Piscivorous Birds of Yellowstone Lake: Their History, Ecology, and Status

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Yellowstone Lake is truly one of the most recognizable geographic features of the Greater Yellowstone area, and, most importantly, the ecological nucleus for native fishes and piscivorous birds in Yellowstone National Park. It is home to the only current nesting colony of American white pelican *(Pelecanus erythrorhyn - chos)* in the National Park System. It is also unique for having the highest-elevation nesting records in North America for colonial nesting birds such as the American white pelican, double-crested cormorant *(Phalacrocorax auritis),* California gull *(Larus californicus),* common loon *(Gavia immer),* and Caspian tern *(Sterna caspia).* In excess of 50% of Yellowstone's bald eagle *(Haliaeetus leucocephalus)* and osprey *(Pandion haliaetus)* nesting pairs are currently associated with Yellowstone Lake and its piscine prey. The magnetism of this unique area for birdlife rests on its remoteness, inaccessibility, and abundant food resources. Only two native fishes are found in Yellowstone Lake: the Yellowstone cutthroat trout *(Oncorhynchus clarki bouvieri)* and the longnose dace *(Catostomus catostomus).* But it is the cutthroat trout biomass that is the main attraction for the piscivorous birds of Yellowstone Lake.

The piscivorous birds and the cutthroat trout of Yellowstone Lake have undergone a kaleidoscope of management practices, public attitudes, philosophical differences, exotic introductions, population changes, and distributional shifts. This paper will intertwine these points while examining the history, ecology, and status of the piscivorous avifauna of Yellowstone Lake.

History

The history, ecology, and status of the piscivorous birds of Yellowstone Lake is best understood by reviewing three important timelines: those of the park itself, of fish management in the park, and of bird management in the park.

By reviewing the Yellowstone timeline, the following events are of significance to the piscivorous nesting birds of Yellowstone Lake:

- 1872: Yellowstone National Park established;
- 1872–1935: predator control era in Yellowstone (this included pelican and eagle eradication);
- 1883: hunting in Yellowstone prohibited;
- 1916–1918: changeover in management authority from the U.S. Calvary to the National Park Service (NPS);
- 1918: Migratory Treaty Act passed, affording some protection for birdlife;
- 1941–1945: World War II;

- 1945–1972: high use of DDT in North America following World War II;
- 1953–1957: DDT spraying in the park to combat spruce budworm;
- 1988: Yellowstone wildfires; and
- 1994: first discovery of exotic lake trout, New Zealand mud snail, and whirling disease.

A review of the fish management timeline reveals the following events that have had a bearing on food abundance for the piscivorous birds of Yellowstone Lake:

- 1872–1948: no fish limits;
- 1889: U.S. Fish Commission and fish stocking program established in the park;
- 1906: 20-fish limit;
- 1948–1953: five-fish limit;
- 1953–1970: three-fish limit;
- 1970–1973: two-fish limit;
- 1973: catch-and-release fishing with size limitations; and
- 2001: catch-and-release fishing for all native fishes.

And lastly, a synopsis of the bird management timeline emphasizes important events that have affected the status of the piscivorous birds of Yellowstone Lake:

- 1890–present: pelican census conducted on the Molly Islands (Yellowstone Lake);
- 1890–1931: era of visitor disturbance on the Molly Islands;
- 1924–1931: pelican control program on the Molly Islands;
- 1945–1959: boat disturbance on and near the Molly Islands;
- 1960–present: the Molly Islands closed to the public (Figure 1);
- 1960–present: no- and slow-motor zones established on the arms of Yellowstone Lake to protect colonial nesting birds and molting waterfowl; and
- 1978–present: campsite closures on Yellowstone Lake to protect nesting ospreys, Frank Island closure to protect nesting ospreys, and Stevenson Island closure to protect nesting eagles.

