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WIND EFFECTS ON *AECHMOPHORUS* GREBE NESTING COLONIES, LAKE ALMANOR, CALIFORNIA

STEVE YONGE and MARGARET WIDDOWSON, ICF, 2895 Churn Creek Road, Suite B, Redding, California 96002; steve.yonge@icf.com

LAWRENCE WISE, Pacific Gas and Electric Company, 300 Lakeside Drive, Oakland, California 94612; Lawrence.Wise@pge.com

ABSTRACT: In late July and early August 2022, sustained winds of 13–42 km/hr and winds gusts of 19–79 km/hr disrupted the colonies of the Western (*Aechmophorus occidentalis*) and Clark's (*A. clarkii*) grebes nesting at Lake Almanor, Plumas Co., California. Many nests washed up on shore downwind of two nesting colonies. At this time, the decrease in the lake level from drawdown and evaporation did not threaten the colonies, so the colonies' nearly complete failure in 2022 was due to windstorms.

The Western Grebe (*Aechmophorus occidentalis*) and Clark's Grebe (*A. clarkii*) are aquatic birds that nest colonially in shallow water, primarily in inland freshwater lakes. Their distribution is similar (La Porte et al. 2020), and they are often observed together. Both species build nests on rafts of submerged aquatic vegetation (open-water nests) or in emergent marsh vegetation (marsh nests) (La Porte et al. 2020). Lake Almanor in Plumas County, California (Figure 1), supports thousands of nesting *Aechmophorus* grebes annually. The birds typically nest between late June and mid-September (Ivey 2004, Plumas Audubon Society 2016). It is unknown when grebes started nesting on Lake Almanor, but there are reports of breeding behavior from the early 1970s (<https://ebird.org/checklist/S25681006>), records of nesting from the 1980s (D. Airola pers. comm.), and anecdotal observations of grebes at the lake back to the 1950s (Plumas Audubon Society 2016).

The nest success of a grebe colony can be affected by various environmental and anthropogenic factors, including declining water levels (Lindvall and Low 1982, Reinsche et al. 2009), windstorms (Allen et al. 2008, La Porte et al. 2014, Hayes et al. 2022), predation (Lindvall and Low 1982), and human disturbance (Ivey 2004). Declining water levels have been reported to cause nest colony failure on Lake Almanor (Ivey 2004, Plumas Audubon Society 2016). Ivey (2004) observed 850 active nests there on 23 August 2002, then on 11 October found most nests “stranded on shore” and concluded that it was “very likely that most nests in the colony were abandoned due to diminishing [water] levels.”

Colony failures due to other factors including windstorms and predation have been observed but not quantified. Windstorms have caused nest and colony loss on other lakes (Allen et al. 2008, La Porte et al. 2014, Hayes et al. 2022), and they reportedly impaired grebe nesting on Lake Almanor in 2012, 2014, and 2015 (Plumas Audubon Society 2012, 2014, 2015). In 2022, we observed and quantified the effects of windstorms on two grebe colonies on Lake Almanor.

Lake Almanor is the primary storage reservoir for the Pacific Gas and Electric Company's (PG&E) Upper North Fork Feather River hydroelectric project. PG&E manages the reservoir and hydroelectric project for uses both at the reservoir and downstream, including multiple environmental needs, recreation, water supply, and generation of electricity. To meet these demands, water is drawn from the reservoir

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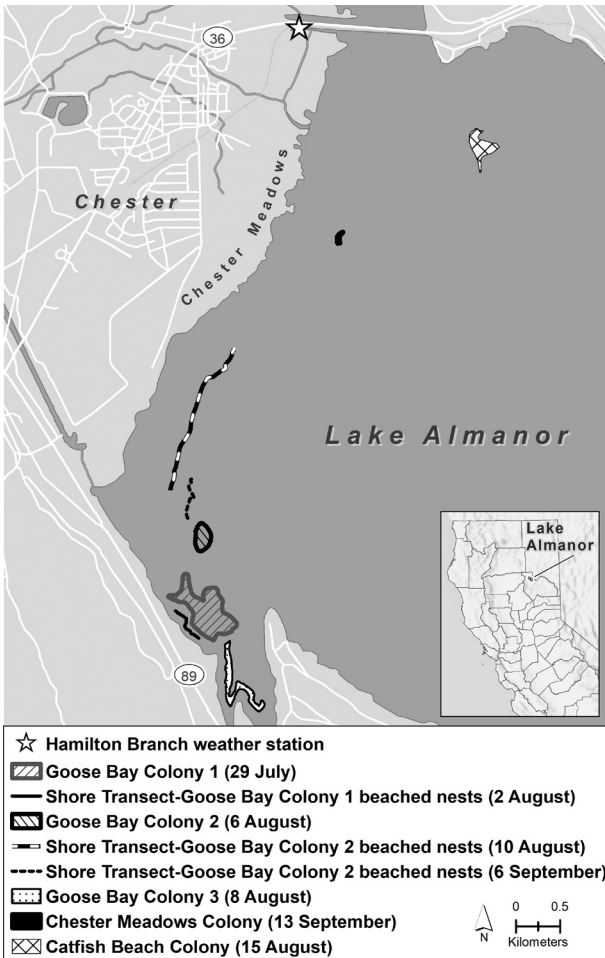


FIGURE 1. *Aechmophorus* grebe nest colonies on Lake Almanor, Plumas County, California, in 2022.

during the summer and fall, coinciding with the grebes' nesting season. The average rate of water drawdown during the 2022 nesting season was 2.4 centimeters per day.

