State of California
THE RESOURCES AGENCY
Department of Fish and Game

# IMPORTANCE OF GREAT BASIN LAKES IN NORTHERN CALIFORNIA TO NONGAME AQUATIC BIRDS, 1977

by

David Winkler

Wildlife Management Branch

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## ABSTRACT

The importance of Great Basin lakes in northern California to summer and fall bird populations was studied and those lakes crucial to the support of individual species were identified. Literature and correspondence reviews of the limnological characteristics of eleven lakes were made, and censuses of nongame aquatic birds were conducted periodically through the summer and early fall at the lakes. Bird populations in this portion of the state segregate their usage of lakes according to the physical and biotic characteristics of each, allowing an identification of those lakes crucial to the sustenance of specific bird populations. Eagle, Goose and Mono Lakes are of outstanding importance to breeding bird populations, and Mono Lake occupies a crucial position in the migratory paths of several species.

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1/ Wildlife Management Branch Administrative Report No. 82-4 (May, 1982).

2/ Supported by Federal Aid in Wildlife Restoration, Project W-54-R-12, Wildlife Management Branch, Nongame Wildlife Investigations, Job V-2. Final Report.

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## RECOMMENDATIONS

1. Develop a management plan for Honey Lake Wildlife Area which would insure adequate nesting areas and food for nongame colonial aquatic birds.

2. Maintain the channel between Negit Island and mainland at Mono Lake. This action, to be considered only as a stopgap measure, must be pursued in conjunction with efforts to reach a compromise with the City of Los Angeles, Department of Water and Power to achieve a long-range solution to the Mono Lake problem through regulation of the lake's level such that the integrity of the nesting islands is insured. Additionally, safeguards must be instituted to protect the water quality in the lake and thus the invertebrates living in the lake.

3. Repeat survey of Great Basin lakes after at least two wet years to assess the extent to which the avifauna expands into aquatic habitats which were dry during the period of this study.

4. Formulate and enforce regulations which would severely restrict human visitation to and aquatic recreation in the vicinity of aquatic bird colonies.

5. Reinitiate the California shorebird and heronry surveys with expansions to include the survey of nesting populations of ibis, crane, rails, curlew, willet, snipe, and terns.

6. Initiate studies at Eagle Lake to determine trends in nesting populations and establish the effects of recreational use of the lake.

# INTRODUCTION

This study was conducted to determine the distribution and abundance of nongame aquatic birds on Great Basin lakes in northern California. Bird populations using a few of these lakes have been studied previously (Gould 1971, 1974; Lederer 1976; Orr and Moffitt 1971; Winkler et al. 1977), and these studies indicate that the lakes are most important to aquatic birds during the breeding and fall migration seasons. The present survey, conducted from June to September, 1977, should thus provide a reliable indication of the current nongame aquatic bird populations of these lakes.

There are several reasons why a survey of this type is needed. Populations of grebes, pelicans, cormorants, egrets and terns in this area were decimated at the turn of the century by market hunting and colony disturbance (Finley 1907; Grinnell and Miller 1944; Thompson 1932), and it is unclear to what extent these populations have recovered. Aquatic birds have definite habitat requirements (e.g., adequate food, appropriate nest sites) which must be met for the maintenance of robust populations. Aquatic habitats of the Great Basin have been altered in the last century by increasing levels of human recreational use and diversions of water for agricultural or municipal use. Available evidence (Gould 1971, Winkler et al. 1977) suggests that these alterations can result in a reduction in habitat quality and a decline in bird populations. Therefore, those lakes which are most important to bird species must be identified and special reference made to those habitats which are being altered or at which alteration appears imminent.

The importance of a lake to a bird species is evaluated through consideration of the species' habitat requirements and the characteristics of the lake. The extent to which a species' habitat requirements are only met at a single lake reflects the importance of that lake to the species. If a species' requirements are met exclusively at lakes which are threatened by adverse habitat alteration, that species' population in the region may be endangered.

## STUDY AREA

The lakes deemed of interest in this study are those natural lakes and reservoirs in the Great Basin, north of Bishop and west of the California-Nevada state line which have surface areas greater than 1000 acres (Figure 1).

Clear Lake National Wildlife Refuge, although not a Great Basin lake, was included in this study since it was known to support the state's largest nesting population of White Pelicans. Although limnological data were collected for Clear Lake, its avifauna will only be dealt with directly in regards to the population of White Pelicans. Ornithological information was gathered for Big Sage Reservior and the Modoc National Wildlife Refuge, but no effort was made to gather information on the limnology of these bodies of water. Tiny Black Lake was included in the hopes that it may provide enlightening comparison with nearby Mono Lake. Neither Eagle Lake nor Lake Tahoe were extensively censused because Eagle Lake's breeding avifauna already had been studied (Gould 1971, 1974; Lederer 1976) and because Tahoe harbors relatively small populations of aquatic birds (Orr and Moffitt 1971). Mono Lake is too large to census with one party, and instead of making inaccurate estimates of the number of birds present in 1977, censuses conducted there by a group of ornithologists in 1976 (Winkler et al. 1977) are presented. Censuses of the Alkali lakes of Surprise Valley and Honey Lake are not possible, as they were dry from the beginning of the study.

The Great Basin is a large arid region characterized by river drainages which end in lakes or sinks without outlets to the sea. The area receives very little precipitation because the Sierra-Cascade crest, forming its western boundary, acts as a huge wall blocking the invasion of moisture-laden winter storms from the Pacific. The predominant vegetation in the basin is sagebrush scrub (Artemisia) interrupted in and near the desert's mountain ranges by stands of juniper (Juniperus) and pinyon or jeffrey pine (Pinus). Although the Great Basin encompasses only the eastern edge of California (Figure 1), many of the lakes of the western half of the basin are within the state's boundaries. Most of the Great Basin lakes in California lie in the state's northern half, and derive their inflow from Sierra-Cascade streams fed by snow trapped from winter storms. Away from these mountains and their reliable stream flows, permanent standing water is rare.

The existing lakes of the Great Basin are scattered remnants of a once extensive system of inland seas which placed nearly a quarter of the Great Basin under water during the Pleistocene Ice Age. Those Pleistocene times of high precipitation, low temperature and low evaporation are now gone, and those once huge inland seas have shrunk, leaving in their stead an array of lakes of varying sizes and chemical compositions. Many of the contemporary lakes are very saline, and few are fresh by normal standards. This condition, coupled with the tendency of most of the lakes to fluctuate widely according to variations in evaporation and precipitation, appears to be responsible for the inferior development of marsh vegetation in Great Basin lakes relative to that of fresher and more stable lakes of other regions.

No limnological field work was done in this study. The following account summarizes information gathered from agency files and published reports on the lakes whose birds have been studied. Perhaps the most significant result of this summary will be to point out the need for further limnological work in the western Great Basin.

