Survival of Female Mallards Molting on Klamath Basin National Wildlife Refuges: Project Update 2007

Administrative Report

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U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY
WESTERN ECOLOGICAL RESEARCH CENTER

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INTRODUCTION

The Klamath Basin in southern Oregon and northeastern California is one of the most important waterfowl areas in North America. In addition to providing important migration and breeding habitat, mallards (*Anas platyrhynchos*) and other ducks breeding throughout California and Oregon move into Klamath Basin marshes during late summer to undergo wing molt (Yarris et al. 1994). During this 30 to 40-day flightless period, when old wing feathers are replaced by new ones, birds may be especially vulnerable to changing conditions of molting marshes and the surrounding landscape.

To determine impacts on molting mallards of changing water management practices in the Klamath Basin and better understand factors that impact population dynamics of mallards in the Pacific Flyway, we used radiotelemetry to study survival of female mallards molting in the Klamath Basin during 2001, 2002, and 2006.

STUDY AREA

Most waterfowl molting habitat in the Klamath Basin is on Lower Klamath, Tule Lake, and Upper Klamath National Wildlife Refuges (NWRs, Fig. 1). The size and hydrology of molting marshes on the three NWRs differ. Molting habitat on Lower Klamath NWR is comprised of seasonal, semi-permanent, and permanent marsh units <100 ha to several hundred hectares in size. We studied mallard survival in emergent Units 8B (290 ha) and 12C (370 ha) which were the main molting areas on Lower Klamath NWR and among the few units that remained flooded in summer and fall during the drought year of 2001 (Fig. 2). On Tule Lake NWR, the main molting habitat was Sump 1-A which was comprised of an 870-ha emergent marsh on the northern end of 3,760 ha of open water. Upper Klamath molting habitat included the 5,800-ha emergent marsh unit of Upper Klamath NWR and other emergent cover and open water areas associated with Upper Klamath and Agency Lakes.

Water levels of these molting marshes varied among refuges and years. During 2001, severe drought and concerns of potential impacts of reduced Upper Klamath Lake levels on endangered sucker fish that reside there greatly reduced summer water releases from Upper Klamath Lake into the Klamath Basin. This resulted in nearly all wetlands except Units 8B and 12C on Lower Klamath NWR going dry (Fig. 2). Sump 1-A on Tule Lake NWR supports endangered suckers and water levels there were better maintained. In 2002 and 2006, more normal precipitation and water releases from Upper Klamath Lake resulted in fewer wetlands on Lower Klamath NWR going dry in late summer. However, the increased water releases from Upper Klamath Lake did reduce the lake level and dry some emergent cover in the Upper Klamath NWR molting marsh in 2002. Water levels in Sump 1-A on Tule Lake NWR were similar all 3 years.

METHODS

Capture and Marking- We used night-lighting and swim-in traps to capture adult female mallards on the main molting marshes at: 1) Lower Klamath NWR (Units 8B and 12C) during 8-30 August 2001, 18 July-15 August 2002, and 15 July -22 August 2006, 2) Tule Lake NWR (Sump-1A) during 8-30 August 2001 and 18 July-15 August 2002, and 3) Tulana Farms near the east border of the north unit of Upper Klamath NWR during 8-15 August 2002. Captured birds were sexed and females aged (Carney 1964, Carney 1992, Dimmick and Pelton 1994). Adult females were weighed ($\pm$ 2.5g), measured (culmen [$\pm$0.05mm], tarsus [$\pm$0.05mm], 9th and 10th primary [$\pm$0.5mm]), and banded. We classified captured females with old wings as premolt, with new wings as post-molt and as early-molt, mid-molt, or late-molt based on primary feather condition and length.

