Audubon's *Aechmophorus* Grebe Conservation Project
Comprehensive Monitoring Report: 2010-2013
Almanor, Eagle, Davis, and Antelope Lakes
Plumas and Lassen Counties, California

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Prepared by

David Arsenault
Plumas Audubon Society
429 Main Street
Quincy, CA 95971

Summary

The Plumas Audubon Society has monitored breeding *Aechmophorus* grebes on Lake Almanor and Eagle Lake from 2010 through 2013 and on Lake Davis and Antelope Lake in 2012 and 2013. This report outlines our monitoring methods and provides a compilation of results from these surveys including disturbance survey results, nest counts, nesting chronology, nest colony maps, and population and brood survey results. The *Aechmophorus* grebe population size, the number of nests, and the reproductive success varied between years and lakes. Water surface elevation level and rate of drop, human disturbance, predation of eggs and adults, habitat availability, and the fish prey population influenced grebe population size, number of nests, and reproductive success.

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 2013. The project has been funded by the Luckenbach Trustee Council with oil spill mitigation funds (Ivey 2004). 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 ceremonies 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 four 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 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 (Appendix A). Nest initiation varies by lake and has ranged from the end of May through the end of June on our study lakes (Table 1). If nest initiation is missed, it can be 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 begins, discrete nesting areas are considered colonies, defined as a group of grebe nests at least 400 m from other grebe nests (Hayes 2013). Colony size is tracked using the Nest Monitoring Survey Form (Appendix A). Colonies are mapped from shore and from kayak as accurately as possible while keeping a >100 m buffer from active nests. Compass bearings to the right and left edge and other reference points in colonies are 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 if possible, increases colony mapping accuracy and also allows observers to get an accurate count of nests and adults. Sometimes colonies are mapped by kayaking around the perimeter of the colony. A solo kayaker maintaining a >10 m buffer and a steady speed, minimizes disturbance to the colony and provides an accurate colony boundary. This type of survey is only conducted for nest colonies in open water and not for colonies in dense vegetation such as willows or tules.

Nest counts are done from strategic observation points around colonies, including on-water points. Nest monitoring is 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 should have some evidence of recent maintenance. Counts should be conducted twice from each location; counting occupied/tended nests as active and empty nests appearing untended as abandoned. Averaging the counts of two separate observers helps 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 should be 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 is 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 are completed after nesting has finished, when surveyors can walk and/or boat through the abandoned nest colony and count old nests (Appendix A).

Disturbance Surveys

Once nesting has begun, disturbance surveys can be conducted, generally June-August (Appendix A). Disturbance surveys should be conducted weekly, but during different days of the week (weekdays, weekends, and holidays) and during different times of the day including crepuscular hours. Colonies should be observed for >1 hour to quantify types of disturbance to grebe colonies and grebe responses. These surveys should be 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 (Appendix A) are conducted by motor boat on larger lakes or by kayak on smaller lakes starting in August. Population surveys (counts) are conducted during brood surveys. Surveys conducted earlier in the breeding season may more accurately estimate the total adult grebe population because grebes begin migrating in August. On Lake Almanor, for example, the adult grebe population appears to peak in mid to late-September, presumably due to migrants (Table 5).

Brood surveys should be conducted after most nests have hatched young, but before the oldest young are full size. Good weather is important for accurate population counts and brood surveys because even slight wind can create choppy water that can significantly reduce grebe detectability and survey accuracy. Survey considerations include boat size and speed as well as observer ability. A faster boat can help complete a survey more quickly on larger lakes. Completing surveys more quickly helps reduce the likelihood of double-counting because grebes will not have moved as far in a shorter period of time. Population and brood counts require at least 2 surveyors, 1 data recorder, and 1 boat driver, but 4 observers, 2 recorders, and 1 boat driver is preferred.

Population counts involve one observer watching each side of the boat and tallying all of the *Aechmophorus* grebes observed while the boat completes a systematic route covering the entire lake. The route should be optimized to avoid double-counting or missing any grebes and observers should be aware of areas where grebes have or have not been counted already during the survey. Clark’s and Western Grebes should be distinguished when possible and otherwise counted as *Aechmophorus* grebes.

Brood surveys target groups of grebes to maximize the sample size along transects. Brood survey transects are 1,000 meters in length. One observer records grebes on one side of the boat as far as can be clearly distinguished by species (Clark’s or Western) and age (adult or juvenile), which is generally 100-250 m depending on visibility due to wind, waves, and the sun's direction. Grebe young are categorized by size as: ⅛, ¼, ⅓, ½, ⅔, ¾, ⅞ or full size compared to adults. Optimally, 10 transects per brood survey are conducted if enough large groups of grebes are encountered. The route around the lake should be tracked with GPS and the start and end points of transects marked as GPS waypoints. The ratio of young to adults is calculated per transect and averaged across transects to determine an average young:adult ratio for a lake. It is important to have data recorders so that observers do not have to look away from the grebes they are counting to record their observations.

On smaller bodies of water that can be thoroughly surveyed and all grebes accurately identified to species and age, transects are not necessary. These lakes should be systematically circumnavigated and all grebes counted by species and age.

Population counts should be conducted during brood surveys to obtain a census of the entire grebe population on the lake. Transect surveyors should count grebes in between transects. In addition, a second set of observers should count all grebes observed on their side of the boat. Thus, two estimates of the total grebe population can be obtained per survey to determine the accuracy of those estimates. The two estimates can be averaged to reduce survey error due to over- or under-counting. Double-counting grebes can be avoided by travelling a systematic route tracked by GPS and noting locations where grebes have already been counted.

