Audubon's *Aechmophorus* Grebe Conservation Project
Comprehensive Monitoring Report: 2010-2016
Almanor, Antelope, Davis, and Eagle Lakes
Plumas and Lassen Counties, California

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Summary

The Plumas Audubon Society has monitored breeding *Aechmophorus* grebes on Lake Almanor and Eagle Lake from 2010 through 2016 and on Lake Davis and Antelope Lake from 2012 through 2016. Water surface elevation and rate of drop, human disturbance, predation of eggs and adults, habitat availability, and the fish prey population all influenced *Aechmophorus* grebe population size, number of nests, and reproductive success, which varied between years and lakes.

Grebes have not nested on Eagle Lake since 2011 because there is no suitable nesting available due to the lowest water levels in the last 140 years. However, the lake has remained important for migrating grebes, which have numbered more than 8,000 in the fall. On Lake Almanor, grebe reproductive success appears strongly influenced by the rate of drop in water surface elevation during the breeding season. We recommend water surface elevation drops of less than -0.72 inches/day from June 25 through September 15, which could result in juvenile:adult ratios greater than 0.5 (i.e. 1 young for every 2 adults). A pilot project to reduce the water drop rate showed that this is extremely challenging due to operational constraints and complexities. To make water management changes more feasible, we are recommending an interim goal of water drops of no more than -0.84 inches/day from July 1 through August 31. We also recommend other measures to help mitigate water management impacts on grebes including restricted boat activity in the north basin when young grebes are present as well as studying and improving the grebe's prey fish.

The slower rates of drop in water surface elevation seen at Antelope Lake (-0.66 inches/day) and Lake Davis (-0.31 inches/day) results in higher grebe reproductive rates on those reservoirs. However, slower and more consistent water level drops alone do not ensure successful reproduction every year. In 2015, there was no successful grebe nesting on Davis and Antelope Lakes due to high winds and low fish prey, respectively.

Aechmophorus grebes are attracted in large numbers to Lake Almanor due to the fish prey population (largely pond smelt) and also because large areas of suitable breeding habitat is available at all water levels we have observed (approx. 4,477 to 4,493 feet water surface elevations: June 25-Sept 15, 2010-2016). Because of these conditions, Lake Almanor has produced at least some young grebes every year, but has the potential to be much more productive.

Introduction

The Plumas Audubon Society, in collaboration with Audubon California, has monitored *Aechmophorus* grebes on four lakes in Plumas and Lassen Counties, northern California from 2010 through 2016. The project has been funded by the Luckenbach Trustee Council with oil spill mitigation funds (Ivey 2004) because grebes are greatly affected by oil spills in the ocean (Humple et al. 2011, Henkel et al. 2013). The primary goal of the project is to determine factors that affect grebe reproduction and to help grebes increase their reproductive success.

The genus *Aechmophorus* is comprised exclusively of two species: Western (*A. occidentalis*) and Clark's (*A. clarkii*) Grebes, which occur in western North America from southern Canada to the Mexico Plateau (Storer and Nuechterlein 1992). Western Grebes have a straight bill with a dull green-yellow color and the black on their head extends below the eye whereas Clark's Grebes have a slightly upturned, bright orange-yellow bill with the white on their cheek extending above the eye. Although these two species share a similar distribution and nest side by side in colonies, their species are maintained through differing plumage, foraging micro-habitat, and advertising calls (Ratti 1979). Western Grebe calls include two distinct "cree-cree" notes, whereas Clark's Grebe calls are a single "creeet" note that is more drawn out.

Western and Clark's Grebes migrate in flocks at night to the Pacific coast, wintering in sheltered bays or estuaries as well as on some inland lakes in California, the Southwest U.S., and central Mexico (Humple 2009). In summer, *Aechmophorus* grebes breed in freshwater lakes with marshy vegetation and large open areas of water. Nests are located in shallow water, generally less than three feet deep. Both the male and female in a pair help to build the nest, which is a floating mound of vegetation. The nest material includes a variety of emergent vegetation including bulrush, cattails, and pondweed (Lindvall and Low 1982, Ivey 2004). The grebes nest in colonies and nests must be continually guarded during the breeding season to prevent usurpation or stealing nest material by other pairs and predation, primarily by avian predators. *Aechmophorus* grebes eat mostly fish, but have also been observed eating crustaceans, insects, worms and salamanders (Storer and Nuechterlein 1992).

Western and Clark's Grebes have elaborate courtship displays that help develop and maintain a strong pair bond, which is necessary for successful reproduction. Courtship involves rushing and weed ceremonies that include synchronized dancing and calling. The typical clutch size for both species is from 2 to 4 eggs. They are usually a pale bluish white and become stained by the nest vegetation to a speckled light to dark brown (Shaw 1998). Downy young of the Western Grebe display a uniform gray along the back, which differs from the almost entirely white young of Clark's Grebe. Eggs hatch asynchronously, often several days apart. Both parents back brood the semi-altricial chicks for their first several weeks, alternating parental duties including incubation, back-brooding, and foraging (Storer and Nuechterlein 1992).

Methods

The following *Aechmophorus* grebe survey protocol is used by the Plumas Audubon Society (PAS) to study and monitor grebes nesting in northeastern California on Eagle, Almanor, Davis, and Antelope Lakes. The protocol is based on Gericke et al. (2006) and modified based on our experience over the last seven breeding seasons.

Some *Aechmophorus* grebes overwinter on the inland lakes monitored by PAS. It is unknown if grebes winter on the same lakes on which they breed, but wintering and summering birds most likely comprise completely different individuals (Humple 2009). It would be useful information to monitor the wintering and migrating grebe population, but our study focuses on breeding grebes and our surveys are conducted primarily during the breeding and post-breeding seasons.

Our monitoring and survey efforts are categorized as follows: nest monitoring surveys, abandoned nest surveys, disturbance surveys, and population and brood surveys. Survey protocols are designed to maintain a buffer of >100 meters from active nests to avoid flushing grebes from their nests and exposing eggs to predators (Gould 1974; Kury and Gochfeld 1975; Lindvall 1975; Ellison and Cleary 1978; Safina and Burger 1983; Shaw 1998). Predators such as gulls and ravens wait for disturbances in colonies to push grebes off nests, and then they move in to try to rob nests of eggs (Sardella 2002).

Nest Monitoring Surveys

Weekly nest monitoring surveys of grebe breeding colonies were conducted from shore using binoculars and spotting scopes and by kayak starting June 1. Nest initiation varies by lake and has ranged from the end of May through the end of July on our study lakes (Table 1). If nest initiation was missed, it was estimated based on the first chicks seen hatching or based on the size of the oldest chicks observed during the first brood survey (Table 2, Ratti 1977). However, once young are full size, estimating the hatch date is less accurate than for younger birds.

Once nesting began, discrete nesting areas were considered colonies, defined as a group of grebe nests at least 400 m from other grebe nests (Hayes 2013). Colony size was tracked using the Nest Monitoring Survey Form. Colonies were mapped from shore and from kayak as accurately as possible while maintaining the greatest buffer possible from active nests. Compass bearings to the right and left edge and other reference points in colonies were taken from observation points and the distance to the reference points estimated. Doing this from multiple points around the colony, both by boat and by shoreline when possible, increased colony mapping accuracy and also allowed observers to get an accurate count of nests and adults. Sometimes colonies were mapped by kayaking around the perimeter of the colony. A solo kayaker maintained a >10 m buffer and a steady speed, minimizing disturbance to the colony and providing an accurate colony boundary. This type of survey was only conducted for nest colonies in open water and not for colonies in dense vegetation such as willows or tules.

Nest counts were done from strategic observation points around colonies, including on-water points. Nest monitoring was conducted before noon, when possible, as this is when adults are more likely to be on their nests (Miller and Johnson 1978, Bogiatto 1998). Counting nests is complicated because an “active” nest doesn’t always have an adult tending it and “abandoned” nests are not simply the empty ones. An active nest was determined by some evidence of recent maintenance. Counts were conducted at least twice from each location; counting occupied/tended nests as active and empty nests appearing untended as abandoned. Averaging the counts of two separate observers helped to obtain an accurate estimate of active and abandoned nests.

Tallying the total number of grebe nests on a lake during one breeding season is also challenging since the number of nests in a colony is constantly changing and grebes will abandon nests and then start new nests in a different area. Our nest counts are the additive sum of the peak number of nests in each colony (Tables 3 and 4). For example, a colony peaks with 150 nests and then a new colony forms peaking at 200 nests, thus our total additive nest count would be 350.

Nest monitoring surveys were repeated once a week for each colony for the duration of the nesting season because grebes continue initiating nests throughout the summer months (Ivey 2004) and the location of nesting colonies can change continuously. On some lakes, as water levels decrease, submergent vegetation (i.e. pondweed, *Potamogeton* spp.) increases and grebes can nest in deeper water. Mapping the colony each time it is counted was important to monitor the changes in colony location. Changes can vary from very slight to major shifts between visits. Colony extents change constantly because nests can be constructed in 1-3 days (Ivey 2004) and abandoned at any time.

Abandoned Nest Surveys

Nests in thick vegetation such as willows and tules often cannot be counted until after nesting has finished without significant disturbance to nesting grebes. In these areas, nest counts were completed after nesting had finished, when surveyors could walk and/or boat through the abandoned nest colony and count old nests.

Disturbance Surveys

Once nesting had begun, disturbance surveys were conducted, generally June-August. Colonies were observed for >1 hour to quantify types of disturbance to grebe colonies and grebe responses. These surveys were done from shore at a distance >500 m to avoid observer disturbance to nesting grebes during surveys.

Population and Brood Surveys

Population counts and brood surveys were conducted by motor boat on larger lakes or by kayak on smaller lakes starting as early as June. Population surveys (counts) were conducted during brood surveys. Surveys conducted earlier in the breeding season may more accurately estimate the total adult grebe population because of migrating grebes. On Lake Almanor, for example, the adult grebe population generally peaks in mid to late-September, presumably due to migrants (Table 5). However, grebes can migrate at any time of the year. In 2014, for example, more than 200 grebes were present on Lake Davis through the end of June, but by mid-July, only half of the grebes remained.

Brood surveys were conducted after most nests had hatched young, but before the oldest young were full size (Robison et al. 2015). Good weather was important for accurate population counts and brood surveys because even slight wind created choppy water that could significantly reduce grebe detectability and survey accuracy. Survey considerations included boat size and speed as well as observer ability. A faster boat helped complete surveys more quickly on the larger lakes. Completing surveys more quickly helped reduce the likelihood of double-counting because grebes had not moved as far in a shorter period of time. Population and brood counts required at least 2 surveyors, 1 data recorder, and 1 boat driver, but 4 observers, 2 recorders, and 1 boat driver was preferred.

Population counts involved one observer watching each side of the boat and tallying all of the *Aechmophorus* grebes observed while the boat completed a systematic route covering the entire lake. The routes were optimized and tracked with GPS to avoid double-counting or missing any grebes and observers were aware of areas where grebes had or had not been counted already during the survey. Clark's and Western Grebes were distinguished when possible, which depended on visibility due to wind, waves, and the sun's direction, and otherwise counted as *Aechmophorus* grebes. Grebe young were categorized by size as: ⅛, ¼, ⅓, ½, ⅔, ¾, ⅞ or full size compared to adults so that their ages could be estimated.

<u>Other Monitoring Methods</u>

Water Surface Elevation

An important component of Plumas Audubon's study of nesting grebes in northeastern California is determining how the management of water surface elevation on artificial reservoirs affects nesting grebes. Water surface elevations for Almanor, Davis, and Antelope Lakes were obtained from the California Department of Water Resources (DWR) California Data Exchange Center (http://cdec.water.ca.gov). Water surface elevations for Eagle Lake were provided by Val Aubrey (www.eaglelakefishing.net) compiled from various sources. Water surface elevation rates of drop are given as negative fractions (e.g. -0.084, Table 4). A rate of -0.084 means that the water surface elevation dropped 0.084 feet (1.008 inches) each day, or 1 foot every 11.9 days.

Wildlife Cameras

In 2012, Plumas Audubon began using wildlife cameras (Bushnell Trophy Cams) to monitor individual grebe nests and determine nest success and disturbances such as predators. After completing a third year of nest monitoring with wildlife cameras in 2014, we have determined that it is the most effective way to monitor nest success, disturbance, and predation for individual nests. Wildlife cameras are attached to natural surfaces, such as stumps, where possible. Otherwise, cameras are attached to t-posts. Cameras do not appear to affect predation or other disturbance at nests.