We attached 26-g (<3% of the body weight) backpack harness radiotags (Dwyer 1972) to 187 female mallards during the study including 60 in 2001 (n = 20 Lower Klamath-8B, 20 Lower Klamath-12C, 20 Tule Lake), 79 in 2002 (n = 19 Lower Klamath-8B, 20 Lower Klamath-12C, 20 Tule Lake, 20 Upper Klamath), and 48 in 2006 (n = 26 in Lower Klamath-8B, 22 in Lower Klamath-12C). Half of the females that we radiotagged were in the early-molt stage, 23% were mid-molt, and 27% were pre-molt. We removed a few primaries from most pre-molt birds to ensure they molted in the unit where we captured them. Females captured in swim-in traps (most at night) were processed (most the next morning) at the capture site and released. Night-lighted females were held uncrowded, in plastic 32" x 24" x 11" cages, provided with water and shade, processed the next morning, and released <18 hours after capture at the capture site. Radio transmitter frequencies were allocated in the frequency band approved for wildlife studies conducted by the Department of Interior. Transmitters provided ≥200 day life, ≥3.2 km reception range from the ground (truck or handheld), ≥24 km range from aircraft and (all but a few) included a mortality sensor (pulse rate doubles when no movement for 6 hours). Transmitters had a contact address and phone number embossed on the bottom.

Radiotracking- We used hand-held and truck-mounted yagi antennae to monitor status (alive, dead) and location (marsh unit) of each radio-tagged bird in the KB twice daily. Scans from strategic high points (e.g., Sheepy Ridge between Lower Klamath and Tule Lake NWRs) were used to help monitor radiotagged waterfowl. Road networks were sufficient to determine the marsh unit of each bird. Hand-held yagi systems were also used to walk-in on and ascertain the status of birds thought to be dead (mortality signal, lack of movement).

We monitored the mallards throughout the molting period, at least weekly in 2001 and 2002 and at least 3 times daily (early morning, afternoon, and late evening) in 2006. We walked in on or boated to mallards when a mortality signal or lack of signal fluctuation indicated possible death. We recovered carcasses as quickly as possible and sent them to the National Wildlife Health Center for necropsy and testing. Information fliers requesting that hunters report radiotagged birds were sent to hunting clubs and posted at hunter check stations. In 2006, we also pinpointed the location of each mallard in the Klamath Basin at least 4 times a week (2 evening and 2 morning locations) from 20 July – 18 October 2006. We obtained three bearings from known locations using a truck mounted null-peak telemetry system and calculated the UTM position using the triangulation data and LOAS software. Morning and evening locations were obtained within a 24 hour period to better calculate daily movement distances.

To determine migration timing, survival, and settling patterns of mallards moving into the Central Valley, we used aircraft equipped with removable strut-mounted antennae (Gilmer et al. 1981) to search for bird missing from Klamath Basin at least monthly during September – January. During 2001-02 and 2002-03 we searched both northeastern California and the Central Valley by aircraft. During 2006, we searched northeastern California by aircraft but only conducted ground searches in the Central Valley.

RESULTS

Molting mallard survival was much lower at Lower Klamath than at Tule Lake or Upper Klamath NWRs. Survival in Lower Klamath NWR Unit 12B was lower than in 8B, especially in 2006 when a large and sustained avian botulism die-off occurred. We have not yet completed survival modeling to calculate survival rates (Preliminary survival curves for 2001 and 2002 are shown in Fig 3). We will use the program MARK (White and Burnham 1999) and AIC (Akaike 1985, Burnham and Anderson 1992) to model survival covariates and estimate survival during 3 intervals: 1) molt (i.e., flightless), 2) postmolt-prehunt, and 3) hunt. Previous modeling indicates that our sample will be adequate to estimate survival with enough precision to allow meaningful modeling of the effects of year, interval, location, capture date, capture unit, capture method, and molt-stage at capture. We will also model effect of body condition (Johnson et al. 1985, Ringleman and Szymczak 1985) at capture because survival may be related to bird condition (Hepp et al. 1986, Reinecke and Shaiffer 1988, Conroy et al. 1989, Dufour et al. 1993). We also will investigate whether available banding data (D. Mauser, unpublished data) are adequate to compare survival of pre- vs. post-molt female mallards that were banded but not radiotagged to investigate possible impacts of radiotags on survival.

In place of maximum likelihood estimates from modeling, we report the apparent survival (e.g., percentage that survived) during 3 periods of time. We provide a percentage range when birds were missing from Klamath Basin and not found elsewhere to reflect the possibility that these birds either survived (high end of the range) or died (low end of the range) and their radiotags were destroyed or sank to the marsh bottom and were not detected.

Percent Surviving Flightless Period- The percentage that survived the flightless period (from date of tagging to estimated 125mm feather length) was much greater in Tule Lake (2001:95-100%, 2002:85%) or Upper Klamath (2002:90%) than in Lower Klamath Unit 8B (2001:50-55% 2002:65%, 2006:62-65%) or Lower Klamath Unit 12C (2001:65-70%, 2002:45%, 2006:14%).