Ecology

The Yellowstone cutthroat biomass on Yellowstone Lake is what attracts the richness and abundance of piscivorous birdlife. The following birds have been documented as nesting in Yellowstone and feeding on the fish of Yellowstone Lake: Caspian tern, common loon, American white pelican, California gull, double-crested cormorant, osprey, bald eagle, common merganser *(Mergus merganser),* American dipper *(Cinclus mexicanus),* great horned owl *(Bubo virginianus),* common raven *(Corvus corax),* great blue heron *(Ardea herodias),* great gray owl *(Strix nebulosa),* and belted kingfisher *(Ceryl alcyon).* However, the

Figure 1. Boat disturbance of the Molly Islands from 1945 to 1959 paved the way for a permanent half-mile closure of the islands to the public beginning in 1960.

principal piscine biomass consumers are the first seven species named. Long-term population data also exist for them, thus allowing an opportunity to review the status of each of these important piscivorous bird species. Due to space limitations, the following discussion will be limited to these seven species.

Interestingly enough, the combination of high elevation and harsh weather conditions make the Yellowstone plateau and Yellowstone Lake some of the most inhospitable places found in the temperate zone of North America for nesting birds. Yellowstone Lake typically freezes from December or January through May, thus forcing all seven species to migrate, with the exception of the bald eagle. Some pairs of bald eagles reside on the Yellowstone plateau throughout the winter, seeking out thermal and open areas with an abundance of waterfowl, fish, and carrion. Other pairs move to lower elevations of the Greater Yellowstone area, and carve out an existence there until additional areas open up on the plateau.

Fish biomass availability is critical for piscivorous birds, but the role weather plays in bird production in Yellowstone National Park cannot be overlooked. Flooding, drought, wind, snow load, rain, hail, lightning, and wildfires all play a role in the overall success or failure of each of these piscivorous bird species. These factors coupled with natural predation and human disturbance can influence the success or failure of a species in any given year.

How can these piscivorous birds feed on the same food biomass and in the

same habitat without competing with one another? The answer lies in our understanding of the ecological role each piscivorous bird species plays within a community, enabling it to survive by achieving niche separation. Our first clues to understanding the ecological role of piscivorous birds lie in the knowledge of the bathymetry of Yellowstone Lake (Figure 2). The ecological role of these species is best explained through resource partitioning. In other words, these species carve out a different part of the resource which allows them to survive.