Aerial Surveys

Aerial surveys make it possible to visit several water bodies in one day to determine the presence/absence of grebes and nests. However, aerial surveys have limitations including the fact that grebes dive when a plane flies too close so aerial flights must be low enough to distinguish grebes from other water birds, but high enough to reduce how often grebes dive. In addition, it can be difficult to distinguish nests in tules, willows, and other dense vegetation and if large numbers of nests are present, they can be difficult to accurately count while flying over (Robison et al. 2010). Thus, more accurate nest counts can be made from high resolution photos taken by an observer or aircraft-mounted equipment. Another limitation to aerial surveys and high-resolution photos is that they are expensive.

Results

Foraging Distribution

Both Clark's and Western Grebes foraged in areas all around each lake and intermixed with one another while foraging. At Eagle Lake, grebes foraged most frequently in the South Basin, Middle Basin, and Buck's Bay, respectively. However, Clark's Grebes were observed foraging most frequently in the shallow-water Middle Basin of Eagle Lake, but they were sometimes found more frequently in the deep-water South Basin. At Lake Almanor, Clark's grebes were most frequently observed foraging in the areas to the west and south of the Lake Almanor Peninsula- which are areas of intermediate depth.

In 1972 and 1973, the California Department of Fish and Wildlife moved about 77,000 pond smelt (native to Japan) from the Shastina Reservoir to Lake Almanor to provide more prey for stocked rainbow trout (Wales 1962, Moyle 2002). It is possible that the smelt introduction allowed grebes to start nesting on Lake Almanor. The first known recorded grebe nesting on Lake Almanor was in 1980 (Attachment B). However, long-time residents of Lake Almanor report seeing grebes on Lake Almanor as far back as the 1950s, but it is unknown if they were nesting on the lake at that time. Natural factors also affect fish prey. At Eagle Lake, for example, a large fish kill occurred in 2009 due to anaerobic conditions caused by ice sheets that disturbed the lake bottom releasing trapped methane gas (V. Aubrey pers. comm.). This could have potentially influenced the low grebe population observed in 2010 (Table 4, Figure 5).

Disturbance Surveys

On Lake Almanor, disturbance surveys were conducted at both the Chester Meadows and Causeway grebe colonies in 2012, 2013, and 2015 (Figures 1-3). Gulls, River Otters, Bald Eagles, Common Ravens, kayakers, ski boats, jet skis, fishing boats, humans on shore, and aircraft were observed in proximity to grebe colonies. Certain types of disturbance caused the grebes to become restless and occasionally leave the colony. Most disturbances were due to avian predators. Predatory events were observed by California and Ring-billed Gulls and Common Ravens, usually when grebes were away from their nests or after nests had been abandoned. River Otters were not observed depredating eggs, but River Otter predation on adult grebes was documented in 2013. Bald Eagles were also observed attacking adult grebes on nests, a Great Horned Owls were photographed on active grebe nests at Goose Bay in 2013 and 2014, and a Northern Harrier was documented in the Causeway colony feeding on a dead grebe on a nest in 2013. Robison (2012) and Bogiatto et al. (2003) documented frequent predation on adult grebes by Osprey, Bald eagle, and Great Horned Owl. Kayakers were also observed in and around colonies (Figures 1-3) and they often caused grebes to leave their nests, which created additional opportunities for gulls and ravens to depredate eggs. Low level passes from aircraft as well as people on shore near colonies also caused grebes to temporarily leave their nests. Power boats were rarely seen coming close to grebe colonies because of the shallow water and the dense vegetation.

Figure 1. Disturbance survey results at Lake Almanor in 2012.

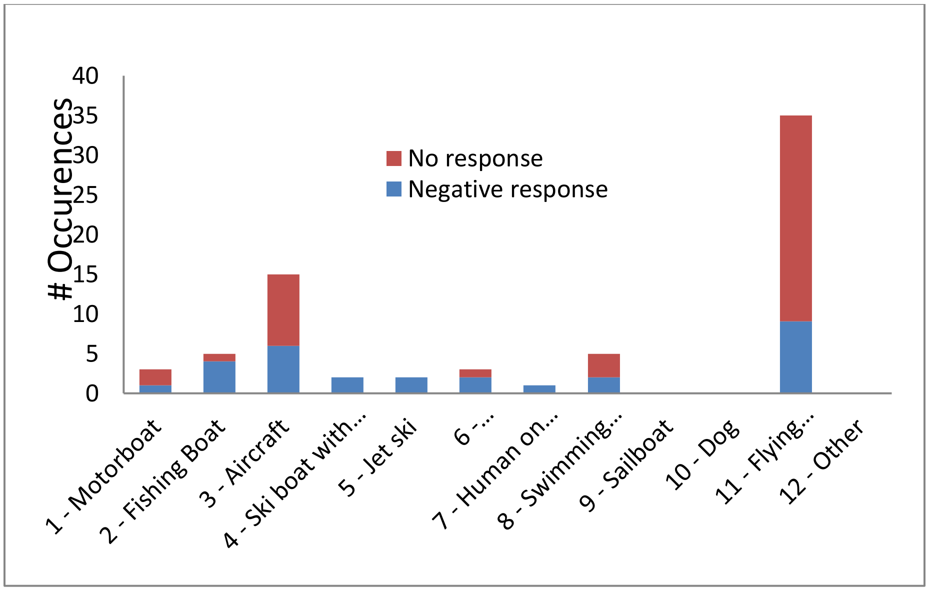


Figure 2. Disturbance survey results at Lake Almanor in 2013.

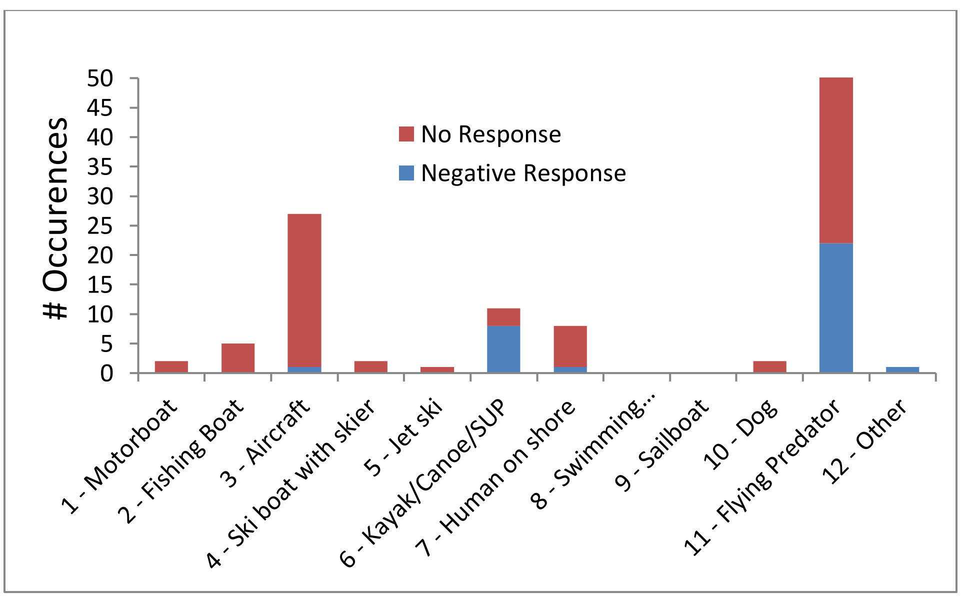
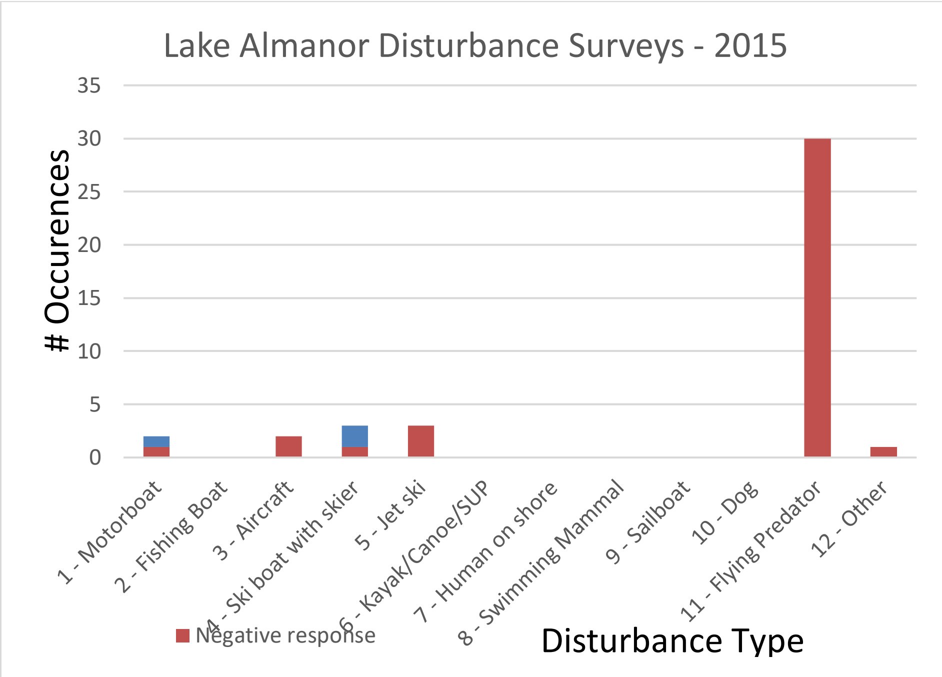


Figure 3. Disturbance survey results at Lake Almanor in 2015.



Nest Monitoring

Wildlife Cameras

Wildlife cameras were used to record activity at grebe nests at Lake Almanor in 2012-16 to help determine nest predators and other factors affecting reproductive success. Wildlife cameras documented disturbance by kayakers, attempted predation of adults by Bald Eagle, Great Horned Owl, and River Otter, and scavenging/egg predation by Coyote, Common Raven, and California and Ring-billed Gulls. On Lake Almanor, nest cameras showed that egg predation/scavenging generally occurred after nests were abandoned due to dropping water surface elevation. In 2016, it appeared that during the second wave of nesting, some grebes were not aggressively defending their nests from aerial predators, apparently due to low prey availability.

Nest colonies

The start, peak, and end of the nesting season varied each year and differed between lakes (Table 1). Grebes started nesting by the end of May through the end of July on Lake Davis, by mid-June to early July on Antelope Lake, from the end of June to the end of July on Lake Almanor, and by mid-July on Eagle Lake (Table 1). The peak number of nests as well as the total nests (sum of the peak number of nests in all colonies) varied between years, especially on Lake Almanor (Figures 4 and 5, Tables 3 and 4). In 2013, Lake Almanor had the most nests observed on any of our study lakes for all years. However, the total number of young produced on Lake Almanor in 2013 was comparable to 2011 when there were only 20% of the nests, but a much higher reproductive rate (Table 4). The most young were produced on Lake Almanor in 2014 (Table 4).

Lake Almanor- The suitable grebe nesting habitat on Lake Almanor varies with the water surface elevation (Figures 8 and 12). When water surface elevation is higher than approximately 4,491 feet, grebes nest in Chester Meadows in the inundated willows (*Salix* spp.) and cattails (*Typha* spp) (e.g. in 2011, early 2012, and 2016, Figure 8). As the lake's water elevation drops below approximately 4,488 feet, suitable nesting habitat becomes available in areas where pondweed (*Potamogeton* spp.) grows in the open water (e.g. in 2010 and 2013-15, Figure 8). Nests were categorized as occurring in three colonies: Causeway, Chester Meadows, and Goose Bay (Table 3). The peak number of nests in each colony varied from 79 to over 1,800 (Table 3, Appendix C).

Eagle Lake- *Aechmophorus* grebes nested in tules in 3 areas in 2010-11 including Stones Ranch, Troxel Bay, and Spaulding (Figure 9). The peak number of nests in each colony varied from 50 to 1,100 (Table 3). The number of nests was related to the water surface elevation, which was highest in 2011, second highest in 2010, and lowest 2012-16 (Figure 13). There was no *Aechmophorus* grebe nesting habitat (inundated tules) available 2012-16 due to low water levels and no *Aechmophorus* grebes have successfully nested on the lake for the last 5 years. The water surface elevation drops at the lowest rate on Eagle Lake compared to our other study lakes.

Table 1. Nesting chronology of grebes at Almanor, Eagle, Davis, and Antelope Lakes 2010-16.