Percent Surviving Entire Prehunt Period- The percentage that survived not only the flightless period but all the way to the start of the Klamath Basin California hunting season (i.e. to 6-12 Oct,) was also much greater for mallards radiotagged in Tule Lake (2001:95-100%, 2002:80%) or Upper Klamath (2002:80%) than in Lower Klamath Unit 8B (2001:45-60%, 2002:47-53%, 2006:58-62%) or Lower Klamath Unit 12C (2001:55-65%, 2002:35%, 2006:14%).

Percent Surviving to Winter-The percentage known to have survived long enough to either leave Klamath Basin alive (n = 67 located in Central Valley) or winter in Klamath Basin (n = 1 from 12C, 3 from 8B) was also much greater for mallards radiotagged in Tule Lake (2001:85-90%, 2002: 60-65%) or Upper Klamath (2002: 60%) than in Lower Klamath Unit 8B (2001:28-39%, 2002: 28-37%, 2006: 35-54%) or Lower Klamath Unit 12C (2001:26-42%, 2002:20-25%, 2006:9%).

Causes of Mortality-Female mallards died from a variety of factors during the molting period. In 2001 and 2002, with only one person monitoring birds on 2-3 refuges, monitoring frequency was only a few times a week and the time between when the bird died and when we detected its death and attempted to recover its remains was <1-7 days. Thus, almost all radiotagged birds that died during molt in 2001 and 2002 showed evidence of predation/scavenging. Remains were adequate for necropsies to conclusively rule out disease or contaminates for only 4 birds in 2001 and 3 in 2002; 14 others in 2001 and 13 in 2002 were suspected to have been killed by predators based upon field evidence but other factors such as disease or impacts of capture and radiotagging could not be ruled out. Elevated levels of lead were detected in blood of 3 dead birds from Lower Klamath, 1 showed signs of Avian Tuberculosis, and 1 tested positive for *Erysipelothrix* bacteria. One bird from Tule Lake NWR had ingested maggots and showed signs of Avian Botulism but the remains of the 5 Lower Klamath birds suspected to have died of botulism (based upon presence of other carcasses or ongoing botulism outbreaks) were inadequate for necropsy. A greater percentage of female mallards that survived molt at Lower Klamath NWR were later shot by hunters (13/33 = 39%) than those that survived molt at Tule Lake NWR or Upper Klamath (11/49 = 22%).

In 2006, with greatly increased monitoring frequency focused on Lower Klamath NWR, the time between when a bird died and when we detected the death and recovered the carcass was hours rather than days. In a few cases, we even encountered radiotagged and other ducks that were incapacitated (tests revealed from botulism) but still alive. Of the 19 radiotagged mallards that died in unit 12C, carcasses from 12 were adequate for testing with the other 7 too chewed up for testing. Of the 12 tested, 11 tested positive for botulism toxin; 1 also had elevated lead levels. Based on the on-going botulism die-off in the unit (confirmed by testing of carcasses of non-radiotagged ducks), the presence of other carcasses nearby each of our dead radiotagged ducks, and other field signs, we conclude that botulism was also probably the primary or contributing factor in the death of the other 7 that died in unit 12C but were too eaten up for testing. Of the 9 radiotagged mallards that died in unit 8B, carcasses from 2 were adequate for testing and the other 7 were too chewed up for testing. Both of the carcasses tested negative for botulism toxin but both had elevated lead levels. Based upon the lack of a known disease die-off in the unit, the fact that each bird had been consumed even though we quickly detected and recovered the remains, we conclude that the other 7 that died in unit 8B were probably killed by predators (although scavenging can not be ruled out because the lack of carcasses for analysis prevented testing for lead or disease). In 2006, 2 of the 15-16 from 8B and 1 of the 3 from 12C that survived prehunt were shot in Klamath Basin.

Timing of Emigration to the Central Valley-Most mallards left Klamath Basin during October and November each year but timing of emigration ranged from 22 August to 15 January.

We will use categorical modeling (Sauer and Williams 1989) and ***AIC*** (Akaike 1985, Burnham and Anderson 1992) to investigate the relationship of study year, capture location, capture body mass and other factors to weekly distribution or timing of migration. We will use a nearest neighbor analysis (Rosing et al. 1998) to test for independence of movements by birds captured together.