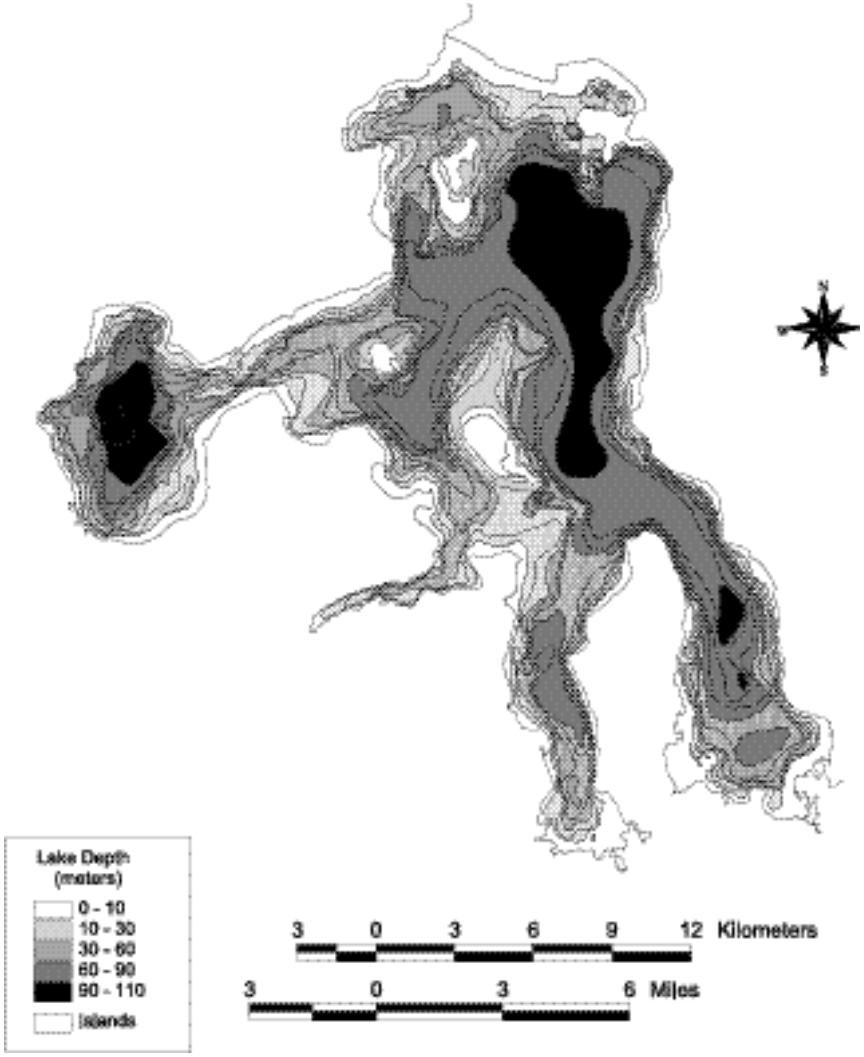

Figure 2. Bathymetry of Yellowstone Lake.

By examining resource partitioning of different lake depths by birds, we find certain birds forage or feed at different depths; thus the term *bathylacustrine for - aging.* Species that are surface feeders include the California gull, American

Table 1. Resource partitioning through bathylacustrine foraging.

	Water depth, ft						
	Surface	0-2	2-4	4-6	6-20	20-60	60+
Common loon					●	●	●
Double-crested cormorant					●	●	●
California gull	●	●					
Caspian tern		●	●				
American white pelican	●	●	●				
Bald eagle	●	●	●				
Osprey			●	●			

white pelican, and bald eagle (Table 1). The above species also forage at depths of 0–2 ft, as does the Caspian tern. At depths of 2–4 ft, the Caspian tern, American white pelican, bald eagle, and osprey are often found foraging. Ospreys can dive deeper than bald eagles, and have been observed diving 4–6 ft into the water to secure piscine prey. Ospreys also have the ability to hover, allowing them to forage out in open waters such as are found over much of Yellowstone Lake. The deeper-water feeders are the common loon and the double-crested cormorant, foraging at levels ranging from 6 to over 60 ft deep.

Piscivorous birds have other means of resource partitioning, such as foraging for different-sized fish or allopiscine prey. Some are either specialized or generalized feeders of different-sized fish, depending on their morphology (Table 2). Common loons and double-crested cormorants usually feed on fish that are 2–9 inches in length, more commonly taking those around 6 inches in size. California

Table 2. Resource partitioning of allopiscine prey.

	Length of fish, inches				
	0-2	2-6	6-9	9-11	11+
Common loon		●	●		
Double-crested cormorant		●	●		
California gull	●	●	●	●	●
Caspian tern	●	●			
American white pelican	●	●	●	●	●
Bald eagle				●	●
Osprey			●	●	

gulls, on the other hand, are generalist feeders, consuming fish from 1 to 11+ inches in size, and can secure prey through either foraging or scavenging. Caspian terns take fish that are smaller, rarely if ever exceeding 6 inches in length. American white pelicans are opportunistic feeders and will take any size prey ranging from 1 to 11+ inches. Although they are often observed taking larger fish, smaller fish are also a part of their diet. Bald eagles typically take adult fish often exceeding 11 inches in size, and on occasion take fish as small as 9 inches. Osprey, on the other hand, take smaller, immature fish ranging from 8 to 11 inches in length.

The piscivorous birds of Yellowstone Lake also partition the resource through a variety of foraging habits or techniques (Figure 3). Bald eagles, for instance, typically hunt from an elevated perch, but also hunt in flight. Capturing fish requires diving into the water talons-first, using the wings as floats. If a fish is caught, eagles either take off with the fish in their talons or, if the fish is heavy, paddle to shore with the prey. American white pelicans stalk fish from the surface of the water. Most often they work in synchronous foraging groups, or flotillas, forcing fish to the shore by flaring their colorful feet and dipping their heads in water until they finally catch fish in their distensible pouch. Caspian terns hunt exclusively from the air, searching shorelines and shallow water areas for small schools of fish. When small fish are sighted, the terns plunge into the water before returning to normal flight with fish draped between their mandibles.

