Conservation Assessment and Management Plan for Breeding Western and Clark's Grebes in California

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TABLE OF CONTENTS

TABLE OF CONTENTS (con't)

TABLE OF CONTENTS (con't)

LIST OF TABLE AND FIGURES

TABLE OF CONTENTS (con't)

TABLE OF CONTENTS (con't)

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EXECUTIVE SUMMARY

In 1990, The *American Trader* oil tanker spilled approximately 400,000 gallons of crude oil into the Pacific Ocean near Huntington Beach, California. Western and Clark's grebes (*Aechmophorus occidentalis* and *A. clarkii*) were among the most prevalent bird species retrieved by cleanup crews in the aftermath. These closely-related waterbirds have only recently been considered separate species, and are consistently two of the most commonly affected birds of oil spill incidents. Since the majority of their populations spend the winter on the Pacific Coast from British Columbia (B.C.) to southern California, they are particularly vulnerable to mortality from oil spills.

This plan will serve to facilitate implementation of a portion of the Final Restoration Plan and Environmental Assessment for Seabirds Injured by the American Trader Oil Spill (American Trader Trustee Council 2001). Restoration options for their ocean wintering areas are limited; therefore, funds from the American Trader Trustee Council (ATTC) paid for this assessment to determine opportunities to enhance grebe productivity at inland breeding locations in northern California as this state supports a significant portion of the global populations of both species. The purpose of the ATTC is to coordinate restoration of wildlife resources affected by the spill. Several important grebe nesting areas were investigated in 2003 including (in order of importance): Eagle Lake (Lassen County), Tule Lake National Wildlife Refuge (NWR—Siskiyou and Modoc counties), Clear Lake (Lake County), Lake Almanor (Plumas County), Thermalito Afterbay (Butte County), Bridgeport Reservoir (Mono County), Goose Lake (Modoc County), Lower Klamath NWR (Siskiyou County), and East Park Reservoir (Colusa County). Eagle Lake is of great significance because of the large numbers of breeding grebes.

In addition to the threat of oil spills, there have been historic declines of *Aechmophorus* grebe populations due to market hunting and extensive nesting habitat loss. In recent years, there is also evidence of declining trends likely due to continuing habitat loss, increasing levels of human disturbance at breeding colonies, and reproductive problems caused by pesticide and heavy metal contamination. Some grebes now breed at reservoirs where nesting vegetation is limited and fluctuating or decreasing water levels and boating-related recreation (e.g., water-skiing and fishing) can cause problems. At other sites, the availability of nest habitat is limiting due to lack of adequate vegetation to support nests. Water level changes (fluctuations and drawdowns) can cause nest losses; grebes usually abandon eggs if their nests become stranded on shore. Low-floating nests are also particularly susceptible to destruction by boat wakes and wave action. Disturbance has caused colony failures and lead to nest abandonment and increased egg predation, and can also cause young chicks to be separated from their parents which can lead to mortality as chicks can not swim for long. Propeller strikes by speeding boats can kill adults and chicks.

Opportunities to enhance productivity of grebes at these sites are also addressed. I recommend a regional approach to *Aechmophorus* grebe conservation, including coordinated monitoring and decision-making processes. Issues to address vary by location, but generally include the need to post nesting colony sites as closed areas to prevent disturbance during the nesting season (usually June-September), maintain stable water levels as much as possible, provide outreach to the public about grebes, post no-wake zones (and in some cases, install wave barriers to protect nests from waves), restore nesting habitat where possible, and monitor the

results of implemented management actions. Many of these improvements could also be applied to other *Aechmophorus* grebe nesting areas throughout their range, and would benefit other over-water nesting birds as well.

Because of the importance of northern California for nesting grebes (5.6% of the estimated global population and 45.1% for the Intermountain West), declining trends at some breeding and wintering sites, and threats to productivity, these grebes need further conservation in the state. A variety of partners should be approached to help pay for projects to benefit these species. Although ATTC funds are limited, various grant programs should be explored to increase opportunities for recommended actions. Conservation projects involving these two grebe species should be integrated into other wetland and bird conservation initiatives such as the Joint Ventures, regional Waterbird Conservation Plans, and Audubon California’s Important Bird Area (IBA) Program.

INTRODUCTION

On 7 February 1990, the *American Trader* oil tanker spilled approximately 416,598 gallons of crude oil into the Pacific Ocean offshore of Huntington Beach, California. The cargo tank was punctured twice by the vessel's own anchor while attempting to moor, and the oil impacted ocean waters (60 square mi—155 square km), shorelines, and marine organisms, including significant numbers of seabirds (American Trader Trustee Council 2001). Western and Clark's grebes were among the most prevalent bird species retrieved by cleanup crews in the aftermath of this spill. These grebes primarily winter at sea along the Pacific Coast where they are consistently two of the most commonly affected birds of oil spill incidents (e.g., Smail et al. 1972, Speich and Thompson 1987, Bayer 1988, Roletto et al. 2000, American Trader Trustee Council 2001).

Restoration options for *Aechmophorus* grebe coastal wintering areas are limited; however, this assessment has been prepared under contract from the National Fish and Wildlife Foundation on behalf of the ATTC to develop a management plan for enhancing productivity of western and Clark's grebes at one or more major inland breeding sites in northern California. Background information on the status of major grebe colonies was gathered, literature was reviewed, and knowledgeable individuals were interviewed to determine recent breeding site population estimates and issues. Field surveys were conducted at nine sites in 2003 to document colony size, nest and brood success, productivity, and levels of mortality, human disturbance and other issues which might be limiting grebe productivity. This was a reconnaissance-level effort and more detailed studies are needed at some locations.

This plan will serve to facilitate implementation of a portion of the Final Restoration Plan and Environmental Assessment for Seabirds Injured by the American Trader Oil Spill (American Trader Trustee Council 2001). It also identifies a range of recommendations and their costs for improving grebe reproductive success which include minimizing human disturbance by establishing seasonal closures near colonies, using outreach to heighten public awareness of the sensitivity of grebe colonies, development of structures to minimize the negative effects of waves from boats and wind fetch, and habitat improvement projects to enhance nesting conditions. A strategy for monitoring is also identified. Potential partners and opportunities for collaboration in grebe conservation efforts (e.g., agencies, Joint Ventures) are also suggested.

Of the 22 grebe species worldwide, two have gone extinct in the past 30 years, two are on the brink of extinction, and three others are on the International Union for Conservation of Nature and Natural Resources' (IUCN—now the World Conservation Union) Red List, and are considered threatened by extinction (O'Donnel and Fjesda 1997). Western and Clark's grebes were considered color phases of the western grebe from 1886 until 1985; therefore, the literature combined them, with few references to the phase of the birds studied (Storer and Neuchterlein 1992). However, their habitat needs and associated conservation issues are essentially the same as they are sympatric on both breeding and wintering sites; they generally nest and forage together. The prevailing threats are loss of habitat, particularly because of the conversion of shallow lakes into agricultural lands, and the re-allocation of water for other uses, as well as the altered function of wetlands, alterations to water levels, and increases in water-based recreation (O'Donnel and Fjesda 1997).

BACKGROUND

Taxonomy

Western and Clark's grebes were both first described in 1858 (Lawrence *in* Baird 1858:894-895), but Clark's was subsequently believed to be a light morph of the western grebe and the genus *Aechmophorus* was considered conspecific until recently. The genus now contains two species (American Ornithologists' Union 1985) of the family Podicipedidae, order Podicipediformes. Within each species there are two subspecies which are geographically distinct; *A. o. occidentalis and A. c. transitionalis* breed from Canada south through the western U.S. to northern Baja California while the other two subspecies (*A. o. ephemeralis* and *A. c. clarkii*) breed on the Mexican Plateau (Storer and Neuchterlein 1992). There are reports of suspected hybrids of western and Clark's grebes; however, studies on the relationships between the two species (Ratti 1979), analysis of DNA-DNA hybridization (Ahlquist et al. 1987), and slight differences in breeding behavior (Neuchterlein 1981) support their separation as species.

Legal status

Both *Aechmophorus* species are covered under the Migratory Bird Treaty Act (MBTA—Code of Federal Regulations 1985) which protects migratory birds and their nests from "take," defined as possession, sale, purchase, barter, transport, import, and export. Abandonment of nests caused by anthropogenic factors can also be considered take. Colonial nesting birds such as grebes are highly vulnerable to disturbance of colonies or manipulation of habitat (e.g., water levels) during the nesting season which could result in a significant level of take. In addition, CDFG Code Section 3505 prohibits take of nests or eggs for a large number of bird species, including *Aechmophorus* grebes.

The western grebe is a candidate species for listing as threatened or endangered in Washington state, and Clark's grebes are a species of concern in Arizona, Montana and Wyoming (Ivey and Herziger in prep). In Canada, the western grebe is considered a sensitive species in Alberta (Hanus et al. 2002a), and is on B.C.'s provincial Red List (candidates for endangered or threatened status) because of population declines, few active breeding sites, and the vulnerability of those sites to habitat erosion and human disturbance (Burger 1997).

Although not a formal legal status, the western grebe appeared on every Audubon Society's Blue List (species of concern), from 1973 to 1982 (Tate 1981, Tate and Tate 1982). On the 1980 list, habitat loss was blamed for its decline, "…with more drastic losses predicted in the future" (Arbib 1979). For the 1982 list, it appeared to be "stabilizing at a reduced level" (Tate and Tate 1982), and it was delisted to a species of "special concern" in 1986 (Tate 1986).

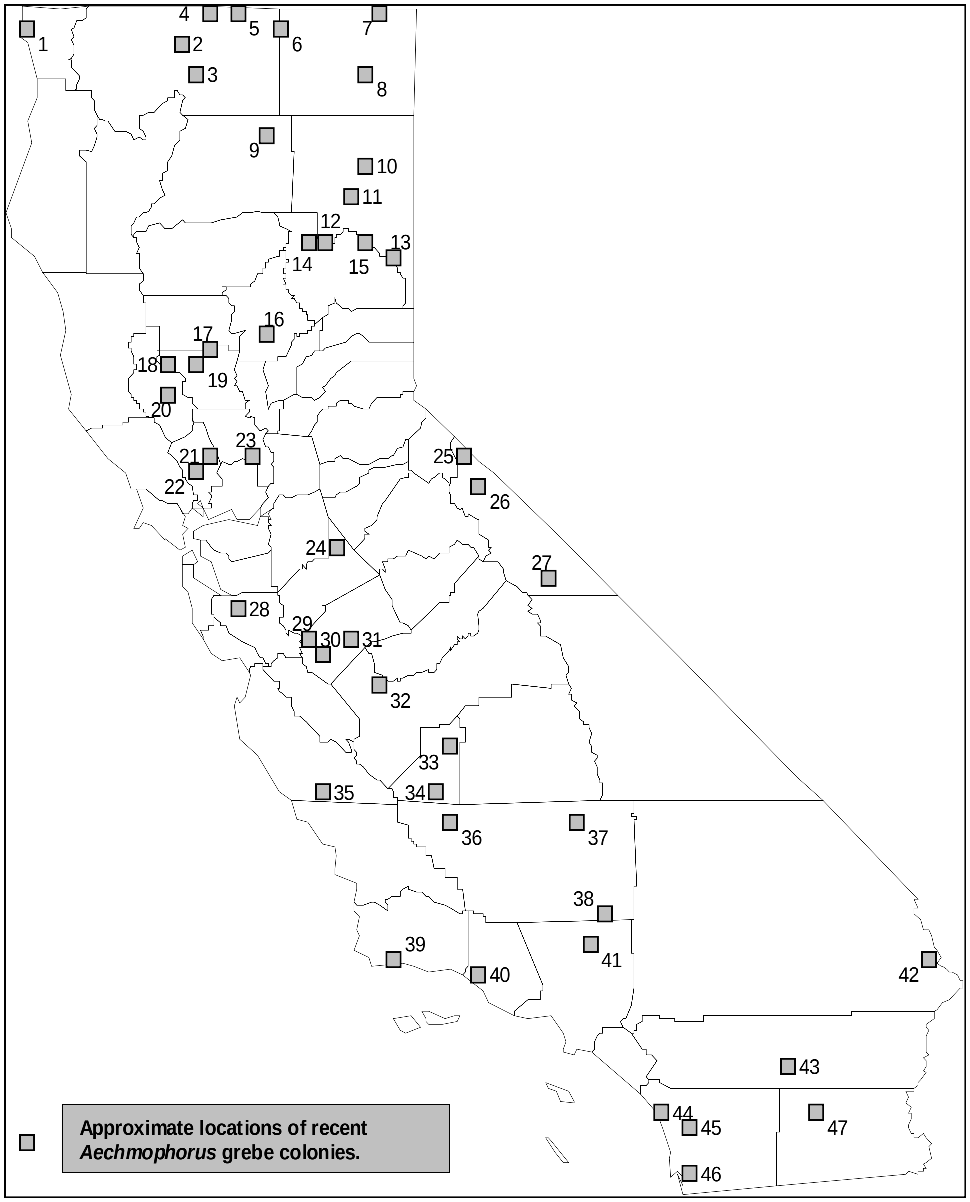
Description

Both species are morphologically similar and are relatively large waterbirds (55-75 cm long and approximately 800-1800 g—Storer and Neuchterlein 1992) with narrow, tailless bodies, and long necks. They are black and sooty dorsally on their backs, heads and necks, and white ventrally. Their crests are triangular and can be raised and spread laterally on display. Both sexes are similar, but the females are slightly smaller with a shorter, thinner bill that appears upturned. The western is distinguished from the Clark's by its yellowish-green bill and the black of the crown extending below its eyes. Clark's have an orange-yellow bill with a sharply-defined black culmen, and in breeding plumage, the white of the head extends above the eyes and the lores.

Geographic distribution

These two species generally share the same breeding distribution (Storer and Neuchterlein 1992). They breed on large lakes, marshes, and reservoirs from southern B.C. eastward to southwest Ontario, central Minnesota and Wisconsin, and south through the western U.S. to northwest Texas and west to southern California. Generally, Clark's grebes become rare towards the north and east portions of the breeding range and are much rarer in Canada (Feerer 1977, Storer and Neuchterlein 1992). The entire state of California is within their breeding range. Figure1 illustrates the distribution of recent colonies in California (1980-2003).

Aechmophorus grebes primarily winter from southern B.C. south along the Pacific Coast, but also at inland lakes and reservoirs which do not freeze from California east to Texas (Storer and Neuchterlein 1992). They are resident at some of these lakes, from central California south to northern Baja California and on the Mexican Plateau.



LEGEND

1. Lake Earl, Del Norte Co.
2. Shasta Valley Wildlife Area, Siskiyou Co.
3. Lake Shastina, Siskiyou Co.
4. Indian Tom Lake, Siskiyou Co.
5. Lower Klamath NWR, Siskiyou Co.
6. Tule Lake NWR, Siskiyou/Modoc Cos.
7. Goose Lake, Modoc Co.
8. Modoc NWR, Modoc Co.
9. Big Lake/Horr Pond, Shasta Co.
10. Grasshopper Valley, Lassen Co.
11. Eagle Lake, Lassen Co.
12. Mountain Meadows Reservoir, Lassen Co.
13. Honey Lake Wildlife Area, Lassen Co.
14. Lake Almanor, Plumas Co.
15. Antelope Lake, Plumas Co.
16. Thermalito Afterbay, Butte Co.
17. Sacramento NWR, Glenn/Colusa Cos.
18. East Park Reservoir, Colusa Co.
19. Funks Reservoir, Colusa Co.
20. Clear Lake, Lake Co.
21. Lake Berryessa, Napa Co.
22. Lake Hennessy, Napa Co.
23. Davis Wetlands, Solano Co.
24. Woodward Reservoir, Stanislaus Co.
25. Topaz Lake, Mono Co.
26. Bridgeport Reservoir, Mono Co.
27. Crowley Lake, Mono Co.
28. Calaveras Reservoir, Santa Clara Co.
29. O'Neill Forebay, Merced Co.
30. Los Banos Creek Reservoir, Merced Co.
31. San Luis NWR, Merced Co.
32. Mendota Wildlife Area, Fresno Co.
33. Corcoran Irrigation Reservoir, Kings Co.
34. South Wilbur Flood Area, Kings Co.
35. Lake San Antonio, Monterey Co.
36. Kern NWR, Kern Co.
37. Lake Isabella, Kern Co.
38. Paiute Ponds, Kern Co.
39. Lake Cachuma, Santa Barbara Co.
40. Lake Casitas, Ventura Co.
41. Palmdale Lake, Los Angeles Co.
42. Lake Havasu, San Bernadino Co.
43. Whitewater River Estuary, Riverside Co.
44. Buena Vista Lagoon, San Diego Co.
45. Lake Hodges, San Diego Co.
46. Sweetwater Reservoir, San Diego Co.
47. Ramer Lake, Imperial Co.

Fig. 1. Approximate locations of recent (1980-2003) colonies of *Aechmorphorus* grebes in California.

Life history

Habitat requirements. ——*Aechmophorus* grebes breed colonially at large freshwater and brackish marshes, lakes, and reservoirs with extensive areas of open water, often bordered by emergent vegetation. There are also two records of brood observations in tidal marshes in B.C., suggesting rare incidences of saltwater breeding (Weber and Ireland 1992). Colony selection is likely influenced by local food constraints, shelter from wind and waves, stem density of nest substrate, water depth, nest locations of early arrivals, size of the breeding population, and other complex interactions among conspecifics (Neuchterlein 1975, Storer and Neuchterlein 1992). At Delta Marsh, Manitoba, Canada, *Aechmophorus* grebes selected sites which had other nesting grebes nearby, and colony growth appeared to radiate out from the earliest nests (Neuchterlein 1975). Nesting areas are generally isolated from disturbance and predators with open water for rearing chicks. Sites are often used in subsequent years.

The two species often nest together, sometimes among eared grebes (*Podiceps nigricollis*) and other waterbird species. They build floating nests which consist of a mound of submergent vegetation, mixed with emergents if they are available. Flooded emergent vegetation or rooted submergent vegetation which reaches the water surface is needed to anchor their nests. In the western U.S., colonies are most commonly established in hardstem bulrush (*Scirpus acutus*), but have also been documented in other emergent plants such as alkali bulrush (*S. maritimus*), cattail (*Typha* spp.), giant burreed (*Sparganium eurycarpum*), Baltic rush (*Juncus balticus*), common reed (*Phragmites australis*), reed canarygrass (*Phalaris arundinacea*), saltgrass (*Distichlis spicata*) and water smartweed (*Polygonum amphibium*) (Storer and Neuchterlein 1992, Burger 1997, pers. observ.). Some submergent plants used in nest construction and anchoring include sago pondweed (*Potamogeton pectinatus*), curly pondweed *(P. crispus)*, long-leaf pondweed (*P. nodosus*), broad-leafed pondweed (*P. natans*), bladderwort (*Utricularia vulgaris*), water milfoil (*Myriophyllum* spp.), muskgrass (*Chara* spp.), and filamentous algae (e.g., *Pithophora* spp.—pers. observ.). Muskrat (*Ondatra zibethicus*) houses are sometimes used as nest sites (pers. observ.). The structure and nest-anchoring function of vegetation is likely more important than the actual plant species.

Occasionally, they nest in very shallow water (<20 cm) (pers. observ.). Nero et al. (1958) reported western grebe nests on dry land on an island in Saskatchewan, Canada, up to 23 m from water. In this case, water levels had recently dropped and nearby historic wetland habitat was not available, apparently causing the grebes to shift their habits to continue nesting in that traditional breeding site. At Delta Marsh, water depths averaged 41 cm, with 90% in water > 25 cm, suggesting that a minimal depth is required for diving to and from nest sites (Neuchterlein 1975). At Eagle Lake, western grebes were found to nest over the shallowest and deepest water, while Clark's were located at intermediate depths (Shaw 1998). At Malheur NWR in eastern Oregon, these grebes did not nest during years when size classes of fish (primarily carp—*Cyprinus carpio*) were too large to serve as prey (Ivey et al. in prep).

For foraging, *Aechmophorus* grebes require semi-permanent and permanent wetlands, lakes, reservoirs, large rivers, estuaries and open ocean with an abundant supply of small fish (generally <9 cm) (e.g., Lawrence 1950). In winter, the vast majority of these birds use coastal habitats including salt and brackish bays, estuaries, and the nearshore zone, but some are also found on inland lakes and large rivers which don't freeze (Storer and Neuchterlein 1992). Off the central California coast, rafts of *Aechmophorus* grebes have been observed up to 20 km from shore (P. Kelly, pers. comm.).

Reproductive ecology.—— The social system of *Aechmophorus* grebes apparently represents colonial nomadism (Neuchterlein 1975). Based on past estimates from Eagle Lake, it is apparent that numbers can fluctuate dramatically between years (Shaw 1998), suggesting low fidelity to breeding sites. Breeding populations have also varied at Malheur NWR, ranging from zero to 3,891 pairs from 1980-98, depending on habitat conditions and prey availability (Ivey et al. in prep).