DISCUSSION

Survival of female mallards molting in the Klamath Basin was lower at Lower Klamath than at Tule Lake and Upper Klamath. Higher disease losses at Lower Klamath NWR that we observed and historic differences between units in frequency of avian botulism suggests that some ecological factor is causing more frequent occurrences of botulism in these units than in molting marshes associated with larger or more permanent bodies of water. We located our radiotagged birds and encountered groups of molting waterfowl on levees and roads at night where they were likely very vulnerable to predators. We speculate that this behavior is more common in smaller molting marshes such as those at Lower Klamath and that vulnerability of mallards to predation increases as the landscape dries and concentrates molting mallards and their predators in the few remaining wetlands. Although the lead may have been ingested elsewhere before birds began molting, the elevated blood levels in 3 birds recovered from Lower Klamath and 2 from Tule Lake suggests residual lead shot may still pose a hazard to mallards in the region.

MANAGEMENT IMPLICATIONS

Because breeding mallards throughout California and Oregon molt in Klamath Basin marshes, the low survival rates we observed for adult female mallards molting in Lower Klamath NWR has implications for waterfowl populations throughout the Pacific Flyway. The high rate of molting female mallard mortality from avian botulism that we measured in 2006 reinforces the need for research to better understand factors related to botulism outbreaks. Providing secure loafing islands or other over-water loafing cover such as dense emergent vegetation could reduce depredation losses and increase survival during years that disease losses were not severe. In addition, providing abundant molting habitat would avoid concentrating molting mallards and their predators and likely increase survival. Potential negative impacts on molting mallard survival that could result if water supplies for Klamath Basin wetland habitats were reduced should be considered when developing water management plans for the region.

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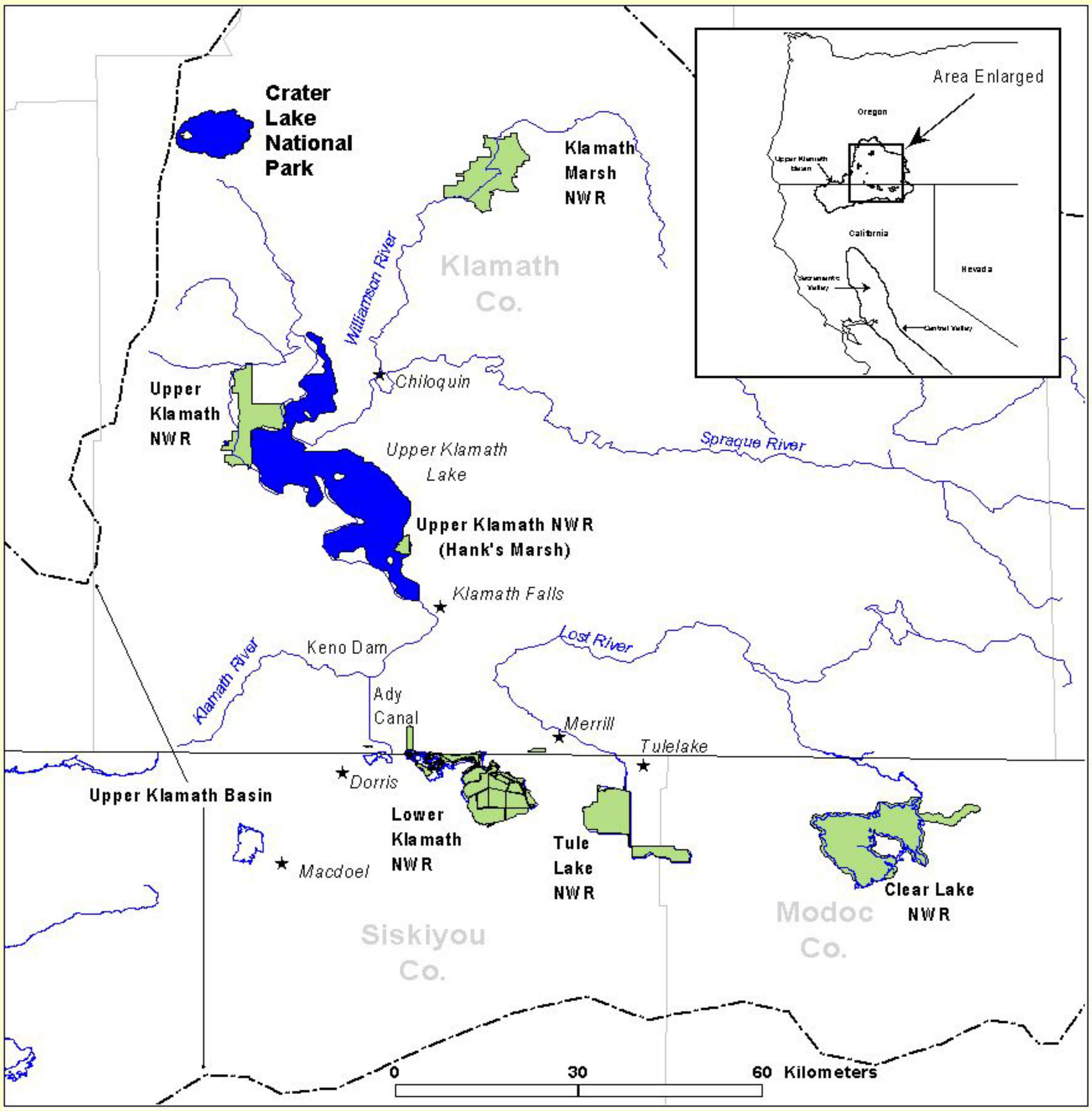
FIGURE LEGENDS