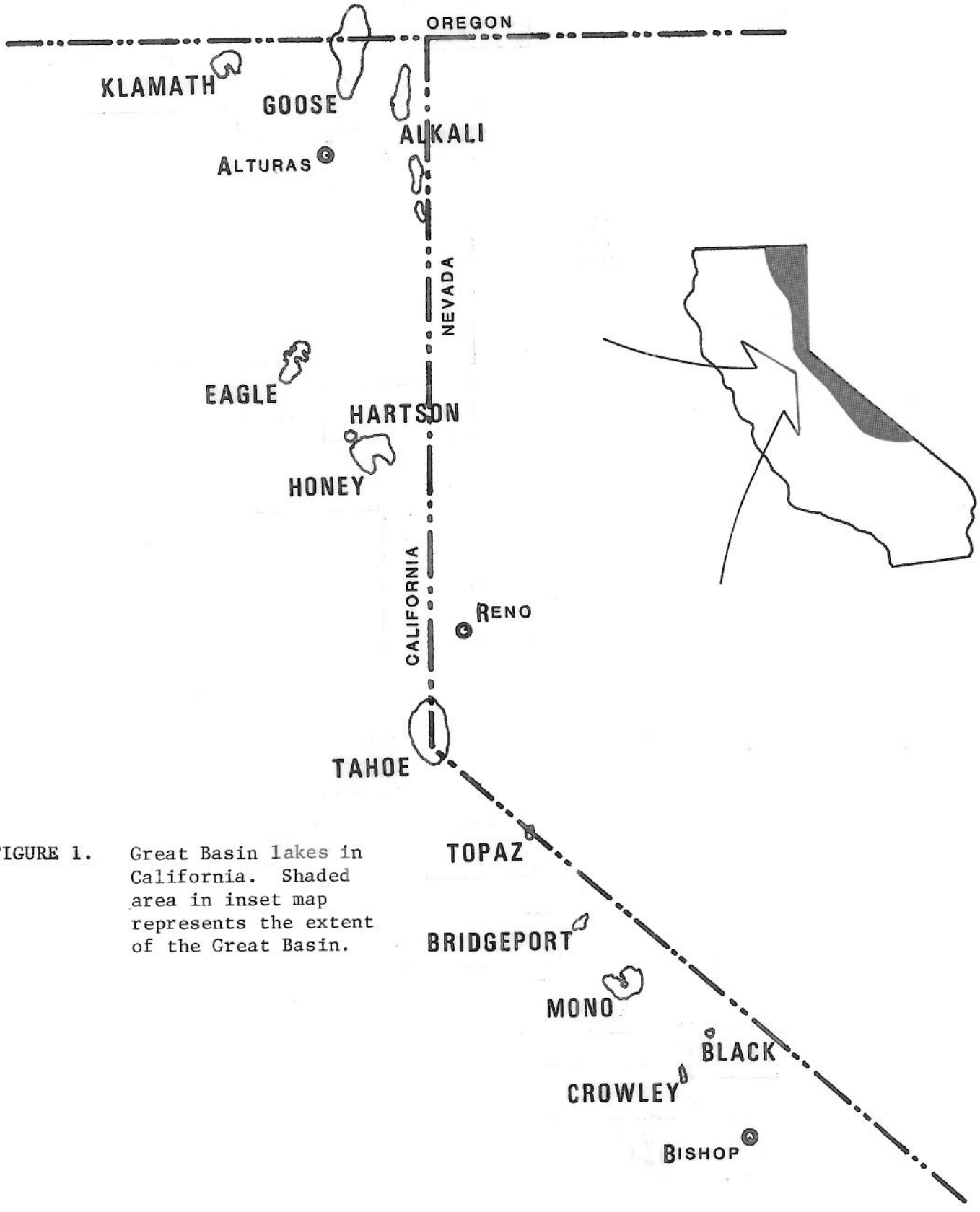


FIGURE 1. Great Basin lakes in California. Shaded area in inset map represents the extent of the Great Basin.

At the northern end of the study area lies Goose Lake, which occupies a shallow fault sump just west of the Warner Mountains and straddles the California-Oregon state line (Figure 1). The lake has occasionally overflowed into the Pit River of the Sacramento River drainage. Extensive irrigation, predominantly in the northern half of the lake's drainage basin, has diverted much of the lake's natural inflow, and the lake will probably never overflow as long as irrigation agriculture persists in the area. Indeed, the lake seldom even approaches overflow elevation. Goose Lake's small volume relative to its surface area (Table 1) makes the potential for evaporative loss high, and the lake has fluctuated from overflow to dryness in the last century. The lake went dry in 1926 and occasionally from 1929-1934 (Harding 1965, Phillips and van Denburgh 1971). Consequently, the lake is fresh relative to other lakes in the Great Basin (Table 2) which, for various reasons, do not dry as readily (Table 1). Goose Lake's relatively fresh waters support several reed beds as well as a healthy fish fauna (Table 3). When the lake is at relatively low stages, there are several islands near its southern and northwestern shores.

Clear Lake National Wildlife Refuge is one of the Klamath Basin refuges administered by the U. S. Fish and Wildlife Service and lies about 40 miles due west of Goose Lake (Figure 1). Formerly a small natural lake, Clear Lake was enlarged (Table 1) by the damming of Lost River in the early 1900's by the Bureau of Reclamation as part of the Bureau's attempts to dry up the Tule Lake Valley (to which Lost River is tributary) for agriculture. At high levels the lake has several small islands near its center peninsula (DFG files, Redding). The lake is fresh (Table 2), not having had time to build up large concentrations of salt and being flushed by inflow and outflow. It seldom, if ever, dries completely (O'Neill pers. comm.). It does, however, fluctuate widely in level due to its shallowness relative to its surface area (Table 1). There is little emergent vegetation around the lake's shores, and the lake supports a limited fish fauna (Table 3).

Just over the Warner Mountains, approximately 15 miles east of Goose Lake lies a series of three alkaline lakes in the closed fault sink of Surprise Valley (Figure 1). Very little is known about these, the Upper, Middle, and Lower Alkali Lakes. While there is always a small body of apparently fresh water (spring-fed?) surrounded by dense reeds on the south end of Middle Alkali Lake, this body, along with a few small spring seeps, often comprises the only standing water in the valley. These lakes are classical playas, being dry much of the time and moderately saline when full. Just as Goose Lake is comparatively fresh for a lake with practically no outlet, the scant data available from the Alkali Lakes (Table 2) indicate that their waters are also relatively fresh. The lakes' salinities and erratic levels prohibit the persistence of fish in the lakes, and, with the exception of the tules surrounding the pond in the south end of Middle Alkali Lake, there is no aquatic vegetation on or around the lakes. Apparently, nothing is known of the invertebrate fauna of the Alkali Lakes. The lakes were dry during this study.

Although Eagle Lake was not included in the field work for this study, enough is known of its ornithology (Gould 1971, 1974, Lederer 1976) to make a brief consideration of its limnology worthwhile. The lake lies in a basin about 25 miles

| Lake | Degree of Fluctuation* | Surface Area (Acres X 1000) | Volume (Acre-feet X 1000) | Maximum Depth (Feet) | Mean Depth (Feet) | Sources |
|---|---|---|---|---|---|---|
| Goose | 2 | | | | | |
| (maximum) | | 124 | 2250 | 24 | 18 | Phillips and van Denburgh 1971 |
| (minimum) | | ----------dry---------- | | | | |
| (average) | | | | 12 | 8 | |
| Clear | 3 | | | | | |
| (historical average) | | 8 | | | | DFG fisheries files, Redding |
| (present maximum) | | 25 | 100 | 17 | 4 | |
| Alkali Lakes | 1 | | | | | |
| Upper (maximum) | | 26 | | | | |
| Middle (maximum) | | 17 | | | | |
| Lower (maximum) | | 7.6 | | | | |
| Eagle | 3 | | | | | DWR 1974, Lederer 1976 |
| (average?) | | 26 | | 90 | 20 | |
| Honey | 1 | | | | | |
| (historical maximum) | | 64 | | 51 | | Harding no date, 1962 |
| (historical average) | | 31 | | | | |
| Topaz | 2 | | | | | |
| (maximum) | | 2.4 | | 90 | | NDFG 1974, 1975 |
| (minimum) | | 1.5 | | 57 | | |
| Bridgeport | 2 | | | | | |
| (maximum) | | 2.5 | | | | |
| Mono | 4 | | | | | Mason 1967, Winkler 1977 |
| (1976 level) | | 41 | 2420 | 155 | 60 | |
| Black | 2 | | | | | |
| (maximum) | | 0.12 | | | | |
| Crowley | 3 | | | | | |
| (maximum) | | 5.3 | 184 | 115 | 35 | Pister 1960 |

TABLE 1. Summary of physical characteristics of northern Great Basin lakes in California. Historical levels refer to those prior to the development of water diversions or dams in a drainage basin.