Both species are monogamous. Courtship occurs during spring migration and shortly after arrival to breeding sites. Because unpaired males outnumber females in late courting groups, a male-biased sex ratio is suggested (Storer and Neuchterlein 1992), and is likely because females are more vulnerable to predation as they spend more time incubating eggs. The two species practice similar elaborate courtship ceremonies (described in detail by Storer and Neuchterlein 1992). Breeding territories only include the immediate vicinity of nests (Palmer 1962); at Eagle Lake, the minimum distance between nests was 1.3 m and averaged 4.9 m (Gould 1974), while in 1996 and 1997, average distances between nests were 4.1 and 8.4 m, respectively (Shaw 1998). At Delta Marsh, this average ranged from 3.4-5.0 m among several colonies (Neuchterlein 1975).

Males and females participate in nest construction which takes 1-3 days. Nests are initiated in northern California from mid-June to as late as mid-August, but there are records of winter nesting from extreme southern California and Lake Mead in southern Nevada (Parmelee and Parmelee 1997). At Eagle Lake in 1996-97, some western grebes began nesting 2-4 weeks earlier than Clark's grebes (Shaw 1998). Both sexes incubate, beginning between the laying of the first and second egg, and eggs begin hatching after 24 days (Lindvall and Low 1982). New material is continually added to nests throughout the incubation period.

Chicks are precocial and climb on their parent's back almost immediately after hatching, riding between their parent's wings until 2-4 weeks old. Back-brooding is essential for survival of young chicks as their plumage is not developed to withstand long periods of swimming and they aren't adapted to loaf on shore. Chicks remain dependent on their parents for 6-7 weeks (Storer and Neuchterlein 1992), and aren't capable of flight until 10 weeks (Ratti 1977). In Utah, parents cared for young until late September (Lindvall and Low 1982), and late nests at Eagle Lake in 1971 (Gould and Koplin 1971) and 2003 (pers. observ.) would have had unfledged chicks through late November. Pair bonds endure at least through nesting, but they may split their brood when the chicks are half grown. It is unknown whether pairs reunite in subsequent years; however, records of fall courtship suggest maintenance of pair bonds (R. Bogiatto, pers. comm.).

Demography.——Age at first breeding is presumed to be one year, but groups of nonbreeding birds are not uncommon (Storer and Neuchterlein 1992). In summer, flocks containing hundreds have been observed along the south coast of B.C. (Campbell et al. 1990) which suggests they may begin breeding their second year. They likely breed annually, although they may not nest during years of unfavorable habitat conditions. Normal clutch size is 1-6 eggs, with an average of <3.7, diminishing through the season; renesting is common (Storer and Neuchterlein 1992). Annual productivity is variable and highly dependent on water conditions, as extreme low or high water levels can limit nesting opportunities. For example, in Manitoba, nesting success ranged from 48-80%, and the ratio of chicks per adult in brood counts ranged from 0.53 to 0.88 (Storer and Neuchterlein 1992).

The oldest known western grebe was still alive after 14 years and there are several records of birds banded as adults living between six and eight years; it is likely that their average longevity is >10 years (Eichhorst 1992).

Feeding ecology.—— *Aechmophorus* grebes frequently peer into the water while feeding; fish are pursued under water and the bottom-dwelling prey in their diets suggests they also forage in the benthos (Storer and Neuchterlein 1992). Incubating females are fed by males (Neuchterlein and Storer 1989), and mate feeding has also been observed in winter (James 1989). Clark's grebes tend to feed farther from shore in deeper water than westerns and more likely to engage in "springing dives" where they slightly leap into the air to dive and forage at deeper depths (Neuchterlein 1981, Ratti 1985, and Buitron 1989).

These species are primarily piscivorous and opportunistic; size class of prey items is more important than the species. In food habit studies, fish were reported to constitute 81% (Lawrence 1950) to 100 % (Wetmore 1924) of their diet. The vast majority of the fish found in stomachs of grebes at Clear Lake were non-game species and the impact of grebe predation on sport fish was considered negligible (Lawrence 1950). Wintering *Aechmophorus* grebes in coastal California are typically observed feeding in small to large groups during daylight hours (P. Kelly, pers. comm.). In contrast, along the southern coast of B.C., grebes are solitary, nocturnal foragers on pelagic-schooling fish, primarily herring (*Clupea harengus*), likely keying on the bioluminescence when fish migrate to the surface at night to feed (Clowater 1998). Other prey items include salamanders (*Ambystoma* spp.), crustaceans, polychaete worms, and a variety of aquatic insects (Storer and Neuchterlein 1992). At Clear Lake, 27 stomachs contained 81% fish 27-88 mm long, 17% insects, and 2% plants (Lawrence 1950). Feathers are also swallowed as they come out during preening which may function to keep fish bones from entering the intestines and help with the formation of pellets which are ejected.

Movements and migration.——Migration is nocturnal for *Aechmophorus* grebes. Movements to breeding areas occur primarily from late April to early May, while travel to wintering areas occur mostly from September through November, peaking in October (Storer and Neuchterlein 1992). Western grebes (and likely Clark's as well) have been found to move to special molt locations following breeding (Stout and Cooke 2003); however, little is known about their routes. Bands from Delta, Manitoba, and Bear River marshes, Utah, have been recovered along the Pacific Coast from southern B.C. to San Diego, and a couple of birds banded in Wyoming were recovered at lakes in Nevada and Arizona (Eichhorst 1992), suggesting that birds from northern breeding areas winter along the Pacific Coast and the southwest U.S. Some populations in the southwest and western U.S. and Mexico are resident. Congregations of about 50,000 have been reported at the Salton Sea (Small 1994) which indicates important staging or wintering use.

Mortality.——A primary cause of nest and egg loss is waves during wind storms (Storer and Neuchterlein 1992). At Eagle Lake in 1996-97, eggs were regularly found floating in water which is evidence of this problem (D. Shaw, pers. comm.), and some were also noted in 2003 (pers. observ.). In southern Manitoba, 69% of grebe nests were destroyed by wind and waves in 1973-74 (Neuchterlein 1975). Chicks may die of drowning or exposure during cold, wet weather if they are not carefully attended by parents.

Fluctuating or decreasing water levels caused by water manipulations or droughts can also cause serious problems at colonies. At Clear Lake in 1999, low water levels combined with disturbance from fishermen resulted in high rates of abandonment and nest predation, and also allowed nest-trampling cattle into the colony (D. Anderson, pers. comm.). At Bear River Migratory Bird Refuge (MBR), Utah, after water levels declined 38 cm in a three-week period, 25% of nests were abandoned (Lindvall and Low 1982). Mammalian predators such as mink (*Mustela vison*) and raccoons (*Procyon lotor*) sometimes raid colonies, destroy eggs and young, and occasionally kill adults, particularly when water levels are low. Mink can access colonies at any water depth (e.g., Neuchterlein 1975). They primarily hunt at night and are very effective in killing large numbers of adults and young, most of which are left unconsumed (pers. observ.). Decreasing water availability can also lead to mortality of flightless, molting grebes as has occurred in the Wilbur and Hacienda flood storage basins (Kings County) in recent years.

Disturbance at nesting colonies is also a major issue for grebes. Adults and chicks are often directly killed by boats (D. Anderson, pers. comm.), and small chicks which become separated from their parents can die of exposure if adults crash-dive to avoid motorboats (Storer and Neuchterlein 1992, Shaw 1998). This appears to be more of a problem when pairs are caring for more than two chicks (D. Shaw, pers. comm.). At Clear Lake, boating recreation has contributed to complete failures of nesting colonies; adequate reproduction has only occurred in three years of a 12-year study (D. Anderson, pers. comm.). In 1997 and 2002, most of the grebe nests at Clear Lake were destroyed, apparently during weed control operations while using airboats to reduce hydrilla (*Hydrilla verticillata*) infestations (D. Anderson, pers. comm.). At Eagle Lake in 2000, a significant positive correlation was found between nest success and distance from the primary boating access and source of disturbance; evidence suggested that disturbance levels negatively affected clutch size (Sardella 2002). At Delta Marsh, a 53% nest abandonment rate was documented for nests located in an area along a canoe trail (Neuchterlein 1975). Disturbances from cars, helicopters and airplanes led to increased predation at Bear River MBR as adults flushed from nests (Lindvall and Low 1982). Predators of grebe eggs and chicks after disturbance have included gulls (*Larus* spp.), corvids, American coots (*Fulica americana*) and Forster's terns (*Sterna forsteri*) (Gould and Koplin 1971, Neuchterlein 1975, Lindvall and Low 1982). Chicks are also vulnerable to predation by gamefish such as bass (*Micropterus* spp.) and pike (*Esox* spp.).

Other human factors have caused mortality. Since the majority of these grebes winter in nearshore areas along the Pacific Coast, they are particularly vulnerable to oil spills where thousands have been killed (Smail et al. 1972, Speich and Thompson 1987, Bayer 1988, Roletto et al. 2000, American Trader Trustee Council 2001). Gill nets and aquaculture are other sources of mortality along the Pacific Coast (Burger 1997). Contaminants such as DDD have contributed to high adult mortality at some nesting sites (e.g., Clear Lake—Herman et al. 1969). Grebes also occasionally die from becoming entangled in broken or discarded fishing lines and discarded plastic or rubber rings (Storer and Neuchterlein 1992).

Grebes are susceptible to several diseases, but avian botulism and avian cholera are the most common. Botulism is a paralytic condition brought on by the consumption of a naturally-occurring toxin produced by the bacterium *Clostridium botulinum*. *Aechmophorus* grebes have often been killed by Type C outbreaks (e.g., National Wildlife Health Center 1998). Type E botulism is connected with the consumption of fish and sometimes kills grebes (U.S. Geological Survey data). Avian cholera is one of the most prevalent diseases among wild North American waterfowl. It is the result of infection with the bacterium *Pasteurella multocida* which kills swiftly, sometimes in a few hours after infection, and can spread quickly through a wetland and cause the death of thousands of birds in a single outbreak (U.S. Geological Survey 2002). Occasionally, avian cholera die-offs have killed grebes at Eagle Lake (e.g., in 1997—National Wildlife Health Center 1997). Grebes sometimes get trapped and die as lakes freeze (Nero 1960, pers. observ.). In March 2003, more than 300 *Aechmophorus* grebes were found dead and emaciated from unknown causes at Lake Elsinore, Riverside County, California (C. Davis, pers. comm.).

Population status and trends

Historically, *Aechmophorus* grebes were more abundant and widespread in their breeding locations, but habitat loss due to wetland drainage, development, and excessive human disturbance has reduced the number of suitable sites throughout their range. In California, more than 90% of the state's historic wetlands have been lost (Dahl 1990) and this likely had a great impact. The once vast Lower Klamath Lake on the Oregon border formerly supported "several thousand" nesting *Aechmophorus* grebes (Finley 1911), but habitat today has been reduced to a series of managed wetlands on Lower Klamath NWR on the California side of the border, supporting only 37 nests in 2003 (Shuford et al. 2003). A critical water shortage in recent years has further limited the available habitat. Similarly, nearby Tule Lake NWR persists as only a remnant of what once was an immense marsh and supports relatively few grebes compared to the "many thousands" reported there in 1899 (Bailey 1902). Large colonies of grebes at Tulare Lake (King and Tulare counties) and Buena Vista Lake (Kern County) were lost from drainage for agriculture (Cogswell 1977). Several other sites which formerly supported colonies are no longer suitable because of habitat loss or levels of human use, including Clear Lake (Modoc County), Topaz Lake (Mono County), and Mono Lake (Mono County), which historically supported a marsh before water diversions made it too saline. In B.C., the western grebe historically nested at seven sites, of which only three remain active (Burger 1997). Construction of reservoirs for irrigation and power generation has compensated for some losses of breeding habitat; however, few support adequate breeding sites and those that do usually are problematic for nesting grebes because of water level changes and human disturbance.

Grebe numbers also have diminished due to direct human pressure. From the late 1800s until about 1906 they were subject to egg collection and intensive market hunting as tens of thousands were shot for their skins. The "fur" of their white ventral plumage was used for capes, coats and hats by the fashion industry (Storer and Neuchterlein 1992), with each bird selling for only 20 cents each (Bent 1963). At Tule Lake in 1899, it was reported that "many thousand grebe skins have been shipped from this one lake…" (Bailey 1902), and large colonies at Lower Klamath Lake and other western marshes were virtually eliminated (Finley 1907, Chapman

1908). The Migratory Bird Act (1913) and MBTA (1918) put an end to grebe egg collection and hunting. Historic and recent records of California *Aechmophorus* grebe colony sites are summarized in Table 1. This is an incomplete record of historic grebe site information, and doubtless more records exist; a more thorough literature review should be conducted.

Table 1. Records of breeding *Aechmophorus* grebes in California before 2002.

Site	Years	Numbers	Comments	Source
Antelope Lake Plumas County	1990s			D. Shuford, pers. comm.
Big Lake/Horr Pond Shasta County	1990s			D. Shuford, pers. comm.
Bridgeport Reservoir Mono County	1990s			D. Shuford, pers. comm.
Buena Vista Lagoon San Diego County	2000			San Diego Natural History Museum (2000)
Buena Vista Lake Kern County	1922	nested abundantly		Lamb (1922)
Calaveras Reservoir Santa Clara County	1990s			D. Shuford, pers. comm.
Clear Lake Lake County	1940s 1958-60 1961		>1,000 nests 0 nests 16 nests major nesting area	Grinnell and Miller (1944) Herman et al. (1969) Herman et al. (1969) Small (1994)
Clear Lake Modoc County	1911	 major area	after dam was built	Finley (1911) Small (1994)
Corcoran Irrigation Reservoir Kings County			recent years	Small (1994)
Crowley Lake Mono County	1990s			D. Shuford, pers. comm.
Eagle Lake Lassen County	1887 1905 1921 1925 1928 1970 1971 1974 1996 1997	 common 50 adults 500 pairs zero nests 1,457 nests 1,918 nests 1,200 nests major area 2,487 nests 1,134 nests	 Spaulding area lack of tules	Grinnell and Miller (1944) Sheldon (1907) Grinnell et al. (1930) Grinnell et al. (1930) Grinnell et al. (1930) Gould (1974) Gould (1974) Lederer (1976) Small (1994) Shaw (1998) Shaw (1998)
Edwards Air Force Base Kern County			few pairs at Paiute Ponds	Small (1994)
Funk's Reservoir Colusa County	2000s			D. Boegener, pers. comm.
Goose Lake Modoc County	1977	598 Clark's major area	majority were Clark's	Ratti (1981) Small (1994)
Grasshopper Valley Lassen County	1991	~100 Clark's	nested for a few years prior to 1991	L. Oring, pers. comm
Honey Lake Lassen County	1887 1990s			Grinnell and Miller (1944) D. Shuford, pers. comm.
Kern NWR Kern County	Recent years	~5 nests		D. Hardt, pers. comm.
Lake Almanor Plumas County	1992 1995-96 1997	500 nests major area zero nests 43 nests		L. Neel, pers. comm. Small (1994) Shaw (1998) Shaw (1998)

Table 1 (con't). Records of breeding *Aechmophorus* grebes in California before 2002.

Site	Years	Numbers	Comments	Source
Lake Berryessa Napa County	1990s			D. Anderson, pers. comm.
Lake Cachuma Santa Barbara County		small number		Small (1994)
Lake Casitas Ventura County		small number		Small (1994)
Lake Earl Del Norte County	1974	18 nests 43 nests small number 15 nests 14 nests		Funderburk (1979) Funderburk (1979) Small (1994) Jaques (1998) Jaques (1998)
Lake Havasu San Bernadino County		 ~3,570 adults	 some year-round	Garrett and Dunn (1981) Rosenberg et al. 1991
Lake Hennessy Napa County	1990s			D. Shuford, pers. comm.
Lake Hodges San Diego County	2000			San Diego Natural History Museum (2000)
Lake Isabella Kern County		small number		Small (1994)
Lake Merced San Francisco County	1885, 1926			Grinnell and Wythe (1927)
Lake San Antonio Monterey County		major area		Small (1994)
Lake Shastina Siskiyou County	1990s			D. Shuford, pers. comm.
Los Baños Merced County	~1938		3 miles south of town	Moffitt (1938)
Los Baños Creek Reservoir Merced County	2000s			D. Woolington, pers. comm.
Lower Klamath Lake Siskiyou County		several thousand		Finley (1907)
Mendota Wildlife Area Fresno County	recent years			Small (1994)
Modoc NWR Modoc County	1990s			D. Shuford, pers. comm.
Mono Lake Mono County	1940	500 nests		Dixon (1940)
O'Neill Forebay Merced County	1990s			D. Shuford, pers. comm.
Palmdale Lake Los Angeles County	1990s	 small number		D. Shuford, pers. comm. Small (1994)
Ramer Lake Imperial County	recent years	5-10 nests		D. Anderson, pers. comm.
Sacramento NWR Glenn and Colusa counties	 recent years			Garrett and Dunn (1981) Small (1994)
Salton Sea Riverside County			mouth of Whitewater R.	Grinnell and Miller (1944) Garrett and Dunn (1981) Small (1994)
San Jacinto (Mystic) Lake Riverside County	1916		7 miles w. of Pennington	Nokes (1917)
San Luis NWR Merced County	2000s			D. Woolington, pers. comm.
Shasta Valley WA Siskiyou County	recent years	avg. 13 nests		R. Smith, pers. comm.

Table 1 (con't). Records of breeding *Aechmophorus* grebes in California before 2002.

Site	Years	Numbers	Comments	Source
Stockton San Joaquin County			before the Delta was reclaimed	Grinnell (1915)
South Wilbur Flood Area Kings County	1982	<50 pairs	flood year	G. Ivey, pers. observ.
Sutter Basin Sutter County	 1938?		 Sandborn Slough	Grinnell (1915) Moffitt (1938)
Sweetwater Res. San Diego County		 small number	 seems to occur through year, most Clark's	Garrett and Dunn (1981) Small (1994)
Thermalito Afterbay Butte County	at least past 20 years			J. Snowden and S. Cordes, pers. comms.
Topaz Lake Mono County	~1938 1963 1976	 nesting 75 adults major area		Moffitt (1938) S. Herman, pers. comm. Feerer and Garret (1976) Small (1994)
Tulare Lake Kings and Tulare counties	historic	large colonies		Cogswell (1977)
Tule Lake Siskiyou and Modoc counties		 major area		Bailey (1902) Small (1994)
Whitewater River Estuary Riverside County	recent years		declined since 1980	Small (1994)
Woodward Reservoir Stanislaus County	1990s			D. Shuford, pers. comm.

Current estimates of global populations are at least 110,000 western grebes and 10-20,000 Clark's grebes (Kushlan et al. 2000). No comprehensive surveys of nesting sites have been conducted, so these numbers are based on peak counts reported during the National Audubon Society's Christmas Bird Counts (CBC). Actual peak counts from CBCs are approximately 107,000 western grebes in 1990 and 3,750 Clark's grebes in 2003 (National Audubon Society 2004).

Available information on population trends is confounding, and it appears that no one source of information is adequate. Breeding Bird Survey (BBS) data from North America from 1966-2001 for these two species combined showed no significant trend throughout their breeding range in California or the western states (Sauer and Hines 2001). However, BBS data likely do not well represent population trends of most waterbird species. For example, BBS trends for sandhill cranes in Oregon for 1980-2000 showed a significant declining trend (-5.3%/year), while extensive breeding population surveys have documented a 22% increase in nesting pairs during the same period (Ivey and Herziger 2000).

There is evidence that breeding western grebes are declining in some regions (e.g., B.C.—Burger 1997, southern Manitoba—Koonz and Rakowski 1985, and Alberta—Hanus et al. 2002b). At Clear Lake, current breeding numbers are approximately 50% less than before contamination with DDD and mercury (D. Anderson, pers. comm.). At Malheur NWR, nest numbers for these two species combined indicated a significant declining trend (-126/year, $p < 0.01$) from 1980-98 (Ivey et al. in prep).

Data from CBCs for the west coast states and B.C. (where the majority of these birds winter) indicate declining trends for western grebes. I analyzed the index of birds counted per party-hour for the past 20 years (1984-2003). For the whole region, there is strong evidence of a significant decline of 0.23 grebes per party hour, per year ($t = -4.6580$, $p = 0.0002$). This is equivalent to a 5.3% annual decline or a range of 3.0-7.9% (95% confidence interval). When each state was analyzed individually, there was strong evidence of a significant decline in Oregon, Washington, and B.C., but not California (although the index was negative, $p = 0.55$). The Oregon data indicated a decline of 0.04/year ($t = -6.4763$, $p = 0.0001$), which is equivalent to a 4.5% annual decline (0.6-8.4%). For Washington, the data indicated a decline of 0.52/year ($t = -3.0803$, $p = 0.0065$), which is equivalent to a 5.5% annual decline (1.7-9.2%). Lastly, the B.C. data indicated a decline of 0.61/year ($t = -6.4763$, $p = 0.0001$), which is equivalent to a 12% annual decline (8.4-16.5%). These data include inland wintering sites and near-shore coastal areas, but do not account for grebes using off-shore pelagic regions. For Clark's Grebes, I analyzed data from 1991-2003 when it appeared that this species was differentiated on all counts (they were first distinguished in the count data in 1981; however, there is an apparent bias in earlier years in species separation). The index showed no significant trends.

