, Cupertino, CA. 1995. Telephone interview by author, 10 November.
- Volunteer rangers. n.d. Mountain View, CA: Privately printed.
- Ward, P. 1953. The American coot as a game bird. In Transactions of the eighteenth North American Wildlife Conference, edited by J. B. Trefethen, 322-29. Washington, DC: Wildlife Management Institute.

Weddle, D. LaCumbre Country Club, Santa Barbara, CA. 1989. Telephone interview by author, 24 January.

_____. LaCumbre Country Club, Santa Barbara, CA. 1994. Telephone interview by author, 27 September.

White, D. H., and D. James. 1978. Differential use of fresh water environments by wintering waterfowl of coastal Texas. Wilson Bulletin 90(1): 99-111.

White, L. City of Palo Alto, CA. 1989. Telephone interview by author, 25 January.

Williams, J. H. [1993]. It happens every year. Boulder, CO: The Nature Conservancy.

Williston, H. L. 1954. Do birds see red? Southern Forestry Notes 93 (September): 2-3.

Wobeser, G., D. L. Rainnie, T. B. Smith-Windsor, G. Bogdan. 1983. Avian botulism during late autumn and early spring in Saskatchewan. Journal of Wildlife Diseases 19(2): 90-94.

Woolington, D., San Luis National Wildlife Refuge Complex, Los Banos, CA. 1995. Telephone interview by author, 20 October.

Wright, J. U.S. Fish & Wildlife Service, Sacramento, CA. 1991. Telephone interview by author, 21 March.

Yocum, C. F., R. J. Rogiatto, and J. C. Eshelman. 1978. Migration of American coots wintering in Northwestern California. California Fish and Game 64(4): 302-5.

Yparraguirre, D. California Dept. of Fish & Game, Sacramento, CA. 1991. Telephone interview by author, 27 March.

_____. California Dept. of Fish & Game, Sacramento, CA. 1993a. Telephone interview by author, 24 September.

_____. California Dept. of Fish & Game, Sacramento, CA. 1993b. Telephone interview by author, 1 October.

- Zahn, G. Kesterson National Wildlife Refuge, Los Banos, CA. 1988.
Telephone interview by author, 21 December.
- Zajanc, A. 1962. Methods of controlling starlings and blackbirds. In Proceedings of the Vertebrate Pest Conference, Sacramento, CA, February 6-7, 1962, by the National Pest Control Assn., Elizabeth, NJ, 190-212.
- Zaldivar, R. A. 1995. Job impact re-evaluated. San Jose Mercury News, 25 January, 1(F) & 4(F).