*1 = Ephemeral; often dries completely.
2 = Markedly astatic; severe seasonal fluctuation but seldom dries completely.
3 = Moderately astatic; fluctuates seasonally but nevers dries completely.
4 = Static; fluctutates very little in one year.

| | Na | K | Ca | Mg | Cl | $NO_3$ | $HCO_3$ | $CO_3$ | $CO_3$+ $HCO_3$ | $SO_4$ | pH | Total Dissolved Solids |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Goose[1] | 35.0 | 2.8 | 1.0 | 0.3 | 12.0 | | 29.0 | 7.4 | | 6.5 | 9.1 | 1270 |
| Lower Alkali[2] | 33.0 | 0.3 | 0.2 | 0.2 | 27.9 | 0.01 | | | 28.9 | 7.4 | | 4150 |
| Middle Alkali[3] | a34.4 | 0.1 | 0.1 | 0.1 | 36.0 | 0.04 | | | 22.1 | 6.2 | | 9240 |
| | b37.0 | | 0.1 | 0.1 | 37.0 | | 7.9 | 5.0 | | 12.9 | | 12519 |
| | b35.1 | | 0.2 | 0.2 | 30.7 | | 22.4 | 5.5 | | 5.9 | 8.9 | 3077 |
| Clear Lake[4] | 7.3 | 3.0 | 8.8 | 6.0 | 1.0 | | | | 71.5 | 2.4 | 7.2 | 118.5 |
| Eagle Lake[5] | a17.2 | 4.6 | 1.4 | 4.6 | 1.9 | 0.20 | 60.0 | 8.5 | 68.5 | 0.0 | 9.1 | 708 |
| | b17.8 | 4.3 | 1.2 | 5.5 | 2.0 | | 61.0 | 8.2 | 69.2 | | 9.0 | 694 |
| | a16.5 | 4.2 | 1.0 | 5.5 | 2.6 | 0.0 | 62.9 | 7.3 | 70.2 | 0.0 | 9.2 | 485 |
| | a15.2 | 2.6 | 1.3 | 5.3 | 1.8 | 0.02 | 73.3 | 0.2 | 73.5 | 0.3 | 8.7 | 405 |
| Topaz[6] | | | | | 4.8 | 0.32 | 63.0 | 0.0 | 63.0 | | 8.05 | 124 |
| | | | | | 4.9 | 0.0 | 89.0 | 0.0 | 89.0 | | 7.72 | 82 |
| | | | | | 6.1 | 1.2 | 89.4 | 0.0 | 89.4 | | 8.18 | 66 |
| | | | | | 9.7 | 0.0 | 167.9 | 0.0 | 167.9 | | 7.86 | 31 |
| Mono[7] | 33.1 | 1.7 | trace | 0.04 | 19.5 | 0.03 | 12.6 | 21.2 | 33.8 | 11.2 | 9.7 | 89740 |
| Crowley[8] | 13.1 | 2.1 | 7.7 | 1.6 | 6.6 | 0.2 | 51.2 | 0.0 | 51.2 | 3.9 | 7.3 | 187 |
| Owens[9] | 36.8 | 2.1 | trace | trace | 25.1 | | 0.0 | 25.2 | 25.2 | 9.7 | | 77098 |
| Walker[10] | 31.1 | 1.5 | 0.2 | 1.3 | 22.3 | 0.04 | 17.7 | 5.5 | 23.2 | 20.3 | 9.2 | 6890 |

TABLE 2. Chemical composition of selected Great Basin lakes. All ions are in percentage of total dissolved solids. Total dissolved solids is in parts per million. Blanks indicate no data.

Sources: [1]Phillips and van Denburgh 1971. [2]Livingstone 1963. [3a]Livingstone 1963. [3b]Harding 1962. [4]Koch et al 1975. [5a]DWR 1974. [5b]DFG files, Redding. [6]NDFG 1974-75. [7]Dana et al 1977. [8]Pister 1960. [9]Harding, no date. [10]DFG files, Redding.

| Lake | No Fish | lamprey (Petromyzontidae) | Cutthroat Trout (Salmo clarki) | Brown Trout (Salmo trutta) | Rainbow Trout (Salmo gairdneri) | Brook Trout (Salvelinus fontinalis) | sucker (Pantosteus) | (Chasmistes) | (Catostomus) | Carp (Cyprinus carpio) | dace (Rhinichthys) | chub (Siphateles) | (Gila) | shiner (Richardsonius) | bullhead (Ictalurus) | Striped Bass (Roccus) | sun perch (Lepomis?) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Goose[1] | | X | | | X | | | | X | | | X | | | X | X | |
| Clear[2] | | | | | X | | | X | X | | X | | | | | | X |
| Alkalies | X | | | | | | | | | | | | | | | | |
| Eagle[3,4] | | | | | X | | | | X | | X | X | | X | X | | |
| Honey | X | | | | | | | | | | | | | | | | |
| Topaz[5] | | | | X | X | | X | | X | X | X | | X | X | | | |
| Bridgeport[5] | | | | X | X | | X | | X | X | X | | X | X | | | |
| Mono | X | | | | | | | | | | | | | | | | |
| Black | ? | | | | | | | | | | | | | | | | |
| Crowley[6] | | | X | X | X | X | | | X | | X | X | | | | | |

TABLE 3. Summary of the available knowledge of the fish faunas of the lakes covered in this survey.

Sources: [1]CDFG fisheries files, Redding. [2]Koch et al. 1975. [3]Gould 1974. [4]Kimsey 1954. [5]Shumway pers. comm. [6]Pister 1965.

northwest of Susanville and was formed when its watershed was dammed by a lava flow (Figure 1). Because the lake has an outlet stream and because there is a large amount of groundwater flow through the lake's basin (DWR 1974), Eagle Lake's waters have not built up large concentrations of salts (Table 2). The lake therefore supports a large fish fauna (Table 3), and most of the lake's shore is lined by healthy stands of emergent vegetation. The major change occurring in the Eagle Lake area which may eventually affect its avifauna is the rapidly increasing level of recreational use of the lake. Some of the lake's most productive reed beds for nesting birds are being destroyed, or their inhabitants are being frightened, by the encroachment of boat ramps and air strips (Gould 1971).

Approximately 15 miles southeast of Susanville lies Honey Lake, one of the largest playas in California (Figure 1). With the present agricultural use of inflow water from the northwest of the lake, the lake level is usually much lower than pre-irrigation levels (Table 1). Indeed, the lake is often completely dry. It was dry and a source of numerous dust storms in the summer of 1977. Due to its erratically fluctuating water level, Honey Lake has no vegetative cover and is presumably lacking a regular vertebrate fauna. Adjacent to the north shore of Honey Lake lie the marshes of the Honey Lake State Wildlife Management Area. The erratic aquatic habitat of Hartson Reservoir is most significant of the habitats in this area for nongame birds. Too small to have been paid any attention to by limnologists, this body of water is probably most important for nongame aquatic birds when the water is high and the low rises in the middle of the basin form islands on which many species rely for nesting. Aquatic vegetation on the reservoir itself is sparse, most likely due to the reservoir's fluctuating level. There are healthy reed beds on the adjacent "east ponds", but these are apparently too small to support large populations of nongame aquatic birds.

Topaz Reservoir lies 120 miles south-southeast of Honey Lake astride the California-Nevada state line (Figure 1). The reservoir is formed by a dam across the West Walker River. Water from the reservoir is used for irrigation, and maximum drawdown usually occurs in fall (Table 1). The reservoir's waters are fresh (Table 2), and the fish fauna is quite diverse (Table 3). Topaz is jointly managed as a recreational fishery by the California and Nevada Departments of Fish and Game. The reservoir has no islands and its shores are devoid of emergent vegetation, probably due to its fluctuating water level.

Although there are no limnological data available for Bridgeport Reservoir, which lies approximately 30 miles southeast of Topaz on the East Walker River (Figure 1), it is known to contain the same fish species as Topaz (Table 3), and it is presumably similar to that reservoir limnologically. Bridgeport does appear to be shallower relative to its volume and inflow than Topaz. Whereas Topaz retained the great majority of its normal surface area during the drought of 1977, Bridgeport shrank to a small channel bisecting extensive mudflats. There is no emergent vegetation cover along most shores of this reservoir, nor are there any islands.

Mono Lake lies 20 miles southeast of Bridgeport Reservoir (Figure 1) and is the most unique of the lakes in this study. The lake is one of the largest in volume in the state (Table 1). Mono has two major islands, both of recent volcanic origin. The northern island (Negit) is composed of a volcanic cone and its basaltic lava flows, while the southern island (Paoha) is composed of

efflorescent lake-bottom sediments brought to the surface by the force of the eruption of a small volcano on the island's northern shore. The lake is famous for its extreme chemistry (Table 2). Not only are the amounts of dissolved solids very high, but there are large quantities of many ions which are usually not common together in water. The lake's water determines to a large extent the composition of its biota by prohibiting the establishment of fish and restricting the macroscopic fauna to two organisms: The brine fly (Ephydra hians), which spends its egg, larval and pupal stages in the lake and an endemic brine shrimp (Artemia monica), which spends its entire life cycle in the lake's distinctive brine. Both of these invertebrates occupy the lake in numbers unequaled elsewhere in the western Great Basin (pers. obs.) and supply a bountiful food resource for those bird species which can effectively forage on them. This rich food supply coupled with the availability of sequestered island nesting sites has made Mono Lake immensely important for several bird species. Mono's shores are devoid of emergent vegetation. Mono Lake is thought to be one of the oldest lakes in North America, having been present without drying for at least 500,000 years (Lajoie 1968).