Grebe numbers have only been monitored at a few important wintering areas. Western grebes in the Puget Sound of Washington declined 95% ($p < .0001$) between 1978 and 1999 (Nysewander et al. 2001). Conversely, in the pelagic zone of the Southern California Bight, *Aechmophorus* grebes have increased about 700% in the last two decades (Takekawa et al. 2004). These confounding data suggest that grebes may have shifted their wintering areas.

Threats to populations

Natural factors.——In the arid regions of the west, *Aechmophorus* grebes breed in lakes and wetlands which are very dynamic as precipitation patterns shift and result in extreme habitat changes from floods and droughts. When conditions are unfavorable at traditional breeding sites, they must move to alternate areas or forego breeding. Consequently, a large and widely distributed array of suitable nesting sites is needed within the landscape to maintain healthy populations of *Aechmophorus* grebes as well as other waterbird species. The availability of alternative suitable breeding habitats is critical for maintaining viable *Aechmophorus* grebe populations in the long term (Hanus et al. 2002b). In addition, waves created by wind fetch can destroy nests.

Habitat loss.——Historically, reclamation projects drained vast wetlands and significantly reduced options for breeding *Aechmophorus* grebes. Human demands for both agricultural and municipal water continue to threaten wetlands. Lower Klamath NWR, a historically important grebe colony site, has experienced recent loss of water during dry years as water rights are adjudicated in the Klamath Basin (D. Mauser, pers. comm.). Water acquisitions are needed to ensure a more secure supply for this refuge, which would result in increased wetland area and improved habitat for grebes and other wetland wildlife. Shoreline developments near nesting sites have also reduced suitable habitat for breeding colonies (Buffam 1964, Gould and Koplin 1971, Gould 1974, Lederer 1976, Burger 1997, Hanus et al. 2002a, 2002b). Cattle grazing can also result in degraded emergent nesting habitat (Gould and Koplin 1971, Burger 1997). Additional habitat threats include altered functioning of wetlands because of eutrophication, pollution, siltation, and the introduction of exotic fish (O'Donnel and Fjesda 1997).

Water management.——Maintenance of stable water levels during the nesting period is critical to successful production. Grebes build floating nests that are vulnerable to changes in water levels and they will usually abandon them if they become stranded on shore. Several important nesting sites are managed to provide irrigation supplies or for power generation, resulting in drastic drawdowns and the potential for considerable nest abandonment and predation of eggs and chicks. Education and cooperation is needed to convince reservoir managers at important breeding areas to limit water level drawdowns and fluctuations during the primary grebe nesting period.

Contaminants.——Since many chemicals accumulate in aquatic and marine food chains, contamination by urban, agricultural and industrial pollution continues to effect grebes. Because of their aquatic affinity and fish-eating habits, *Aechmophorus* grebes are particularly vulnerable and have been significantly impacted. Since the majority of these grebes winter in nearshore areas along the Pacific Coast, they are particularly vulnerable to mortality from oil spills which have killed large numbers of *Aechmophorus* grebes in this region (Smail et al. 1972, Speich and Thompson 1987, Bayer 1988, Roletto et al. 2000, and American Trader Trustee Council 2001). Those actually killed by spills are higher than reported in pickups as a portion of the dead birds are likely to sink, drift out to sea, or be removed by scavengers.

Bioaccumulations can also cause sublethal effects such as reducing eggshell thickness, potentially leading to reduced hatchability. Contaminants can likely reduce overall fitness for survival and therefore may effect populations as has been demonstrated in other fish-eating birds (e.g., common loons [*Gavia immer*]—Evers et al. 2002). In 1955, evidence of bioaccumulation causing significant mortality emerged when *Aechmophorus* grebes began to die off at Clear Lake following treatments with DDD for insect control. The breeding population before treatment was >1,000 nests (Hunt and Bischoff 1960), with large numbers of grebes found dead following application; only 30 remained in 1960 and only 16 nests were found in 1961 (Herman et al.1969). The DDD stress on Clear Lake is now much reduced, since much of the chemical has degraded. However, low level contamination with DDT and its breakdown products is persistent and still causing eggshell thinning at this site; the population has only recovered to about half its pre-DDD levels (D. Anderson, pers. comm.).

Aechmophorus grebes are also susceptible to heavy metals. High levels of mercury from an adjacent mine have impacted breeding grebes at Clear Lake where they contained about twice the mercury levels of birds from Eagle and Tule lakes and clearly exhibited lower reproductive success (0.06 chick:adult ratios for 1994—Elbert and Anderson 1998). However, following mine remediation activities, mercury no longer appears to be affecting productivity (Anderson et al. in prep). At Lake Berryessa (Napa County) in April 1982, liver samples examined from eight dead western grebes were found to have harmful concentrations of mercury in their kidneys, which may have contributed to their death (Litrell 1991). The infamous western grebe die-off at Clear Lake may have been due to an unrecognized multiple stress from mercury and other contaminants, rather than DDD alone (Suchanek et al. 2002).

A variety of other contaminants could cause problems for these grebes. In the Puget Sound of Washington, significant levels of mercury, arsenic, DDE, PCBs and chlordane accumulations were found in wintering *Aechmophorus* grebes (Henny et al. 1990). Off the coast of B.C., large wintering flocks are threatened by chemical pollution (Burger 1997). At Bear River MBR, elevated levels of DDE, PCBs and DDD were documented in grebes in the mid-1970s (Lindvall and Low 1979), and although DDE levels correlated with eggshell thickness, no effects on productivity were observed (Lindvall and Low 1980).

Disturbance.——The colonial nesting behavior of *Aechmophorus* grebes amplifies their sensitivity to human disturbance (Forbes 1988). Adults are kept away from nests which can lead to mortality of eggs or chicks from hypothermia or hyperthermia and also can also facilitate increased predation. Disturbance at the end of the nesting season is particularly harmful because late-nesting birds don't have time to renest. Recreational boating disturbance has been implicated in the loss of historic nesting areas in B.C. (Burger 1997), and reduced productivity at several sites in California.

Disease.——Although diseases are a naturally-occurring phenomena, the rates of outbreaks appear to be increasing at some sites. There is speculation that elevated salinities and nutrient loads have amplified the frequency of botulism at the Salton Sea (U.S. Fish and Wildlife Service 2000) where some of these grebes winter. Some diseases relatively new to the west, such as Exotic Newcastle's Disease and West Nile Virus, could have significant impacts on *Aechmophorus* grebes. It is likely that the grebes' susceptibility to various diseases is increased when they are exposed to contaminants which lower their fitness for survival as has been shown for marine birds (e.g., Schreiber and Burger 2002, Chapter 15).

Summary of recent conservation actions

Four North American Joint Ventures cover the breeding and wintering ranges of *Aechmophorus* grebes in California: Central Valley (CVJV—Central Valley Joint Venture 2004), Intermountain West (IWJV—Intermountain West Joint Venture 2004), Pacific Coast (PCJV—Pacific Coast Joint Venture 2004), and San Francisco Bay Joint Ventures (SFBJV—San Francisco Bay Joint Venture 2004). These Joint Ventures develop partnerships among private and public individuals, groups, and agencies to achieve common goals of restoration, conservation, and protection of wetland habitats. They have recently expanded their missions to allow consideration of habitat needs of all birds (including waterbirds). Wetland projects to enhance grebe breeding and wintering sites should be coordinated with the Joint Ventures because they have sources of funding through grants. The IWJV was established in 1994 (Ratti and Kadlec 1992), and has led to many wetland projects that have likely improved habitats for breeding grebes. For example, restoration projects at Tule Lake NWR have provided seasonal wetlands which are used as nesting sites by *Aechmophorus* grebes (D. Mauser, pers. comm.).

The North American Waterbird Conservation Plan (Kushlan et al. 2000), an initiative to advance the conservation of waterbirds and their habitats, will further assist in the achievement of *Aechmophorus* grebe conservation goals. A partnership of non-governmental agencies, private individuals, academics, and federal and state governmental agencies will develop the regional waterbird plans. A plan is which includes the Intermountain West portions of California (Sierra

Nevada and Great Basin Bird Conservation Regions) is currently underway (Ivey and Herziger in prep).

The World Conservation Union (IUCN) Species Survival Commission's *Grebes: Status, Survey and Conservation Action Plan* includes these two grebe species and proposes identification and protection of key international sites for *Aechmophorus* grebes (O'Donnel and Fjeldsa 1997). Specific recommendations include conservation of important wintering sites along the west coast of North America, and evaluation of the potential of western grebes as keystone indicators of wetland health and wetland bird population trends in North America.

STUDY AREA

Aechmophorus grebe colonies were investigated at several lakes and reservoirs in northern California in 2002 and 2003. The primary sites surveyed were Eagle Lake (elevation 5,100'), Tule Lake NWR (4,050'), Clear Lake (1,326'), Lake Almanor (4,600'), Thermalito Afterbay (140'), Bridgeport Reservoir (6,466'), Goose Lake (4,733'), Lower Klamath NWR (4,050'), and East Park Reservoir (1,131') (Figure 2). Most of these sites are considered in the Intermountain West Region Waterbird Conservation Plan (Ivey and Herziger in prep.), except for Clear Lake, Thermalito Afterbay, and East Park Reservoir which will be incorporated into a different plan in the future. The approximate lat-long coordinates of each colony are listed in Table 2, and maps of each site in Figures 3-10.

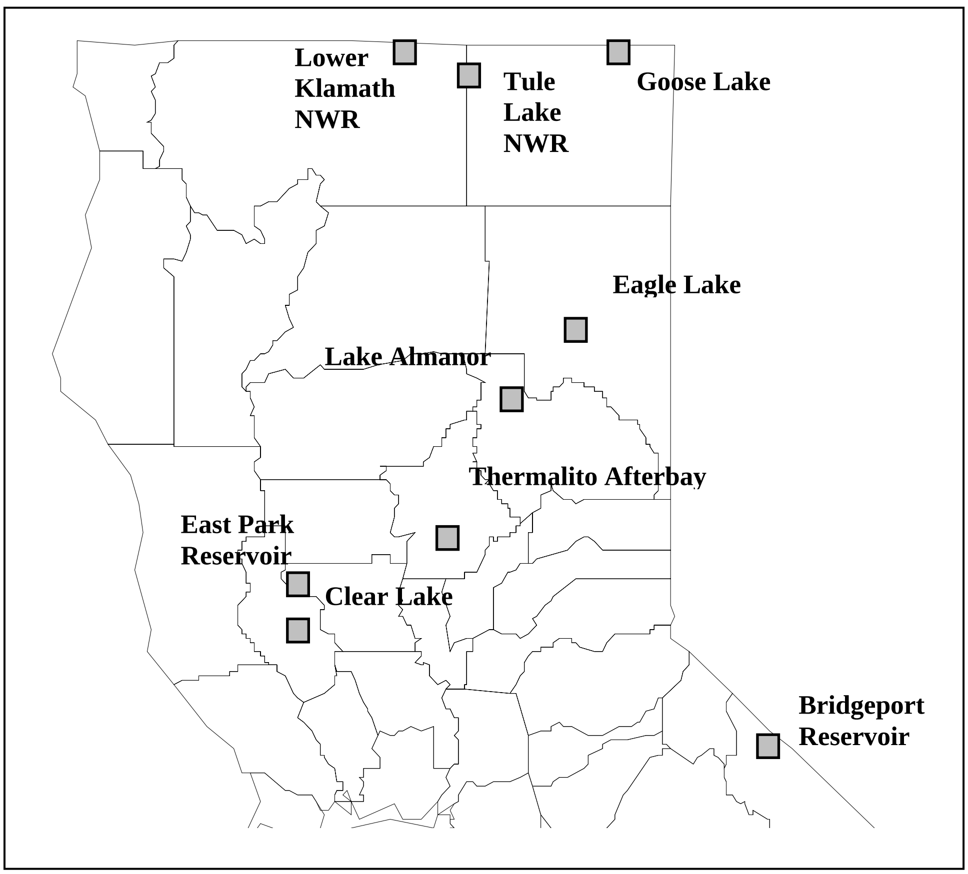


Fig. 2. Locations of *Aechmophorus* grebe colonies surveyed in California, 2003.

Table 2. Approximate lat-long coordinates of California *Aechmophorus* grebe colonies assessed in 2003.

Site	Latitude	Longitude
Eagle Lake		
North Basin	40° 39' 57" N	120° 40' 03" W
Spaulding	40° 39' 01" N	120° 45' 48" W
Troxel Bay	40° 39' 24" N	120° 41' 59" W
Tule Lake NWR		
Northeast Sump 1A	41° 56' 18" N	121° 31' 08" W
Southwest Sump 1A	41° 53' 01" N	121° 32' 31" W
West Sump 1A	41° 54' 01" N	121° 32' 50" W
Clear Lake		
Anderson Marsh	38° 55' 26" N	122° 38' 32" W
Long Tule Point	39° 02' 02" N	122° 51' 30" W
Oaks Arm	39° 00' 38" N	122° 40' 09" W
Rodman Slough North	39° 07' 08" N	122° 53' 10" W
Rodman Slough South	39° 06' 60" N	122° 53' 06" W
Lake Almanor		
Causeway	40° 18' 41" N	121° 12' 24" W
Chester	40° 17' 46" N	121° 13' 02" W
West Shore	40° 15' 44" N	121° 14' 11" W
Thermalito Afterbay		
East	39° 28' 19"N	121°38' 38" W
West	39° 29' 03"N	121°39' 45" W
Bridgeport Reservoir	38° 16' 34"N	119°13' 19" W
Goose Lake	41° 59' 34"N	120° 19' 41" W
Lower Klamath NWR		
Unit 3A	41° 59' 22" N	121° 32' 50" W
Unit 12C	41° 54' 14" N	121° 40' 10" W
East Park Reservoir	39° 19' 11"N	122° 29' 28" W

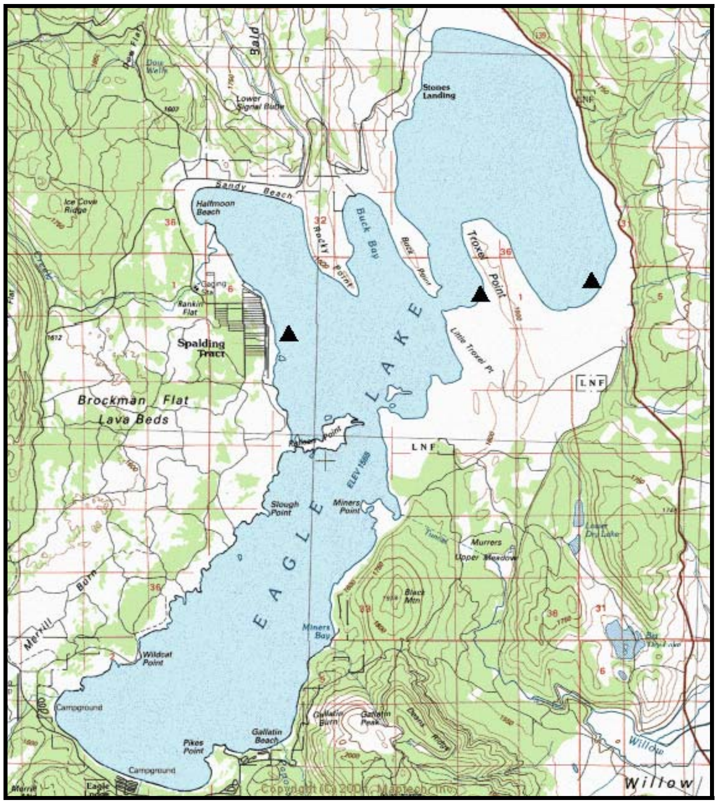


Fig. 3. Approximate locations of *Aechmophorus* grebe nesting colonies at Eagle Lake, Lassen County, California, 2003.

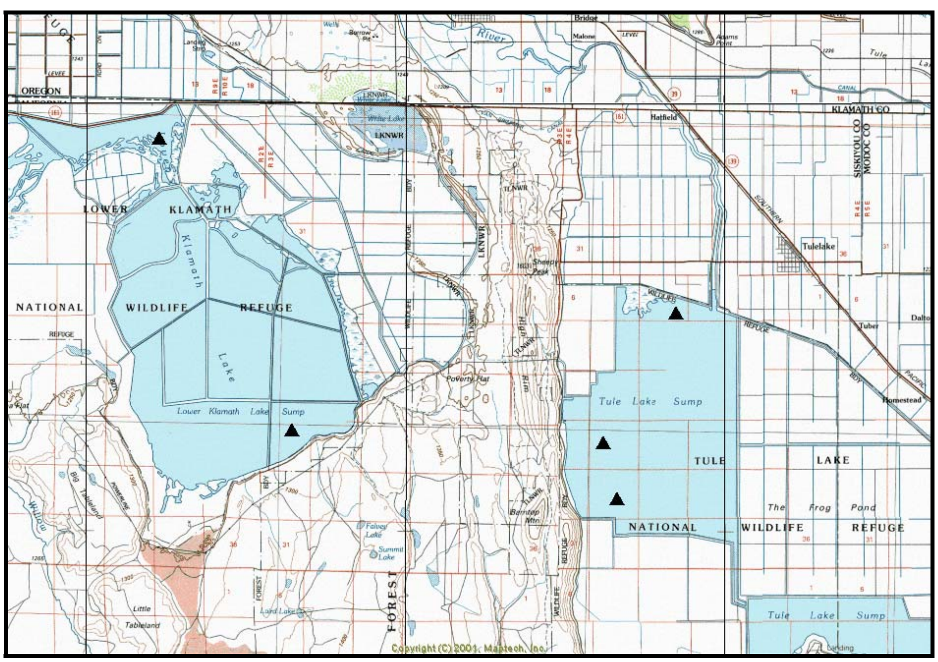


Fig. 4. Approximate locations of *Aechmophorus* grebe nesting colonies at Tule Lake and Lower Klamath National Wildlife Refuges, Siskiyou and Modoc counties, California, 2003.

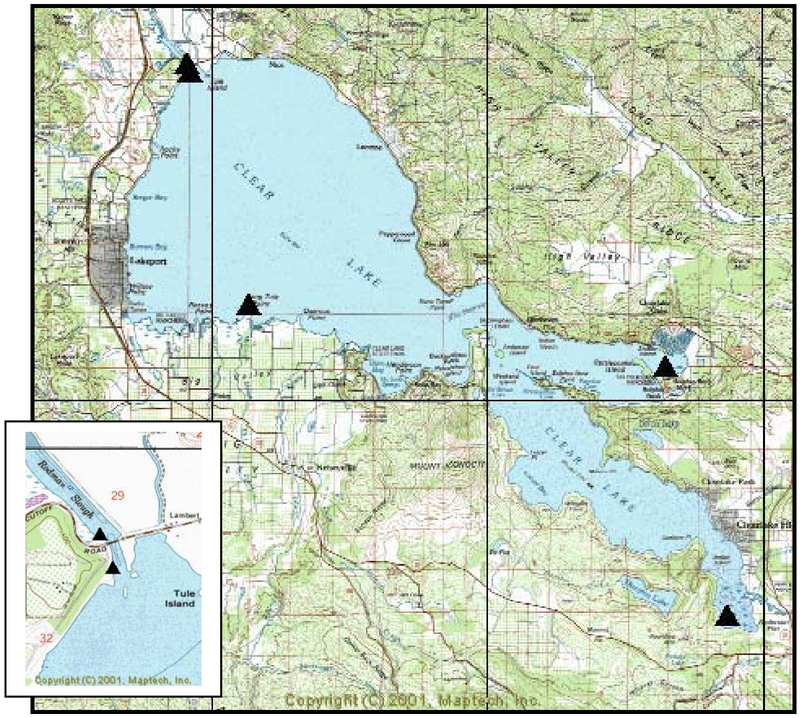


Fig. 5. Approximate locations of *Aechmophorus* grebe nesting colonies at Clear Lake, Lake County, California, 2003.