Other Monitoring Methods

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/cgi-progs/mapper). 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 second year of nest monitoring with wildlife cameras in 2013, we have determined that it is the most effective way to monitor nest success, disturbance, and predation for individual nests. In 2014, we plan to increase the sample size of nests monitored with wildlife cameras. Wildlife cameras are attached to natural surfaces, such as stumps, where possible. Otherwise, cameras are attached to t-posts with bird perching deterrents (spikes) affixed to the top. 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 (Appendix C). 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 apparently influenced the low grebe population observed in 2010 (Table 4).

Disturbance Surveys

On Lake Almanor, disturbance surveys were conducted at both the Chester Meadows and Causeway grebe colonies, totaling approximately 28 hours of observations in 2012 (Figure 1) and 35 hours in 2013 (Figure 2). 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 Owl was photographed on an active grebe nest at Goose Bay in 2013, and a Northern Harrier was

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

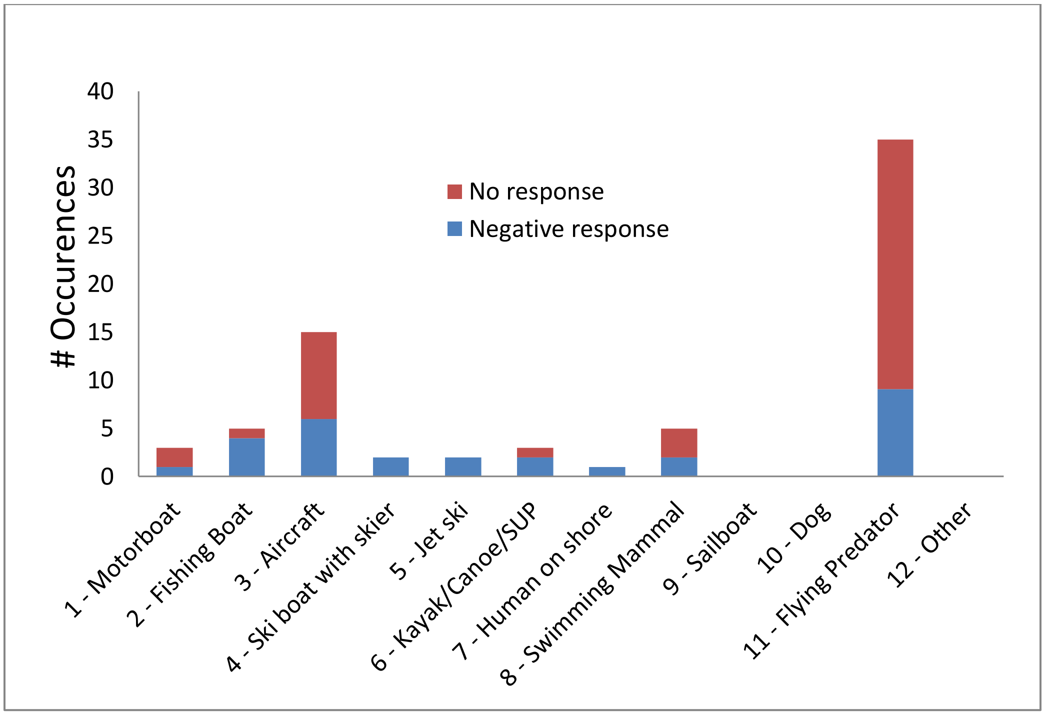
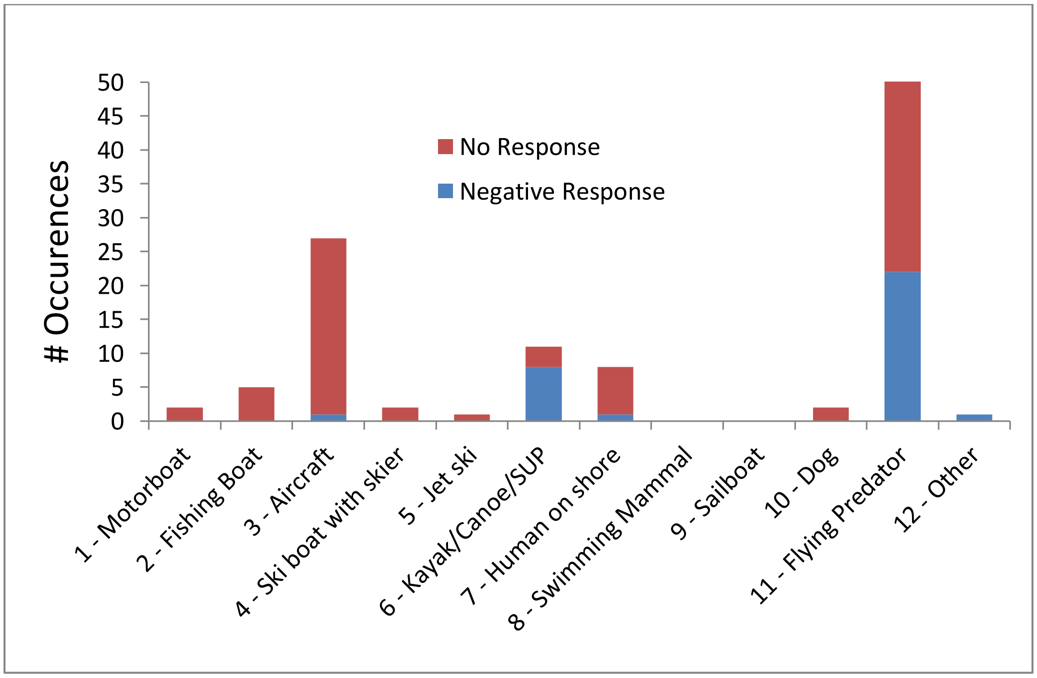


Figure 2. Disturbance survey results at Lake Almanor in 2013.



documented in the Causeway colony feeding on a dead grebe on a nest in 2013. Robison (2012) and Bogiatti 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 1-2) 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.