Mono Lake's islands probably have been important to nesting gulls since their formation several thousand years ago. Because the lake is close to the source of its unusually reliable inflow from the snow pack of the Sierra Nevada and because it has a large volume relative to its surface area (Table 1), Mono Lake shows little seasonal fluctuation in lake level. In 1940 the Los Angeles Department of Water and Power began diversion of the tributary streams to Mono Lake, rerouting this water into the 300 miles of aqueduct and Owens River bed leading to Los Angeles. The amount of the diversions steadily increased, and by 1970 the city was diverting essentially all the flow in the lake's major natural tributary streams, leaving the creek's deltas dry and barren of riparian vegetation. The lake is shrinking at a rate of about 1.8 vertical feet per year, and the encroaching lake bed is connecting what have been islands for the thousands of years since their formation to the mainland. Negit Island, home of over 80 percent of Mono's nesting gulls and about 75 percent of the entire nesting population in the state, was connected to the mainland in the fall of 1977, and the other islands will follow within the next thirty years. These islands, once land-bridged, no longer provide the protection from land predators which the gulls seem to require. The dropping level of the lake may have even more far-reaching consequences, for, as the lake's volume decreases, the particulate concentration of its already extreme water increases. This increasing salinity may eventually make the lake uninhabitable by the phytoplankton, brine shrimp, brine fly, and aquatic birds (Winkler 1977), thus creating an ecological desert where there is now one of the most productive yet simple ecosystems on the continent.

Approximately 25 miles southeast of Mono Lake lies Black Lake (Figure 1). The smallest lake in this review, there is nothing rigorous known of its limnology. It appears to be very shallow and is probably fed by submerged springs. The lake's water seems to be very saline, but there are well-developed stands of tules on much of the lake.

The southermost lake in this review is Crowley Reservoir, located about 30 miles south-southeast of Mono Lake (Figure 1). The reservoir was formed by the damming of the Owens River in Long Valley by the Los Angeles Department of Water and Power for use as a storage reservoir for the Los Angeles aqueduct system. Being a storage reservoir, its level fluctuates regularly, and emergent vegetation is sparse along its shores. There are no islands in the lake, and it normally freezes over from December or January through April (Pister 1960). Productivity in the reservoir is high due to its shallowness (Table 1), moderate dissolved solids content (Table 2) and the recent inundation of its basin, making large amounts of organic material available to the lake ecosystem. The lake supports a very productive fish fauna (Table 3).

Honey Lake and the Alkali Lakes of Surprise Valley are characterized by frequent summer dryness and lack of either vegetation or a regular vertebrate fauna. These lakes support sporadic bird populations. In years when the lakes manage to retain water in summer, they are likely to support populations of shorebirds. In a series of physical severity, Mono Lake must certainly stand next in line. Mono lacks both emergent vegetation and fish, but it makes up for these shortcomings in the birds' eye by providing large islands and an immensley productive invertebrate fauna. The few species which can adapt to these conditions find a haven here which is unequaled in the entire western half of the Great Basin. The numbers of breeding California Gulls (Larus californicus) comprise one of the world's two largest aggregations of the species, and the numbers of migrant shorebirds and grebes visiting Mono each summer and fall are unrivaled in the Great Basin west of the Great Salt Lake. Mono Lake is one of the world's two or three most important staging areas for the Wilson's Phalarope (Steganopus tricolor) and Eared Grebe (Podiceps caspicus). Numbers observed there apparently are the largest reported anywhere. Tiny Black Lake is difficult to categorize. It apparently has highly saline waters, thus presumably lacking fish, but it has fine stands of tules as do the lakes which follow. Regardless, Black Lake has a very small breeding avifauna, probably due to nothing more than its small size. The two major factors which appear to exclude the development of reeds and tules are widely fluctuating lake levels and high salinity. When both these factors are moderated, lakes of a generally distinctive and relatively common type arise. In this study we have Goose and Eagle Lakes, Hartson Reservoir and vicinity, and much of the Klamath Basin refuges in this category. All these sites (with the possible exception of the vicinity of Hartson Reservoir in very dry years) harbor healthy fish populations and are bordered entirely or in part by emergent vegetation. All are relatively shallow over most of their area and provide islands for nesting. Thus these lakes are ideally suited for nesting piscivorous birds, and it is on these lakes that most such nesting occurs. The four large reservoirs in this study, Clear, Topaz, Bridgeport, and Crowley, occupy the end in the series. These bodies of water generally have the lowest dissolved solids contents, but it is apparently their fluctuating water levels which prevent the establishment of large stands of emergent vegetation. These reservoirs support large populations of fish which consume much of the invertebrate production in the lakes before it reaches levels accessible to birds, and these lakes, with the exception of Clear Lake, generally lack islands. These factors combined make these lakes most suitable only for migrant piscivorous birds.

## METHODS

The birds of most of the lakes in this survey were censused during one day periods three to five times between June 23 and September 7, 1977 (Appendix 1). Although efforts were made to determine the breeding status and abundance of every species present, the procurement of unquestionable substantiating evidence was usually not justified if it meant the investment of more than half a day's field work. Spending more than this length of time at any single locality on a given lake would generally mean the sacrifice of valuable censusing time elsewhere, for the large geographic area covered in this survey placed severe limitations on the amount of time available during each visit to a given lake.

Birds were censused from as many localities on the lakes' shores as were necessary to insure that the entire surfaces of the lakes were searched for birds. The duration of a given census was not set at any prescribed interval; a census site was vacated for a new site when all the birds visible were identified and censused. Censuses were conducted with 7X35 binoculars and a 15-60X zoom spotting scope.

The short time available for censusing each lake in this survey prohibited accurate censusing of the American Bittern (Botaurus lentiginosus), White-faced Ibis (Plegadis chihi), Virginia Rail (Rallus limicola), Sora (Porzana carolina), and Yellow Rail (Coturnicips noveboracensis). The status of these species in the Great Basin wetlands of California is very poorly understood, and populations of these birds in this region, especially the ibis and Yellow Rail, may be of key importance to maintaining a robust population in the state. Although waterfowl were informally censused, no effort has been made to analyze their populations since the Department of Fish and Game conducts regular aerial censuses in the northeastern corner of the state where the only significant populations of waterfowl in California's Great Basin nest. The sizes of populations of marsh and wet meadow nesting birds--such as the Sandhill Crane (Grus canadensis), Willet (Catoptrophorus semipalmatus), Long-billed Curlew (Numenius americanus), Common Snipe (Capella gallinago) and Spotted Sandpiper (Actitis macularia)--were not determined in this study, but California's Great Basin wetlands appear to support key portions of the state-wide populations of at least the crane, willet and curlew.

In summary, this survey is intended to reveal reasonably comprehensive and representative data only for those species which restrict their activities to aquatic habitats relatively free of dense vegetative cover and having open water at least 100 acres in extent. Accurate censuses for those species briefly described above which do not meet these requirements will require a more painstaking approach which concentrates the censusing effort on relatively small areas of habitat.

# RESULTS

Analysis of the status and habitat preferences of 19 nongame aquatic bird species occurring in the Great Basin, based on their distribution during the nesting season and the fall migration season, were made (Tables 4, 5, and 6). Data on diets and foraging methods of these species (Table 7) are based on references from the literature and on my own observations. References from outside the Great Basin were included when sufficient data from the Great Basin were not available.

The few sightings of those nongame aquatic bird species not treated in the main body of this report are summarized in Appendix 2. Species accounts below include relevant details on species' distributions supplementary to data in Tables 4, 5, and 6.