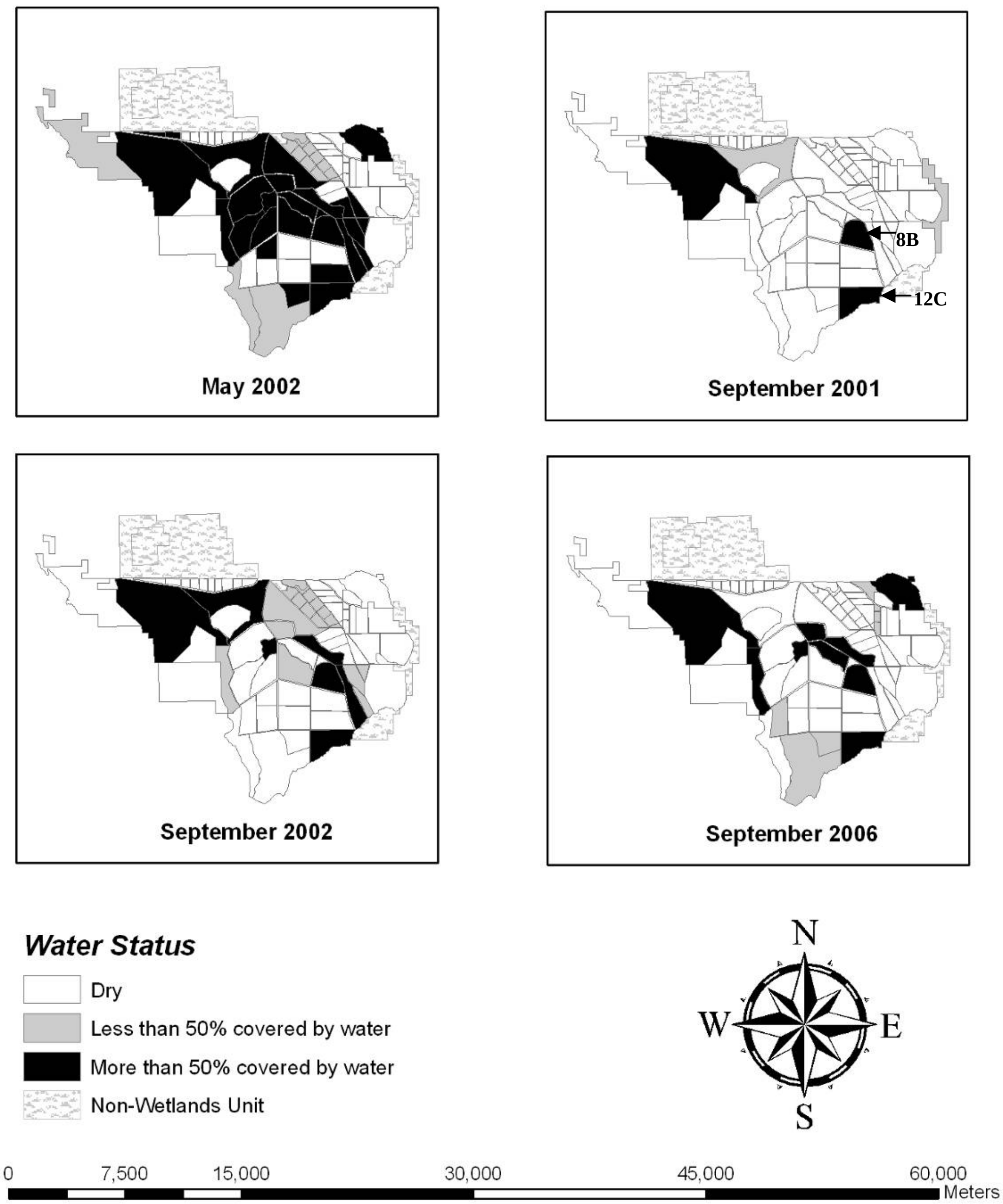
Figure 1. Klamath Basin region study area.