Nesting chronology				
Lake	**Year**	**Start**	**End**	**Peak**
Almanor	2010	22-Jul	27-Sep	31-Aug
Almanor	2011	1-Jul	30-Sep	30-Jul
Almanor	2012	23-Jun	15-Sep	13-Aug
Almanor	2013	8-Jul	25-Sep	5-Aug
Almanor	2014	30-Jun	10-Sep	11-Aug
Almanor	2015	25-Jun	16-Sep	19-Aug
Almanor	2016	23-Jun	14-Sep	1-Aug
Eagle	2010	15-Jul	6-Sep	6-Aug
Eagle	2011	10-Jul	8-Sep	3-Aug
Davis	2012	2-Jun	11-Aug	24-Jul
Davis	2013	25-May	4-Aug	20-Jun
Davis	2014	30-Jun	18-Jul	12-Jul
Davis	2015	7-Jul	18-Aug	10-Jul
Davis	2016	22-Jul*	25-Aug*	5-Aug*
*Based on age of young- no nests were located.				
Antelope	2012	15-Jun	1-Sep	14-Aug
Antelope	2013	17-Jun	12-Sep	1-Aug
Antelope	2014	22-Jun	22-Aug	14-Jul
Antelope	2015	7-Jul	7-Aug	30-Jul
Antelope	2016	21-Jun	12-Sep	3-Aug

Table 2. Estimated number of days since hatch for *Aechmophorus* grebes in different size classes (based on Ratti 1977).

Size Class	Estimated # Days Since Hatch
One-eighth	1-7
One-fourth	3-12
One-third	13-18
One-half	19-23
Two-thirds	24-33
Three-quarters	30-40
Seven-eighths	34-50
Full	51-70

Table 3. Peak number of nests in each grebe colony at Almanor, Eagle, Davis and Antelope Lakes 2010-16.

Colony/Lake	Peak Nests						
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Causeway	285	0	316	1,835	1,147	1,542	26
Chester Meadows	351	580	725	79	0	0	1,064
Goose Bay	0	0	0	1,249	1,444	995	0
Almanor Total	**636**	**580**	**1,041**	**3,163**	**2,598**	**2,537**	**1,090**
Stones Ranch	200	1,100	0	0	0	0	0
Spaulding	50	396	0	0	0	0	0
Eagle Total	**250**	**1,496**	**0**	**0**	**0**	**0**	**0**
Davis Total	**-**	**-**	**30**	**35**	**14**	**71**	**88***
Antelope Total	-	-	**20**	**20**	**29**	**13**	**29**

*Based on peak number of broods counted during lake-wide survey- no nests were located.

Figure 4. Peak number of grebe nests at Lake Almanor and Eagle Lake 2010-16.

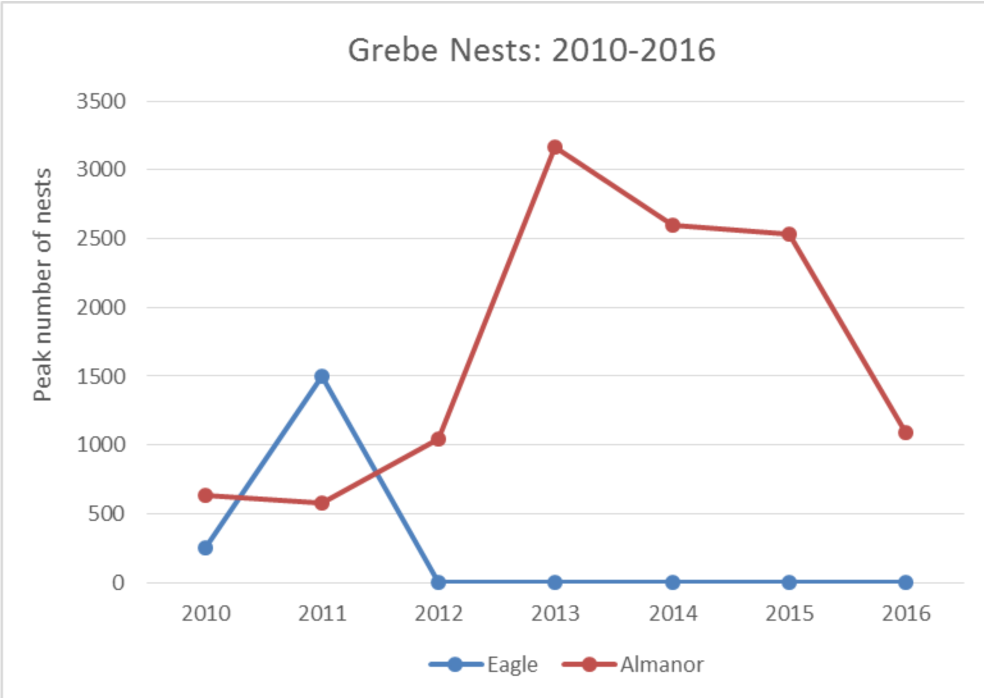
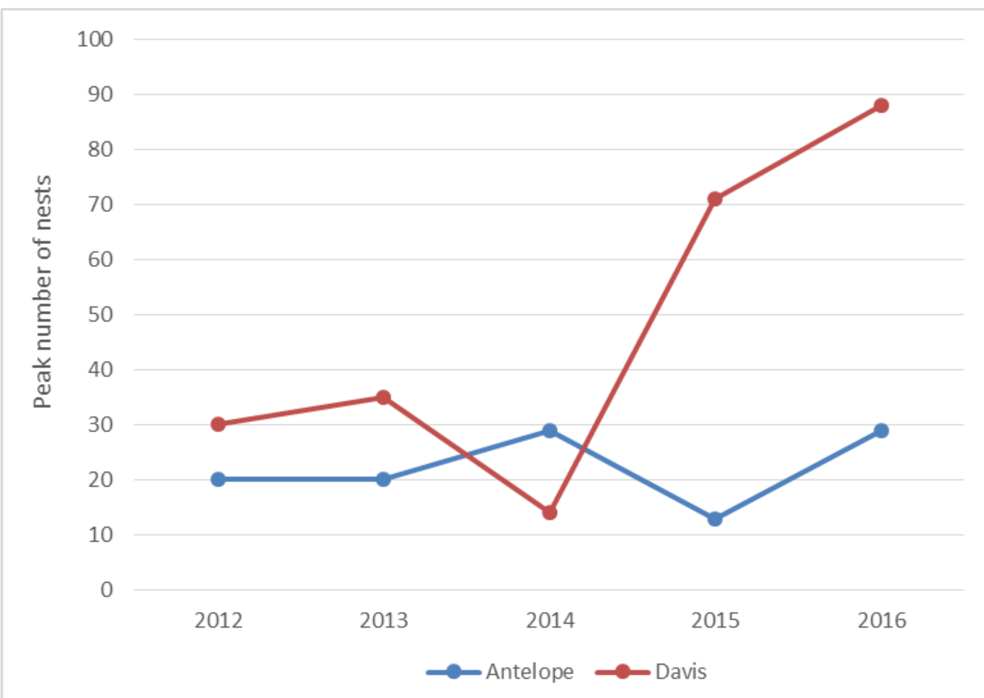


Figure 5. Peak number of grebe nests at Lake Davis and Antelope Lake 2012-16.



Lake Davis- *Aechmophorus* grebe nesting habitat on Lake Davis occurs in the inundated willows at the north (shallow) end of the lake in 2012-13 and in pondweed in an open water area further south in 2014-15 (Figure 10). Grebes use the structure of the willows to build nests with pondweed and other aquatic vegetation occurring in and around the willows. Because of the more linear distribution of the habitat in 2012-13, grebe nests were scattered in patches along the lake's shoreline, rather than in more discrete colonies as seen in the colonies that formed in open water in 2014-15 (Figure 10). The peak number of nests was consistent in 2012 and 2013, with 30 and 35 nests respectively, but that dropped to a peak of 14 nests in 2014, all of which failed due to wind (Table 3). The total number of nests rose dramatically in 2015 to 71, but all of those nests also failed due to wind. In 2016, there were at least 88 nests on Lake Davis based on the peak number of broods counted during lake-wide surveys. However, we do not know where any of the nests were located, but they were not in any of the areas used 2012-15 because we surveyed those areas throughout the season.

Antelope Lake- Although Antelope Lake has miles of shoreline with emergent vegetation and multiple coves which appear to meet habitat requirements for nesting grebes, almost all of the grebe nests from 2012-16 were in only one area of the lake near the Lost Creek Cove boat ramp (Figure 11). Although there was potential human disturbance to the nest colony due to its proximity to the boat ramp, boat traffic was never observed pushing grebes from the colonies. Nests were located near the shore in the cove and further out in open water. Few nests were observed to be abandoned due to water level decreases, and those nests that did eventually become stranded on dry land had no evidence of depredation. The peak number of nests on Antelope Lake was 20 in both 2012 and 2013, 29 in 2014 and 2016, and a low of 13 in 2015 (Table 3). All of the nests failed in 2015, presumably due to a lack of fish prey.

Table 4. Summary of nests, adults, and juvenile *Aechmophorus* grebes on Almanor, Eagle, Davis and Antelope Lakes 2010-16.

Lake	**Year**	**# nests**	**Ave adult census**	**Ratio adults: nests**	**Peak ratio juv:adult**	**Est. # young**	**Ave brood size**	**Ave % Clark's**
Almanor	2010	636	2,900	4.56	0.06	175	1.1	5
Almanor	2011	580	2,446	4.22	0.46	1,160	1.5	7
Almanor	2012	1,041	3,830	3.68	0.19	811	1.5	6
Almanor	2013	3,163	5,209	1.65	0.26	1,119	1.4	6
Almanor	2014	2,598	5,137	1.98	0.30	1,336	1.5	6
Almanor	2015	2,537	4,948	1.95	0.23	984	1.5	6
Almanor	2016	1,090	4,457	4.09	0.04	181	1.5	3
Eagle	2010	250	1,700	6.80	0.08	138	1.7	4
Eagle	2011	1,496	4,056	2.71	0.30	1,200	1.0	15
Eagle	2012	0	5,950	0.00	0.00	0	0.0	11
Eagle	2013	0	2,287	0.00	0.00	0	0.0	4
Eagle	2014	0	2,571	0.00	0.00	0	0.0	4
Eagle	2015	0	6,143	0.00	0.00	0	0.0	7
Eagle	2016	0	3,484	0.00	0.00	0	0.0	5
Antelope	2012	20	82	4.10	0.60	49	2.4	0
Antelope	2013	20	62	3.10	0.37	22	2.3	0
Antelope	2014	29	68	2.34	0.76	52	1.8	0
Antelope	2015	13	65	5.00	0.00	0	0.0	0
Antelope	2016	29	88	3.03	0.74	68	1.8	0
Davis	2012	30	138	4.60	0.55	63	1.8	0
Davis	2013	35	158	4.51	0.35	53	1.3	3
Davis	2014	14	132	9.43	0.00	0	0.0	0.5
Davis	2015	71	118	1.66	0.00	0	0.0	0
Davis	2016	88**	180	2.05	0.60	115	1.3	0

*The ratio of juveniles:adults is a measure of reproductive success.
**Based on number of broods- no nests were located.

Figure 6. The average number of adult grebes on Lake Almanor and Eagle Lake 2010-16.

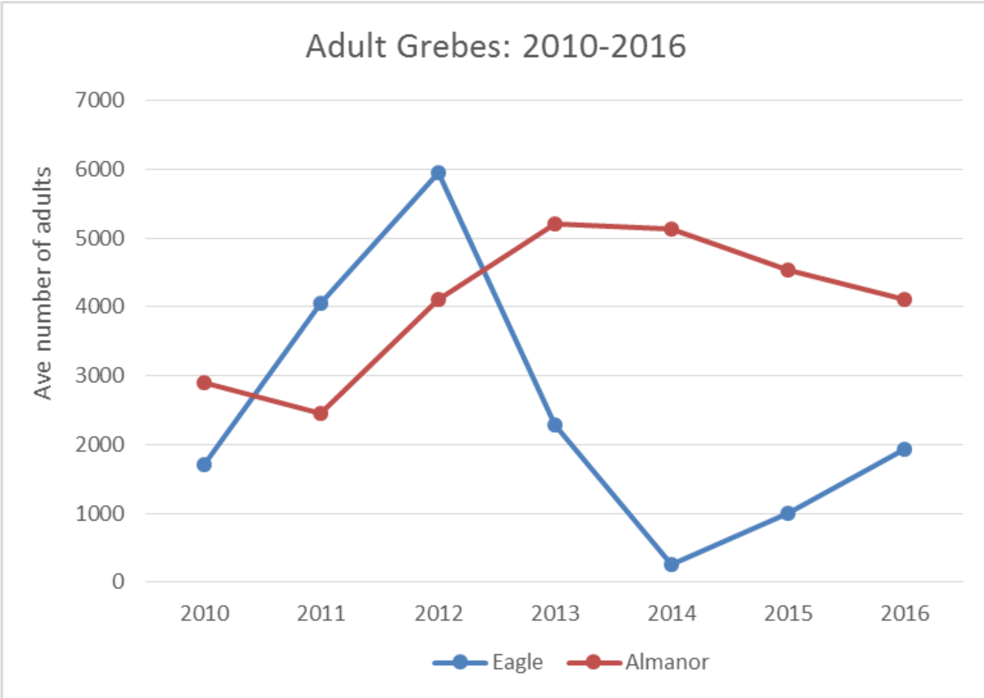


Figure 7. The average number of adult grebes on Lake Davis and Antelope Lake 2012-16.