## Species Accounts

Eared Grebe (Podiceps caspicus): Eagle Lake is the outstanding breeding area for this species in the Great Basin of California. Declines in the Eared Grebe's population there (Lederer 1976) may be due to high levels of human recreational use, but further investigation is required. This grebe has bred in small numbers at Topaz Lake (Moffitt 1938), is likely to breed near Hartson Reservoir, and may breed at Black and Goose Lakes. The few data available indicate that the present breeding populations in eastern California are of approximately the same size as those in eastern Oregon (Willett 1919) and eastern Washington (Yocom et al.1958), and that the population at Eagle Lake may be larger than it was 70 years ago (Sheldon 1907).

The numbers observed during the fall migration on Mono Lake outnumber those on any of the other lakes surveyed by a factor of at least 500. Although undetermined numbers of Eared Grebes are known to pass along the Pacific Coast and through the Salton Sea at this time, Mono Lake is certainly one of the most important staging areas for this species on the entire continent.

Western Grebe (Aechmophorus occidentalis): Eagle Lake harbors by far the largest breeding populations of this species in California's Great Basin. This grebe breeds sporadically at Bridgeport and Crowley Reservoirs (Gaines 1977) and has nested at Topaz Lake (Moffitt 1938). Populations of Western Grebes nesting in California appear to be holding their own, and they are probably larger than those in Oregon (Willett 1919) or Washington (Yocom et al. 1958). Inland migrant populations of this species in California are relatively small, as the bulk of the population, centered in the northern Great Plains, apparently migrates directly west to wintering grounds on the Pacific Northwest Coast without coming as far south as interior California (Munro 1954).

Pied-billed Grebe (Podilymbus podiceps): This species' propensity to nest on very small bodies of water may cause an underestimate of the numbers of birds breeding in northeastern California. Regardless, these populations are likely larger than those in eastern Oregon (Willett 1919) or eastern Washington (Yocom et al.1958). As in the other grebes, Eagle Lake is the most important breeding area for this species in the California portion of the Great Basin.

| Species | Status | Mainland & Shore: Emergent vegetation | Mainland & Shore: Bare ground | Mainland & Shore: Ground with cover | Mainland & Shore: Trees and shrubs | Island: Tule-reed mats | Island: Bare ground | Island: Ground with cover | Island: Trees and shrubs | Water Depth: 0-1 meter | Water Depth: 1-5 meters | Water Depth: Over 5 meters | Salinity (TDS): 0-1000 ppm | Salinity (TDS): 1000-10,000 ppm | Salinity (TDS): Over 10,000 ppm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Eared Grebe[1,2] | C-L* | X | | | | | | | | X | X | | X | | |
| | A-L | | | | | | | | | X | X | X | | X | X |
| Western Grebe[2] | C-L | X | | | | | | | | | X | X | X | X | |
| | C-L | | | | | | | | | | X | X | X | X | |
| Pied-billed Grebe[2] | FC-L | X | | | | | | | | X | X | | X | | |
| | R-L | | | | | | | | | X | X | | X | X | |
| White Pelican[3,4] | C-L | | | X | | X | X | X | | X | X | | X | X | |
| | FC-L | | | | | | | | | X | X | X | X | X | |
| Double-crested Cormorant[4,5] | FC-L | | | | X | | X | X | X | X | X | | X | X | |
| | FC-L | | | | | | | | | X | X | X | X | X | |
| Great Blue Heron[5,6] | U-L | | | | X | X | X | X | X | X | | | X | X | |
| | FC-WS | | | | | | | | | X | | | X | X | X |
| Great Egret[5,6] | U-L | | | | X | X | | | X | X | | | X | X | |
| | R-L | | | | | | | | | X | | | X | X | |
| Snowy Egret[5,6] | FC-L | | | | X | X | X | X | X | X | | | X | X | |
| | U-WS | | | | | | | | | X | | | X | X | X |
| Black-crowned Night Heron[5,6] | U-L | X | | | X | X | X | X | X | X | | | X | X | |
| | R-L | | | | | | | | | X | | | X | X | X |
| American Coot[2,5] | U-L | X | | | | | | | | X | X | | X | X | |
| | C-WS | | | | | | | | | X | X | | X | X | X |
| American Avocet[7,8] | C-L | | X | | | | X | | | X | | | | X | X |
| | A-L | | | | | | | | | X | | | | | X |
| Black-necked Stilt[7,8] | U-L | | X | | | | X | | | X | | | X | X | |
| | R-L | | | | | | | | | X | | | | | X |
| Wilson's Phalarope[7,8] | R-L | X | | | | | | | | X | X | | | X | |
| | A-L | | | | | | | | | X | X | X | | X | X |
| Northern Phalarope[7,8] | --- | X | | | | | | | | X | X | | X | X | |
| | A-L | | | | | | | | | X | X | X | | X | X |
| California Gull[4,9,10] | A-L | | | | | X | X | X | | X | X | | X | X | |
| | C-WS | | | | | | | | | X | X | X | X | X | X |
| Ring-billed Gull[4,9,10] | C-L | | | | | X | X | X | | X | X | | X | X | |
| | R-WS | | | | | | | | | X | X | X | X | X | X |
| Forster's Tern[10] | FC-L | X | | | | X | X | | | X | X | X | X | X | |
| | U-L | | | | | | | | | X | X | X | X | X | |
| Caspian Tern[10] | U-L | | | | | X | X | X | | X | X | X | X | X | |
| | U-L | | | | | | | | | X | X | X | X | X | |
| Black Tern[10] | U-L | X | | | | | | | | X | X | | X | | |
| | R-L | | | | | | | | | X | X | | X | | |

TABLE 4. Status and habitat preferences of nongame aquatic birds of the western Great Basin. A=abundant, C=common, FC=fairly common, U=uncommon, R=rare, L=local, WS=widespread.

Sources: [1]Yocom et al. 1958. [2]Gould 1974. [3]Knopf 1974. [4]Behle 1958. [5]Palmer 1962. [6]Gill 1977. [7]Bent 1927. [8]Palmer 1967. [9]Vermeer 1970. [10]Bent 1921.

*Upper entries refer to status and habitat during nesting, lower entries to status and habitat after the completion of nesting.

| Species | Goose Lake 1977 | Klamath Basin 1976 | Eagle 1970 | Eagle 1974 | Modoc NWR 1977 | Hartson 1977 | Topaz 1977 | Bridgeport 1977 | Mono 1976 | Black 1977 | Crowley 1977 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Eared Gr | 9 (?) | 6860 (1950) | 4000* | 0 | 1 | 3 (?) | 0 | 0 | 50,270 | 20 (?) | 1 |
| West Gre | 730 (40?) | 2675 (403) | 3000* | 2400* | 3 | 1 | 25 | 40 | 0 | 0 | 2 |
| P-b Greb | 0 | 310 (175) | 300* | | 6 (1) | 0 | 0 | 0 | 0 | 0 | 0 |
| D-c Corm | 54 (30) | 1048 (433) | 0 | 22* | 32 (1) | 0 | 0 | 7 | 0 | 0 | 0 |
| W Pelica | 8 (?) | 1899 (876) | 200 | | 23 | 0 | 0 | 97 | C | 0 | 1 |
| G B Hero | 6 (6) | 380 (178) | 74* | 18* | 3 (1) | 0 | 0 | 0 | 0 | 0 | 2 (3?) |
| Gr Egret | 0 | 115 (80) | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sn Egret | 80 (60?) | 20 (14) | | | 20 | 1 (2) | 0 | 0 | 0 | 0 | 0 |
| B-c N He | 11 (3) | 94 (41) | | | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| Am Coot | 198 (1) | | 5000* | | 60 (21) | 250 | 7 | 15 | 7 | 1 | 25 |
| Am Avoce | 12 (10) | | | | 35 (4) | 40 (4) | 0 | 40 | 2679 | 35 (7) | 13 (3) |
| B-n Stil | 0 | | | | 20 (2) | 60 (?) | 0 | 3 | 15 | 0 | 1 |
| W Phalar | 0 | | | | 6 | 60 (1?) | 0 | 45 | 15586 | 125 (3?) | 0 |
| Ca Gull | 1205 (720) | 1980 (728) | | 26* | 10 | 15 (0) | 50 | 425 | 50000 (30000) | 20 | 105 |
| R-b Gull | 0 | 11818 (3890) | | | 6 | 100 (0) | 1 | 0 | 2 | 0 | 0 |
| Cas Tern | 400 (200) | 420 (175) | 0 | 0 | 3 | 1 | 0 | 8 | 10 (5) | 0 | 3 |
| Fors Ter | 453 (220) | 1170 (220) | 300* | 56* | 7 | 1 | 1 | 7 | 25 | 0 | 0 |
| Black Te | 0 | 500 (20) | 400* | 46* | 15 (2) | 21 | 0 | 6 | 0 | 0 | 1 |