<u>Nest Monitoring</u>

Wildlife Cameras

Wildlife cameras were used to record activity at grebe nests at Lake Almanor in 2012 and 2013 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.

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 or beginning of June on Lake Davis, by mid-June on Antelope Lake, around the beginning 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 (Tables 3 and 4). In 2013, Lake Almanor had the most nests observed on any of our study lake 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).

Lake Almanor- The suitable *Aechmophorus* grebe nesting habitat on Lake Almanor varies with the lakes' water surface elevation (Figure 2). 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 and early 2012, Figure 3). 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, Figure 3). At water surface elevations of around 4,489 and 4,490, the grebe nesting habitat consists of a narrow band along the edge of the willows. 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).

Eagle Lake- *Aechmophorus* grebes nested in tules in three areas in 2010 and 2011 including Stones Ranch, Troxel Bay, and Spaulding (Figure 4). 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 in 2012 and 2013 (Figure 8). There was no *Aechmophorus* grebe nesting habitat (inundated tules) available in 2012 and 2013 due to the low water levels and no *Aechmophorus* grebes successfully nested on the lake during both 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 2010-2013.

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
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
Antelope	2012	15-Jun	1-Sep	14-Aug
Antelope	2013	17-Jun	12-Sep	1-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 2010-2013.

Colony/Lake	Peak Nests			
	2010	**2011**	**2012**	**2013**
Causeway	285	0	316	1,835
Chester Meadows	351	580	725	79
Goose Bay	0	0	0	1,249
Almanor Total	**636**	**580**	**1,041**	**3,163**
Stones Ranch	200	1,100	0	0
Spaulding	50	396	0	0
Eagle Total	**250**	**1,496**	**0**	**0**
Davis Total	**-**	**-**	**30**	**35**
Antelope Total	-	-	20	20

Table 4. Summary of nests, adults, and juvenile *Aechmophorus* grebes on Almanor, Eagle, Davis and Antelope Lakes 2010-2013.

Lake	Year	# nests	Ave adult census	Ratio Adults: nests	Peak ratio juv:adult	Est. # young	Ave Brood Size	Rate of water level drop**	Ave % Clark's
Almanor	2010	636	2,900	4.56	0.06	175	1.1	-0.08	5
Almanor	2011	580	2,446	4.22	0.46	1,160	1.5	-0.06	7
Almanor	2012	1,041	4,108	3.95	0.19	757	1.5	-0.03	6
Almanor	2013	3,163	5,209	1.65	0.26	1,119	1.4	-0.07	6
Eagle	2010	250	1,700	6.80	0.08	138	1.7	-0.01	4
Eagle	2011	1,496	4,056	2.71	0.30	1,200	1.0	-0.02	15
Eagle	2012	0	5,950	0.00	0.00	0	0.0	-0.01	11
Eagle	2013	0	2,287	0.00	0.00	0	0.0	-0.02	4
Antelope	2012	20	82	4.10	0.60	49	2.4	-0.06	0
Antelope	2013	20	62	3.10	0.37	22	2.3	-0.05	0
Davis	2012	30	138	4.60	0.55	63	1.8	-0.03	0
Davis	2013	35	158	4.51	0.35	53	1.3	-0.03	3

*The ratio of young:adults is a measure of reproductive success.
**Rate of water surface elevation drop during the nesting periods shown in Table 1. The higher the rate, the faster the drop.

Table 5. Results of population surveys conducted at Lake Almanor 2010-2013.

Lake Almanor Population Surveys		
Year	**Date**	**Adults**
2010	22-Sep	3,000
	12-Oct	2,900
2011	7-Sep	2,360
	30-Sep	2,446
2012	1-Aug	3,275
	30-Aug	3,851
	20-Sep	4,108
2013	16-Aug	5,181
	30-Aug	5,431
	12-Sep	5,604
	2-Oct	5,209

Lake Davis- *Aechmophorus* grebe nesting habitat on Lake Davis occurs in the inundated willows at the north (shallow) end of the lake (Figure 5). 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, grebe nests were scattered in patches along the lake's shoreline (Figure 5), rather than in more discrete colonies. The peak number of nests was consistent between years with 30 and 35 nests in 2012 and 2013, respectively (Table 3).

Antelope Lake- Although Antelope Lake has miles of shoreline with emergent vegetation and multiple coves which appear to meet habitat requirements for nesting grebes, only one area located near the Lost Creek Cove boat ramp supported an active grebe colony in both 2012 and 2013 (Figure 6). 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 colony. 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 (Table 3).