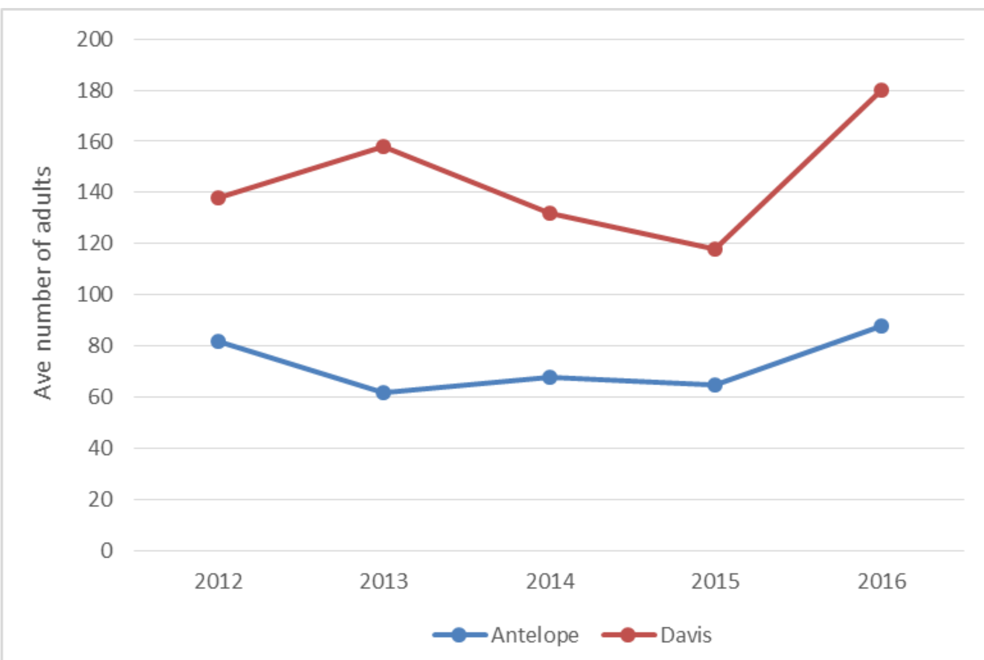


Table 5. Results of population surveys conducted at Lake Almanor 2010-2016.

Year	Date	Adults
2010	22-Sep	3,000
	12-Oct	2,800
	Ave	**2,900**
2011	7-Sep	2,360
	30-Sep	2,533
	Ave	**2,446**
2012	1-Aug	3,275
	30-Aug	3,851
	20-Sep	4,364
	Ave	**3,830**
2013	16-Aug	5,181
	30-Aug	5,431
	12-Sep	5,604
	2-Oct	4,619
	Ave	**5,209**
2014	27-Aug	6,544
	12-Sep	4,411
	19-Sep	4,456
	Ave	**5,137**
2015	27-Jul	4,475
	20-Aug	7,743
	3-Sep	4,871
	18-Sep	4,278
	30-Sep	3,371
	Ave	**4,948**
2016	27-Jul	3,779
	11-Aug	4,458
	25-Aug	4,748
	8-Sep	4,845
	Ave	**4,457**

Figure 8. Lake Almanor Grebe Colonies 2010-16.

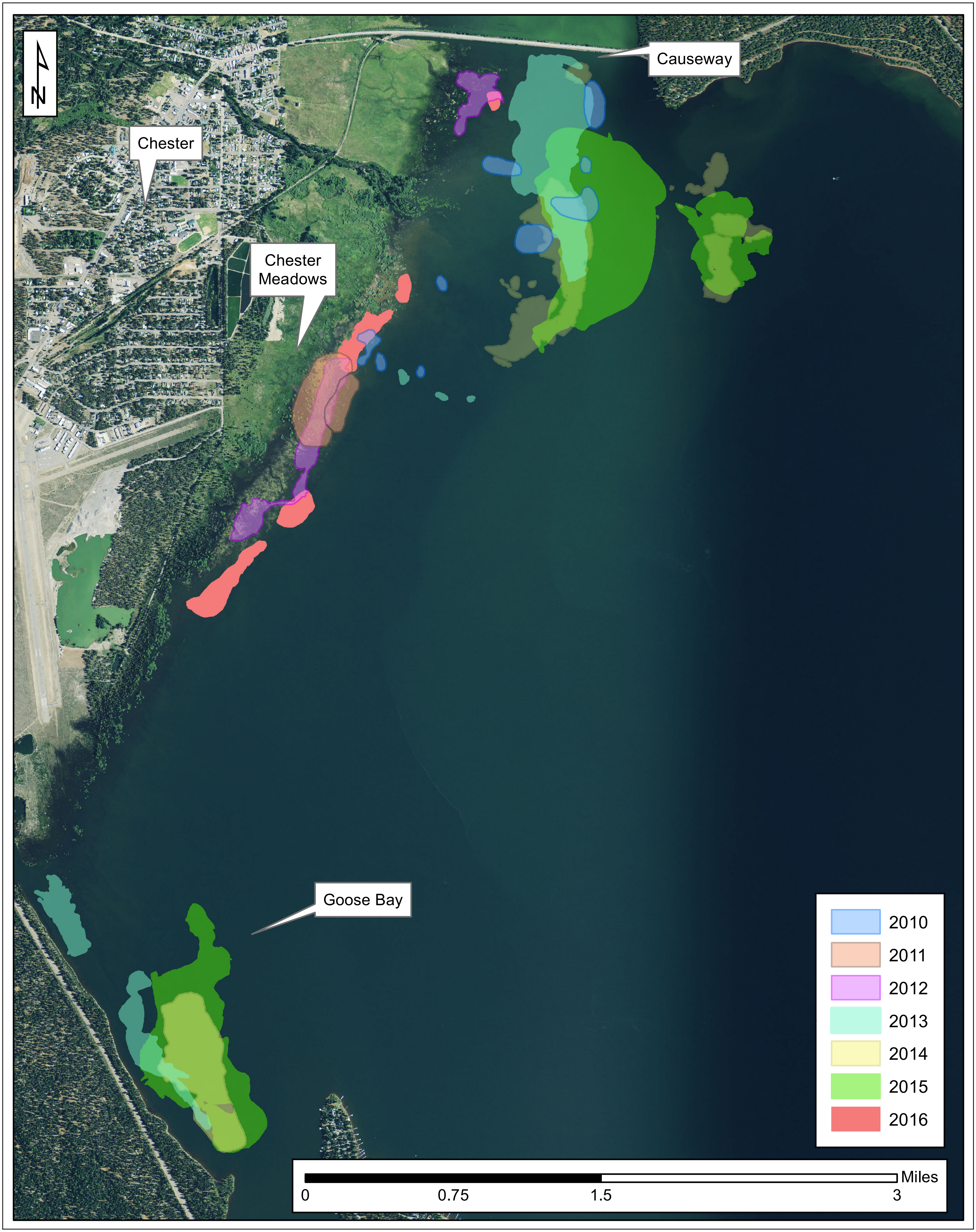


Figure 9. Eagle Lake grebe colonies 2010-11.

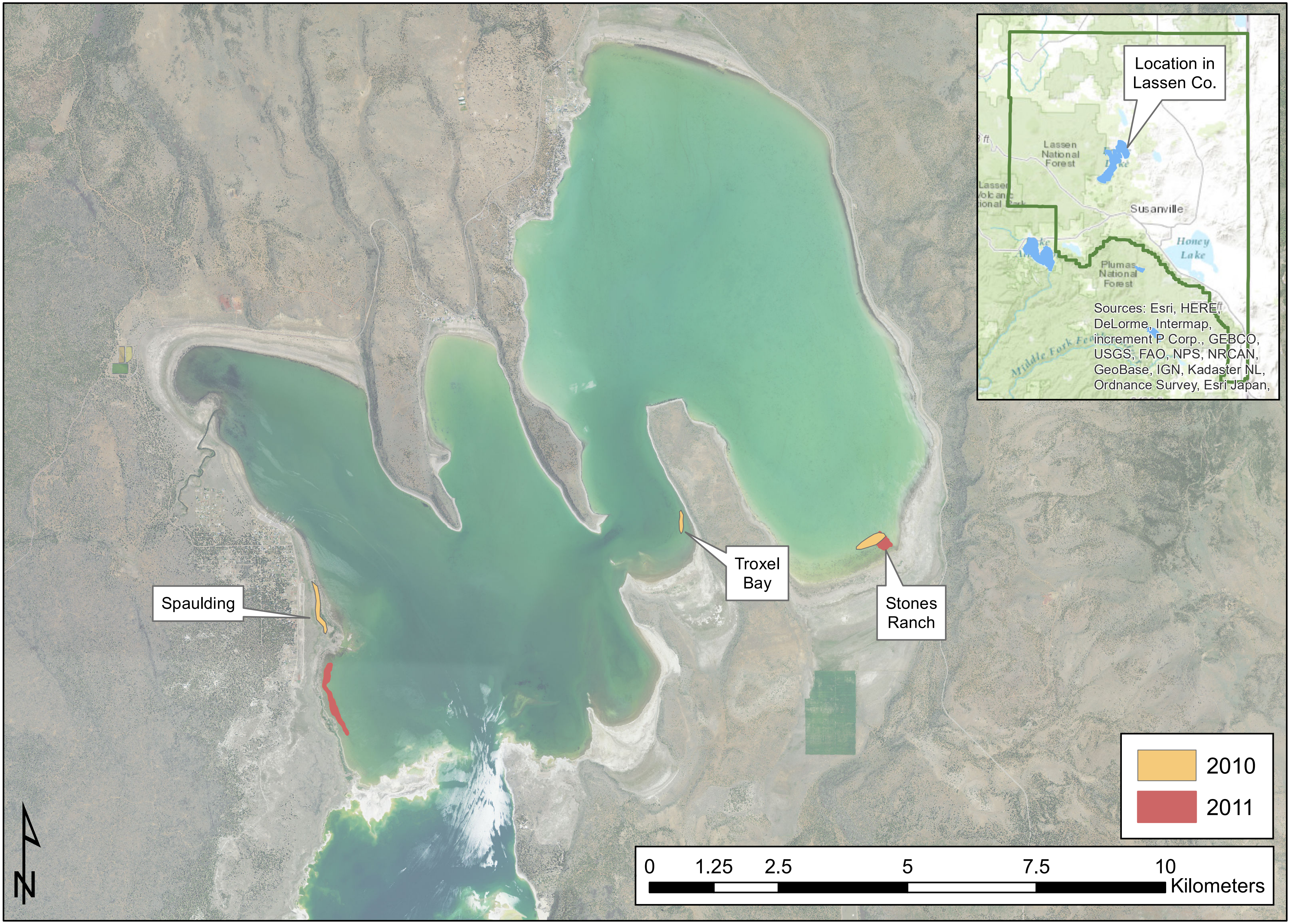


Figure 10. Lake Davis grebe nests and colonies 2012-15.