Table 5. Peak populations of selected species of birds observed on lakes of the Great Basin and northeastern plateau of California before July 15, 1977. Data from Mono (Winkler et al 1977) and Eagle Lakes (Gould 1971, Lederer 1976) and the Klamath Basin (O'Neill pers. comm.) are from different years. Values in parentheses represent estimated production of young, and question marks in parentheses are for those species strongly suspected of breeding but for which substantiating evidence is lacking. Asterisks indicate those species which are known to breed but for which data are incomplete. Species whose rows are left blank are those for which no data are available.

| Species | Goose | Hartson | Topaz | Bridgeport | Mono | Black | Crowley | Stillwater |
|---|---|---|---|---|---|---|---|---|
| Eared Grebe | 2 | 22 | 127 | 1 | 707,000 | 34 | 0 | 50 |
| Western Grebe | 260 | 0 | 56 | 36 | 1 | 0 | 65 | 210 |
| White Pelican | 66 | 0 | 18 | 53 | 0 | 0 | 119 | 1,350 |
| Double-crested Cormorant | 72 | 0 | 0 | 34 | 8 | 0 | 75 | 75 |
| Great Blue Heron | 24 | 2 | 45 | 28 | 4 | 0 | 22 | 45 |
| Great Egret | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 40 |
| Snowy Egret | 5 | 10 | 0 | 0 | 20 | 0 | 5 | 30 |
| Black-crowned Night Heron | 3 | 25 | 0 | 0 | 2 | 0 | 0 | 80 |
| American Coot | 320 | 35 | 3 | 0 | 380 | 2 | 6,150 | |
| American Avocet | 550 | 1,375 | 0 | 30 | 3,950 | 450 | 141 | |
| Black-necked Stilt | 0 | 40 | 0 | 0 | 6 | 0 | 0 | |
| Wilson's Phalarope | 1,000 | 795 | 0 | 10 | 93,000 | 500 | 4 | 800 |
| Northern Phalarope | 185 | 51 | 0 | 10 | 21,613 | 5,500 | 0 | |
| California Gull | 50 | 85 | 127 | 520 | 23,137 | 155 | 815 | 400 |
| Ring-billed Gull | 100 | 10 | 7 | 0 | 0 | 0 | 0 | 50 |
| Caspian Tern | 46 | 0 | 1 | 25 | 24 | 0 | 24 | 5 |
| Forster's Tern | 98 | 3 | 0 | 0 | 6 | 0 | 21 | 50 |
| Black Tern | 0 | 3 | 0 | 0 | 12 | 0 | 0 | |

TABLE 6. Peak numbers of birds of selected species observed on lakes of the Great Basin in California after July 15, 1977. Data from Mono Lake (Winkler et al. 1977) are for the summer of 1976, and data from Stillwater National Wildlife Refuge (Howard pers. comm. 1977) in west-central Nevada are included for comparison. Species for which rows are left blank are those for which no data were available.

| Species | DIET | | | | | | | | FORAGING MODE | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Aquatic insects | Terrestrial insects | Crustaceans | Small fish | Large fish | Small mammals and birds | Amphibians and reptiles | Vegetation | Aerial dive | Surface dive | Shallow water dabble | Shallow water stab | Water surface grasp | Terrestial grasp | Terrestial graze |
| Eared Grebe[1] | X | X | - | - | | | - | | | X | | | | | |
| Western Grebe[1] | - | | | X | | | | | | X | | | | | |
| Pied-billed Grebe[1] | X | X | X | X | | | | | | X | | | | | |
| White Pelican[1] | | | | X | X | | | | | X | | | | | |
| Double-crested Cormorant[1] | | | - | X | X | | | | | X | | | | | |
| Great Blue Heron[1] | - | - | X | X | | X | X | - | | | | X | | | |
| Great Egret[1] | X | X | X | X | | X | X | | | | | X | | | |
| Snowy Egret[1] | X | X | X | X | | | X | | | | | X | | | |
| Black-crowned Night Heron[1] | X | | X | X | | - | - | | | | | X | | | |
| American Coot[2] | - | - | - | | | | | X | | X | X | | X | X | X |
| American Avocet[3,4] | X | | X | | | | | - | | | X | | X | X | |
| Black-necked Stilt[3,4] | X | X | X | | | | | | | | X | | X | X | |
| Wilson's Phalarope[3,4] | X | X | X | | | | | | | | X | | X | X | |
| Northern Phalarope[3,4] | X | - | X | | | | | | | | | | X | X | |
| California Gull[5,6] | - | X | X | - | | X | - | | X | | X | | X | X | |
| Ring-billed Gull[7] | | X | | - | | X | | | X | | X | | X | X | |
| Forster's Tern[7] | X | | | X | | | | | X | | | | | | |
| Caspian Tern[7] | | | - | X | | - | | | X | | | | | | |
| Black Tern[7] | X | X | - | | | | | | X | | | | | | |

TABLE 7. Diets and preferred foraging modes of selected Great Basin aquatic bird species. "X" in the diet columns denotes a major diet item and "-" denotes a less preferred item.

Sources: [1]Palmer 1962. [2]Bent 1926. [3]Bent 1927. [4]Wetmore 1925. [5]Winkler et al. 1977. [6]Greenhalgh 1952. [7]Bent 1921.

White Pelican (Pelecanus erythrorhynchos): Pelicans have sporadically attempted nesting at Goose Lake (1976?), Hartson Reservoir (1976) and Big Sage Reservoir (1950's). The nesting at Goose Lake is hypothetical, but approximately 300 unattended eggs were found on an island in the south end of the lake on June 25, 1977 with only eight adult pelicans present. It is believed that these eggs represent an abortive nesting attempt either from the summer of 1976 or 1977. Analysis of two of these eggs revealed no high pesticide levels. Pelicans nesting in the adjacent Klamath Basin, predominantly at Clear Lake National Wildlife Refuge, comprise the only regular nesting population remaining in the state, and it must be given the most careful attention. The major threat to the pelicans' continued presence in this protected area appears to be visitation to the nesting colonies by wildlife photographers (O'Neill pers. comm.). It is difficult to assess the importance of this population relative to others in North America, for pelican colonies, by virtue of the ephemeral nature of their nesting habitat, are constantly shifting in distribution and density. However, the California population comprises approximately 15 percent of the world's population. If the nesting populations of California, Nevada, Utah and Oregon (e.g., those colonies in the Great Basin) are combined they comprise nearly half of the total world's population (Sloan 1973).

Double-crested Cormorant (Phalacrocorax auritus): Cormorants nest sporadically at Eagle Lake (Lederer 1976), Bridgeport Reservoir (Gaines 1977), Hartson Reservoir (DFG files), Modoc National Wildlife Refuge (Table 5), Big Sage Reservoir (DFG files), and Goose Lake (Table 5). No data are available on numbers breeding in adjacent states, but populations in Utah appear to be declining drastically (Mitchell 1975), and populations nesting at Nevada's Pyramid Lake are decreasing rapidly, a result of the lowering of the lake level (Kennedy pers. comm.).

Great Blue Heron (Ardea herodias): This heron nests sporadically at Goose Lake, Eagle Lake, Modoc National Wildlife Refuge, and at Big Sage Reservoir where up to 50 birds have been counted (DFG files). The Great Blue may nest near Crowley Reservoir.

Great Egret (Casmerodius albus): There are no known nesting areas for this species in the Great Basin of California although it is a regular breeder in the adjacent Klamath Basin.

Snowy Egret (Leucophoyx thula): Breeds sporadically at Goose Lake and at Hartson Reservoir where up to 150 birds have been reported (DFG files).

Black-crowned Night Heron (Nycticorax nycticorax): Sporadic nesting recorded at Hartson Reservoir, with up to 430 breeding birds noted (DFG files), and at Goose Lake.

American Coot (Fulica americana): The coot's adaptability to man-altered habitats may often give a distorted impression of its abundance, and there is no reason to suppose that the coot's populations in the Great Basin of California are faring any better than those of other nongame aquatic birds. Eagle Lake is the species' only major breeding ground in California's Great Basin.