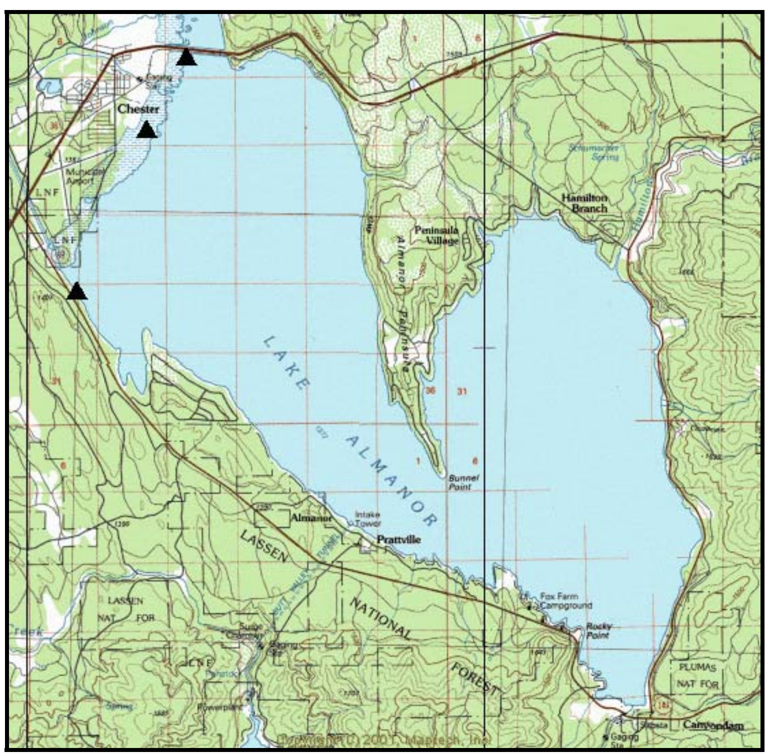


Fig. 6. Approximate locations of *Aechmophorus* grebe nesting colonies at Lake Almanor, Plumas County, California, 2003.

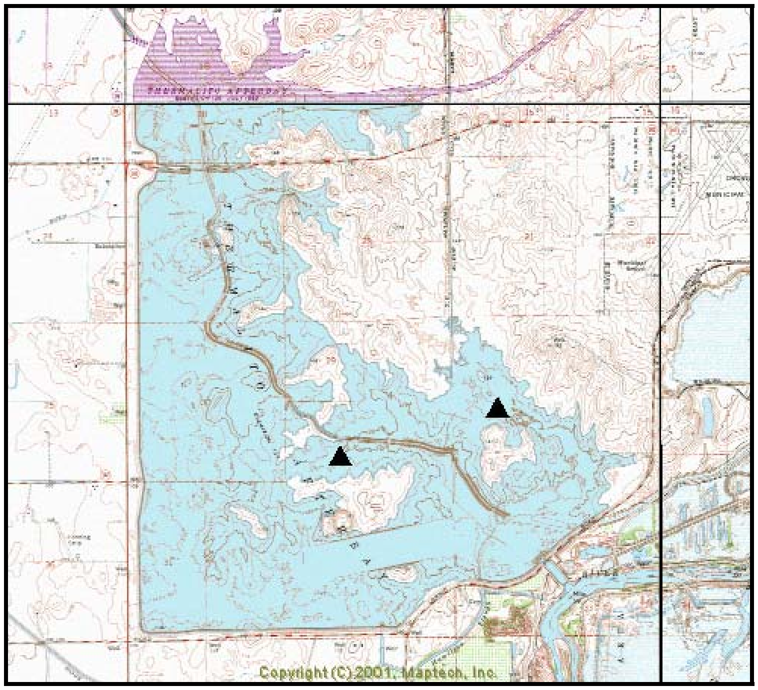


Fig. 7. Approximate locations of *Aechmophorus* grebe nesting colonies at Thermalito Afterbay, Butte County, California, 2003.

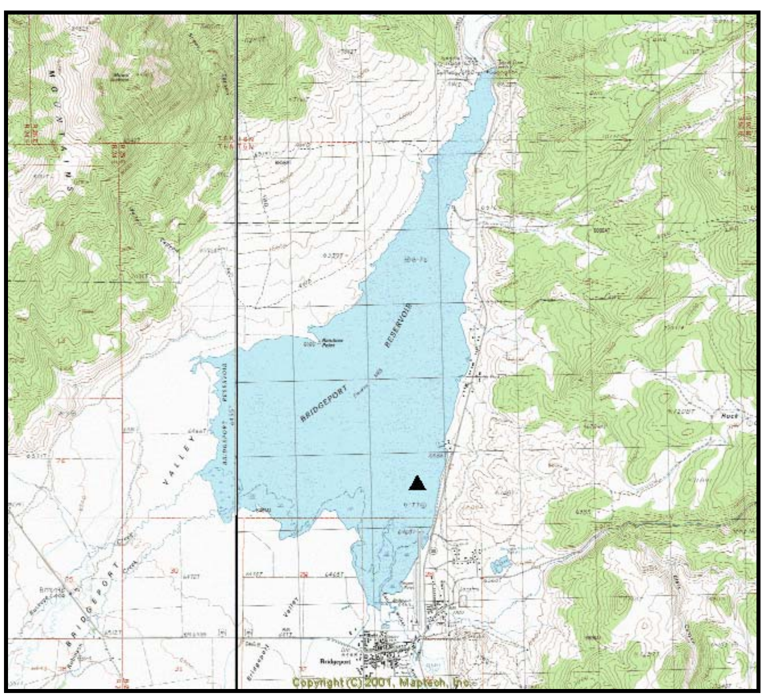


Fig. 8. Approximate locations of *Aechmophorus* grebe nesting colony at Bridgeport Reservoir, Mono County, California, 2003.

Fig. 9. Approximate locations of *Aechmophorus* grebe nesting colony at Goose Lake, Modoc County, California, 2003.

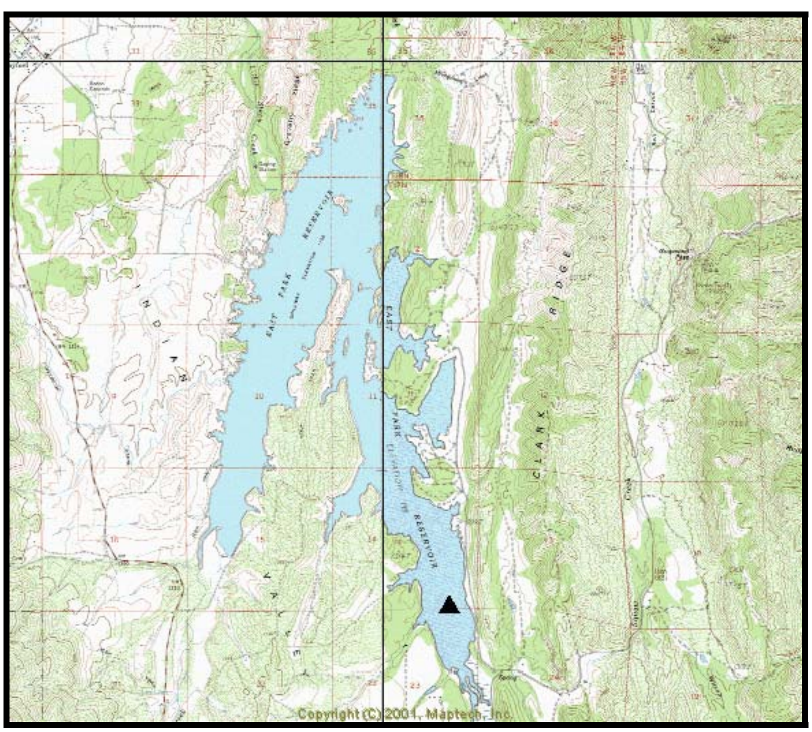


Fig. 10. Approximate location of *Aechmophorus* grebe nesting colony at East Park Reservoir, Colusa County, California, 2003.

METHODS

A variety of field survey techniques were used to locate *Aechmophorus* grebe colonies and estimate number of nests, reproductive success, nesting and fledging chronology, and species composition. In 2002, field work was limited because the contract was not awarded until late in the breeding season. On 28 August, reconnaissance was conducted of Goose Lake (using an airboat), Eagle Lake (with spotting scope from the shore), and a nest survey of Lake Almanor (also with a spotting scope). On 29 August, reconnaissance was made of Topaz Lake where grebes had been reported nesting historically. Lake Almanor was revisited on 11 October.

In 2003, most colonies were located via aircraft, and counted by a skilled bird surveyor (I have over 20 years experience conducting aerial waterbird and waterfowl surveys) from an altitude of approximately 100 m while flying at a speed of about 100 mph. On 5 August, sites in the Central Valley which had recent sightings or potential habitat were surveyed: Black Butte Reservoir (Glenn County), Clear Lake (Lake County), Clifton Court Forebay (Contra Costa County), Comanche Reservoir (San Joaquin County), East Park Reservoir, Indian Valley Reservoir (Lake County), Lake Berryessa, Lake Pillsbury (Lake County), Los Baños Creek Reservoir (Merced County), Los Vaqueros Reservoir (Contra Costa County), Modesto Reservoir (Stanislaus County), O'Neill Forebay (Merced County), Stony Gorge Reservoir (Glenn County), Thermalito Afterbay, Turlock Reservoir (Stanislaus County), and Woodward Reservoir (Stanislaus County). Another flight on 19 August covered northern California sites: Eagle Lake, Goose Lake, Lake Almanor, Lake Leavitt (Lassen County), and Mountain Meadows Reservoir (Lassen County).

Further assessment of sites was focused on areas where nests had been located on the flights from 17 – 25 August using a spotting scope from shore. At Mountain Meadows Reservoir, only chicks were noted from the air, so no further surveys were conducted. Tule Lake and Lower Klamath NWRs were surveyed by refuge staff using airboats, but also monitored by myself from shore. Several other minor colonies in northern California (supporting less than 10 nests each) were reported by local biologists.

To determine nesting success and assess fates, a sample of nests was examined at Eagle Lake on 23 August using a float tube. I selected this site because of its high importance to grebes; no formal data was collected at other sites. Nests were considered successful if at least one egg hatched, as evidenced by fragments of egg shell membranes. If there was no indication of hatching and depredated eggs were found in the nest bowl, nests were considered failed. Those which contained no egg fragments were classified as an unknown fate; however, these were most likely unsuccessful as eggs may have been removed by predators or wave action.

To derive indices of productivity, classify adults to species, and to determine brood size distribution, and nest initiation, hatching, and fledging periods, brood counts were conducted as well. Complete coverage could not be accomplished in one day for several large sites; therefore, a series of transects were used. Boat or canoe surveys were conducted from 10 September-20 September along five transects at Clear Lake, nine transects at Eagle Lake, the west half of Lake Almanor, and the main body of Thermalito Afterbay. Using a spotting scope from the shore, counts were conducted on about 80% of Bridgeport Reservoir on 21 September, but because of the long distances, chick sizes and species were not classified. Ideally, complete counts would yield more accurate estimates of these parameters.

Broods were classified using methodology developed by D. Anderson of U.C. Davis which he has used for several years at Clear Lake and Eagle Lake. This technique involves using a motorboat traveling at a speed of about 5 mph along transects and classifying all grebes observed within 100 m. Chick size was based on comparison with parents and assigned one of the following classes: one-quarter, one-third, one-half, two-thirds, seven-eighths and full size. Chick growth data from Ratti (1977) were used to assign ages to various brood classes for estimating nest initiation, hatching and fledging chronology.

RESULTS

Colony size

In 2003, estimates of breeding populations from selected sites totaled 7,334 adults (Table 3). Total nest numbers were likely higher, because estimates were mostly derived from single surveys, and at least at Eagle Lake and Thermalito Afterbay, some nests had hatched before the survey date. Also, in 2002, I visited Lake Almanor and observed many more nests at the West Shore site (850), with some birds still actively building nests.

Table 3. Estimated breeding populations of *Aechmophorus* grebes at selected sites in California, 2003.

Site	Colony	Number of nests	Total nests	Population estimate
Eagle Lake				
	North Basin	1,100		
	Troxel Bay	450		
	Spaulding	250		
	Total		1,800	3,600
Tule Lake NWR[1]		636	636	1,272
Clear Lake (Lake County)				
	Long Tule Point	350		
	Anderson Marsh	70		
	Oaks Arm[2]	25		
	Rodman Slough N/S	25		
	Total		470	940
Lake Almanor				
	Chester	320		
	West Shore	112		
	Causeway	8		
	Total		440	880
Thermalito Afterbay				
	West	90		
	East	5		
	Total		95	190
Bridgeport Reservoir		80	80	160
Goose Lake		60	60	120
Lower Klamath NWR[1]		37	37	74
East Park Reservoir		20	20	40
Mountain Meadows Reservoir [3]		~10	10	20
Indian Tom Lake[4]		9	9	18
Kern NWR[5]		~5	5	10
Ramer Lake[6]		~5	5	10
Totals			**3,667**	**7,334**

[1]U.S. Fish and Wildlife Service data.
[2]Estimated from broods observed on 10 September 2003 flight.
[3]Estimated from broods observed on 19 August 2003 flight.
[4]D. Shuford, pers. comm.
[5]D. Hardt, pers. comm.
[6]D. Anderson, pers. comm.

Relative importance of sites surveyed

Eagle Lake.——Eagle Lake is a very important *Aechmophorus* grebe nesting site, supporting numbers believed to be among the highest in the world (Gould 1974, Shaw 1998). Recent estimates of nest numbers have ranged from 1,134 in 1997 to 2,487 in 1996 (Figure 11), averaged 1,639 from 1970-97 (Shaw 1998), and 1,807 from 1996-2003. This represents about 2.8% of the global population, and 22% of the grebe populations breeding in the Intermountain West (portions of 11 states) (Ivey and Herziger in prep). Based on the limited numbers from most other sites in California reported in recent years, it is likely the largest breeding area in the state. In 2003, it hosted 49.1% of the population of the selected sites.

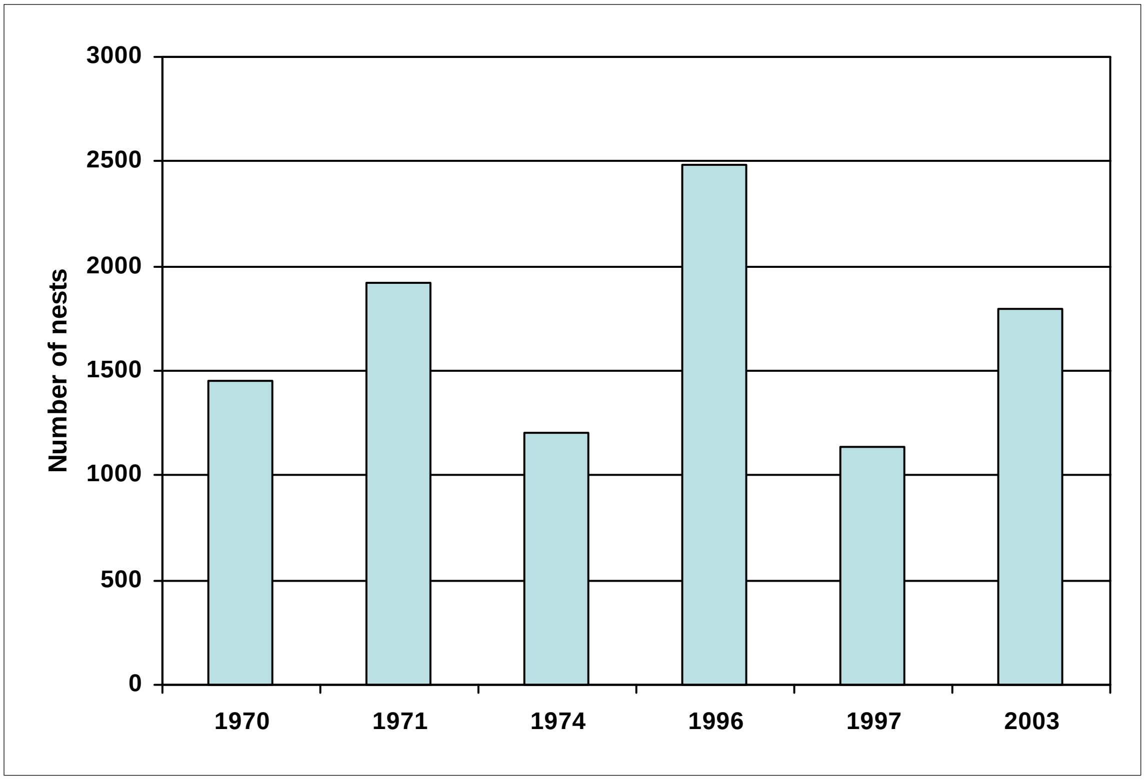


Fig. 11. Estimated nest numbers of *Aechmophorus* grebes from Eagle Lake, Lassen County, California (1970-71—Gould 1974, 1974—Lederer 1976, 1996-97—Shaw 1998, 2003—GLI).

Tule Lake NWR.—— This refuge represented 7.8% of the breeding population in the Intermountain West (Ivey and Herziger in prep), and the second highest number of the selected sites (17.3%).

Clear Lake.—— This site was the third most important of the selected sites (12.8%); however, it has not yet recovered its pre-DDD population levels of over 1,000 nests.

Lake Almanor.——This site represented 5.4% of the *Aechmophorus* grebes in the Intermountain West (Ivey and Herziger in prep). It was the fourth most important of the selected sites with 440 nests (12.0%), although 2002 numbers (850) were higher than both Tule Lake NWR and Clear Lake in 2003 (636 and 470, respectively).

Thermalito Afterbay and Bridgeport Reservoir.——Bridgeport Reservoir represented 1.0% of the population in the Intermountain West (Ivey and Herziger in prep.). Both these sites hosted moderate numbers of nesting *Aechmophorus* grebes in 2003, with 2.6% and 2.2% of the selected sites, respectively.

Goose Lake.——Sixty nests (1.6%) were found on a flight of both sides of the state line in 2003 (all nests were in California), representative of 0.7% of the Intermountain West (Ivey and Herziger in prep.). Ground surveys revealed that all nesting birds were Clark's. However, almost 600 Clark's grebes were counted during the breeding season in 1977 (Ratti 1979); this decline may be due to loss of habitat (see Discussion).

Other sites.——Lower Klamath NWR, East Park Reservoir, and Mountain Meadows Reservoir all had 1.0% or less of the grebes surveyed at the selected sites, representing 0.5% of the Intermountain West population for Lower Klamath NWR, and 0.1% for Mountain Meadows Reservoir.

Colony and nest habitat

Eagle Lake.——Nests were built within dense stands of hardstem bulrush and constructed of bulrush, sago pondweed, and bladderwort (Figures 12-15). Water depths at nest sites ranged from approximately 1-2 m. The bulrush likely buffered the negative effects of waves on nests to some extent. An additional colony site at the mouth of Pine Creek (northeast of Spaulding) which has been active in recent years (Sardella 2002) was not used in 2003.

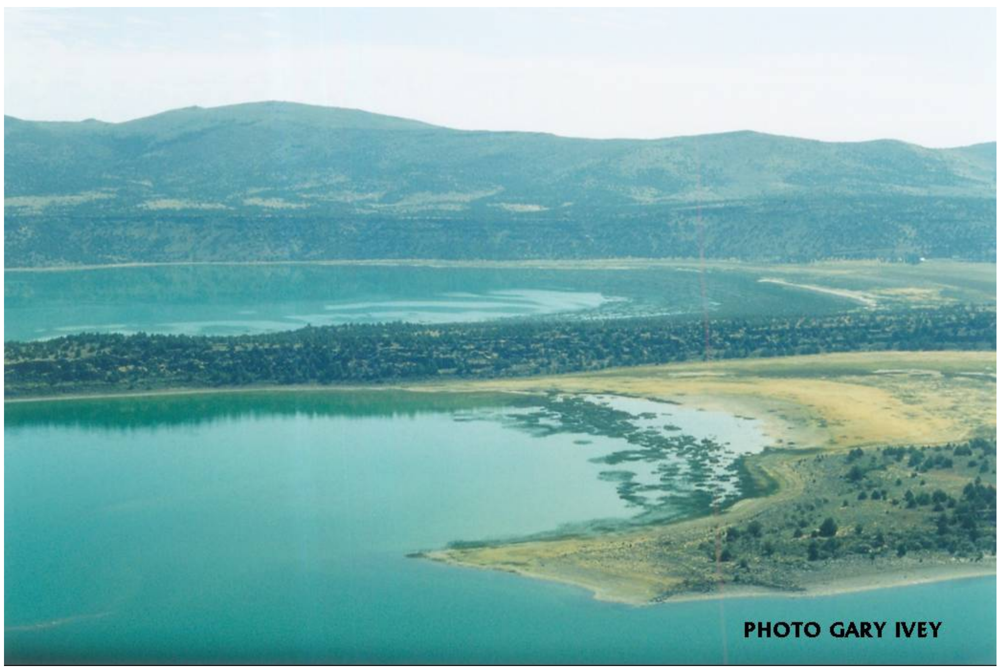


Fig. 12. Troxel Bay (foreground) and North Basin (background) *Aechmophorus* grebe colony sites at Eagle Lake, Lassen County, California, 2003.