Figure 3. Lake Almanor grebe colonies 2010-2013

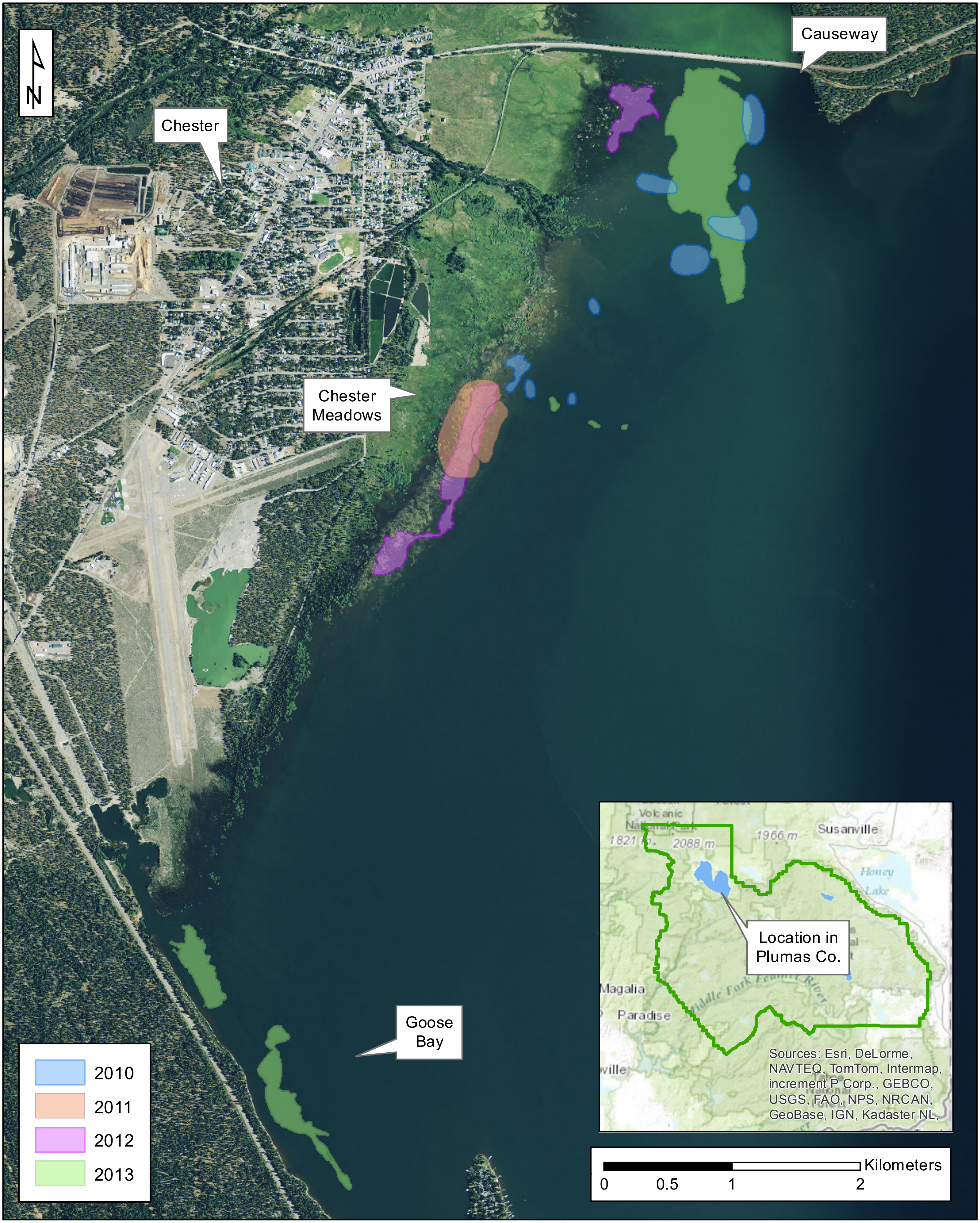


Figure 4. Eagle Lake grebe colonies 2010-11.