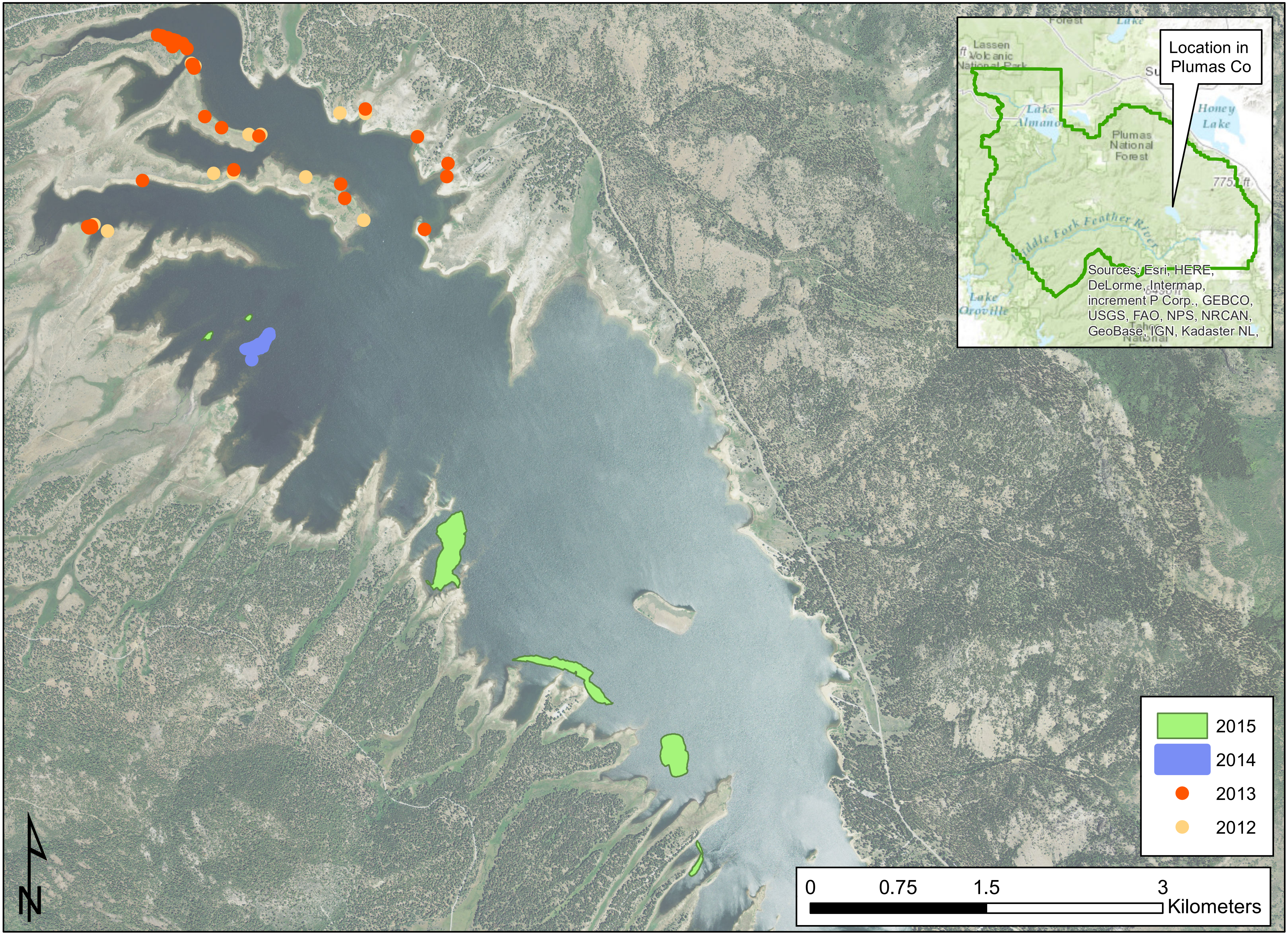


Figure 11. Antelope Lake Grebe Colonies 2012-16.

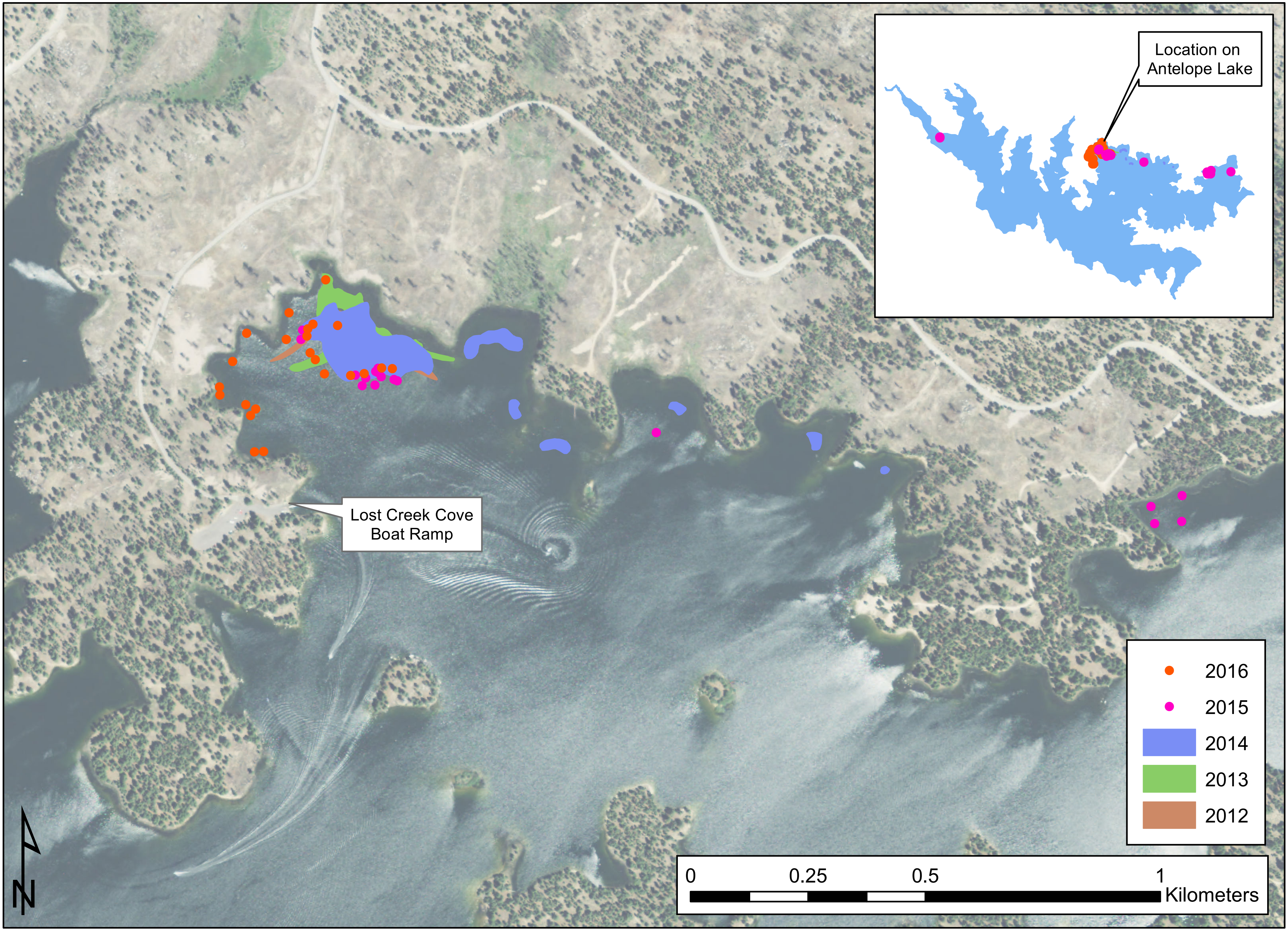


Figure 12. Water surface elevation at Lake Almanor June 23 through September 30, 2010-16. Average drop of inches per day is shown for each year (average -0.78 inches/day).

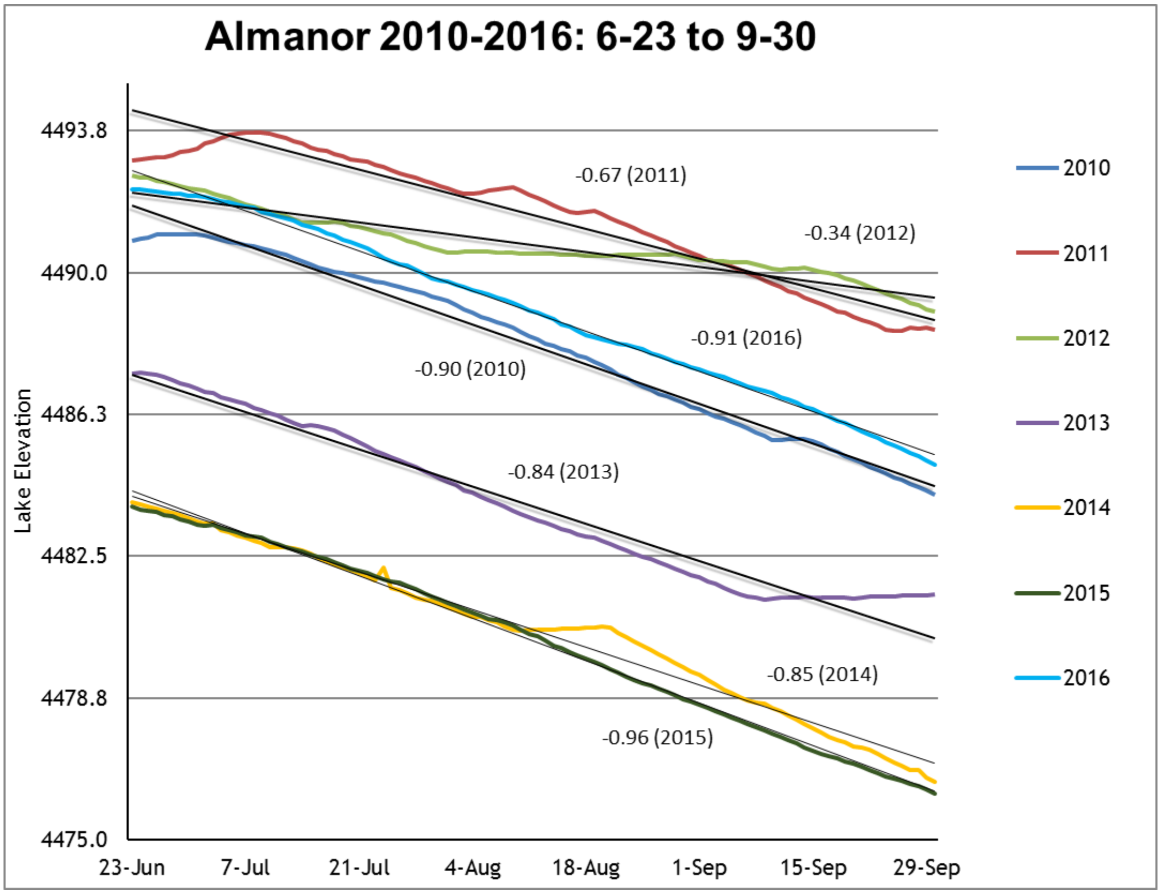


Figure 13. Water surface elevation at Eagle Lake May 29 through September 30, 2010-13 (average -0.15 inches/day).

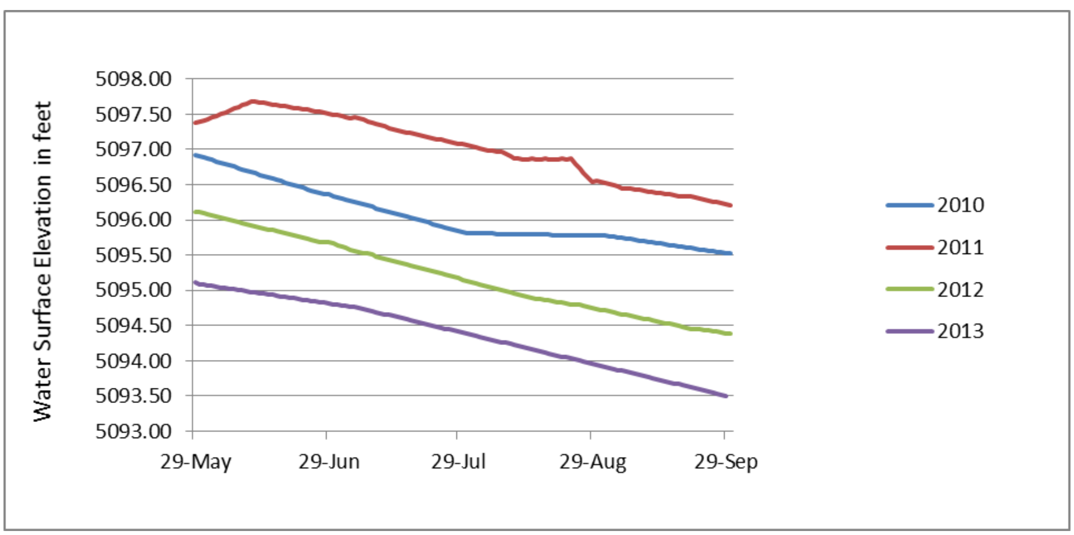


Figure 14. Water surface elevation at Lake Davis May 29 through August 15, 2012-16 (average -0.31 inches/day).