Fig. 13. ***Aechmophorus*** **grebe nests in hardstem bulrush at the North Basin colony, Eagle Lake, Lassen County, California, 2003.**

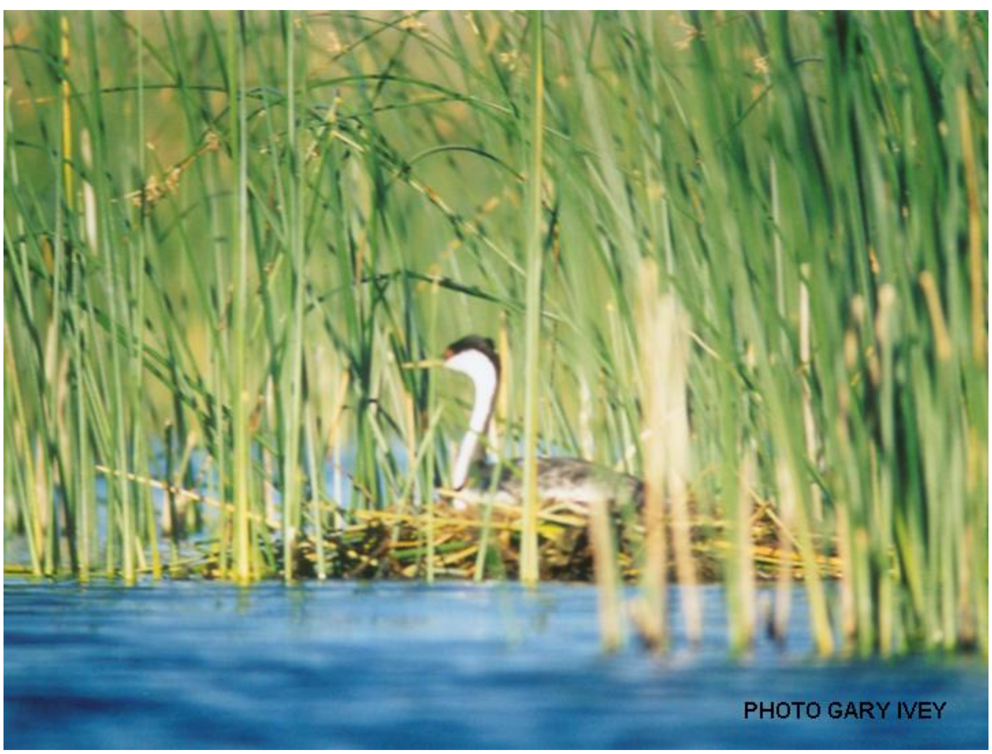


Fig. 14. Western grebe on nest at Eagle Lake, Lassen County, California, 2003.

Fig. 15. *Aechmophorus* grebe nest at Eagle Lake, Lassen County, California, 2003.

Tule Lake and Lower Klamath NWRs.——Nests were built within dense stands of hardstem bulrush, and constructed of bulrush and sago pondweed. Water depths at nest sites ranged from approximately 0.5-1.0 m (D. Mauser, pers. comm.).

Clear Lake.——At the Long Tule Point and Anderson Marsh colony sites, nests were built along the margins of dense stands of hardstem bulrush (Figure16). Nests at the two Rodman Slough colonies and Oaks Arm were more out in open water areas in beds of submerged aquatic plants (Figure 17). Nests were built of bulrush and various pondweeds and other aquatic plants.

Fig. 16. Anderson Marsh colony showing *Aechmophorus* grebes (white spots) on nests, Clear Lake, Lake County, California, 2003.

Fig. 17. Western grebe on nest at Rodman Slough colony, Clear Lake, Lake County, California, 2003.

Lake Almanor.——Nests were built in shallow (< 0.5 m depth), open water about 70 m from shore, in vast beds of pondweeds (*P. nodosus, P. crispus, P. pectinatus*) which had leaves extending to the surface (Figures 18-19). Although there was moderate boat activity on the lake, the shallow water and large area of aquatic plants apparently protected nests as waves were dampened before they reached the colony (Figure 18).

Fig. 18. *Aechmophorus* grebes building nests at the West Shore colony site at Lake Almanor, 17 August 2003 (note the dampening of waves by vegetation in the shallow waters of the site).

Fig. 19. Lake Almanor's West Shore *Aechmophorus* grebe colony, 17 August 2003.

Thermalito Afterbay.——Nests were built within dense stands of long-leaf pondweed, using the same for nesting material. Both colony sites were in narrow bays which were protected from wind fetch and waves (Figure 20).

Fig. 20. Clark's grebe on nest at West Colony site, Thermalito Afterbay, Butte County, California, 2003.

Bridgeport and East Park Reservoirs.——Nests at both these sites were built in dense stands of water smartweed using the same for nest material (Figures 21-23).

Fig. 21. *Aechmophorus* grebe nesting habitat (water smartweed) at Bridgeport Reservoir, Mono County, California, 2003.

Fig. 22. *Aechmophorus* grebe nests at Bridgeport Reservoir, Mono County, California, 2003.

Fig. 23. *Aechmophorus* grebe habitat at East Park Reservoir, Colusa County, California, 2003.

Goose Lake.——Nests were built in sparse stands of hardstem bulrush among dense beds of flat-stem pondweed (*P. zosteriformis*), using both for nesting material (Figures 24-26). Water depths at nest sites ranged from 0.3 to 0.6 m.

Fig. 24. Aerial view of Clark's grebe colony among the hardstem bulrush stands at Goose Lake, Modoc County, California, 2003.

Fig. 25. Clark's grebe on nest at Goose Lake, Modoc County, California, 2003.

Fig. 26. Clark's grebe nest with eggs at Goose Lake, Modoc County, California, 2003.

Nest success

Eagle Lake.——On 23 August 2003, a sample of 250 nests was checked, of which 23 were still actively being incubated. Fates of the other 227 nests were 118 (52%) hatched, 15 (6.6%) showed evidence of depredation and 94 (41.4%) lacked eggs or had eggshell fragments which indicated failure. Therefore, the apparent nest success rate was estimated at 52% which is within the range reported for 2001-02 at this site (44-58%—Sardella 2002). Four eggs were found floating in water (Figure 27), and it is likely that they were washed out of nests by waves, contributing to the high percentage of undetermined fates.

Fig. 27. *Aechmophorus* grebe nest showing egg floating in water at Eagle Lake, Lassen County, California, 2003.

Clear Lake.——While the Long Tule Point colony supported an estimated 350 nests on 5 August, no evidence remained when P. Kelly and I returned via canoe on 20 August and their fate is unknown. Nests were probably abandoned for some reason and wind and waves destroyed the nest platforms.

Lake Almanor.——There was evidence of almost total failure of the colonies here due to declining water levels. On the initial visit on 23 August 2002, 850 nests were present, but by 11 October, most had been stranded on shore and only a few chicks were noted. Water levels had drastically dropped 0.79 m (Project 2105 Committee 2003). It is very likely that most nests in the colony were abandoned due to diminishing levels as nest being built during the first visit would not have hatched until the third week of September.

This event occurred again in 2003. While there were active nests and some new construction on 17 August, on 21 September, water levels had significantly declined, and both the West Shore and Chester colony nests had been stranded on shore. I noted evidence of depredated eggs, but the birds probably abandoned due to a 1.25 m decline in lake levels and depredation likely occurred afterwards. Water level declines during incubation are a critical issue for grebes nesting here.

Other areas.——No nest success data was collected at other sites.

Brood surveys

These data allow for derivation of two indices of productivity: chicks per brood and chicks per adult. The brood index is likely biased because broods are split by the parents. The second index is only valid if no significant immigration or emigration has taken place during the breeding season. If total counts could be conducted at all sites, estimates of young per pair would provide better productivity information; however, there are logistical problems in collecting this data in a timely manner at larger sites. Such surveys would require more than one crew and careful coordination would be necessary to cover large areas such as Eagle and Clear lakes. Therefore, chick:adult indices are discussed below. Results of brood surveys are summarized in Table 4.

Lake Almanor.——This was the site with the lowest productivity (0.10 chick:adult). Such a poor rate was likely due to lowered water levels and would not maintain a population in the long term.

Clear Lake.——There was low productivity here as well (0.19), which supports my suspicion of failure in the largest colony (350 nests) at Long Tule Point. This may be due in part to boating disturbance as well as the lingering effects of DDD and mercury contamination.

Eagle Lake and Bridgeport Reservoir.——Relatively good productivity was recorded at these sites (0.47 and 0.56, respectively). Historic and 2003 data for Eagle Lake has ranged from 0.11 to 0.62, and averaged 0.43 (Table 5).

Thermalito Afterbay.——This site had the highest productivity index (0.64). However, there was a strong bias in the data because failed breeders apparently had departed the site before brood counts were conducted, resulting in inflated indices; only 156 adults were present and should have been much higher based on the nest surveys and brood chronology information (see Discussion).

Other areas.——No formal brood counts were conducted at other sites; however, broods were abundant at Tule Lake NWR along the tour route at the south end of Sump 1A in late August 2003 and most adults I observed had chicks.

Table 4. Brood surveys of *Aechmophorus* grebes at selected lakes in California, 2003.

Species	Western grebe	Clark's grebe	Totals
Eagle Lake[1]			
Single adults	389	124	513
Barren pairs	64	12	76
Pairs with broods	220	63	283
Singles with broods	133	63	196
Total broods	353	126	479
Total chicks	492	178	670
Chicks:brood	1.39	1.41	1.40
Total adults	1090	337	1427
Chick:adult	0.45	0.53	0.47
Clear Lake[1]			
Single adults	174	105	279
Barren pairs	153	63	216
Pairs with broods	112	17	129
Singles with broods	19	7	26
Total broods	131	24	155
Total chicks	153	38	191
Chicks:brood	1.17	1.58	1.23
Total adults	723	272	995
Chick:adult	0.21	0.14	0.19
Lake Almanor			
Single adults	745	6	751
Barren pairs	45	3	48
Pairs with broods	67	0	67
Singles with broods	22	0	22
Total broods	89	0	89
Total chick	101	0	101
Chicks:brood	1.13	0	1.13
Total adults	991	12	1003
Chick:adult	0.10	0	0.10
Thermalito Afterbay			
Single adults	17	17	34
Barren pairs	7	5	12
Pairs with broods	13	14	27
Singles with broods	11	33	44
Total broods	24	47	71
Total chicks	37	63	100
Chicks:brood	1.5	1.3	1.41
Total adults	68	88	156
Chick:adult	0.54	0.72	0.64
Bridgeport Reservoir[2]			
Single adults			47
Barren pairs			12
Pairs with broods			60
Singles with broods			34
Total broods			94
Total chicks			128
Chicks:brood			1.36
Total adults			225
Chick:adult			0.56

[1]D. Anderson, unpub. data.
[2]Species not classified because of long distances.

Table 5. Productivity (chick to adult index) at Eagle Lake, California, 1971-2003.

Year	Chick:adult index	Source
1971	0.47	Gould (1974)
1994	0.47	Elbert and Anderson (1998)
1996	0.62	Shaw (1998)
1997	0.11	Shaw (1998)
2003	0.47	D. Anderson, unpub. data

Nesting and fledging chronology

It is important to know the range of dates when grebes are actively nesting, rearing broods, and when chicks are fledging in order to plan the timing of conservation measures. Table 6 summarizes brood size data and these periods, while Figures 28 and 29 illustrate estimated nesting and brooding chronology. The earliest nests were initiated during the third week of June at Eagle Lake and Lake Almanor. Although these sites are at higher elevations, the availability of nesting vegetation in 2003 may have affected nest initiation timing; Lederer (1976) reported that high water levels at Eagle Lake in 1974 caused delayed nesting of up to one month. Nests begun after 10 July possibly represent renesting attempts. Previous studies at Eagle Lake found initiation during the first week of June in 1970-71 (Gould 1974), the first week of July in 1996 (Shaw 1998) and 14 June in 1997 (Shaw 1998). Fledging chronology at all sites indicated broods hatched as early as the second week of July and some would have remained flightless until late November.

Table 6. Estimated size classes of *Aechmophorus* grebe broods and estimated initiation, hatch, and fledge periods at selected lakes in California, 2003.

Size class	Number of broods	Initiation period	Hatch period	Fledge period
Eagle Lake[1]				
1/4 (~3-12 days)	11	12-22 Aug	6-15 Sept	15-24 Nov
1/3 (~13-18days)	7	7-21 Aug	31 Aug-5 Sept	9-14 Nov
1/2 (~19-23 days)	58	2-6 Aug	26-30 Aug	4-8 Nov
2/3 (~24-33 days)	212	23 July-1 Aug	16-25 Aug	25 Oct-3 Nov
7/8 (~34-50 days)	164	6-22 July	30 July-15 Aug	8-24 Oct
Full size (~51-70 days)	27	16 June-5 July	10-29 July	24 Sept-7 Oct
Clear Lake[1]				
1/4 (~3-12 days)	42	3-12 Aug	27 Aug-5 Sept	5-14 Nov
1/3 (~13-18days)	16	28 July-2 Aug	21-26 Aug	30 Oct-4 Nov
1/2 (~19-23 days)	53	23-27 July	16-20 Aug	15-29 Oct
2/3 (~24-33 days)	36	13-22 July	6-15 Aug	28 Sept-14 Oct
7/8 (~34-50 days)	8	26 June-12 July	20 July-5 Aug	14-27 Sept
Full size (~51-70 days)	0			
Lake Almanor				
1/4 (~3-12 days)	2	13-23 Aug	7-17 Sept	16-25 Nov
1/3 (~13-18days)	0			
1/2 (~19-23 days)	22	3-7 Aug	27-31 Aug	5-9 Nov
2/3 (~24-33 days)	18	24 July-2 Aug	17-26 Aug	26 Oct-3 Nov
7/8 (~34-50 days)	11	6-23 July	31 July-16 Aug	9-25 Oct
Full size (~51-70 days)	2	17 June-6 July	11-30 July	25 Sept-8 Oct
Not aged due to distance	34			
Thermalito Afterbay				
1/4 (~3-12 days)	0			
1/3 (~13-18days)	0			
1/2 (~19-23 days)	4	4-8 Aug	28 Aug-1 Sept	6-10 Nov
2/3 (~24-33 days)	25	25 July-3 Aug	18-27 Aug	27 Oct-4 Nov
7/8 (~34-50 days)	42	7-24 July	1-17 Aug	10-26 Oct
Full size (~51-70 days)	0			

[1]D. Anderson, unpub. data.

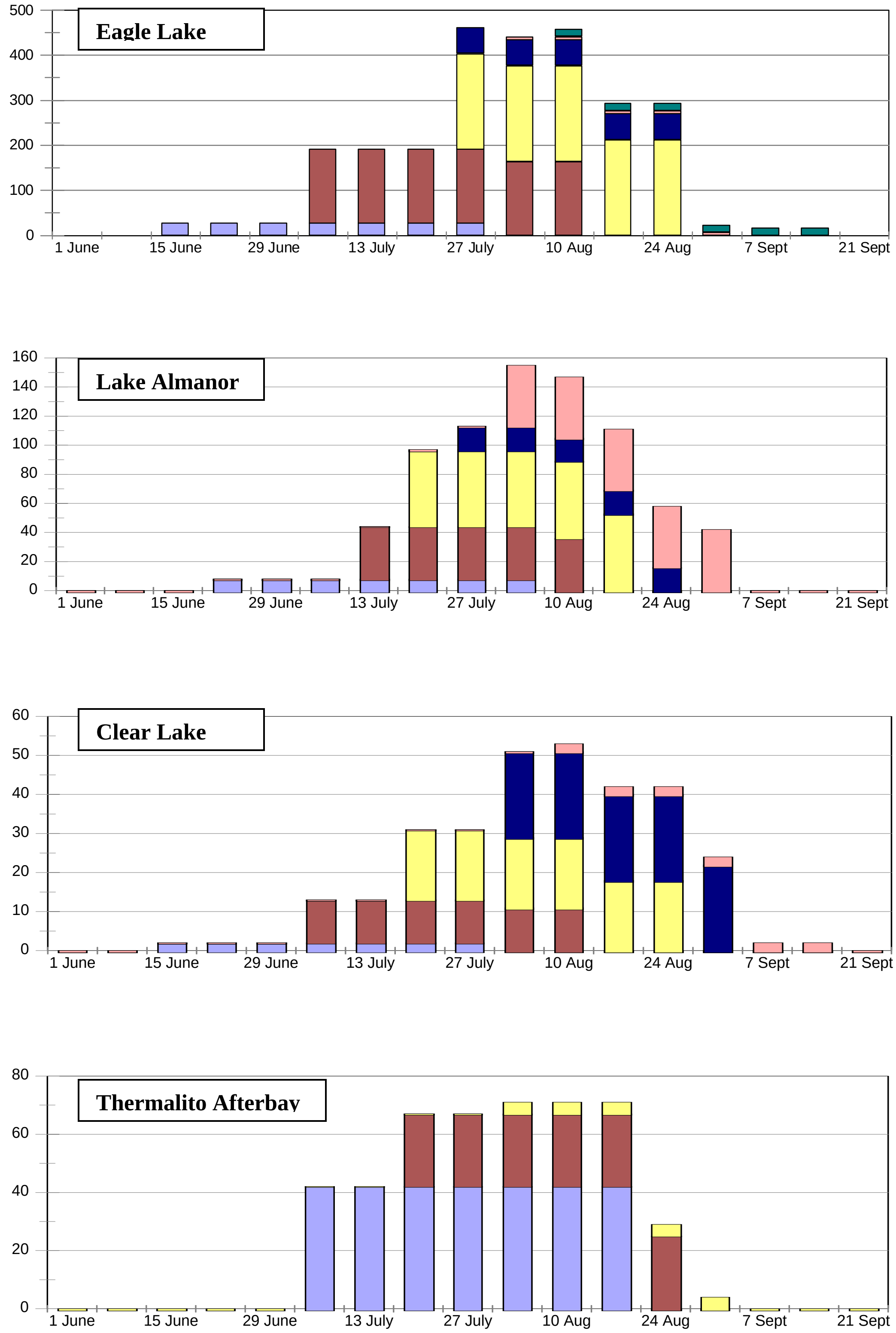


Fig. 28. Chronology of *Aechmophorus* grebe nesting period at selected lakes in California, 2003. The different colors represent different cohorts, based on estimated nest initiation dates.

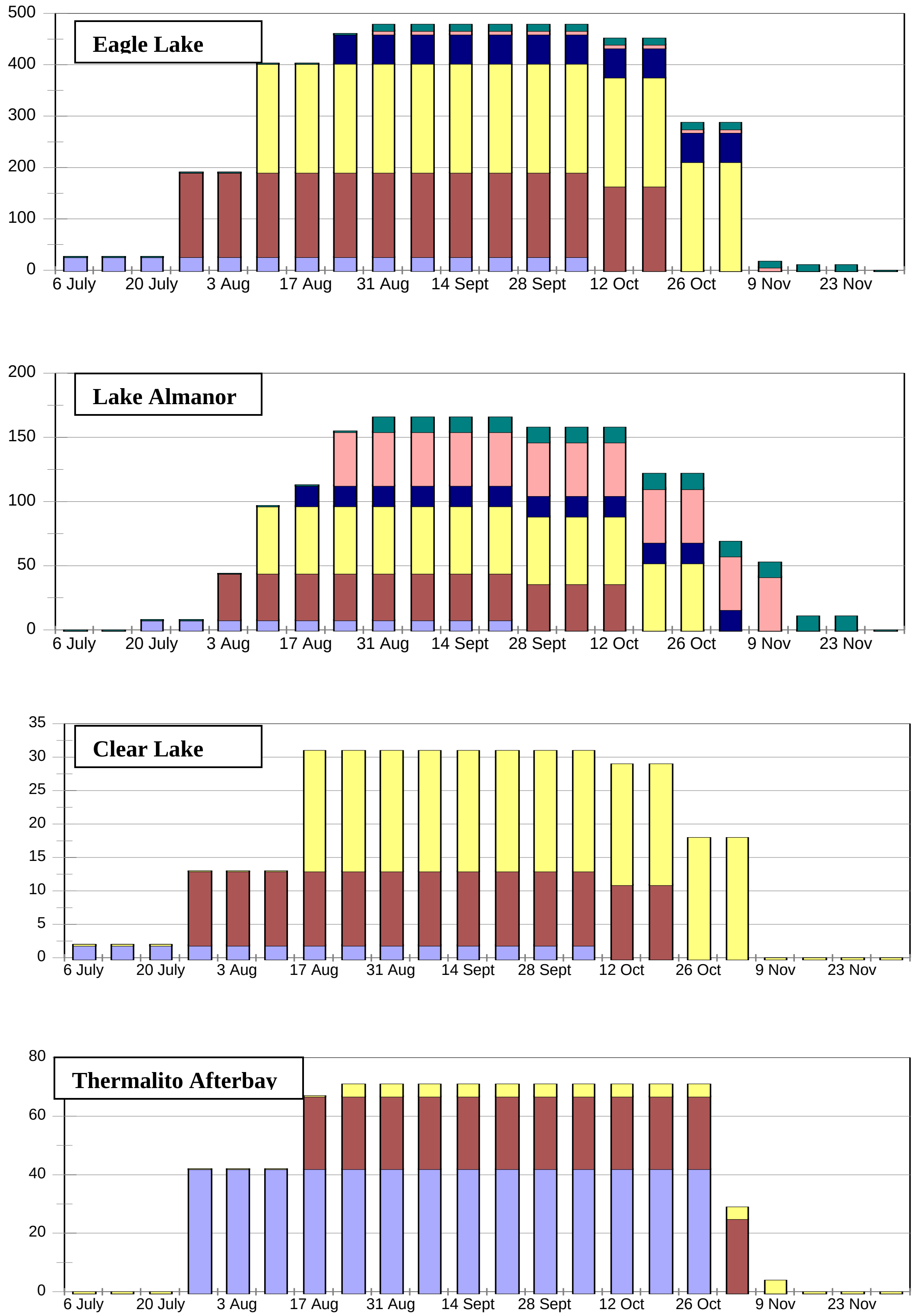


Fig. 29. Chronology of *Aechmophorus* grebe brooding period at selected lakes in California, 2003. The different colors represent different cohorts, based on estimated hatch dates.