Figure 5. Lake Davis grebe nests 2012-13

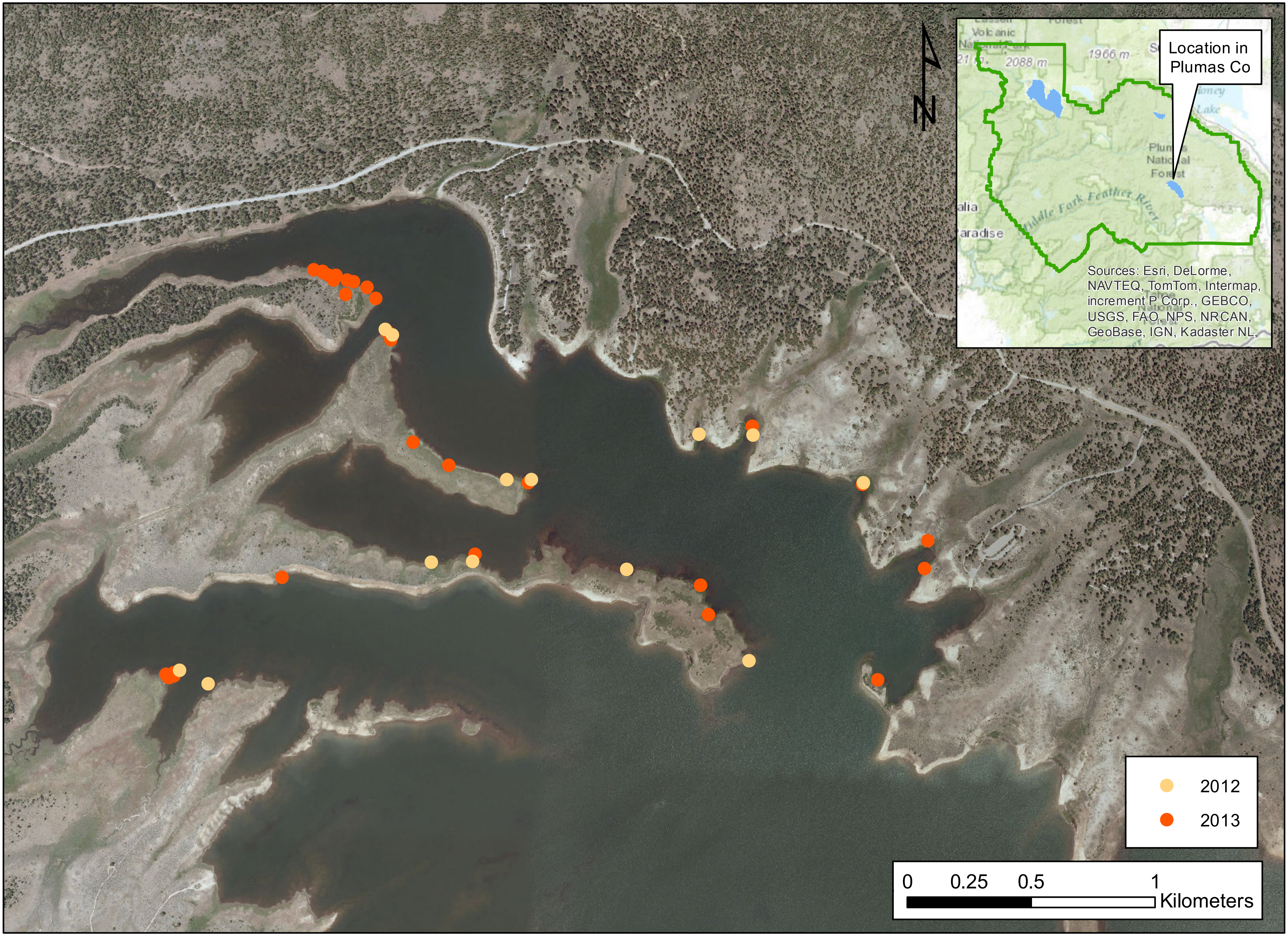


Figure 6. Antelope Lake grebe colonies 2012-13

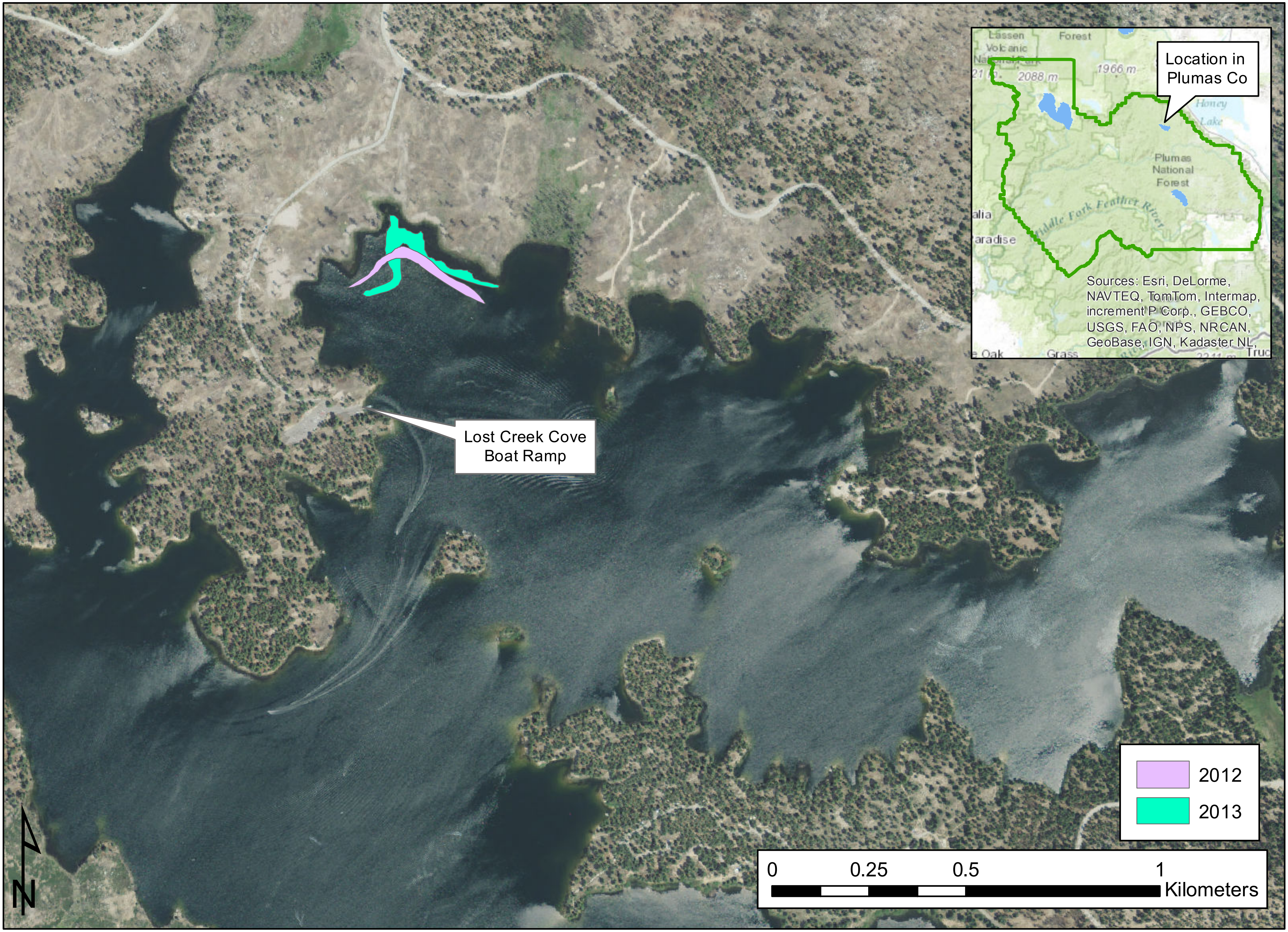


Figure 7. Water surface elevation at Lake Almanor May 29 through September 30, 2010-2013.