To improve our understanding of the factors that affect grebe colonies, we monitored the grebes' nesting activity on Lake Almanor from 2020 to 2023 (PG&E 2023). Because of a delay in colony monitoring in 2020 and lack of access to Lake Almanor during the Dixie wildfire in 2021, 2022 was our first full season of monitoring grebe nesting. During the nesting season we surveyed weekly from shore and kayak to map colonies and count active and inactive nests. In 2022, grebes nested in open water and constructed nests of submerged aquatic vegetation. That year, we documented six windstorms that disrupted two of five grebe nesting colonies on the reservoir: Goose Bay colonies 1 and 2 (Figure 1).

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Winds at Lake Almanor frequently increase during the afternoon, blow predominantly from the south-southeast, and often reach speeds that produce waves and whitecaps. To assess the wind's effects on colonies during 2022, we monitored wind speed, direction, and duration from the Hamilton Branch weather station (station PG600; MesoWest, University of Utah 2022) on the northeast side of the lake (Figure 1). In addition to our weekly surveys, we also surveyed immediately after windstorms, which we define as winds roughly in the upper 10% of all wind measurements (wind speed, wind gust, and duration) recorded. Windstorms occurred on average roughly 8 times per month (June–September) during the 2020, 2021, and 2022 nesting seasons (station PG600; MesoWest, University of Utah 2022). During the post-windstorm surveys, we observed the colony, counted active and inactive nests, compared the colony's location and size to that pre-windstorm, and we searched the shoreline downwind of the colony to determine whether nests had been blown ashore and beached. We define *beached* nests as those blown ashore or blown into shallow water during windstorms and found in a distinct wrack line on the downwind shoreline and define *stranded* nests as those that remained in place but were left above the water level because of drawdown and evaporation of the reservoir.

On 29 July 2022, Goose Bay Colony 1 supported 1173 active nests. This colony was constructed in a large patch of sago pondweed (*Stuckenia pectinata*) in 0.6 to 1.5 m of water and about 60 m offshore (i.e., the distance from the nest nearest to shore). On 2 August this colony had decreased to 23 active nests and the bed of sago pondweed was mostly gone. Along the western edge of Goose Bay, we then observed 94 beached nests and another 19 abandoned or partially destroyed nests floating 6 m offshore. Winds 18–42 km/hr and gusts of 27–79 km/hr were measured on 30 July between 15:50 and 19:00. From the abrupt disappearance of active nests and little change in water depths at the colony's location, we conclude that this windstorm destroyed 1150 grebe nests (98%). Goose Bay Colony 1 did not recover from the windstorm, supporting a maximum of just 34 nests for the remainder of the nesting season.

On 6 August 2022, Goose Bay Colony 2 (Figure 1) supported 645 active grebe nests. The colony was constructed in northern water-milfoil (*Myriophyllum sibiricum*) in approximately 1.6 to 2.2 m of water and lay about 549 m offshore. On 9 August, Lake Almanor experienced another afternoon windstorm, with 8.3 hours of sustained winds of 13–32 km/hr and wind gusts of 21–51 km/hr. The next day, only two active nests remained, and the dense mat of northern water-milfoil that had dominated this colony was mostly gone. Along the downwind shoreline of Chester Meadows, we counted 640 beached nests (Figure 1), mostly on the windward side of partially submerged tree stumps at the Chester Meadows shoreline. Most nests were intact and had been blown ashore singly or in small clusters. From these observations, we conclude that the windstorm destroyed the colony.

On 31 August grebes at Goose Bay Colony 2 had reestablished 222 nests that were 200 m offshore in water 0.9–1.5 m deep. On 4 September, this colony had decreased to 12 active nests with the mat of water-milfoil still intact. During a follow-up kayak survey on 6 September, the colony was found to be inactive with 141 abandoned nests 150 m offshore in 0.6–0.8 m of water. We also found 135 beached nests (Figure 1) along the shoreline downwind of this colony. Lake Almanor experienced four windstorms between 31 August and 3 September that evidently caused Goose Bay Colony 2 to fail for the second time. Afternoon and early evening windstorms on these 4 days lasted 4 to 7 hours and had average sustained winds of 14–27 km/hr and average wind gusts of 19–40 km/hr (maximum sustained winds were 32 km/hr; maximum wind gust was 50 km/hr).

The cumulative result of these six windstorms was the destruction of 2003 nests in two colonies. Grebes continued to attempt to nest on Lake Almanor, establishing three other smaller colonies in the northwest portion of the lake. However, only nine

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juvenile grebes were observed during surveys of the entire lake, and we concluded that in 2022 nesting on Lake Almanor was largely unsuccessful.

Nest stranding or receding water levels that threatened nesting were documented at two colonies: Catfish Beach, where we observed 158 stranded nests over the course of the nesting period, and Goose Bay Colony 3, where 87 nests were threatened by shallow water levels (Figure 1). While stranding and shallow water levels can contribute to nest and colony failure at Lake Almanor, our observations demonstrate that windstorms destroyed most of the nests in 2022.

Grebes are persistent and rapid nest builders (La Porte et al. 2020); their colonies can expand and contract rapidly (Parmelee and Parmelee 1997, Hayes et al. 2022), which can confound our ability to determine why colonies succeed or fail. Both declining water levels and windstorms can cause colonies to fail, and the role of each should be evaluated carefully. Frequent and thorough nest counts and colony monitoring are essential to distinguish between stranded and beached nests.

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