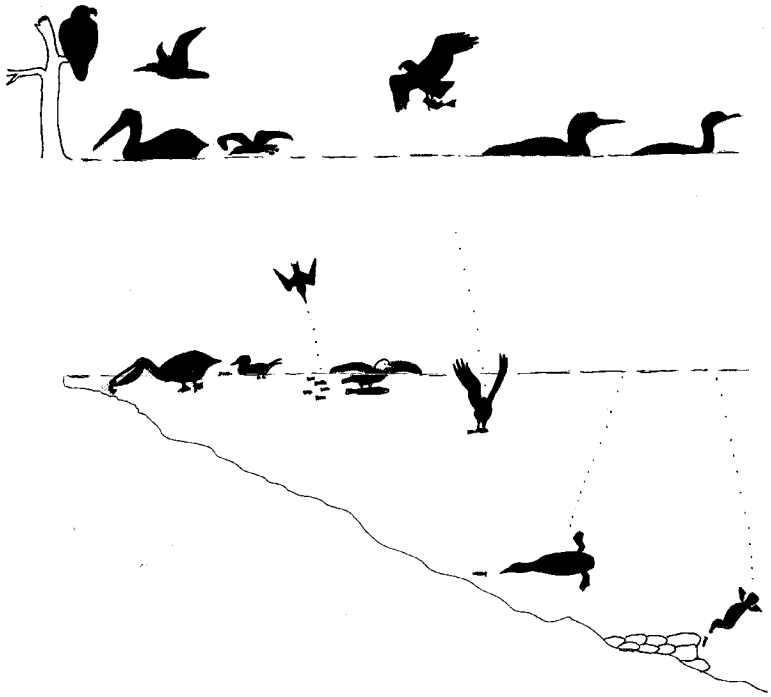

Figure 3. Resource partitioning—foraging habits.

Ospreys can hunt from an elevated perch, but most typically hunt by hovering. Once a fish is sighted, they "stair-step," dropping in elevation until they finally plunge talons-first into the water. Osprey become totally submerged, then bob back up to the surface and use their wings to lift off. Once the fish is oriented head-first and secured, the osprey does a body shake to eliminate excess water. Common loons dive from a floating position on the surface of the water. They stalk their prey long-distance and catch up with the fish easily due to their speed. When a fish is caught, loons return to the surface where they swallow the fish whole, head-first. Double-crested cormorants also dive from a floating position on the surface of the water. They are best suited for searching the deeper, darker depths or rocky shoal areas, scouring nooks and crannies for prey at close distances. Once a fish is caught, cormorants return to the surface of the water where they, like loons, swallow their prey whole, head-first.

Lastly, resource partitioning of the nesting substrate is another way the piscivorous birds of Yellowstone Lake can exist in the same habitat (Figure 4). Bald eagles select large trees and build large platform nests down in the tree where the nest and young are shaded by the adults early in life and by branches later on. Ospreys typically build in the tops of trees or on rock pinnacles. Their nests have a telescoping profile, i.e., are smaller at the top than at the base. They normally shade the eggs and the young with their wings. Common loons nest on the water's edge of lakes. Their nest is a simple floating mass of vegetation camouflaged and concealed by the shoreline. Caspian terns, California gulls, American white pelicans, and double-crested cormorants are colonial nesting birds, and all

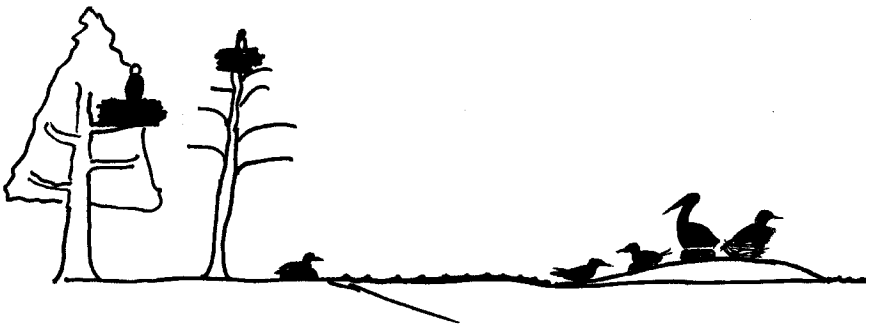

Figure 4. Resource partitioning—nesting substrate.

nest on the Molly Islands. Caspian tern nests are simple scrapes or depressions on a sandy substrate, usually on the lower points of the islands, but are heavily defended by the adults from avian predators. California gulls build very simple nests in rocky substrates midway up on the islands. American white pelicans build simple elevated mounds of sand debris and guano; they nest on the higher parts of the islands. Double-crested cormorants nest on the highest part of the islands. Their nest consists of elevated sticks and weeds cemented by guano.