American Avocet (Recurvirostra americana): Breeding is probably regular at the localities cited in Table 5, and the avocet breeds sporadically at Mono Lake (pers. obs.) and Bridgeport Reservoir (Gaines 1977).

Black-necked Stilt (Himantopus mexicanus): Stilts probably breed sporadically in the northeastern corner of the state, expecially at Hartson Reservoir. However, positive substantiating evidence of breeding is only available from Modoc National Wildlife Refuge. The local and patchy distribution of the stilt make it difficult to assess the robustness of its present populations.

Wilson's Phalarope (Steganopus tricolor): This species has nested as far south as the vicinity of Bishop (Grinnell and Miller 1944), but recent evidence is lacking for most suspected breeding localities. Wilson's Phalaropes were known to breed at Eagle Lake in 1977 (Gaines pers. comm.) and were strongly suspected of breeding at Hartson Reservoir, Sierra Valley Marsh, South Lake Tahoe, Bridgeport Reservoir (Gaines 1977), Mono Lake and Black Lake. The total nesting population in California must be less than a thousand birds, and the fall migrant populations dwarf those breeding by two orders of magnitude. Peak populations observed at Mono Lake (Winkler et al.1977) indicate that it is one of the two or three most important fall staging areas for this species in the world (Martinez pers. comm., Behle 1958 and pers. comm., Gill 1972b). The drastic effects of the current deterioration of Mono Lake are placing the future maintenance of this species' population in jeopardy.

Northern Phalarope (Lobipes lobatus): The Northern Phalarope occurs in California only as a migrant from its arctic breeding grounds. This species is circumpolar in its distribution, and it makes extensive use of migration corridors over the open sea and over inland areas of both continents of the Northern Hemisphere. The lakes of the Great Basin, supporting fewer of this species, are thus less important than to its more restricted relative the Wilson's Phalarope.

California Gull (Larus californicus): Breeding is probably sporadic at Goose Lake, Eagle Lake and Hartson Reservoir. Only at Mono Lake are breeding populations regular and consistent in numbers, for all the others are subject to the vagaries of widely fluctuating lake levels. The situation at Mono, however, may soon change, for the lake's dropping levels have placed its colonies in danger of decimation by land predators. Negit Island, home to over 80 percent of Mono's gulls, was connected to the mainland by a land bridge in November, 1977, and a similar fate is destined to follow for the other nesting sites within two years. The Department of Fish and Game in cooperation with the Bureau of Land Management and the National Guard blasted a deeper channel north of Negit Island before the gulls returned to the lake to nest in early April, 1978. It must remain clear that this solution will only protect the colony for a maximum of five years and that the channel required to protect the integrity of the islands will grow ever larger as the lake continues to drop. Mono's 50,000 California Gulls comprise about 95 percent of the state's total nesting population and it is one of the two or three largest nesting aggregations of the species in the world. While the possibility exists that the gulls may be able to nest successfully in the face of potential predation from terrestrial predators or that they may be able to move to Paoha Island (itself doomed to land bridge connection within thirty years), gambling on these possibilities amounts to risking the survival of nearly all the state's California Gulls and a substantial proportion of the entire world population.

Ring-billed Gull (Larus delawarensis): Breeding of this species in California is restricted to the northeastern corner of the state. At the few localities at which it breeds (Table 5) it is more abundant than the California Gulls with which it nests. The total state breeding population is probably under 12,000

birds. California's breeding population has probably always been small (Grinnell and Miller 1944, Johnston and Foster 1954), and it must comprise a small proportion of the total continent-wide population.

Forster's Tern (Sterna forsteri): Nesting is probably regular at Eagle Lake and sporadic at Goose Lake. This tern may breed sporadically at Bridgeport Reservoir (Gaines 1977). California's northeastern populations are probably stable.

Caspian Tern (Sterna caspia): Apparently a regular breeder at Mono Lake and a sporadic nester at Goose Lake and Hartson Reservoir (DFG files). Has bred at Bridgeport Reservoir (Gaines 1977). Although populations of this species in California's Great Basin are small, they are probably stable.

Black Tern (Chlidonias niger): A regular breeder at all areas indicated in Table 5. The small remaining population in northeastern California appears to be holding its own, and this species appears to be adapting to nesting in rice fields in the Central Valley.

## Habitat and Population Trends

This is the first systematic survey of the bird populations of the Great Basin lakes in California ever conducted. The lack of a similar survey conducted at an earlier date makes concrete assessment of trends in populations impossible, but trends in several populations can be assessed through consideration of the extent of depredation by man, and trends in most of the populations can be inferred through consideration of known changes in the amount and quality of available habitat.

Human settlement east of the Sierra Nevada in the late nineteenth century had several direct effects on the avifauna. Populations of grebes, egrets and terns were decimated to provide adornment for the hats and lapels of high society (Finley 1907). The large fish-eating pelicans and cormorants were persecuted at the same time by short-sighted individuals under the mistaken impression that these birds compete with man for game fish. Colonies of these sensitive species were visited by parties of men who clubbed young, destroyed eggs and shot the few adults which had not abandoned their colonies on the party's approach (Thompson 1932). Fortunately, protective laws and a more enlightened public developed in time to halt this destruction, and populations of most species appeared to recover at least partially from the low populations induced by such abuse (Grinnell and Miller 1944). In addition to these forces which have been responsible for the decline of bird populations in the past, there is now an ever-increasing threat that the nesting birds remaining will disappear if human visitation into and near their nesting areas is not curtailed. Disturbance to nesting colonies by water skiers and pleasure boaters at Eagle Lake may be making great inroads on breeding productivity there (Gould 1971), and construction of marinas and air strips has already resulted in the loss of large areas of nesting habitat. Even well-intentioned visits to nesting colonies by wildlife photographers and the like, no matter how carefully they are conducted, may cause severe interference with breeding in the more sensitive nesters, especially cormorants and pelicans (O'Neill pers. comm.).

The most pervasive factor that has had the potential of adversely affecting aquatic bird populations has been the indirect force of habitat alteration. Because no accurate censuses exist for the area of this study prior to the date of most of the habitat modifications which have taken place, it is impossible to say definitely how drastically the bird populations have been affected. Only a general picture of the trends in the populations can be gained through a consideration of the changes in the quality and extent of the required habitat of ecologically similar groups of species. A more rigorous analysis of population trends will be possible only after the passage of time with the data in this report then used as a baseline for comparison.

The construction of reservoirs often results in the inundation of marshes occupying low areas in the watercourse being dammed. These marshes are prevented from becoming reestablished around the shore by the fluctuating water levels usually associated with these reservoirs. This sort of habitat alteration has occurred in the basins of Topaz, Bridgeport, and Crowley Reservoirs (see Study Area). The loss of marsh habitat apparently caused the disappearance of nesting grebes which used to nest at Topaz Lake (Moffitt 1938). Wherever marsh habitat has been lost it is almost certain that any grebes or herons which had been nesting in it will also be lost. Because reservoirs generally provide little nesting habitat for any aquatic species, that portion of the breeding avifauna which is lost is not likely to be replaced. The second major source of habitat alteration is the diversion of streams tributary to a wetland for use elsewhere in agricultural or municipal applications. Water diversions have affected both Goose and Honey Lakes by reducing their total surface area (see Study Area), thus reducing the amount of habitat available to aquatic birds. It is not clear how much smaller the present bird populations of these lakes are than those of pre-civilization times, but it is likely that the reduction in the amount of available habitat led to a decline in the size of the bird populations associated with these lakes. The habitat alterations presently occurring at Mono Lake as a result of water diversions exemplify the complexity of consequences which can follow from the decrease of a lake's size. In the process of the lake's shrinking, islands which for centuries have provided sanctuary for nesting gulls from terrestrial predators are becoming connected to the mainland and the salinity of the lake's water is climbing steadily. Predictions indicate that the lake will reach a stabilized level in about 70 years at which time the salinity will be three and a half times the present levels. Water of this concentration will apparently be uninhabitable by the lake's phytoplankton, flies, and shrimp (Winkler 1977). Birds now relying on Mono Lake for sustenance would thus be denied their traditional food resources, and the salinity of the water would likely prohibit them from using the lake even as a resting area.