Species composition

The relative abundance of the two *Aechmophorus* species was different at each site (Table 7). Grebes observed nesting at Goose Lake in 2002-03 were all Clark's, but in the late 1970s, some western grebes were recorded, and this site supported the largest known breeding concentration of Clark's (at least 568 adults—Ratti 1981). At Thermalito Afterbay, 56% of the adults were Clark's, while 66% of the broods were Clark's, suggesting higher nesting success than western grebes. At Clear Lake, 27% of the adult grebes classified were Clark's; 40% was reported in 1976 (Feerer 1977). However, only 16% of the broods were Clark's in 2003, indicating poorer nest success in this species. At Eagle Lake, Clark's grebes accounted for 24% of adults and 26% of broods. Past estimates of the relative abundance of adult Clark's was 13% in 1976 (Feerer 1977), and approximately 7.8% of the adults and 7.5% of the young in 1996-97 (Shaw 1998); this suggests an increasing trend. At Lake Almanor, Clark's accounted for 1% of the adults, and none of the chicks observed.

Table 7. Relative proportions of western and Clark's grebes at selected lakes in California, 2003.

	Adults		Broods	
Site	**% Western**	**% Clark's**	**% Western**	**% Clark's**
Eagle Lake	76	24	74	26
Clear Lake	73	27	84	16
Lake Almanor	99	1	100	0
Thermalito Afterbay	44	56	34	66
Goose Lake	0	100	0	100

Mortality

While checking nest success at Eagle Lake on 23 August 2003, I found two dead adult western grebes and one eared grebe. One of the western grebes and the eared grebe died after becoming entangled in fishing lines; the other western grebe was dead on the nest missing its head, probably taken by a great horned owl (*Bubo virginianus*). Several dead ducks were observed in and around the colony, likely victims of avian botulism as a few ducks also exhibited symptoms of the disease. This bacterium could also affect grebes.

DISCUSSION

Based on the importance of California to nesting *Aechmophorus* grebes, the evidence of declines at wintering sites, and the vulnerability of these birds to a number of anthropogenic problems previously discussed, I recommend that both species be added to the FWS' list of Birds of Conservation Concern (U.S. Fish and Wildlife Service 2002), as well as to California's Bird Species of Special Concern list (Point Reyes Bird Observatory 2003), and that conservation efforts for these birds receive a high priority. Northern California supports a significant portion of the global breeding populations of western and Clark's grebes (approximately 5.6%) and the Intermountain West (45.1%); Eagle Lake is the most important site (2.8% of the global population and 22% of those in the Intermountain West). In addition, all but one of the sites surveyed (Thermalito Afterbay) is considered a California IBA (Cooper 2004). Also, the majority of the populations of these two species winter along the California coast. Therefore, California has a high responsibility to maintain these populations, and the state could be economically impacted if these species ever became federally listed as threatened or endangered. Potential partners for grebe conservation projects could include Joint Ventures, federal and state agencies, counties, universities, and non-governmental organizations (e.g., Audubon California, The Nature Conservancy). For those colony sites in the Central Valley, a grant might be available from CALFED (CALFED Bay-Delta Authority 2004), a consortium of state and federal appointed officials focused on improving water quality and quantity responsible for managing state and federal water export projects and habitat restoration.

Colony presence, size, and reproductive success are often affected by water conditions which change within and between breeding seasons. Because of the dynamics of wetland conditions in the arid west, its feast-or-famine water regimes require waterbirds to be able to shift between suitable breeding sites when necessary; therefore, it is important to maintain as many sites as possible so birds have alternate choices when local breeding area conditions are poor. Resident populations (e.g., Clear Lake—D. Anderson, pers. comm.) would likely show much higher site fidelity. Consequently, I recommend a regional approach to *Aechmophorus* grebe conservation (e.g., Frederick et al. 1996), including coordinated monitoring and decision-making processes which will allow water decisions to more accurately reflect the needs of the *Aechmophorus* grebe populations. The regional waterbird conservation plans can provide a forum for such coordination.

The demography of these species is poorly understood, as longevity, adult survival rates, and recruitment haven't been formally studied in enough detail to understand the implications of management actions. Because we know they are relatively long-lived (>10 years) and have relatively small clutch and brood sizes, it is possible that attaining high adult survival is more important for population maintenance than improving productivity.

Conservation issues

Based on my review of the literature and field work in 2002 and 2003, improvement of grebe productivity could be accomplished through a combination of management and regulatory programs. Actions should be taken to reduce adult and juvenile mortality, increase nest success, and enhance and maintain suitable breeding areas. Conservation needs vary by site. Many of these recommendations could also be applied to other grebe nesting sites in California which are not specifically addressed in this report. For example, these include two areas with heavy boating use: Lake Havasu (San Bernadino County), where several thousand grebes nest (Rosenberg et. al 1991), and Lake Berryessa which has had nesting grebes periodically (D. Anderson, pers. comm.). These actions could also be applied to other *Aechmophorus* grebe nesting sites throughout their range, and would benefit other over-water nesting birds as well.

Reduce mortality.——Grebe mortality from boat strikes and fishing line entanglements could be reduced by providing an interpretive sign or poster at boat ramps to educate the general public, boaters, and fishermen about grebe conservation, and encourage them to steer clear of grebes and clean up discarded fishing lines (Appendix 1). To further a grebe conservation ethic, an interpretive program should be developed for use at agency facilities, campfire talks, and meetings of recreation groups and other interests (Appendix 2).

Increase nesting success.——The following actions are recommended to increase nest success: reduce disturbance to nesting colonies, maintain stable water levels, and protect nests from waves. Based on the chronology of nesting grebes of this and past studies, timing should generally be from 1 June through 30 September. However, these dates should be adjusted to local situations as nesting conditions vary each year, and some southerly locations may support earlier nesting.

It can be considered a violation of the MBTA to disturb nesting birds, and agencies managing recreational activities on grebe nesting lakes should take action to protect the public from being cited. Therefore, colony locations at areas open to boating should be posted as closed to public entry during the nesting season (Appendix 3). This should be accomplished in consultation with CDFG and the FWS. Although I found no specific recommendations for disturbance buffer distances for *Aechmophorus* grebes, several authors have reported guidelines for other species of nesting waterbirds which could be applicable to grebes. Buffer zones of 200 m were suggested for nesting common terns (*S. hirundo*) and black skimmers (*Rynchops niger*) (Erwin 1989), 180 m for mixed skimmer/tern colonies (Rodgers and Smith 1995), 150 m for nesting great blue herons (*Ardea herodias*) (Vos et al. 1985), and 100 m for mixed nesting waterbird colonies (Rodgers and Smith 1995, 1997), nesting common terns (Burger 1998), and least (*S. antillarum*) and royal terns (*S. maxima*) (Erwin 1989). A waterbird’s response to disturbance can depend on how habituated they are to humans (e.g., Nisbet 2000), and this might be a consideration for a reduction in the buffer zone at sites where birds appear more tolerant. Therefore, for closure area, I recommend a minimum of a 100 m buffer for exposed colonies, and a 50 m buffer where nests are screened by vegetation (e.g., bulrush), but the buffer width should be decided on a case-by-case basis. The boundaries should be marked with buoys every 50 meters (Appendix 3). If colonies are near shore, the shoreline adjacent to the colonies should be posted as well, using signs on metal or carsonite posts. Enforcement could be accomplished by adding grebe closure monitoring to existing boating regulation patrols.

To buffer wave action at sites where waves are a problem, temporary floating wave barriers could be anchored onto closure buoys (Appendix 3 and 4). This technique deserves some experimental application. Further evaluation of the efficacy of these barriers and their benefits is needed. Where possible, enhancement of emergent vegetation would also help buffer the effects of waves.

As much as possible, water levels should be kept stable through the nesting season. A gradual decline of less than 0.5 m would not likely have great impacts on nesting in most locations, but could be disastrous for nests in shallow water; therefore, it is important to understand the local nesting colony conditions. Where water levels can be controlled, they should be maintained to at least keep nests afloat until they hatch.

Enhance and maintain breeding habitat.——Breeding habitat appears to be limited at some sites, and some vegetation enhancement may be warranted to provide structure and cover for nests. It may be possible to transplant small stands of hardstem bulrush to increase the effective nesting area for *Aechmophorus* grebes. The establishment of water smartweed stands would also be beneficial, as this plant is excellent nesting substrate and provides protection from waves. This might be accomplished by transplanting or perhaps by seeding moist soil areas during early summer drawdowns.

Monitor efficacy of implemented conservation measures.——If these recommendations are implemented, it is likely that they will result in improved production of *Aechmophorus* grebes. Monitoring programs should be established to document nest numbers, nest success, and productivity before and for three years after implementation of conservation measures (Appendix 5). Detailed studies of the effects of wave action and the benefits of wave barriers on nest success should be conducted at sites where waves are a problem.

Recommendations for selected sites

Eagle Lake.——Eagle Lake is significant to *Aechmophorus* grebe populations in California, the Intermountain West, and also globally. Issues which should be addressed include reducing boating and fishing-induced disturbance and mortality, and protecting nests from waves caused by boats and wind.

Cooper (2004) reported a large increase in the number of fishermen using this lake since the 1970s, and that visitation doubled in the 1980s. He also noted that boating disturbance was the greatest threat to waterbirds. Several researchers have reported chronic problems with shoreline development and human disturbance (primarily from boating and fishing) on nesting grebes (Gould and Koplin 1971, Gould 1974, Lederer 1976, Shaw 1998, Sardella 2002). Boating was implicated in causing nest destruction, abandonment, and egg inundation (Lederer 1976). Water-skiing and increased use of personal watercraft may also contribute to disturbance of nesting grebes (P. Chappell, pers. comm.). Fishermen often take their boats into the tule beds to fish for trout where grebes are nesting (Sardella 2002, D. Anderson, pers. comm.). Fishing line entanglement is likely one of the most frequent causes of mortality of adults at this site (R. Bogiatto, pers. comm.), and was also observed in this study. Of the four colonies on the lake, Spaulding experienced the highest level of boating disturbance and the lowest nest success and mean clutch size in both 2000 and 2001; a significant positive correlation was found between nest success and distance from a major boating access point and source of disturbance at Spaulding in 2000 (Sardella 2002). He suggested a management strategy including establishment of no-wake zones and prohibiting entrance into emergent vegetation.

There is also evidence that the high level of disturbance at Spaulding has caused a portion of the grebes to relocate their nesting areas to other regions of the lake (Shaw 1998, Sardella 2002). Spaulding may have been preferred historically because it is protected from the prevailing winds (Sardella 2002); however, percentages of the total nests on the lake have decreased at Spaulding while increasing at other sites (Figure 30).

Grebe nests are particularly susceptible to destruction from waves caused by wind or boat wakes at this site. Because of its proximity to the boat launch facility, Spaulding receives more boat wakes than other Eagle Lake sites (Sardella 2002). It is also subject to high winds almost daily during the summer (Sardella 2002); however, colonies located on the east side of the lake are more exposed to prevailing west and southwest winds.

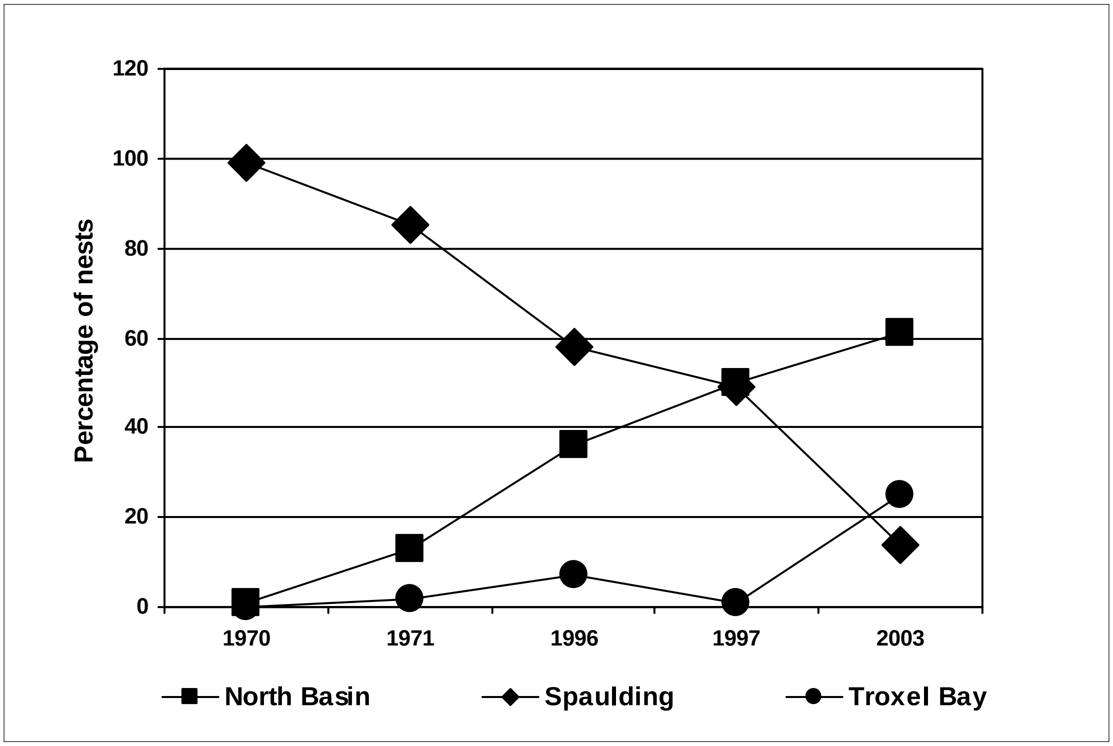


Fig. 30. Percentage of nests at major *Aechmophorus* grebe colonies at Eagle Lake, California, 1970-71 (Gould 1974), 1996-97 (Shaw 1988), and 2003 (GLI).

<u>Management recommendations</u>:

1. Reduce mortality and disturbance through public outreach at boat launch facilities and recreation-oriented businesses. Develop an interpretive sign or poster to educate the general public, boaters, water-skiers, users of personal watercraft, and fishermen about grebe conservation and encourage them to steer clear of grebes and clean up discarded fishing lines (Appendix 1). Develop an interpretive program for campfire talks on grebe conservation (Appendix 2).

2. Instigate a seasonal closure of colony sites during the nesting period (1 June-30 September). Because nests here are within fairly dense stands of bulrush, closure buoys should be placed 50 m from the outer edge of the bulrush stands adjacent to colonies (Appendix 3). For colony sites where boat wakes are a problem (e.g., Spaulding) the closed area bounds should be at 100 m. An alternative that would likely be more beneficial to grebe production would be to install wave barriers and anchor them to the closure buoys (in this case, a 50 m buffer could be used at Spaulding). I estimate that approximately 1,000 m of wake barrier material would be adequate to protect the majority of nests at the three primary colony sites (Appendix 4). Areas supporting the highest nesting densities should receive priority for protection. There are concerns of use of tire-types due to the possible effect on water quality; therefore other styles are preferable. I recommend some experimentation; a couple of designs and their efficacy should be studied. On the land side of the colonies, signs should be placed to provide

a 100 m buffer for exposed colonies and a 50 m buffer for colonies screened from view by vegetation. Establish local regulations to enforce the seasonal closures.

3. Conduct at least two nest surveys and one brood count before project implementation and for three years after to document effects of management on productivity (Appendix 5).

Proposed project budget and funding options:

Table 8 details a proposed budget for conservation projects at Eagle Lake. These numbers are preliminary and need further consideration. Although ATTC funds are limited, other agencies and organizations would likely be willing to cost-share projects and such partnerships should be pursued. Some aspects of the budget (e.g., enforcement and monitoring) could be met with in-kind contributions. Potential partners include CDFG, Lassen National Forest (NF) and Bureau of Land Management (BLM) who own lands along much of the shoreline of the lake. Also, Lassen County and state agencies involved in management of Eagle Lake are important and necessary partners. For research and monitoring activities, researchers and students from universities and non-profit organizations would likely be willing partners. The FWS Region 1 Migratory Bird Office may be willing to help with funding on a partnership basis. Staffs of California State University (CSU) Chico and U.C. Davis have a history of working on biological investigations here and CSU Chico maintains the Eagle Lake Field Station on the east shore of the lake and would be obvious partners in Eagle Lake projects. Biologists at Point Reyes Bird Observatory (PRBO) have also conducted waterbird investigations here. Ducks Unlimited, Inc. (DU), Audubon California, and other conservation groups may be interested in helping to implement projects.

The IWJV can provide grant funds on a matching basis for such projects and I recommend a proposal be submitted to help fund a project here. At least $200,000 was available for distribution to partners in FY2004 (the exact amount varies annually with funding availability). The maximum amount for which partners may apply for an individual project is $50,000. Only one partner in the partnership may serve as grantee. Funds are provided on a cost-share basis and a direct match is not required. However, IWJV funds must be cost-shared with partner funds at least on a 1:1 basis to be considered. A partner is any individual, organization or agency who contributes financially to the project. Partner funding may be generated from federal, state, or private sources. Project monitoring and evaluation will not be considered for funding by IWJV. However, the cost of monitoring activity and project evaluation, where they are related to the project, may be used to leverage assistance funding. This match may be accumulated from habitat work accomplished in the project area two years *prior* and two years *after* submission of the funding request. These funds may be cash or in-kind contributions. A detailed proposal could be developed for such a grant and a proposal for Eagle Lake could also include other sites (e.g., Lake Almanor), depending on the actions selected for implementation.

Table 8. Four-year proposed project budget (rough estimate) for recommended grebe conservation measures at Eagle Lake, Lassen County, California.

Project component	Estimated cost
1. Educate the public	
3 grebe conservation signs, posts, hardware, installation	$2,100.00
Interpretive presentations	$1,000.00
Develop interpretive program	$500.00
Subtotal	**$3,600.00**
2. Seasonal closure of nesting colonies	
Enforcement labor (estimated at 3 hrs/day, @$25/hr and 120 days)/year	$36,000.00
Labor to locate colonies, measure boundaries, install/remove/maintain buoys and signs	$20,000.00
60 closure buoys, ground tackle, anchor and lines, stickers, shipping for 3 colonies	$10,200.00
Metal signs for shorelines, decals, posts and hardware for Spaulding colony	$900.00
Subtotal	**$67,100.00**
3. Install wave barriers	
Construct/acquire wave barriers for 3 colonies (1,000 m)	$96,000.00
Labor to install/remove/maintain wave barriers for 3 colonies	$12,000.00
Study to evaluate wave barriers	$10,000.00
Subtotal	**$118,000.00**
4. Monitor and evaluate colonies	
Labor and costs for aerial surveys of nesting colonies (8 flights—8 hrs, pilot & 2 staff)	$12,160.00
Monitoring reports and evaluations	$5,000.00
Labor and costs for boat surveys of broods (4 surveys—12 hrs, 3 staff)	$4,320.00
Subtotal	**$21,480.00**
TOTAL	**$210,180.00**

Tule Lake and Lower Klamath NWRs.—— Tule Lake NWR is an important nesting site for grebes, and Lower Klamath NWR could support more with some habitat improvements. Conservation needs include a secure water supply for Lower Klamath, and restoration of wetland habitats and emergent nest cover; because of their NWR status, human disturbance is not a factor here. Lower Klamath NWR has experienced critical water shortages in recent years, as this refuge is last in line to receive over-allocated water in the Klamath Basin (D. Mauser, pers. comm.). Provision of additional water would enhance habitat for nesting *Aechmophorus* grebes.

Although no productivity data was available for 2003, the chick to adult ratio at Tule Lake in 1994 was 0.34 (Elbert and Anderson 1998), which may indicate problems at this site. Grebe nests in Sump 1A do not appear to be particularly susceptible to destruction from waves as the submergent vegetation buffers waves (D. Mauser, pers. comm.); however, this issue needs to be further investigated. At the southwest end of the sump where the largest colony occurs, the sparse stands of hardstem bulrush do not provide much protection from wind or as cover. Both Sumps 1A and 1B have vast areas of open water with no structure for nesting grebes. These sites would likely support more nests if additional hardstem bulrush could be established in wind-sheltered, open water areas. This may be feasible at Sump 1B through transplanting. Also, creation of large nesting islands, perpendicular to prevailing winds, would help shelter grebe nests, as well as provide nesting habitat for other species (e.g., American White Pelican [*Pelecanus erythrorhynchos*]). Restoration of agricultural areas on Tule Lake to seasonal wetlands would also benefit *Aechmophorus* grebes.