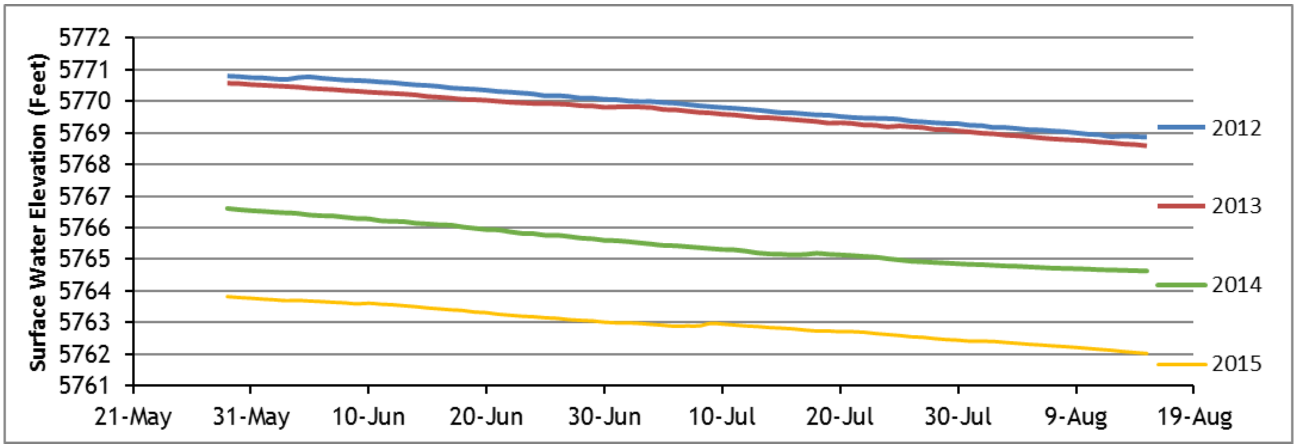
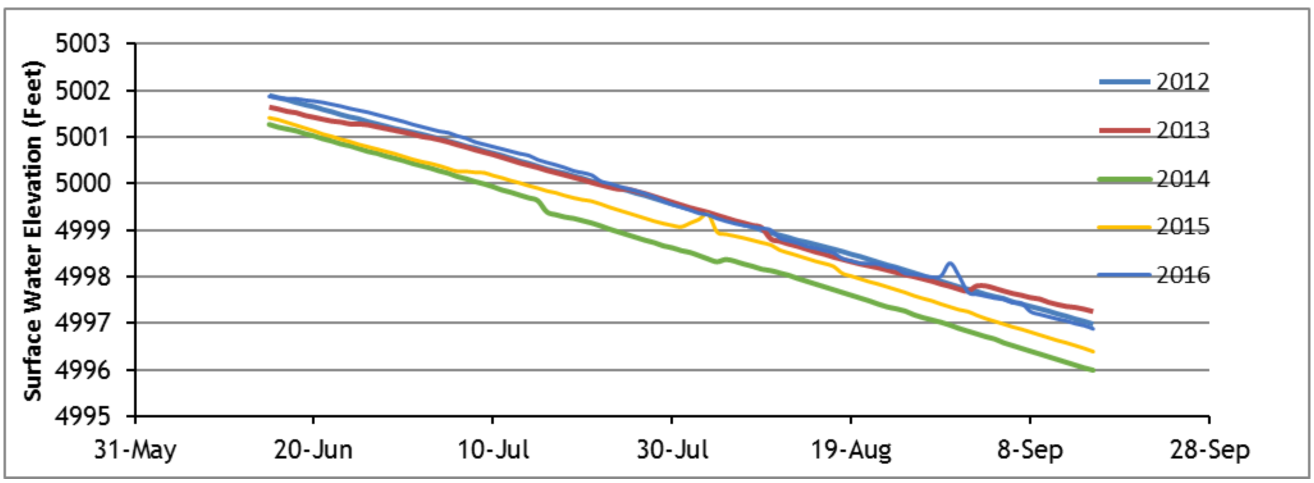


Figure 15. Water surface elevation at Antelope Lake June 15 through September 15, 2012-16 (average -0.66 inches/day).



Population Monitoring

At least 2 lake-wide population/brood surveys were conducted on our study lakes each year except for Eagle Lake, where only 1 such survey was conducted in 2010 and 2011. The total number of adults on a lake varied during the season, peaking from late August to late September, which was influenced by migrant grebes (Table 5).

By comparing known nesting dates based on nest surveys, we found that brood surveys can give an accurate estimate of nesting chronology if there is a sufficient sample size of young and the survey is timed so that most of the young are between ¼ and ¾ in size. Brood surveys also provided an estimate of reproductive success, measured as the ratio of juveniles:adults (Robison 2012, Robison et al. 2015).

<u>Water Surface Elevation</u>

The change in water surface elevation both within and between years was greatest at Lake Almanor (Figures 12-15). Eagle Lake, a natural, terminal lake in the Great Basin, dropped at the slowest rate of all the lakes (Figure 13). Water surface elevation dropped more steadily at Davis and Antelope Lakes (Figures 14 and 15), the latter more rapidly of the two.

There is a clear pattern that the rate of drop in water surface elevation strongly influences *Aechmophorus* grebe nest success. There are other factors affecting reproductive success that are additive to the effects of water level drop including predation by raptors, gulls, corvids, and mammals; wind, fish prey, and water level (the actual level as opposed to the rate of drop in water level). Despite all of the additional factors affecting grebe reproductive success, water level drop has the strongest and most consistent influence across all years and all lakes and therefore has a significant influence on grebe reproductive success.

To more robustly assess the influence of water level drop, we compared reproductive success of grebes between lakes and years, as well as within lakes and years, using a variety of indicators of reproductive success.

Between-lake comparison:

Almanor, Davis, and Antelope Lakes all have river otter, Great Horned Owl, Bald Eagle, Ring-billed and California Gulls, and Ravens as predators of grebe nests and adults. Lake Almanor and Davis can be more affected by wind depending on when storms occur in the summer and nest locations. Human disturbance is also present on all of the lakes. The average rate of water level drop at Lake Davis is -0.31 inches/day (Figure 14), at Antelope Lake it is -0.66 inches/day (Figure 15), and at Lake Almanor it is -0.78 inches/day (Figure 12). Davis and Antelope Lakes have consistently higher reproductive rates compared to Lake Almanor (Table 4). However, Lake Davis was strongly affected by summer storms in 2014-15 and Antelope Lake was strongly affected by fish prey in 2015. Due to the size of the lake and the large area of suitable habitat available, grebes nesting at Lake Almanor are less susceptible to the effects of wind and prey availability.

Within-lake comparison:

At Davis and Antelope Lakes we were able to identify causes of low reproduction in 2014 and 2015 based on our wildlife camera data and other behavioral observations and clues. The wind clearly destroyed all grebe nests at Lake Davis in 2014 and 2015, which we documented during weekly visits and with wildlife cameras located at nest sites. In 2012-13, when the water level was higher, grebes were able to nest in the inundated willows and were therefore sheltered from wind effects. In 2016, there were no summer wind storms that affected nests so we know they were not affected even though we don't know where they nested. In 2015, it was apparent that the fish prey population had crashed based on the low number of nests that were initiated despite the same amount of nesting habitat available as in other years, similar numbers of adult grebes present, as well as a pattern of grebes arriving and quickly departing the lake throughout the summer as recorded on our weekly surveys.

Lake Almanor had consistently lower reproductive success despite fluctuations in the total number of adult grebes on the lake and the total number of nests. However, due to the large grebe population on Lake Almanor and the consistently available nesting habitat, some young were always produced on the lake each year (Table 4).

Between-year comparison:

Our conclusion of the strong effect of water level drop on grebe reproductive success has been largely drawn from between-year comparisons at Lake Almanor. The rate of water level drop is much more variable both within and between-years at Lake Almanor compared to Davis and Antelope Lakes (Figures 12, 14, and 15). There is a strong relationship between reproductive success and the rate of drop in water surface elevation at Lake Almanor (Figures 16, 17, and 18). We have excluded 2012 from these analyses due to the strong effect of the Chips Fire that year. 2012 still produced a decent number of young (Table 4), but the abnormally slow rate of water drop and the effect of the fire on reproduction does not fit the pattern seen in other years and therefore is an outlier.

Throughout our study, we have measured reproduction as the ratio of juveniles:adults on each lake because this has long been the standard among grebe researchers (Robison et al. 2015, Storer and Nuechterlein. 1992). To more robustly analyze the effect of water level drop on grebe reproduction, we also used the total number of young produced each year (Figure 17), as well as the number of young produced per nest (total number of young on lake/total number of nests, Figure 18) as alternative measures of reproductive success. Because the total number of adults and the total number of nests varies each year, there is some degree of independence between these measures of reproduction. The analysis shows a strong relationship between the rate of water level drop and grebe reproduction across all measures of reproduction (Figures 16, 17, and 18).

Within-year comparisons:

The rate of water level drop varies not only between years, but also within years throughout the grebe breeding season (Figure 12). There are often plateaus over several week periods where the rate of water level drop slows considerably (Figure 12). We looked at some of these plateaus in relationship to when most of the young grebes were produced. We found a strong relationship between the timing of such plateaus and when most young grebes were produced (Figure 19). For example, in 2011, 90% of the young produced were from nests that were active between July 25 and August 25. We can estimate this based on the size of the young counted during lake-wide surveys (Table 2).

Figure 16. Rate of drop in water surface elevation (inches per day) related to reproductive success measured as the ratio of juveniles:adults at Lake Almanor in 2010-2016 (2012 excluded due to effect of Chips Fire).

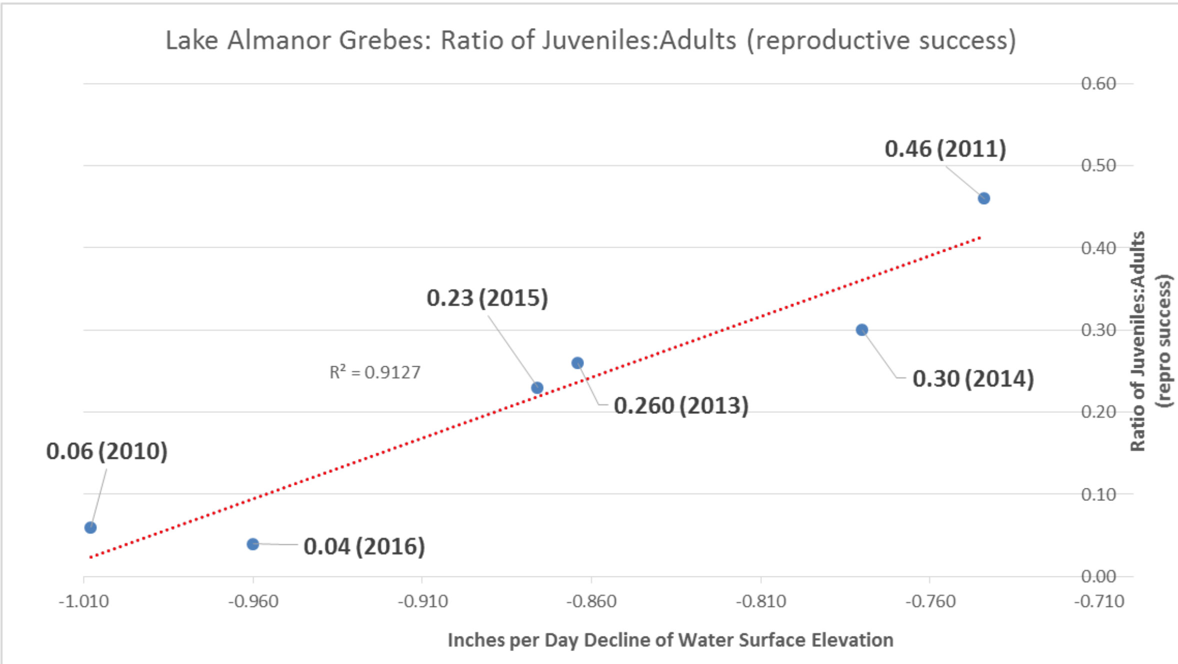


Figure 17. Rate of drop in water surface elevation (inches per day) related to reproductive success measured as the total number of young produced at Lake Almanor in 2010-2016.