Status

Determining the true status of birds requires an understanding of the many variables, both natural and anthropogenic, that influence population dynamics. A review of historical management actions, coupled with knowledge of the ecology of the bird, is of paramount importance since it fills in informational gaps regarding a particular species and creates a more complete picture of its status, both past and present.

Osprey. The osprey of Yellowstone National Park and Yellowstone Lake are doing remarkably well (Figure 5). Nesting pairs increased following the 1988 Yellowstone wildfires. Since food is highly abundant, the limiting factor continues to be availability of nest sites. Following the wildfires, snags increased and consequently so did the number of nesting pairs, since osprey most often select burned or dead trees for their nests. Heavy winds knocked down a large number of standing snags, and therefore contributed to the trough experienced in 1995 and 1996. DDT is no longer a threat as it was midway through the last century. Osprey productivity is dynamic and remains weather dependent. In 2001, there were 59 nesting pairs of osprey on Yellowstone Lake, fledging a total of 26 young.

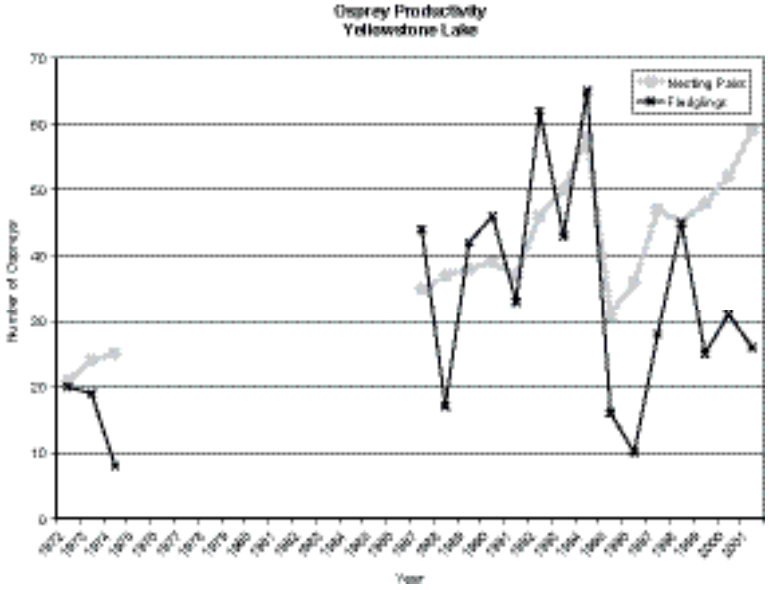

Figure 5. Osprey productivity, Yellowstone Lake, 1972–2001.

Bald eagle. Bald Eagle nesting pairs continue to gradually increase on Yellowstone Lake and throughout the park (Figure 6). Fledgling numbers rarely if ever exceed one per nest. The elimination of DDT in 1972 paved the way for the increase in numbers we experience today. Large nesting trees continue to fall down, contributing to the annual fluctuation of nesting pairs. Bald eagle produc-

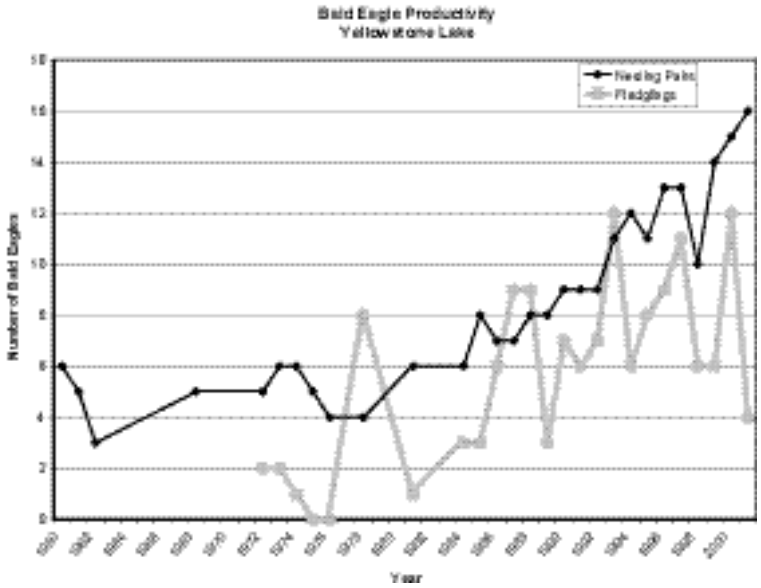

Figure 6. Bald eagle productivity, Yellowstone Lake, 1960–2001.

tivity is dynamic and highly influenced by weather. In 2001, 16 nesting pairs fledged only four eaglets.