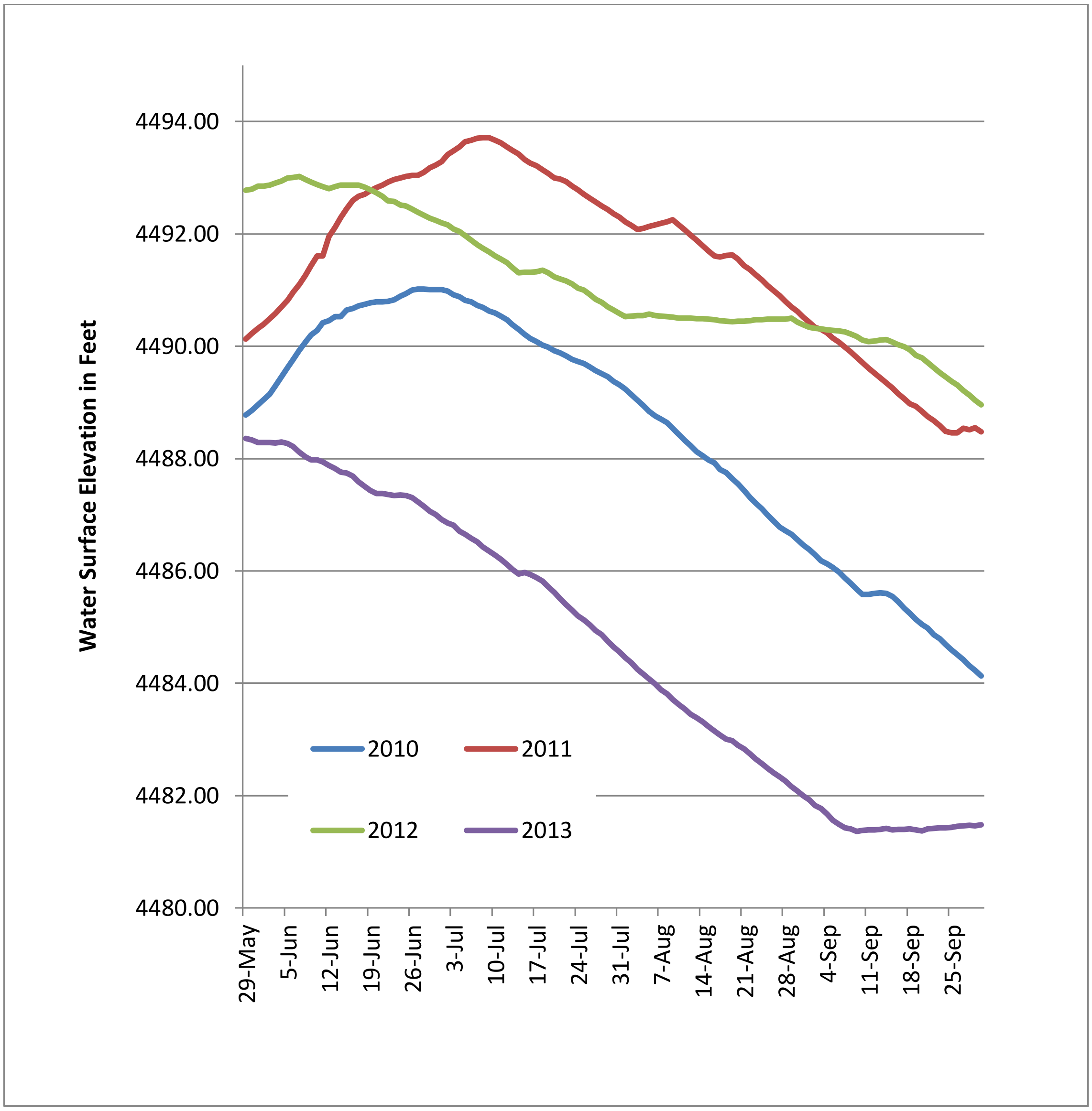


Figure 8. Water surface elevation at Eagle Lake May 29 through September 30, 2010-2013.

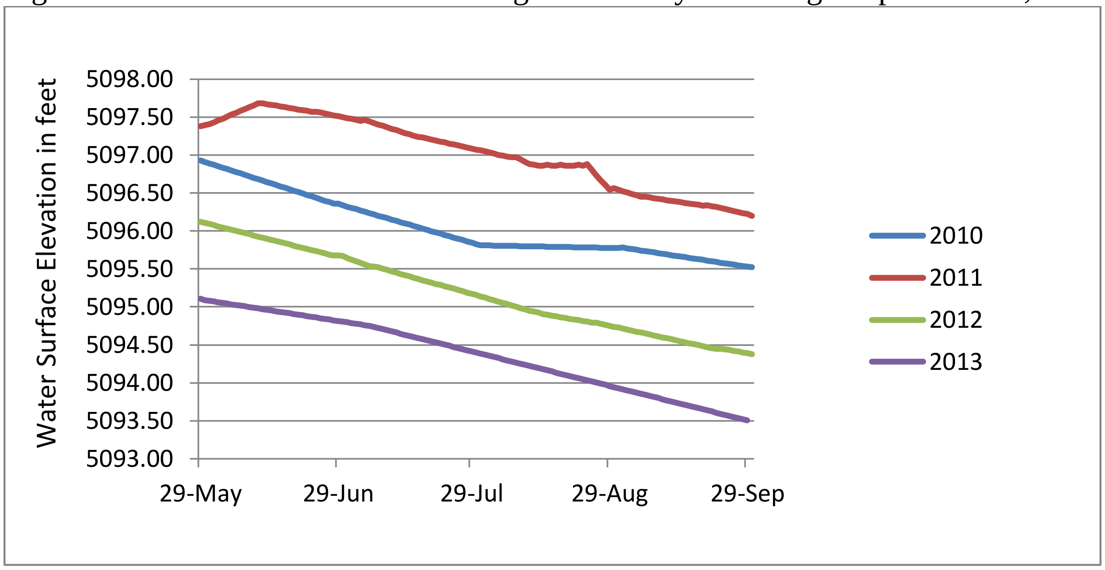


Figure 9. Water surface elevation at Lake Davis May 29 through August 11, 2012-2013.