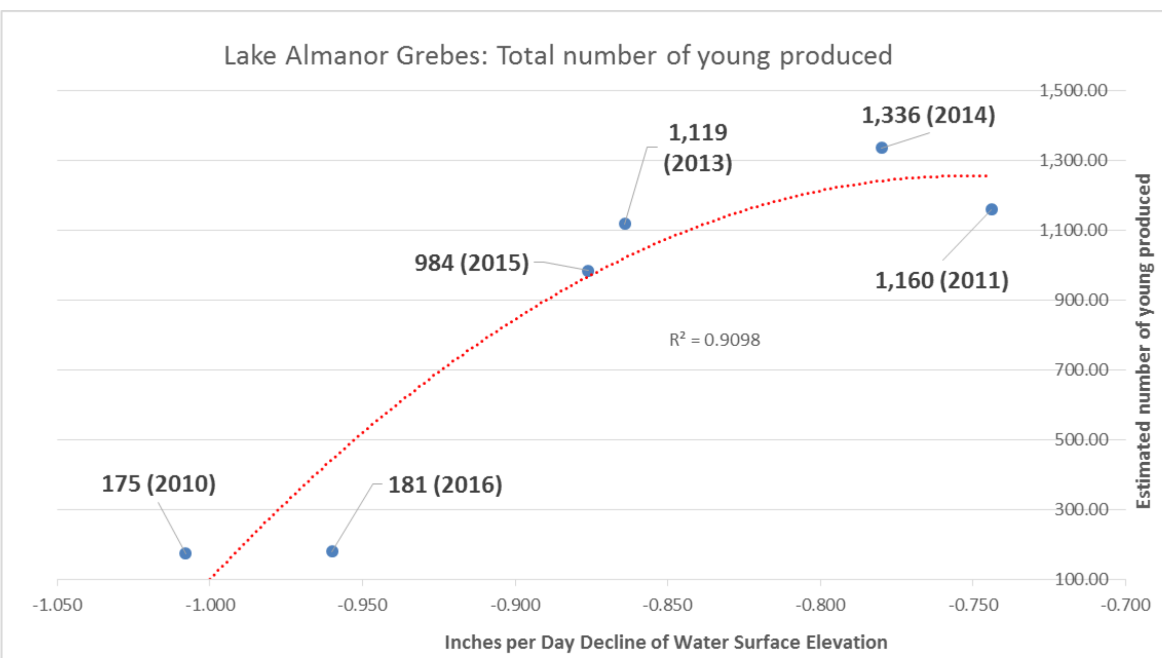


Figure 18. Rate of drop in water surface elevation (inches per day) related to reproductive success measured as the number of young per nest at Lake Almanor in 2010-2016.

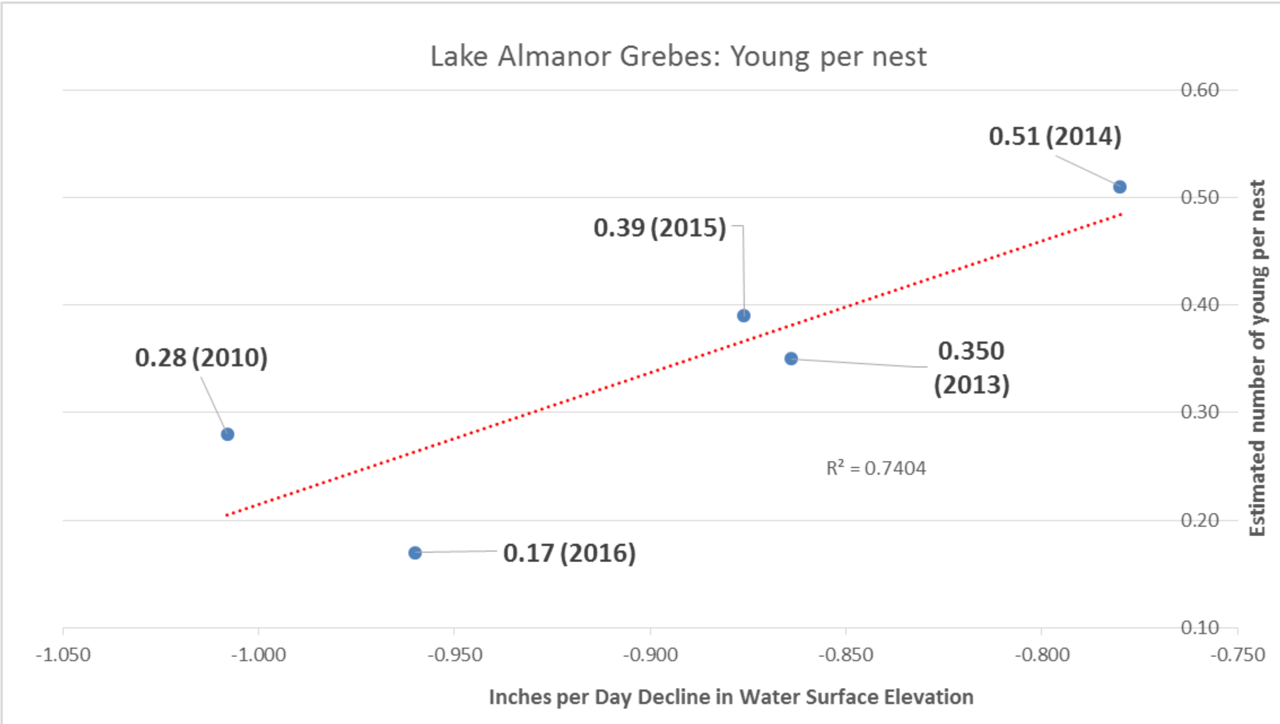
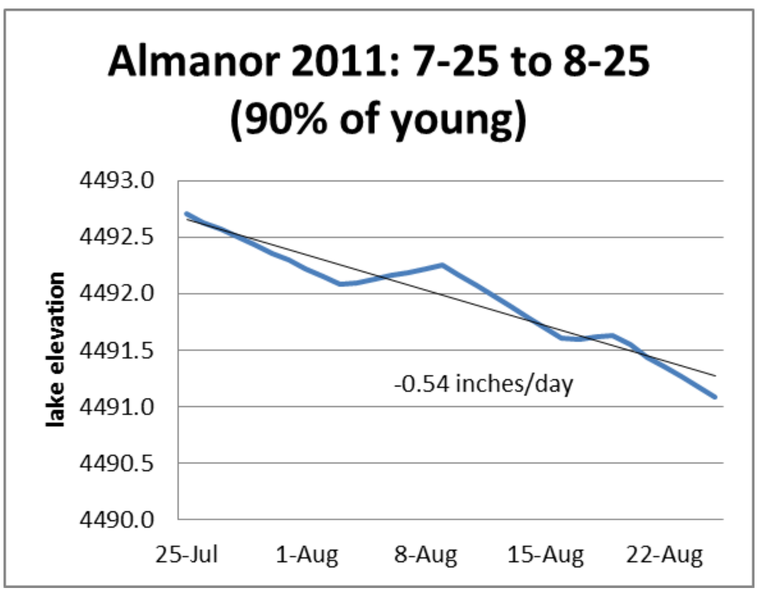


Figure 19. Rate of drop in water surface elevation (inches per day) during the nesting period for nests that produced 90% of the young on Almanor in 2011. The average rate of drop for the entire nesting period was -0.74 inches/day.



Discussion

It has been proposed that springing dives by the Clark's Grebe, where birds essentially leap from the water before submerging, may allow them to reach deeper below the surface, contributing to foraging niche separation between the two *Aechmophorus* species (Storer and Nuechterlein 1992). However, our data does not support this hypothesis. There does appear to be some foraging habitat separation between Clark's and Westerns Grebes, but it is not clear exactly what the mechanism of separation is. The distribution of foraging grebes on lakes varies throughout the season and is presumably tied to the distribution of fish prey.

We found that the timing of nesting is different between our study lakes. Some of the timing is tied to the availability of nesting habitat. For example, the pondweed used for nesting at Lake Almanor generally does not grow densely at the surface until at least late June and the plant's growth is related to water surface elevation. However, nesting habitat is generally available on all of the lakes for some time before grebes begin nesting. Therefore, other factors such as the life cycle of fish prey must influence the timing of nesting. Weather and elevation also do not seem to be an important factor influencing nest timing because the earliest breeding occurs on Lake Davis, which is located at the highest elevation (5,770 feet) and Lake Almanor is located at the lowest elevation (4,490 feet), whereas Eagle Lake warms earliest in the season and has the latest grebe nesting. Shaw (1998) discussed the possibility of competition between Eared Grebes and *Aechmophorus* grebes as a factor that may influence the timing of nesting at Eagle Lake.

Water surface elevation was related to the number of *Aechmophorus* grebe nests at Eagle Lake, consistent with Weems (2012) and Robison et al. (2016) findings at Eagle and Clear Lakes. There were the most nests during the highest water year, the second most nests during the second highest water year, and no nests during the lowest 5 water years. Grebes require inundated tules for nesting at Eagle Lake and all of the tule patches were out of the water in 2012 through 2016. The water surface elevation drops at the lowest rate on Eagle Lake compared to our other study lakes so water level drop has little effect on nesting grebes when suitable habitat is available because the water does not drop fast enough to strand active nests.

Water surface elevation and rate of drop were very similar between years for both Lake Davis and Antelope Lake, but the number of nests varied. However, in 2015 and 2016 there were dramatically more nests at Lake Davis and fewer nests at Antelope Lake in 2015. All of the nests at both lakes failed in 2015 and also in 2014 at Lake Davis. Reproductive success at Antelope Lake in 2014 and 2016 was the highest ever seen on any lake, while grebes at Lake Davis experienced total nesting failure in 2014 and 2015 due to the lower water levels and high winds in July. The water level drop at Lake Davis (-0.31 inches/day) and Antelope Lake (-0.66 inches/day) was at rates intermediate to those seen at Lake Almanor (-0.78) and Eagle Lake (-0.15) and within a range conducive to successful grebe nesting on these lakes.

On Lake Almanor, grebe reproductive success is strongly influenced by the rate of drop in water surface elevation during the grebe breeding season. Water surface elevation drops greater than 0.72 inches/day from June 25 through September 15 results in juvenile:adult ratios less than 0.5 (i.e. 1 young for every 2 adults), which contributes to further population declines. A pilot project June-August 2016 demonstrated that this it is extremely challenging for PG&E to slow the water drop rate during the grebe breeding season due to operational constraints and complexities. To make water management changes more feasible, we are recommending an interim goal of water drops of no more than -0.84 inches/day from July 1 through August 31. We also recommend other measures to help mitigate water management impacts on grebes including restricted boat activity in the north basin when young grebes are present as well as studying and improving the grebe's prey fish.

Boat travel corridors could be implemented in the north basin, from the north tip of the Lake Almanor West peninsula to the mouth of Bailey Creek, allowing boat traffic to the North Shore Campground, but restricting much of this area so that young grebes are not affected by motor boats. Motor boat disturbance influences mortality of young grebes and reducing boat traffic where large numbers of young grebes are found could help significantly improve their survivorship.

In addition, better understanding habitat needs of pond smelt and other grebe prey fish as well as stocking such prey could significantly improve grebe reproduction and survival. Identifying spawning habitat and protecting and improving those habitats may help maintain a stable prey fish population. *Aechmophorus* grebes are attracted in large numbers to Lake Almanor due to the fish prey population and also because large areas of suitable breeding habitat is available at all water levels we have observed (approx. 4,477 to 4,493 feet water surface elevations: June 25-Sept 15, 2010-2015). Because of these favorable conditions, Lake Almanor has produced at least some young grebes every year, but has the potential to be much more productive.

It is evident that a variety of factors affect nesting success of *Aechmophorus* grebes at our study lakes and that the interaction between these factors is complex. However, our results show that reducing the rate and making more consistent water level drops at Lake Almanor during the grebe breeding season would have a significant positive effect on grebe reproductive success. In addition, restricting boat activity in the north basin when young grebes are present and studying and improving the grebe's fish prey (largely pond smelt) would have a positive interactive effect contributing to population recovery for these species.

Literature Cited

Anderson, D.W., S.M. Gericke, S. Hampton, and P.R. Kelly. 2007. Western and Clark's Grebe Conservation and Management at Clear Lake, California. 2006 Annual Report. Prepared for National Fish and Wildlife Foundation and American Trader Trustee Council.

Bogiatto, R. J. 1998. Nesting ecology of ducks at Eagle Lake, Lassen County, California. California Fish and Game 84(2):61-73

Bogiatto, R. J., B. A. Sardella, and J. J. Essex. 2003. Food habits of Great Horned Owls in northeastern California with notes on seasonal diet shifts. Western North American Naturalist 63(2): 258-263.

Ellison, L. N., and L. Cleary. 1978. Effects of human disturbance on breeding of double-crested cormorants. Auk 95:510-517.

Elbert, R.A., D. W. Anderson. 1998. Mercury levels, production, and hematology in western grebes from three California lakes, USA. Environmental Toxicology and Chemistry 17:210-219.

Gould, G. I. Jr. 1974. Breeding success of piscivorous birds at Eagle Lake, California. M. S. thesis, Humboldt State University, Arcata, CA.

Gericke, S.M., D.W. Anderson, and P. Kelly. 2006. Western and Clark's grebe conservation and management at Clear Lake, California. Presented to the American Trader Trustee Council and the National Fish and Wildlife Foundation. 31 January, 31pp.