Management recommendations:

1. Enhance water supplies to seasonal wetlands at Tule Lake NWR by refurbishing the pump station for wetland restoration ($20,700 is needed to match FWS and Bureau of Reclamation [BOR] funds). Refurbishing the existing pump with above-water motors will allow for the reliable operation of the station and provide wetland management capability for the 3,500 acre Sump 1B project as well as up to 3,500 acres of managed wetlands within the agricultural lease lands of Sump 3 on Tule Lake NWR (D. Mauser, pers. comm.).

2. After experimentation with feasibility, establish additional hardstem bulrush habitat in wind-sheltered portions of Sump 1B by transplanting segments of rootstalks from other sites on the refuge. Consider building large, linear nesting islands to protect emergent areas from wind fetch at Sump 1B.

3. Increase the acreage of wetlands on Tule Lake NWR by levee construction to allow restoration and management of wetlands (contact D. Mauser for details). In the past it has required about $30,000 for the construction to build wetlands on former agricultural lands on this refuge. Depending on topography, this usually equates to 500 to 1,000 acres of wetland. These wetlands typically develop some thin cattail stands and extensive areas of sago pondweed as well as green algae after the first year of flooding. Both eared and *Aechmophorus* grebes use them (D. Mauser, pers. comm.).

4. Conduct at least two nest surveys and one brood count before project implementation and for three years after to document effects of management on productivity (Appendix 5).

5. Consider using the refuge visitor center to provide interpretive information on grebe conservation (Appendices 1 and 2).

Proposed project budget and funding options:

Table 9 details a proposed budget for potential conservation projects at Tule Lake NWR. These numbers are preliminary and need further consideration. Although ATTC funds are limited, other agencies and organizations would likely be willing to cost-share projects here and such partnerships should be pursued. Some aspects of the budget (e.g., monitoring) could be met with in-kind contributions. The FWS, CDFG, BOR and Tule Lake Irrigation District are potential partners for projects here. Staffs of U.C. Davis and PRBO have a history of working on biological investigations here and would be obvious partners in projects. DU, Audubon California, and other conservation groups may be interested in helping to implement projects. As previously discussed, a grant proposal should be submitted for IWJV funding support for projects here also.

Table 9. Four-year proposed project budget (rough estimate) for recommended grebe conservation measures at Tule Lake NWR, Siskiyou and Modoc counties, California.

Project component	Estimated cost
1. Refurbish Tule Lake pump station	
Boom truck rental	$500.00
Pull and load old pumps	$1,100.00
Steel to modify existing sumps	$1,400.00
30" flap gate	$1,700.00
Electrical wiring	$5,000.00
Pump station operation and electric bills	$5,000.00
Site excavation and backfill	$5,000.00
120' of a 30" pipe to build manifold and additional discharge	$6,000.00
Labor	$10,000.00
Pump motors, shafts, impellers	$30,000.00
Subtotal	**$65,700.00**
2. Improve grebe nesting habitat at Tule Lake	
Implementation of goal to establish 100 acres of new hardstem bulrush habitat	$10,000.00
Experiment with feasibility	$3,000.00
Build four large, linear islands to reduce wind fetch	$50,000.00
Subtotal	**$63,000.00**
3. New levee construction for seasonal wetlands	
Labor	$20,000.00
Fuel and equipment	$10,000.00
Subtotal	**$30,000.00**
4. Monitor and evaluate colonies	
Labor and costs for aerial surveys of nesting colonies (8 flights—8 hrs, pilot and 2 staff)	$12,160.00
Labor and costs for boat surveys of broods (4 surveys—12 hrs, 3 staff)	$4,320.00
Monitoring reports and evaluations	$4,000.00
Subtotal	**$20,480.00**
5. Educate the public	
Interpretive presentations	$1,000.00
Develop interpretive program	$500.00
Subtotal	**$1,500.00**
TOTAL	**$180,680.00**

Clear Lake.——Historically, Clear Lake supported over 1,000 breeding *Aechmophorus* grebe pairs, but this population was devastated by the use of insecticides (primarily DDD) in the 1950s. Subsequently, mercury contamination has contributed to reduced productivity and the population has not fully recovered from these effects. Fishing and boating activities may now be the major factor limiting potential for recovery, and in 1997 and 2002, most of the grebe nests were apparently destroyed by weed control operations (D. Anderson, pers. comm.). Productivity in 1994 was only 0.06 chicks per adult (Elbert and Anderson 1998) and in 2003 was still low at 0.19. Livestock grazing is an issue when the water levels are low and cattle consume nesting vegetation (D. Anderson, pers. comm.).

Fig. 31. Fishing activity near active *Aechmophorus* grebe nests at Rodman Slough, Clear Lake, California, 2003.

Management recommendations:

1. Reduce mortality and disturbance through public outreach at boat launch facilities and recreation-oriented businesses around the lake. Develop an interpretive sign or poster to educate the general public, boaters, and fishermen about grebe conservation and encourage them to steer clear of grebes and clean up discarded fishing lines (Appendix 1). Develop an interpretive program for talks on grebe conservation to be used by local agencies and groups (Appendix 2).

2. Instigate a seasonal closure of colony sites during the nesting period (1 June-30 September). Post the boundaries in the water using a 50 m buffer (Appendix 3). For colony sites where boat wakes are a problem (e.g., Long Tule Point), the closed area should be placed at 100 m. For Rodman Slough, the mouth of the slough should be posted as a no-wake zone. Alternatively, install a wave barrier (approximately 1,000 m) anchored to the closure buoys at 50 m on the wind-exposed side of the Long Tule Point colony and other problem sites to dampen waves caused by boats and wind (Appendix 4). This latter option would likely be more beneficial to grebe production. Areas supporting the highest nesting densities should receive priority for protection. There are concerns of use of tire-types due to the possible effect on water quality; therefore oil boom types are preferable. I recommend some experimentation; a couple of designs and their efficacy should be studied. Establish local regulations to enforce the seasonal closures.

3. After experimentation with feasibility, establish additional hardstem bulrush habitat in wind-sheltered areas by transplanting segments of rootstalks from other sites around the lake. Fence the shoreline along the Long Tule Point site to protect the shoreline from cattle grazing impacts.

4. Conduct at least two nest surveys and one brood count before project implementation and for three years after to document effects of management on productivity (Appendix 5).

Proposed project budget and funding options:

Table 10 details a proposed budget for conservation projects at Clear Lake. These numbers are preliminary and need further consideration. Although ATTC funds are limited, other agencies and organizations would likely be willing to cost-share projects here and such partnerships should be pursued. Some aspects of the budget (e.g., enforcement and monitoring) could be met with in-kind contributions. Potential partners include Lake County and state agencies involved in management of Clear Lake. For research and monitoring activities, researchers and students from universities and non-profit organizations would likely be willing partners. The FWS Region 1 Migratory Bird Office and CDFG may be willing to help with funding on a partnership basis. Staff and students of U.C. Davis have a history of working on biological investigations here and would be obvious partners in projects. DU, Audubon California, and other conservation groups may be interested in helping to implement projects. Although the site is somewhat outside their bounds, the Central Valley and San Francisco Bay Joint Ventures should be asked for support for Clear Lake projects, possibly in concert with other grebe nesting areas within their boundaries.

Table 10. Four-year proposed project budget (rough estimate) for recommended grebe conservation measures at Clear Lake, Lake County, California.

Project component	Estimated cost
1. Educate the public	
10 grebe conservation signs, posts, hardware, installation	$7,000.00
Interpretive presentations	$1,000.00
Develop interpretive program	$500.00
Subtotal	**$8,500.00**
2. Seasonal closure of nesting colonies	
Enforcement labor (estimated at 4 hrs/day, @$25/hr and 120 days)/year	$48,000.00
60 closure buoys, ground tackle, anchor and lines, stickers, shipping for 3 colonies	$10,200.00
Labor to locate colonies, measure boundaries, install/maintain buoys	$10,000.00
Subtotal	**$68,200.00**
3. Install wave barriers	
Construct/acquire wake barriers (Long Tule Point)	$96,000.00
Study to evaluate wave barriers	$10,000.00
Labor to install/maintain wave barriers	$8,000.00
Subtotal	**$114,000.00**
4. Improve grebe nesting habitat	
Establish 100 acres of new hardstem bulrush habitat	$20,000.00
Fencing to protect bulrush habitat	$10,000.00
Subtotal	**$30,000.00**
5. Monitor and evaluate colonies	
Monitoring reports and evaluations	$5,000.00
Labor and costs for aerial surveys of nesting colonies (8 flights—3 hrs, pilot & 2 staff)	$4,560.00
Labor and costs for boat surveys of broods (4 surveys—8 hrs, 3 staff)	$2,880.00
Subtotal	**$12,440.00**
TOTAL	**$233,140.00**

Lake Almanor.——Lake Almanor is a valuable site for nesting western grebes, but it is also a power-generation reservoir, operated by Pacific Gas and Electric Company (PG&E), although Lassen NF owns much of the shoreline. The most important conservation need for this site is protecting nests from declining water levels which likely caused low productivity in 2002 (when no formal brood survey was conducted but nest success appeared very low) and 2003 (a 0.10 chick:adult ratio). The loss of nests due to drawdown of the lake for power generation could be considered take under the MBTA and should corrected or perhaps mitigated. Also, development of recreation areas on the lake near Chester could impact these colonies. Seasonal closures or wave barriers are not necessary at this time as water is so shallow and submergent vegetation so thick that boats cannot closely approach colonies, and vegetation provides a natural wave barrier. However, the colony should be monitored as conditions could change.

Management recommendations:

1. Work with PG&E to maintain stable water levels as much as possible through the grebe nesting period (1 June-30 September).

2. Reduce mortality and disturbance through public outreach at boat launch facilities and recreation-oriented businesses around the lake. Develop an interpretive sign or poster to

educate the general public, boaters, and fishermen about grebe conservation and encourage them to steer clear of grebes and clean up discarded fishing lines (Appendix 1). Develop an interpretive program for campfire talks on grebe conservation (Appendix 2).

3. Avoid placing new recreational developments within 300 m of colony sites.

4. Conduct at least two nest surveys and one brood count before project implementation and for three years after to document effects of management on productivity (Appendix 5). Nest counts could be conducted from shore with a spotting scope here to reduce costs.

<u>Proposed project budget and funding options</u>:

Table 11 details a proposed budget for potential conservation projects at Lake Almanor. These numbers are preliminary and need further consideration. Although ATTC funds are limited, other agencies and organizations would likely be willing to cost-share projects here and such partnerships should be pursued. Some aspects of the budget (e.g., monitoring) could be met with in-kind contributions. Potential collaborators include CDFG, Lassen NF, and Plumas County and state agencies which are involved in the management of this site are important and necessary partners. For research and monitoring activities, researchers and students from universities and non-profit organizations such as Audubon California would likely be willing partners. The FWS Region 1 Migratory Bird Office may be willing to help with funding on a partnership basis. As previously discussed, a grant proposal should be submitted for IWJV funding support for projects here also. A detailed proposal could be developed for such a grant and a proposal for Lake Almanor could also include other sites (e.g., Eagle Lake), depending on the actions selected for implementation. The local Audubon chapter could possibly be enlisted to help with nest counts and monitoring because they could track colonies with a scope from shore.

Table 11. Four-year proposed project budget (rough estimate) for recommended grebe conservation measures at Lake Almanor, Plumas County, California.

Project component	**Estimated cost**
1. <u>Educate the public</u>	
3 grebe conservation signs, posts, hardware, installation	$2,100.00
Interpretive presentations	$1,000.00
Develop interpretive program	$500.00
Subtotal	**$3,600.00**
2. <u>Monitor and evaluate colonies</u>	
Labor and costs for aerial surveys of nesting colonies (8 flights—6 hrs, pilot & 2 staff)	$9,120.00
Monitoring reports and evaluations	$5,000.00
Labor and costs for boat surveys of broods (4 boat surveys—8 hrs, 3 staff)	$2,880.00
Subtotal	**$17,000.00**
TOTAL	**$20,600.00**

Thermalito Afterbay.——This is a moderately important grebe nesting site. *Aechmophorus* grebes have nested here for at least 20 years (J. Snowden and S. Cordes, pers. comms.), but no efforts have been made to count them or monitor their success (S. Cordes, pers. comm.), and this site presents some serious challenges. If these concerns were resolved, it is likely that much higher numbers of grebes would breed here with improved productivity.

Although formal nest success surveys were not conducted, my observations of water-skiing activities within the major colony site and drastic water level fluctuations (>1 m) likely caused some abandonment of nests and lowered production. Productivity indices were probably biased as I only found 156 adults during the brood survey on 20 September, when at a minimum there should have been 190 breeders and likely more. Since 59% of the nests were in the earliest-nesting cohort and based on brood age they hatched between 1 and 17 August, a substantial number of nests hatched before nests were counted on 5 August (Figure 28).

During my 18 August visit, I walked to within 150 m of the West Colony site late in the evening and inspected the colony with a spotting scope. I observed direct disturbance to the colony from water-skiing. A nearby slalom course ends just to the east of the site, and a boat pulling a water-skier repeatedly entered the channel in the middle of the colony to turn around and resume skiing. Almost all the grebes remained off their nests while the boat was within 100 m, with the exception of a couple birds which I suspect were defending newly-hatched chicks (Figures 32-33). They appeared extremely disturbed and dove repeatedly while the boat was in close proximity. Prolonged disturbance of this type can lead to egg loss due to temperature exposure and predation from avian predators such as gulls and crows which are common around the afterbay. It is probable that some nests were abandoned because of repeated disturbance from water-skiers. This sort of disturbance is in violation of the MBTA and CDFG code, and management agencies should take preventative actions.

Also during the nesting period, water levels fluctuated dramatically on a weekly basis due to pumpback power generation operations. This causes a water level change of up to 1.66 m which is much less than ideal for grebes. Typically, over-water nesting birds will abandon their nests if levels become too low as they become more vulnerable to terrestrial predators. During a visit to the West Colony on 20 August 2003, S. Cordes, P. Kelly and I observed that water levels were very low and at least one grebe appeared to be incubating a nest which was stranded on shore. I was surprised that this bird remained on the nest; it would have been quite accessible to terrestrial predators such as raccoons which are common here. It is possible that some nests were abandoned because of the extreme water level changes, and this issue warrants further study. If these water-level changes are in fact depressing grebe productivity, this effect should be corrected, or perhaps mitigated.

Fig. 32. Water-skiers preparing for take-off adjacent to the *Aechmophorus* grebe colony at Thermalito Afterbay, August 2003.

Fig. 33. Water-skiers adjacent to the *Aechmophorus* grebe colony at Thermalito Afterbay with nests on both sides of the boat (bird in foreground is on its nest), August 2003.

Management recommendations:

1. The water-ski slalom course at the West Colony site should be moved to another location.

2. Instigate a seasonal closure of colony sites during the nesting period (1 June – 30 September). Mark the bounds of known colonies and post them using buoys at the neck of the bay where the grebes nest to also serve as a no-wake zone (Appendix 3). On land, use metal signs to mark the closed areas. Establish local regulations to enforce the seasonal closures.

3. Reduce mortality and disturbance through public outreach at boat launch facilities around the afterbay. Develop an interpretive sign or poster to educate the general public, boaters, water-skiers and fishermen about grebe conservation and encourage them to steer clear of grebes and clean up discarded fishing lines (Appendix 1).

4. Because of the drastic water level fluctuations, I recommend that this issue be further studied and that CDFG and the California Department of Water Resources (CDWR) provide funding for or conduct such a study. Perhaps a graduate student could take on the project for a thesis.

5. Conduct at least two nest surveys and one brood count before project implementation and for three years after to document effects of management on productivity (Appendix 5). Nest counts could be conducted from shore here with a spotting scope to reduce costs.

Proposed project budget and funding options:

Table 12 details a proposed budget for conservation projects at Thermalito Afterbay. These numbers are preliminary and need further consideration. Although ATTC funds are limited, other agencies and organizations would likely be willing to cost-share projects here and such partnerships should be pursued. Some aspects of the budget (e.g., enforcement and monitoring) could be met with in-kind contributions. The FWS, CDWR, CDFG's Oroville Wildlife Area, Butte County and other state agencies involved in management of the afterbay are important and necessary partners. For research and monitoring activities, researchers and students from universities and non-profit organizations would likely be willing partners. The FWS Region 1 Migratory Bird Office and the BOR may be willing to help with funding on a partnership basis. DU, Audubon California, and other conservation groups may also be interested in helping to implement projects. The CVJV might help with funding, and a detailed proposal could be developed for such a grant which might include other sites (e.g., Clear Lake, East Park Reservoir), depending on the actions selected for implementation. The local Audubon chapter could possibly be enlisted to help with nest counts and monitoring because they could track colonies from shore.

Table 12. Four-year proposed project budget (rough estimate) for recommended grebe conservation measures at Thermalito Afterbay, Butte County, California.

Project component	Estimated cost
1. Seasonal closure of nesting colonies	
Enforcement labor (estimated at 1 hrs/day, @$25/hr and 120 days)/year	$12,000.00
Labor to locate colonies, measure boundaries, install/maintain buoys and signs	$10,000.00
10 closure buoys, ground tackle, anchor and lines, stickers, shipping for 2 colonies	$1,700.00
10 metal signs for shorelines, decals, posts and hardware for 2 colonies	$300.00
Subtotal	**$24,000.00**
2. Educate the public	
3 grebe conservation signs, posts, hardware, installation	$2,100.00
Subtotal	**$2,100.00**
3. Monitor and evaluate colonies	
Monitoring reports and evaluations	$5,000.00
Labor and costs for aerial surveys of nesting colonies (8 flights—2 hrs, pilot & 2 staff)	$3,040.00
Labor and costs for boat surveys of broods (4 boat surveys—6 hrs, 3 staff)	$2,160.00
Subtotal	**$10,200.00**
TOTAL	**$36,300.00**

Bridgeport Reservoir.——Breeding *Aechmophorus* grebes occurred in moderate numbers here. Because they nest in thick stands of water smartweed, they were apparently protected from boating disturbance and waves. Boating activity was limited to a few small fishing boats during my visits. The shore is heavily grazed by cattle and sheep, eliminating most of the marsh habitat (Cooper 2004); however, because grebes were nesting in water smartweed, they did not appear to be effected in 2003. Monitoring of this colony to ensure water levels are adequate during the nesting season is warranted.

Management recommendations:

1. Reduce mortality and disturbance through public outreach at boat launch facilities and recreation-oriented businesses around the reservoir. Develop an interpretive sign or poster to educate the general public, boaters, and fishermen about grebe conservation and encourage them to steer clear of grebes and clean up discarded fishing lines (Appendix 1).

2. Monitor the colony and water levels during the nesting season to ensure that nests don't get stranded on shore. Conduct at least two nest surveys and one brood count before project implementation and for three years after to document effects of management on productivity (Appendix 5).

Proposed project budget and funding options:

Table 13 details a proposed budget for conservation projects at Bridgeport Reservoir. These numbers are preliminary and need further consideration. Although ATTC funds are limited, other agencies and organizations would likely be willing to cost-share projects here and such partnerships should be pursued. The FWS, CDFG, Walker River Irrigation District, and Mono County and state agencies involved in management of Bridgeport Reservoir are important and necessary partners. An IWJV grant proposal could potentially include grebe projects for this site. The local Audubon chapter could possibly be enlisted to help with nest counts and monitoring because they could track colonies from shore.

Table 13. Four-year proposed project budget (rough estimate) for recommended grebe conservation measures at Bridgeport Reservoir, Mono County, California.

Project component	Estimated cost
1. Educate the public	
2 grebe conservation signs, posts, hardware, installation	$1,400.00
Subtotal	**$1.400.00**
2. Monitor and evaluate colonies	
Monitoring reports and evaluations	$2,000.00
Labor and costs for boat surveys of broods (4 boat surveys—2 hrs, 2 staff)	$480.00
Nest counts from shore using spotting scope (8 surveys—2 hrs, 1 staff)	$480.00
Subtotal	**$2,960.00**
TOTAL	**$4,360.00**

Goose Lake.——Goose Lake hosted moderate numbers of nesting Clark's grebes in 2003. Historically, it was thought to be a major breeding area for this species in the U.S. and Canada (Small 1994). However, habitat has apparently changed since the late 1970s when 568 Clark's grebes were counted during the breeding season (Ratti 1977)--only 60 nests were present in 2003. I suspect that marsh habitat has significantly declined, likely from the erratic water regime in the last two decades (deep flooding and drought), and the habitat remaining is limiting the potential for nesting. It would be beneficial to expand the area of hardstem bulrush to provide additional nest cover for grebes and other over-water nesting birds. This site receives very light public use, and boats are rarely used here so disturbance is not an issue presently. Wind fetch may be a problem, but needs further study. This area could be managed cooperatively with ODFW.