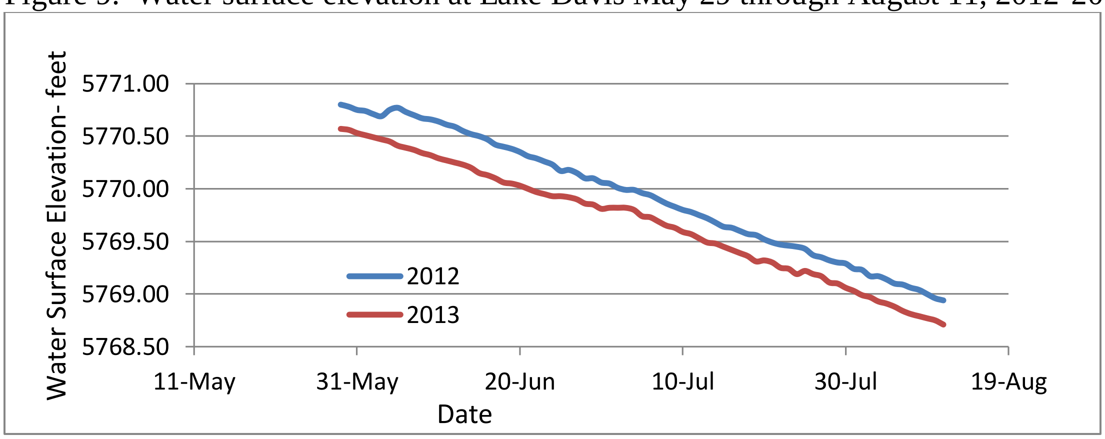
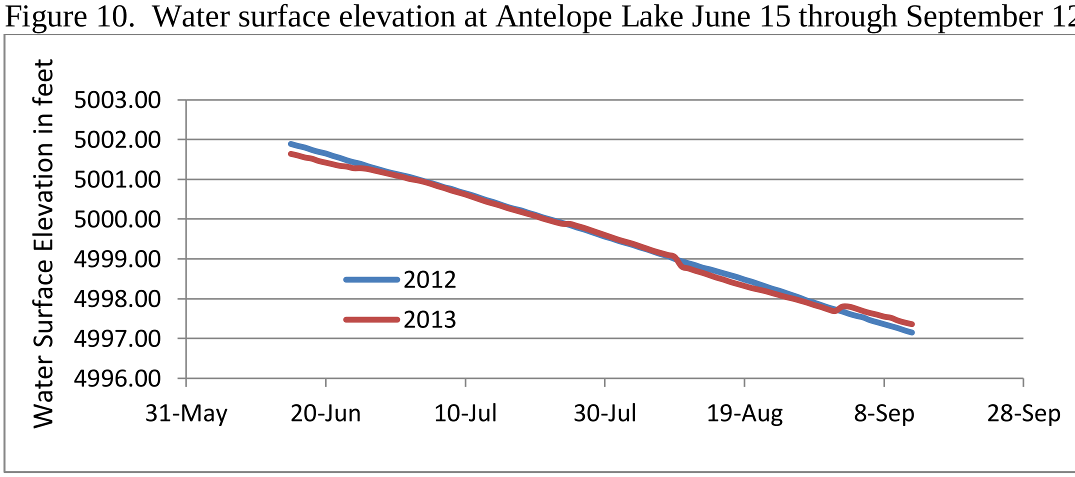


Figure 10. Water surface elevation at Antelope Lake June 15 through September 12, 2012-2013.



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 young:adults (Robison 2012).

Water Surface Elevation

The change in water surface elevation both within and between years was greatest at Lake Almanor (Table 4, Figure 7). Eagle Lake, a natural, terminal lake in the Great Basin, dropped at the slowest rate of all the lakes (Table 4, Figure 8). Water surface elevation dropped more steadily at Davis and Antelope Lakes (Table 4, Figures 9 and 10), the latter much more rapidly.

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) 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 2 water years. Grebes require inundated tules for nesting at Eagle Lake and all of the tule patches were out of the water in 2012 and 2013. 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.

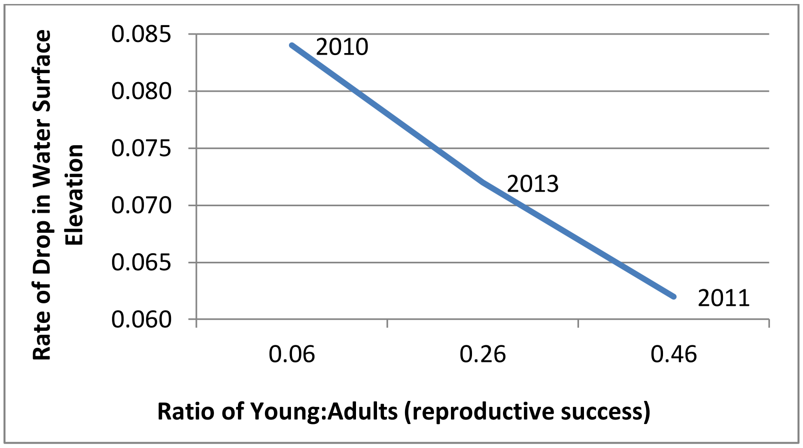
Water surface elevation and rate of drop were very similar between years for both Lake Davis and Antelope Lake as were the number of nests. The reproductive success was lower at both lakes in 2013 compared to the year before and it is unknown what most influenced this pattern. The water level drop at Lake Davis (-0.025) and Antelope Lake (-0.055) was at rates intermediate to those seen at Lake Almanor and within a range conducive to successful grebe nesting on these lakes.