Grinnell, J., J. Dixon, and J. M. Linsdale. 1930. Vertebrate natural history of a section of northern California through the Lassen Peak region. University of California Publications in Zoology 35:156-157.

Hayes, F. 2013. Summary report for breeding *Aechmophorus* grebes at Clear Lake, Lake County, California, during 2010-2013. Report to Audubon California. October.

Henkel, L.A., H Nevins, M Martin, S Sugarman, J.T. Harvey, and M.H. Ziccardi. Chronic oiling of marine birds in California by natural pertroleum seeps, shipwrecks, and other sources. Marine Pollution Bulletin 79(1-2): 155-163.

Humple, D. L. 2009. Genetic Structure and Demographic Impacts of Oil Spills in Western and Clark's Grebes. MSc. Thesis, Sonoma State University. 101 pp.

Humple, D.L., H.M. Nevins, E.M. Phillips, C Gibble, L.A. Henkel, K Boylan, and D.J. Girman. 2011. Demographics of *Aechmophorus* grebes killed in three mortality events in California. Marine Ornithology 39:235-242.

Ivey, G. 2004. Conservation assessment and management plan for breeding western and Clark's grebes in California.

Kury, C. R., and M. Gochfeld. 1975. Human interference and gull predation in cormorant colonies. Biological Conservation 8:23-34.

Lederer, R. J. 1976. The breeding populations of piscivorous birds of Eagle Lake. American Birds 30:771-772.

Lindvall, M. 1975. The Breeding Biology of the Western Grebe on a Utah Marsh. M.S. Thesis. Utah State University.

Lindvall, M. and J. B. Low. 1982. Nesting ecology and production of Western Grebes at Bear River Migratory Bird Refuge, Utah. Condor 84:66-70.

Miller, H. W. and D. H. Johnson. 1978. Interpreting the results of nesting studies. Journal of Wildlife Management 42(3): 471-476.

Moyle, P.B. 2002. Inland Fishes of California. 2nd ed. University of California Press. Pp. 232-234.

Ratti, J. T. 1977. Reproductive separation and isolating mechanisms between sympatric dark-and light-phase Western Grebes. Dissertation, Utah State University, Logan, Utah.

Ratti, J. T. 1979. Reproductive separation and isolating mechanisms between sympatric dark-and light-phase Western Grebes. Auk 96: 573-586.

Robison, K.M. 2012. A Multi-year Analysis of Brood Size and Phenology in Western and Clark's Grebes (*Aechmophorus occidentalis* and *A. clarkii*) at Two Northern California Lakes. MSc. Thesis. University of California, Davis.

Robison, K.M., D.W. Anderson, and R.E. Robison. 2015. Brood size and nesting phenology in Western Grebe (*Aechmophorus occidentalis*) and Clark's Grebe (*Aechmophorus clarkia*) in northern California. Waterbirds 37(2).

Robison, R.E., D.W. Anderson, and K.M. Robison. 2016. Quantifying Change in Wetland Extent & Wetland Quality: Effects on a Western and Clark's Grebe Breeding Population, Eagle Lake, CA: 1998-2010. Presented at the Grebe Research Symposium, Chester, CA. August 19.

Robison, K.M., R.E. Weems, D.W. Anderson, and F. Gress. 2010. Western and Clark's Grebe Conservation and Management in California. 2009 Annual Report. Prepared for Kure/ Stuyvesant Trustee Councils and National Fish and Wildlife Foundation. Feb.

Robison, K.M., R.E. Weems, D.W. Anderson, L.A. Henkel, and A. Brickey. 2009. Western and Clark's Grebe Conservation and Management in California. 2008 Annual Report. Prepared for the American Trader and Kure/ Stuyvesant Trustee Councils and National Fish and Wildlife Foundation.

Robison, K.M., R.E. Weems, D.W. Anderson, and S. Hampton. 2008. Western and Clark's Grebe Conservation and Management in California. 2007 Annual Report. Prepared for American Trader Trustee Council and National Fish and Wildlife Foundation.

Safina, C., and Burger, J. 1983. Effects of human disturbance on reproductive success in the black skimmer. Condor 85:164-171.

Sardella, B. 2002. The effect of human disturbance on Aechmophorus grebe nest success at Eagle Lake, Lassen County California. MSc. thesis, Chico State University, Chico, CA.

Shaw, D. 1998. Changes in population size and colony location of breeding waterbirds at Eagle Lake, California between 1970 and 1997. M. S. thesis, Chico State University, Chico, CA.

Storer, R. W. and G. L. Nuechterlein. 1992. Western and Clark's Grebe. In The Birds of North America, No. 26 (A. Poole, P. Stettenheim, and F. Gills, eds.). Philadelphia: The Academy of Natural Sciences; Washington, DC: The American Ornithologists' Union

Wales, J. H. 1962. Introduction of pond smelt from Japan into California. California Fish and Game 48:141-142.

Weems, R.E. 2012. Lake elevation and reproductive success in Western and Clark's grebes at two northern California lakes. MSc. Thesis. University of California, Davis.

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Attachment A
Compilation of *Aechmophorus* grebe population and nest counts on Eagle Lake.

Year	Adult Population	Ratio juveniles:Adults	Number of Nests	Data Source
1928	-	-	0	Grinnell et al. 1930
1970	-	-	1,457	Gould 1974
1971	-	0.47	1,918	Gould 1974
1974	-	-	1,200	Lederer 1976
1994	-	0.47	-	Elbert and Anderson 1998
1996	-	0.62	2,487	Shaw 1998
1997	-	0.11	1,134	Shaw 1998
2002	15,400	-	-	Robison et al. 2008
2003	10,200	0.47	1,800	Ivey 2004
2006	-	~0.70	-	Robison et al. 2010
2007	3,400	0.03	Very few	Robison et al. 2008
2008	2,500	0.58	450	Robison et al. 2009
2009	4,500	0.38	700	Robison et al. 2010
2010	1,700	0.08	250	Arsenault 2014
2011	4,056	0.32	1,496	Arsenault 2014
2012	5,950	0	0	Arsenault 2014
2013	2,287	0	0	Arsenault 2014
2014	2,571	0	0	Arsenault 2015
2015	6,143	0	0	Arsenault 2016a
2016	3,484	0	0	Arsenault 2016b

Attachment B
Compilation of *Aechmophorus* grebe population and nest counts on Lake Almanor.

Year	Adult Population	Ratio Juveniles:Adults	Number of Nests	Source
1980	50+	-	Some	Dan Airola
1981	60+	0.00	None	Dan Airola
1982	-	-	380	Dan Airola
1983	1,000+	-	48+	Dan Airola
1984	-	-	567	Dan Airola
1986	-	-	445	Dan Airola
1996	0	-	None	Shaw 1998
1997	-	-	43	Shaw 1998
2002	-	-	850	Ivey 2004
2003	-	0.10	440	Ivey 2004
2006	-	-	7	Anderson et al. 2007
2007	1,000+	-	500	Robison et al. 2008
2008	1,350+	0.19	450+	Robison et al. 2009
2009	-	0.14	569	Robison et al. 2010
2010	2,900	0.06	636	Arsenault 2014
2011	2,446	0.46	580	Arsenault 2014
2012	3,830	0.19	1,041	Arsenault 2014
2013	5,209	0.26	3,163	Arsenault 2014
2014	5,137	0.30	2,598	Arsenault 2015
2015	4,948	0.23	2,537	Arsenault 2016a
2016	4,457	0.04	1,090	Arsenault 2016b

Attachment C
Compilation of *Aechmophorus* grebe nest counts on Lake Almanor 2010-16.

Lake Almanor Grebe Nest Counts 2010-16

Almanor 2010

Colony	5-Aug	8-Aug	31-Aug	6-Sep	15-Sep	Peak
Causeway- A	0	0	33	59	24	59
Causeway- B	0	0	7	9	3	9
Causeway- C	0	0	77	93	45	93
Causeway- D	0	0	88	105	44	105
Causeway- E	0	0	19	15	1	19
Meadows/Mouth-A	0	0	39	26	7	39
Meadows- B	0	0	7	7	0	7
Meadows- C	0	0	130	83	14	130
Meadows- D	150	175	0	0	0	175
Total	***150***	***175***	***400***	***397***	***138***	636

Almanor 2011

Colony	22-Jul	29-Jul	5-Aug	15-Aug	31-Aug	7-Sep	14-Sep	30-Sep	Peak
Meadows 1	80+	250+	230+	52+	0	0	480*	0	480
Meadows 2	0	0	0	84	100	93	90	12	100
Total	***80+***	***250+***	***230+***	***136+***	***100***	***93***	***90***	***12***	***580***

*old (abandoned) nest count- nests in this colony were difficult to count while active because they were in the dense willows so the abandoned nest count was used to estimate the peak number of nests.

Almanor 2012

Colony	16-Jun	27-Jun	16-Jul	25-Jul	30-Jul	1-Aug	7-Aug	13-Aug	15-Aug	19-Aug	22-Aug	28-Aug	31-Aug	4-Sep	Peak
Meadows	0	18	160	440	450	-	460	525	-	-	14	5	5	3	525
Causeway West	0	0	0	0	11	26	118	209	260	316	316	56	-	14	316
Meadow South	-	-	-	-	-	-	-	85	-	-	200	117	-	55	200
Total	***0***	***18***	***160***	***440***	***461***	***26***	***578***	***819***	***260***	***316***	***530***	***178***	***5***	***72***	***1,041***

Almanor 2013

Colony	10-Jul	19-Jul	24-Jul	29-Jul	1-Aug	5-Aug	6-Aug	13-Aug	22-Aug	26-Aug	2-Sep	6-Sep	11-Sep	18-Sep	Peak
Causeway	24	126	855	1,265	1,215	1,835	1,790	1,670	1,320	1,165	980	787	655	260	1835
Shoreline	-	-	43	0	-	-	-	-	-	-	-	-	-	-	43
Open Water	-	36	8	0	-	-	-	-	-	-	-	-	-	-	36
Goosebay North	1	550	870	362	335	265	258	25	0	-	-	-	-	-	870
Goosebay Mid	-	-	8	16	38	63	66	72	71	41	1	0	-	-	72
Goosebay South	-	-	93	104	106	188	190	247	307	290	174	105	43	4	307
Total	**25**	**712**	**1,877**	**1,747**	**1,694**	**2,351**	**2,304**	**2,014**	**1,698**	**1,496**	**1,155**	**892**	**698**	**264**	**3,163**

Almanor 2014

Colony	1-Jul	10-Jul	15-Jul	22-Jul	24-Jul	29-Jul	11-Aug	18-Aug	26-Aug	8-Sep	17-Sep	26-Sep	Peak
Causeway- Mouth of the River	30	505	131	24	-	200	503	260	225	40	-	0	505
Causeway- East of the Island	0	0	642	91	-	0	78	63	23	0	-	0	642
Chester Meadows	0	7	0	0	-	0	0	0	0	0	-	0	7
Goose Bay	0	0	0	0	180	706	1,444	1,025	465	160	-	0	1,444
Total	**30**	**512**	**773**	**115**	**180**	**906**	**2,025**	**1,348**	**713**	**200**	**0**	**0**	**2,598**

Almanor 2015

Colony	25-Jun	30-Jun	9-Jul	16-Jul	20-Jul	24-Jul	27-Jul	4-Aug	13-Aug	19-Aug	28-Aug	4-Sep	9-Sep	16-Sep	Peak
Causeway	0	18	11	180	-	375	509	907	1,272	1,542	1,049	499	246	0	1,542
Goose Bay	1	1	0	250	544	-	716	995	420	633	612	663	380	0	995
Total	**1**	**19**	**11**	**430**	**544**	**375**	**1,225**	**1,902**	**1,692**	**2,175**	**1,661**	**1,162**	**626**	**0**	**2,537**

Almanor 2016

Colony	27-Jun	30-Jun	7-Jul	11-Jul	14-Jul	18-Jul	21-Jul	28-Jul	1-Aug	8-Aug	15-Aug	18-Aug	24-Aug	1-Sep	9-Sep	Peak
Causeway	0	0	0	0	0	0	0	0	0	2	9	17	26	16	3	26
Chester meadows	11	30	145	224	379	386	449	490	701	4	0	792*	0	0	0	792
Lower Meadows	0	0	0	0	0	0	-	-	-	11	23	67	169	76	18	169
Meadows-Goose Bay	0	0	0	0	0	0	-	-	-	0	-	27	103	18	0	103
Total	**11**	**30**	**145**	**224**	**379**	**386**	**449**	**490**	**701**	**17**	**32**	**111**	**298**	**110**	**21**	**1,090**

*Count of nest mounds after colony abandonment to refine nest estimate