Most of the species treated in this report once had large populations in the marshes and lakes of the Central Valley (Grinnell and Miller 1944). With the drainage of these extensive wetlands, these species' populations were severely reduced, if not eliminated, in the Central Valley. Northeastern California has long been thought to form the final stronghold for nonmarine aquatic birds in California (Grinnell and Miller 1944). Although populations of many of the species under question appear to be maintaining themselves quite well in the Klamath Basin (Table 5), large populations of nongame aquatic birds on the lakes of the Great Basin in California are rare, and in this region each species generally has only one or two lakes which can be considered as major breeding or migratory staging areas (Table 5). Although habitat alterations during the early part of this century almost certainly left populations of most of the

species disucssed here smaller than those of pre-civilization times, it is not clear whether populations have experienced a general decline since that time. Regardless, the aquatic bird populations of California's Great Basin lakes, as small as they may seem, often comprise a significant portion remaining of what were once much larger state-wide populations.

## DISCUSSION

Most of the aquatic bird species nesting in the Great Basin have incorporated into their life histories a low year-to-year nest-site tenacity as an adaptation to the widely fluctuating levels of many of the lakes on which they nest. These species are opportunists whose reproductive capacities and nest-site selection vary in parallel with variations in the quality and distribution of nesting habitat. Probably as a result of this adaptability, populations of these birds often fluctuate radically in size from year to year. Thus, the interpretation of any changes in population levels of these species can only be made over the long term and in conjunction with a consideration of coincident changes in the quality of the habitat. Wildlife managers must not allow themselves the luxury of dismissing downward population trends as being merely natural population fluctuations unless there is firm evidence that the populations have declined due to a temporary reduction in habitat quality and that the quality of the habitat and the bird populations associated with it will soon return to normal. Populations of all the nongame aquatic birds in the Great Basin are so small or limited in range that any decline must be treated seriously and investigated thoroughly.

Several Great Basin lakes stand out as being of key importance in supporting nongame aquatic bird populations in California. Eagle Lake is outstanding in the diversity and number of breeding birds which it supports. It is especially important to the Western, Eared and Pied-billed grebes, Great Blue Heron, American Coot and Black Tern, supporting larger populations of these species during the nesting season than any of the other lakes surveyed. All these populations are threatened by increased human visitation to the lake, and recent down trends in populations of grebes, Great Blue Heron and terns (Table 5) must be given serious and careful attention.

Goose Lake supports key populations of Double-crested Cormorant, Snowy Egret, Caspian Tern and Forster's Tern. There are no imminent human threats to the continued presence of these nesting birds at Goose Lake. It must remain clear, however, that the habitats offered by Goose Lake vary greatly in extent and quality from year to year in conjunction with the wide fluctuations in the lake's water level. Similar problems affect the habitats at Hartson Reservoir, which, in years of intermediate water levels, can support a fauna similar to that of Goose Lake. Assumptions regarding the importance of these lakes must therefore be made with caution, as both lakes can lose all their habitat for nesting birds given lake levels low or high enough.

Mono Lake is both a crucial breeding and migratory staging area. Its colony of California Gulls is at least the second largest in the world, and the numbers of Eared Grebs and Wilson's Phalaropes observed there are higher than those

reported from any other lake in the world. Ironically, Mono is faced with the most extensive and difficult to mitigate habitat alterations of all the lakes studied. The gull colony is threatened by the invasion of terrestrial predators as the islands which it occupies are being connected to the mainland by the receding water level. Every portion of the lake's biota which has been studied is faced with extermination as salinities in the lake's water climb. There are no other lakes in the western Great Basin which meet the apparent habitat requirements of the gull: isolated islands for nesting and a highly productive food supply. The fate of migrant birds now relying on Mono Lake is difficult to predict, as it is not known whether the birds, especially Eared Grebes, will be able to make the flight from their staging areas in Oregon and extreme northern California to the Salton Sea, their next reliable staging area south of Mono, if Mono changes to the extent that it can no longer sustain them. This flight would amount to a continuous journey of at least 700 miles, and there is not enough information on the physiology of these birds to predict their migratory capabilities. Although the other lakes briefly discussed above support populations of unquestionable importance in maintaining populations in California, Mono Lake stands apart in supporting a unique biota of crucial importance to sustaining world populations of California Gulls, Eared Grebes and Wilson's Phalaropes.

The present condition of the breeding avifauna of California's Great Basin lakes inspires little optimism for its future well-being. Populations of most species are small and sporadically distributed. Most, if not all, populations are smaller than those which occupied the area before the arrival of Western civilization. The reasons for these small populations and declines in the past are usually obvious: aquatic birds cannot nest where they are constantly disturbed by human intrusion or where there is no food, cover or water. Several species demonstrated that their populations have had the capacity for recovery, at least in part, from human depredations at the turn of the century. There are no indications that this growth will continue, as there is very little, if any, reliable habitat remaining in the Great Basin which is not already being used by nesting birds. There are no large lake basins in the Great Basin of California which have not been substantially altered by man. Allowing water to flow into a sink which supports large numbers of birds is all too often considered a waste of water which would be better put to some use immediately profitable to humans. It is unfortunate that the two lakes (Eagle and Mono) which are faced with the most serious threats to their habitats are also the lakes which currently support the most significant bird populations in California's Great Basin. The habitats at either of these lakes are not beyond salvation however, and the preservation of these areas, both of which are unique in this area in their characteristics and in the problems they face, stands as a great and immediate challenge to resource managers and conservationists throughout the West. The small sizes of the populations of nongame aquatic birds remaining in California are an urgent reminder of the scarcity and value of the few unspoiled wetlands remaining in the state. These water birds are a unique and irreplaceable part of our biotic heritage, the health and diversity of which must be protected for future Californians. As the lands of California's Great Basin come under increasing human development, preservation of the few remaining remnants of this portion of the state's avifauna will require the most careful and dedicated attention to the problems of each and every species population and each and every lake.

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APPENDIX 1: Schedule of Censuses

| Locality | Dates Visited |
|---|---|
| Hartson Reservoir | June 23, July 19, August 4, September 4 |
| Modoc N.W.R. | June 24, July 22, August 4, September 4 |
| Goose Lake | June 25-26, July 20, August 4, September 5-6 |
| Alkali Lakes | June 28 |
| Topaz Reservoir | June 29, July 22, August 3, August 30, September 3 |
| Bridgeport Reservoir | June 29, August 3, August 18, August 30 |
| Mono Lake | June 30, July 3-8, 23-25, August 2-3, 19, 22, 30-31 September 1 |
| Crowley Reservoir | July 13, August 1, September 3 |
| Black Lake | July 14, August 1, September 3 |
| Big Sage Reservoir | July 21 |
| Eagle Lake | August 5, September 4 |
| Klamath Basin | September 7 |

APPENDIX 2: Observations of Less Common Species of Nongame Birds Needing Aquatic Environments

White-faced Ibis (Plegadis chihi): One observed in a flooded field near Honey Lake S.W.M.A., August 4.

Sandhill Crane (Grus canadensis): Single pairs of adults with downy young were observed in Surprise Valley, June 28 and at Modoc N.W.R., June 24. Strongly suspected of breeding on the Fleming unit of Honey Lake S.W.M.A.

Golden Plover (Pluvialis dominica): Two seen south shore Goose Lake, September 5.

Ruddy Turnstone (Arenaria interpres): One seen southeast shore Mono Lake, August 31.

Long-billed Curlew (Numenius americana): Pair of adults with one downy young observed near south end Goose Lake, June 26. Two pairs strongly suspected of breeding at Hartson Reservoir.

Baird's Sandpiper (Calidris bairdii): Two seen south shore Goose Lake, September 5.

Sanderling (Calidris alba): One seen south shore Goose Lake, September 5.

Bar-tailed Godwit (Limosa lapponica): One studied near Negit Island, Mono Lake, July 8. Description submitted to California Rarities Committee.

Willet (Catoptrophorus semipalmatus): Strongly suspected of breeding in Surprise Valley and Honey Lake Valley.

Lesser Yellowlegs (Tringa flavipes): Three seen near Modoc N.W.R., July 22.

Bonaparte's Gull (Larus philadelphia): Numbers of this species seen in the Great Basin in the summer of 1977 were much higher than normal. This unusual abundance throughout the summer was observed elsewhere in California and may have been related to the drought.

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