Reproductive success of *Aechmophorus* grebes at Lake Almanor was related to the rate of drop in water surface elevation (Figure 11). In 2010, the water surface elevation dropped more rapidly than in any other year and grebes had the lowest reproductive success. In 2013, the water surface elevation dropped at the second fastest rate and grebes had an intermediate level of reproductive success. Grebe pairs with failed nests due to stranding or predation were able to re-nest because there was a large amount of suitable habitat available through the 2013 breeding season. In 2010-12, the average ratio of adults to nests was 4.25 (1 nest for every 4.25 adults in the population) indicating that only half of the adult grebe population nests each year. In 2013, the ratio of adults to nests was just 1.65 (1 nest for every 1.65 adults in the population), indicating that each breeding pair re-nested 2.5 times on average.

Of the years 2010, 2011, and 2013, the water surface elevation dropped at the lowest rate in 2011 contributing to the greatest reproductive success that we have observed at Lake Almanor. In 2012, however, the water surface elevation dropped at the lowest rate (-0.028) of all years observed at Lake Almanor, but the grebe's reproductive success (0.19) was at an intermediate level and does not match the trend seen during the other years (Figure 11). One influential factor was the Chips Fire, a 75,000-acre forest fire on the Plumas National Forest, that burned up to the south and west sides of Lake Almanor from July 29 through August 31, 2012. The fire created extreme smoke conditions during the peak of grebe nesting on the lake. Our disturbance surveys showed that human disturbance to grebes was reduced during the fire because people were not fishing and recreating at the lake due to the heavy smoke and road closures. However, the heavy smoke may have negatively affected reproductive success due to increased predation, reduced foraging success, and/or other effects. The Chips Fire affected power transmission lines and downstream power generation, so the water surface elevation was maintained until the issues could be resolved.

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 water surface elevation drops slower than a rate of -0.06 (0.72 inches/day, 1 foot every 16.7 days) from July 1 through September 30 greatly improves grebe reproductive success at lake Almanor.

Figure 11. Rate of drop in water surface elevation related to reproductive success at Lake Almanor in 2010, 2011, and 2013.



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Attachment A
Data Sheets:

- Grebe Nest Monitoring Survey Form
- Grebe Post-nesting/Abandoned Nest Survey Form
- Grebe Disturbance Survey Form
- Grebe Brood Survey Form

Grebe Nest Monitoring Form- 2014

Date	Observor(s)	Lake	Colony	UTM NAD83	Survey Type[1]	# Active Nests[2]	Total nest mounds[3]	Adult West	Adult Clark's	Adult *Aech*	# Young	# Broods	Comments

[1]Boat, shoreline, etc.

[2]Includes nests that are being actively constructed, have intact eggs, or an adult is incubating.

[3]Includes nests that cannot be verified as active and are possibly under construction or abandoned.

Grebe Post-Nesting/Abandoned Nest Survey Form 2014

Date: Observer(s): Water Body: Colony:

Reference #	Location		Water Depth (cm)	Distance to Nearest Nest	Condition of Nest	Nest Success	Evidence of Predation	Comments
	UTME	UTMN						

Grebe Disturbance Survey Form 2014

Body of Water:		Date:		Observer(s):	
Colony:		Time Period:		Location (UTM):	
Describe Weather:					
Time	Type of Disturbance *	Grebe Response **	Intensity (1-10 scale)	% of colony responding	Duration

* Types of Disturbance:

1= Motorboat	2= Fishing Boat	3= Aircraft	4= Ski boat with skier
5= Jet Ski	6= Kayak/Canoe	7= Human (type)	8= Swimming mammal
9= Sailboat	10= Dog	11= Flying Predator	12= Other

** Response to Disturbance:

1= No Response	2= Distress call through colony
3= Colony restless but stationary	4= Birds leave nest but remain in colony area
5= Birds leave colony	6= Nest predation due to adults vacancy

Grebe Brood Survey Form 2014

Date: Water Body: Complete census?:

Observers: Recorder:

Weather (describe): Page: of Pages

Grebe[1] Species	# Adults[2]	# Young	Size class of young[3]	Transect number	GPS pt ID	Start time	End time

[1]Species: W= Western, C= Clark's, X= Unknown.

[2]indicate # of adults without young; if with young mark 1 and then the number of young in next column.

[3]Young classified by size compared to adult: 1/8,1/4, 1/3, 1/2, 2/3, 3/4, 7/8,full (juvenal plumage).

	Adult	Juv	**Juveniles**	F	7/8	3/4	2/3	1/2	1/3	1/4	1/8
Western			Western								
Clark's			Clark's								
Unknown			Unknown								
Total											

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

Year	Adult Population	Ratio Young: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

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

Year	Adult Population	Ratio Young: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	4,108	0.19	1,041	Arsenault 2014
2013	5,209	0.26	3,163	Arsenault 2014