Common loon. Only one to two common loon pairs nest on Yellowstone Lake in any given year (Figure 7). Their numbers remain relatively stable with minor fluctuations from year to year. Flooding and drought can have similar negative effects when it comes to nesting. Fledgling loons vary from 0 to 4 in any given year. In 2001, three loonlets fledged from two nests. Yellowstone Lake loons show nearly identical trends parkwide.

Caspian tern. In recent years, Caspian tern numbers have declined (Figure 8). A total of three nesting pairs fledged three young in 2001. In 1990, there were 28 nesting pairs fledging 28 young. Causes for the decline appear to be twofold: weather, in the form of flooding; and disturbance of the islands. Caspian terns are extremely sensitive to disturbance, whether it be from predators or humans. One visit to the islands during incubation or early hatching can result in failure. Even though the Molly Islands are technically closed to the public, occasionally boaters are caught on or close to the islands in a closed area. A concerted effort needs to be made to better educate the boaters of Yellowstone Lake as to the sensitivity of the Molly Islands and to better enforce the closure.

California gull. California gull numbers moderately fluctuate from year to year (Figure 9). During the 1940s, their numbers were significantly higher, which corresponded with the period of boat disturbances on the Molly Islands, allowing a feasting on eggs by predators such as gulls. In 2001, a total of 90 California gulls nested, which resulted in 95 fledglings. Since California gulls nest on the

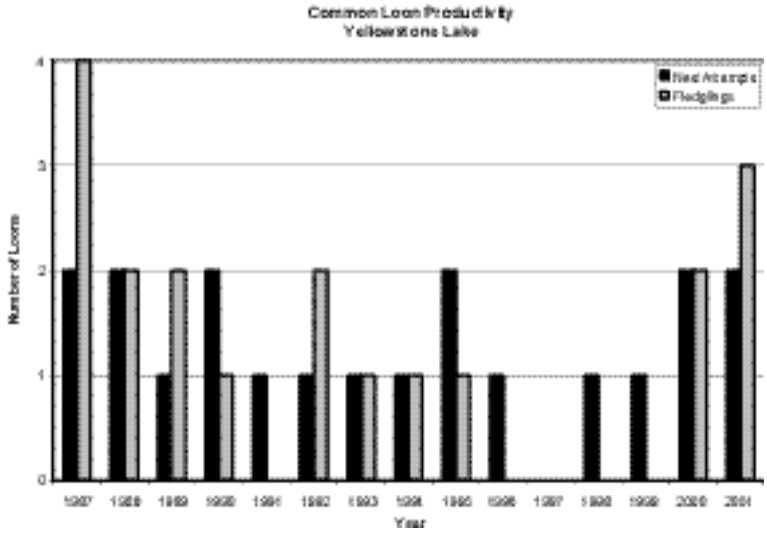

Figure 7. Common loon productivity, Yellowstone Lake, 1987–2001.

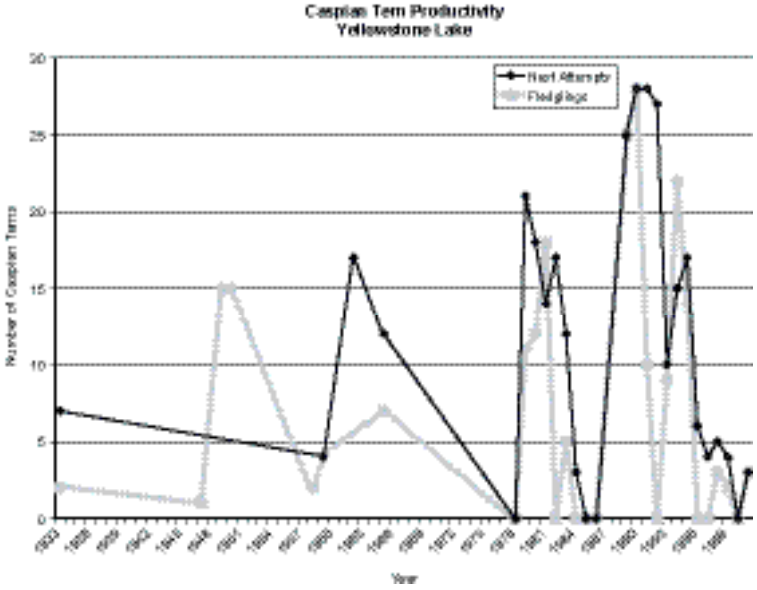

Figure 8. Caspian tern productivity, Yellowstone Lake, 1933–2001.