Management recommendations:

1. Develop methodology for establishment of additional hardstem bulrush habitat. Expand the area of hardstem bulrush in the vicinity of the existing colony and at other sites around the lake where there are significant inflows.

2. Conduct at least two nest surveys and one brood count before project implementation and for three years after to document effects of management on productivity (Appendix 5). Brood counts may be difficult at this site due to the large area, shallow water levels, and the small number of grebes.

Proposed project budget and funding options:

Table 14 details a proposed budget for potential conservation projects at Goose Lake. These numbers are preliminary and need further consideration. Although ATTC funds are limited, other agencies and organizations would likely be willing to cost-share projects here and such partnerships should be pursued. Some aspects of the budget (e.g., monitoring) could be met with in-kind contributions. The FWS, CDFG, ODFW, and Oregon State Parks are potential partners for projects here. DU, Audubon California and Oregon, and other conservation groups may be interested in helping to implement projects. As previously discussed, a grant proposal should be submitted for IWJV funding support for projects here also and might be combined with projects at other sites.

Table 14. Four-year proposed project budget (rough estimate) for recommended grebe conservation measures at Goose Lake, Modoc County, California, and Lake County, Oregon.

Project component	Estimated cost
1. Establish additional hardstem bulrush habitat	
Establish 100 acres of new hardstem bulrush habitat	$20,000.00
Subtotal	**$20,000.00**
2. Monitor and evaluate colonies	
Labor and costs for aerial surveys of nesting colonies (8 flights—8 hrs, pilot and 2 staff)	$12,160.00
Labor and costs for boat surveys of broods (4 boat surveys—5 hrs, 3 staff)	$1,800.00
Monitoring reports and evaluations	$2,000.00
Subtotal	**$15,960.00**
TOTAL	**$35,960.00**

East Park Reservoir.——In 2003, this site supported a small colony. Because grebes nest in thick stands of water smartweed here, they are apparently protected from boating disturbance and waves. However, boating activity was high during my visits, and boating mortality could be a problem. Monitoring of this colony to ensure water levels are adequate during the nesting season is also warranted.

Management recommendations:

1. Reduce mortality and disturbance through public outreach at boat launch facilities and camping areas around the reservoir. Develop an interpretive sign or poster to educate the general public, boaters, and fishermen about grebe conservation and encourage them to steer clear of grebes and clean up discarded fishing lines (Appendix 1).

2. Instigate a seasonal closure of the colony during the nesting period (1 June – 30 September). Mark the boundaries of the colony with buoys at the mouth of the bay where they nest 50 m from the water smartweed edge to serve as both closure and wake zone marking (Appendix 3). Establish local regulations to enforce the seasonal closures.

3. Maintain water smartweed stands as wildlife habitat. Institute a no-spray policy for this plant.

4. Conduct at least two nest surveys and one brood count before project implementation and for three years after to document effects of management on productivity (Appendix 5). Brood counts may be difficult at this site due to the large area and the small number of grebes.

Proposed project budget and funding options:

Table 15 details a proposed budget for potential conservation projects at East Park Reservoir. These numbers are preliminary and need further consideration. Although ATTC funds are limited, BOR (the managing agency), and other organizations would likely be willing to cost-share projects here and such partnerships should be pursued. Some aspects of the budget (e.g., monitoring) could be met with in-kind contributions. CDWR and CDFG are potential partners for projects here. DU, Audubon California, and other conservation groups may be interested in helping to implement projects. As previously discussed, a grant proposal should be submitted for CVJV funding here also, possibly in combination with projects at other sites.

Table 15. Four-year proposed project budget (rough estimate) for recommended grebe conservation measures at East Park Reservoir, Colusa County, California.

Project component	**Estimated cost**
1. Educate the public	
2 grebe conservation signs, posts, hardware, installation	$1,400.00
Subtotal	**$1,400.00**
2. Seasonal closure of nesting colonies	
Enforcement labor (estimated at 1 hrs/day, @$25/hr and 120 days)/year	$12,000.00
Labor to locate colonies, measure boundaries, install/maintain buoys	$2,000.00
10 closure buoys, ground tackle, anchor and lines, stickers, shipping	$1,700.00
Subtotal	**$15,700.00**
3. Monitor and evaluate colonies	
Labor and costs for aerial surveys of nesting colonies (8 flights—2 hrs, pilot and 2 staff)	$3,040.00
Monitoring reports and evaluations	$2,000.00
Labor and costs for boat surveys of broods (4 boat surveys—3 hrs, 2 staff)	$720.00
Subtotal	**$5,760.00**
TOTAL	**$22,860.00**

Topaz Lake.——Although no nesting grebes were located in 2002 or 2003, this has been an important historical site (Small 1994, S. Herman, pers. comm.) and is a California IBA. The habitat has been extensively altered, with the Walker River channelized and diverted for alfalfa cultivation (Cooper 2004). Cooper (2004) also noted that wetland restoration would be greatly beneficial.

Management recommendations:

1. Transplant hardstem bulrush and water smartweed at the inlet of the lake on the south shore to increase nesting habitat. Although ATTC funds are limited, potential partners include IWJV, CDFG, FWS, and Walker River Irrigation District.

2. Monitor periodically for the return of nesting grebes. If nests are located, the following actions should be implemented. Develop an interpretive sign or poster to educate the general public, boaters, and fishermen about grebe conservation and encourage them to steer clear of grebes and clean up discarded fishing lines (Appendix 1). Consider an interpretive program (Appendix 2). Also instigate a seasonal closure of the colony during the nesting period (1 June – 30 September). Mark the boundaries of the colony with buoys at the mouth of the bay where they nest 50 m from the vegetation edge to serve as both closure and wake zone marking (Appendix 3). Establish local regulations to enforce the seasonal closures. Evaluate conditions to determine the need for wave barriers (Appendix 4). Conduct nest and brood

surveys after project implementation to document effects of management on productivity (Appendix 5).

Recommended research

Additional research that would improve our understanding of the demography, migration and life history of these birds is warranted. I recommend initiation of a banding and marking program at major colony sites to address the following questions:

- Are these grebes mostly philopatric to breeding sites or are they nomadic?
- What are adult and juvenile annual survival rates?
- Where are important staging and molting areas of these grebes?
- Do Clark's and westerns use different migration paths and wintering areas?
- At what age do they first breed and what is their longevity? Design a population model for these species.

CONCLUSION

Conservation of *Aechmophorus* grebes is in the public's interest as future declines of these birds could lead to their listing as threatened or endangered which results in a very costly process for recovery actions. It is important to maintain sensitive bird populations, and direct conservation actions should be applied to vulnerable species such as *Aechmophorus* grebes. Even though they have been reported not to have high site fidelity due to changing habitat conditions, the protection of the current breeding sites is imperative, as there are few alternative sites. Implementation of the recommendations within this report would also likely benefit other over-water nesting waterbird and waterfowl species. These actions could also be applied to grebe nesting lakes in other states and provinces as well. Although ATTC has limited funds for implementation of *Aechmophorus* grebe projects, it is likely that the Joint Ventures and local, state and federal agencies and organizations would be interested in cost-sharing projects, and such partnerships should be actively pursued for implementation.

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APPENDICES

APPENDIX 1. DRAFT *AECHMOPHORUS* GREBE CONSERVATION SIGNS FOR RECREATIONAL LAKES.

Figure 34 is a draft version of a sign or poster to educate the public about grebe conservation. Agency logos could be changed or added as needed. If produced as a poster, it could be laminated, where necessary, for posting on sign boards at boat launch facilities, or as a sign with its own mounting hardware. Posters could be printed for about $10.00 each in volume. Laminating costs are about $3.00 per square foot, so a 2' x 3' poster would cost about $28.00.

For signs, I recommend they be ordered as embedded phenolic resin signs. Signs made from these panels are impervious to moisture, have high impact resistance, are fire retardant, and are resistant to UV rays, graffiti, oil, grease, cigarette burns, and most staining materials. They have digitally or screen-printed subsurface images that are fused into a single panel with phenolic and melamine resins under the effect of high temperature and pressure to form graphic panels of exceptional quality (e.g., http://www.lightcraft.com/O_fiberglas.cfm). They are warranted by the manufacturers for 10 years. Using this process, a 3' x 4' sign would cost about $400.00, and posts and mounting hardware, depending on design, could cost up to an additional $100.00. Placement should be at local boat ramps, and possibly at campgrounds and concessions.

Fig. 34. Draft poster to encourage grebe conservation at recreational lakes.

APPENDIX 2. DRAFT INTERPRETIVE PROGRAM OUTLINE FOR *AECHMOPHORUS* GREBE CONSERVATION AT RECREATIONAL LAKES.

The following is a draft outline for an interpretive presentation which could be given at campfire talks or developed into a poster or slide show to educate the public and encourage them to support and participate in grebe conservation.

Title: Grebes need attention!

- *Aechmophorus* grebes, two very similar species: Western and Clark's grebes with nearly identical life histories.

- Species identification:
  - Western's breeding plumage: black through the eye, greenish yellow bill.
  - Clark's breeding plumage: white surrounding the eye, orange-yellow bill.

- Life history:
  - They are almost always in water.
  - Eat small fish and aquatic insects.
  - Have fascinating courtship rituals—they run and dance on top of the water.
  - Nest colonially.
  - Build floating nests.
  - Lay 1-6 eggs; 24 days incubation; about 70 days to fledge.
  - Both parents care for young; very young chicks are backbrooded (they ride on their parent's back) until about two-four weeks old; broods are often divided by parents for care.

- Historically:
  - Thousands of grebes were reported nesting at some sites in California in the early 1900s where numbers are now greatly diminished.
  - Market hunting—thousands were shot for their skins used in the fashion industry early in the 20th Century.
  - Habitat loss—over 90% of California's historic wetlands have been lost, effectively reducing breeding sites.

- Recent history:
  - Some grebes have adapted to nesting at reservoirs where habitat is limited and water levels and boating recreation can cause problems.
  - Pesticides such as DDD and DDT, and heavy mercury contamination have impacted grebe productivity at some nesting sites (e.g., Clear Lake).
  - Most of these grebes winter along the Pacific Coast where they are exposed to contaminants and are extremely vulnerable to oil spills.
  - Evidence of declines at some breeding areas, and some wintering populations have declined 5%/year for the past 20 years.

- Breeding site problems:
    - Disturbance in colonies can lead to nest abandonment, and increased egg predation.
    - Low-floating nests are susceptible to destruction by boat wakes and wave action.
    - Water level changes can also cause nest loss; grebes usually abandon nests if they become stranded.
    - Speeding boats can kill adults and chicks through prop strikes; disturbance that separates young chicks from parents can lead to mortality as chicks cannot swim for long.
    - Habitat for nesting is limited at some breeding sites.

- What can be done?
    - Post colony sites as closed areas during the nesting season (June-September)
    - Post no-wake zones 100 m from colonies, and in some cases, install wave barriers to protect nests from waves.
    - Maintain stable water levels during the nesting season.
    - Restore nesting habitat where possible.
    - Advise boaters about avoiding swimming grebes.
    - Clean up discarded fishing line.
    - Create educational programs to teach people about grebes, including watching at a distance with binoculars and spotting scopes.

APPENDIX 3. RECOMMENDED SPECIFICATIONS FOR POSTING CLOSED AREAS AROUND *AECHMOPHORUS* GREBE COLONIES.

To protect grebe colonies from disturbance, they should be posted as seasonally closed areas from 1 June-30 September. Closure buoys should be placed in the water 50 m apart and marked with signs applied as decals. For exposed colonies, closure boundaries should be marked on the water side 100 m from the colony, while 50 m should be adequate where nests are concealed by vegetation. At sites with boat wake issues, closures should be posted 100 m from the colony, regardless of vegetation. Each buoy would cost approximately $165.00, including ground tackle, anchor, and shipping. Measurements need to be taken at each site to determine the number of buoys needed. Some maintenance costs would be required, and at Eagle Lake, additional funds would be needed to cover annual installation and removal, as well as winter storage because of winter ice.

For areas with public access to the shore, closed area boundaries should be posted along the shoreline using metal sign posts with mounted aluminum closed area signs. Signs should be placed to provide a 100 m buffer for exposed colonies and a 50 m buffer for colonies screened from view by vegetation. Figure 35 is a draft version of a closed area sign which could be produced on standard 8" x 11" aluminum sign boards, and also as a large sticker for mounting on buoys. Metal signs would cost about $10.00 each and sign posts about $12.00 each. Sign decals should be able to be produced for <$5.00 each but may only have a life of three years. Closure dates can be adjusted, as necessary.

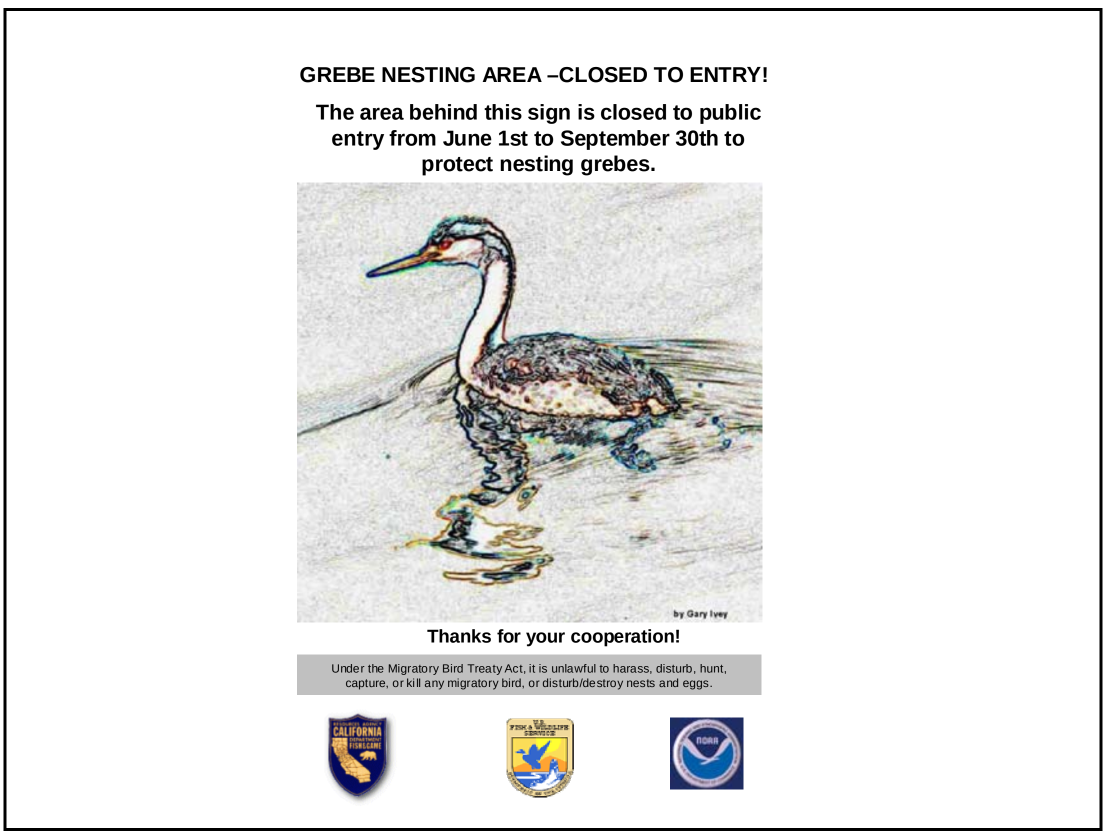

Fig. 35. Draft closed area sign for grebe conservation at recreational lakes.

APPENDIX 4. DESIGN CRITERIA FOR TEMPORARY FLOATING WAVE BARRIERS.

There are several possibilities for breakwater structures, and a cost-analysis of the various options is needed. A simple tire design (Figure 36) might be effective and possibly the least expensive, since it could perhaps be constructed by volunteers, but there are possible water quality issues. Some oil boom styles might also serve as simple temporary breakwaters. Booms with longer skirts would likely perform best. These styles cost about $32/foot and come in 50 and 100 foot lengths. They have the advantage of being easy to deploy and are portable. Several researchers have studied various styles and one which appears promising is a floating flexible membrane wave barrier, described by Kim and Kee (1997). Custom designs of this sort may be less expensive and merit further consideration. Barriers should be anchored to the closure buoys and should be clearly visible above water to prevent boats from causing them damage.

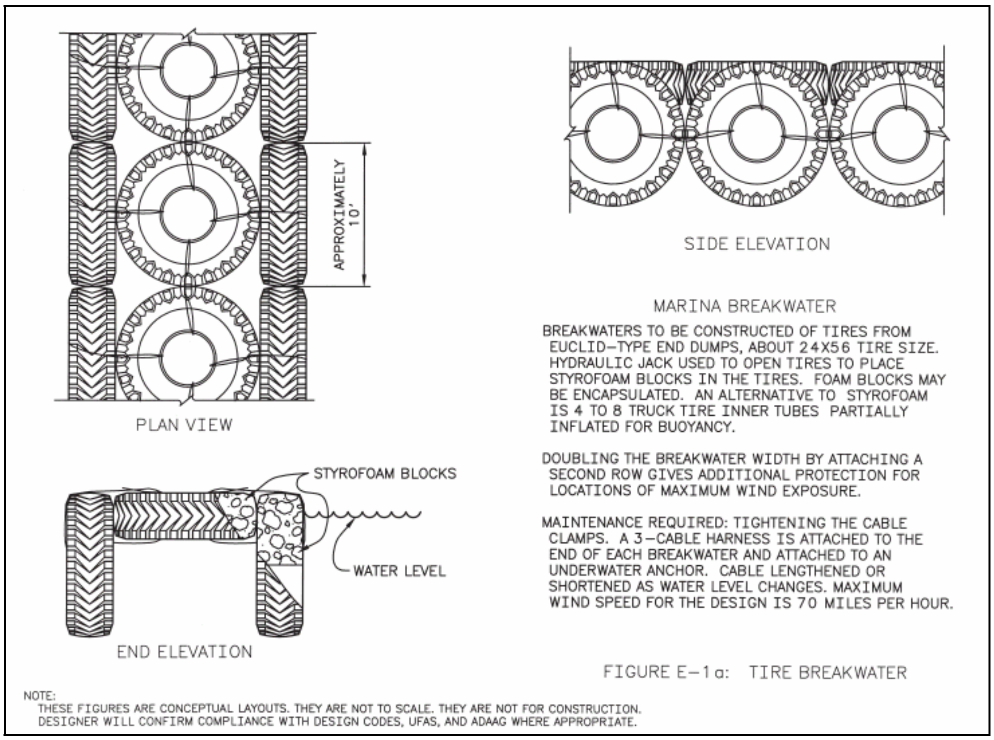

Fig. 36. Tire structure breakwater design from the Bureau of Reclamation (http://www.usbr.gov/pmts/architecture/recfac/RFG-ch3.pdf).

APPENDIX 5. RECOMMENDATIONS FOR MONITORING EFFICACY OF IMPLEMENTED CONSERVATION MEASURES FOR *AECHMOPHORUS* GREBE COLONIES IN CALIFORNIA.

I recommend that monitoring programs be established to document the response of nesting *Aechmophorus* grebes to implemented conservation measures in terms of nest numbers and productivity. I suggest monitoring before project implementation and for three years after. Hanus et al. (2002a) provide a good overview of grebe monitoring techniques.

Recommended methodology

Locate colonies and count nests. ——Colonies can be most efficiently counted from the air by two observers at most sites. Several sites could be counted during a single survey flight to save air time. Ideally, three surveys (four weeks apart) should be conducted, but two may be adequate. Based on nesting chronology (Figure 28), counts should be accomplished in late June, late July, and late August (but will vary with local nesting conditions).

Document nest success.——Because of potential problems of disturbance causing abandonment during nest visits, I do not recommend documentation of nesting success unless there is a specific question which needs to be addressed (e.g., are water level changes reducing grebe productivity at Thermalito Afterbay?). In areas where nests can be observed from shore, repeated observations using a spotting scope could provide information about nest success and effects of water levels or disturbance. Nests which are vacated before the full term of incubation should be categorized as unsuccessful. If nest studies are conducted, individual monitored nests should be visited about every seven days and the data should be analyzed using the nest survival model in Program Mark (White and Burnham 1999) as described by Dinsmore et al. (2003). Nest data can also be used to estimate nesting, hatching and fledging chronology.

Estimate productivity. ——Ideally, two brood surveys should be conducted (mid-July and September) to improve age estimates of classified chicks (those that are younger can be more accurately aged), and derive better information about hatching chronology. At a minimum, one survey in mid-September is recommended, following the methodology used by D. Anderson for brood classification. Counts should be conducted from a boat with one driver and two observers, traveling at a speed of about 5 mph. Depending on the size of the site, complete surveys might be accomplished, or survey transects should be delineated and counted for a large sample of broods. Sites with incomplete coverage should strive to classify at least 50% of the broods for an adequate sample size. Calculation of chicks per adult from collected data will provide an index to productivity which can be used to gauge the success of management actions. At sites where complete counts can be accomplished, productivity data should also be expressed as young per nest.