lower topography of the Molly Islands, they are subject to water-level fluctuations on Yellowstone Lake.

Double-crested cormorant. The double-crested cormorant has increased in Yellowstone National Park since the era of nest disturbance and DDT use ended

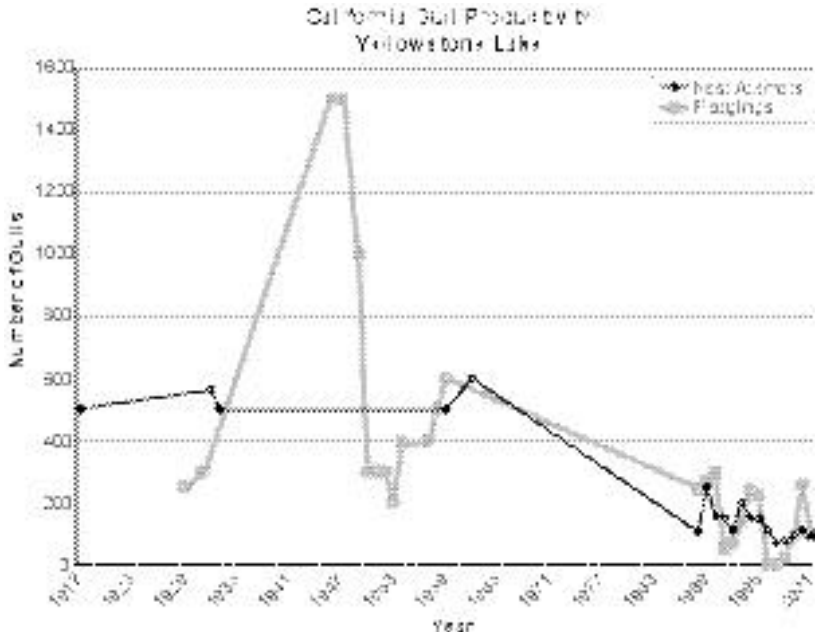

Figure 9. California gull productivity, Yellowstone Lake, 1917–2001.

Figure 10. Double-crested cormorant productivity, Yellowstone Lake, 1946–2001.

(Figure 10). Today, the number of nesting pairs and fledglings fluctuates from year to year. Flooding and disturbance are the two principal factors affecting production. In 2001, a total of 111 double-crested cormorant nests were constructed, fledging 75 young.

American white pelican. Of the piscivorous birds found on Yellowstone lake, none have a more pronounced annual fluctuation than the American White Pelican (Figure 11). Pelican control in the 1920s, followed by human disturbances in the 1940s and 1950s, kept the population at low levels. Since that time, pelican numbers have fluctuated greatly from year to year, both in the number of nesting attempts and fledged juveniles. Flooding takes its toll on pelican production, as does disturbance from either humans or predators. Pelican nest attempts

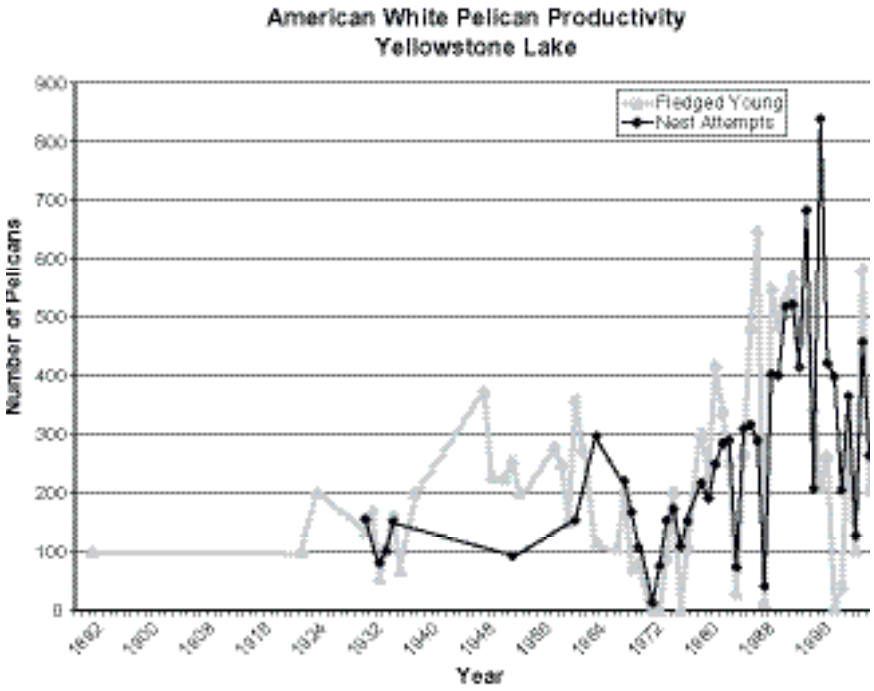

Figure 11. American white pelican productivity, Yellowstone Lake, 1892–2001.

reached their peak in 1994, when 839 pairs nested, whereas peak production occurred in 1985, with 650 fledged juveniles. In 2001, a total of 264 pelicans nested, fledging 205 young.

Yellowstone Lake is a unique, natural, dynamic environment. The importance of fish and fish biomass for the piscivorous birds of Yellowstone Lake cannot be overemphasized. The shallow-spawning cutthroat trout of the lake provide tremendous food biomass for birds and mammals. The discovery of lake trout in Yellowstone Lake in 1994, combined with that of the New Zealand mud snail and whirling disease in the same year, only add fuel to concerns about the ecology of

aquatic environments in Yellowstone, such as Yellowstone Lake. On the horizon are other serious threats, such as acid rain, global warming, climate change, methyl mercury contamination from geothermal deposits and natural wildfires, and increases in human visitation to the park.

Making doom-and-gloom predictions about the future of Yellowstone Lake piscivorous birds is not recommended, since there are too many variables to comprehend. Yellowstone Lake is a dynamic aquatic environment, so it is important that we let it play out as naturally as possible with little human intervention.

Summary

The piscivorous birds of Yellowstone Lake have undergone a kaleidoscope of management practices, public attitudes, philosophical differences, exotic introductions, population changes, and distributional shifts. When reviewing the history, ecology, and status of the piscivorous birds of Yellowstone Lake, we find bald eagle and osprey numbers incrementally increasing in recent years. Double-crested cormorant numbers have improved since the first half of the 20th century; however, these numbers show that their populations are starting to stabilize. On the other hand, Caspian tern numbers are decreasing, primarily due to weather and disturbance. California gull numbers have decreased from the mid-20th century, but have now reached a more natural condition. Common loon numbers fluctuate ever so slightly from year to year, whereas American white pelican numbers have improved from the first half of the 20th century. However, they fluctuate wildly from year to year. After 16 years of study, it becomes apparent that weather highly influences bird productivity in Yellowstone.

How do the piscivorous birds of Yellowstone Lake occupy the same habitat? What type of niches do they occupy? This is best explained through resource partitioning of fish prey sizes, foraging at different water depths, foraging using specialized techniques, and selecting different nest substrates, to name a few.

What about the doom-and-gloom predictions for the piscivorous birds of Yellowstone Lake? Does the presence of exotic organisms in an environment automatically mean a decline in indigenous species? Will we lose bird species richness? Probably not. What about species abundance? Perhaps, but we don't know to what degree and what time frame we are talking about. Predictions are useless without completely understanding the byzantine variables involved. The safest action one can take is to just let things play out. Only time will tell. We have no idea what other variables are on the horizon. But in the meantime, we need to keep the human variables to an absolute minimum.

Two thousand years ago, the Roman prescient Lucretius proclaimed, "Once something changes it can never be again what it was before." The same can be said for the ecological complexity of Yellowstone Lake. Monitoring and mitigating for the degree and rapidity by which Yellowstone Lake changes will be the ultimate challenge for this generation of ecologists and those yet to come.

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