Figure 2. Water status of Lower Klamath National Wildlife units during spring (May 2002 as an example) and during September 2001, 2002, and 2006.

Figure 3. July-November survival (based on preliminary analysis) during 2001 and 2002 of female mallards radiotagged before or in the early or mid stage of wing molt at Lower Klamath, Tule Lake, or Upper Klamath National Wildlife Refuges.


Crater
Lake
National
Park
Klamath
Marsh
NWR
Area Enlarged
Oregon
California
Nevada
Williamson River
Klamath
Co.
Chiloquin
Upper
Klamath
NWR
Upper Klamath
Lake
Sprague River
Upper Klamath NWR
(Hank's Marsh)
Klamath Falls
Lost River
Keno Dam
Klamath River
Ady
Canal
Merrill
Tulelake
Dorris
Upper Klamath Basin
Lower
Klamath
NWR
Tule
Lake
NWR
Macdoel
Clear Lake
NWR
Modoc
Co.
Siskiyou
Co.
0
30
60 Kilometers

Water Availability for Lower Klamath NWR in 2001, 2002, and 2006



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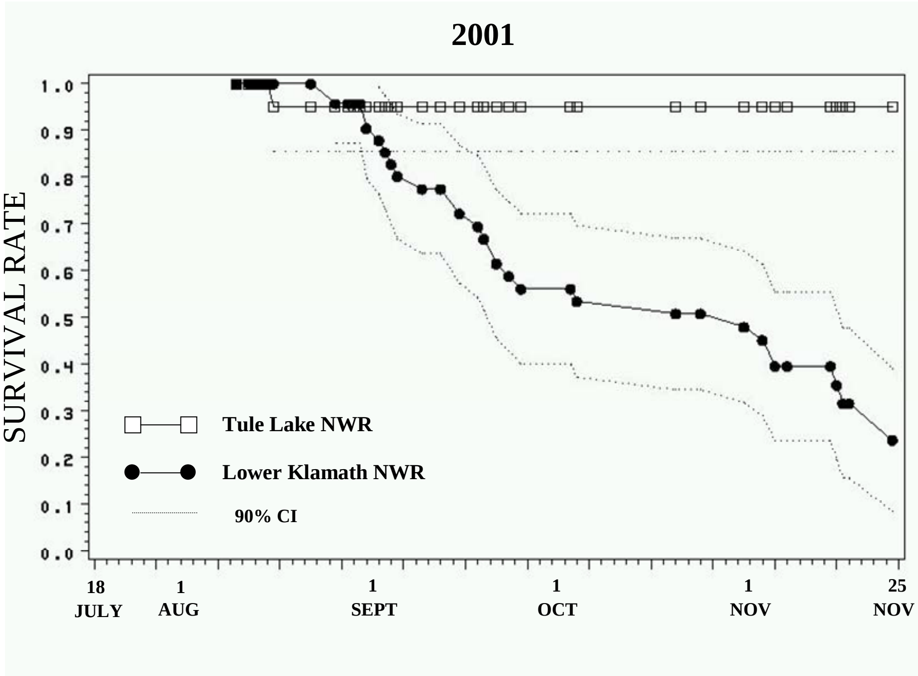
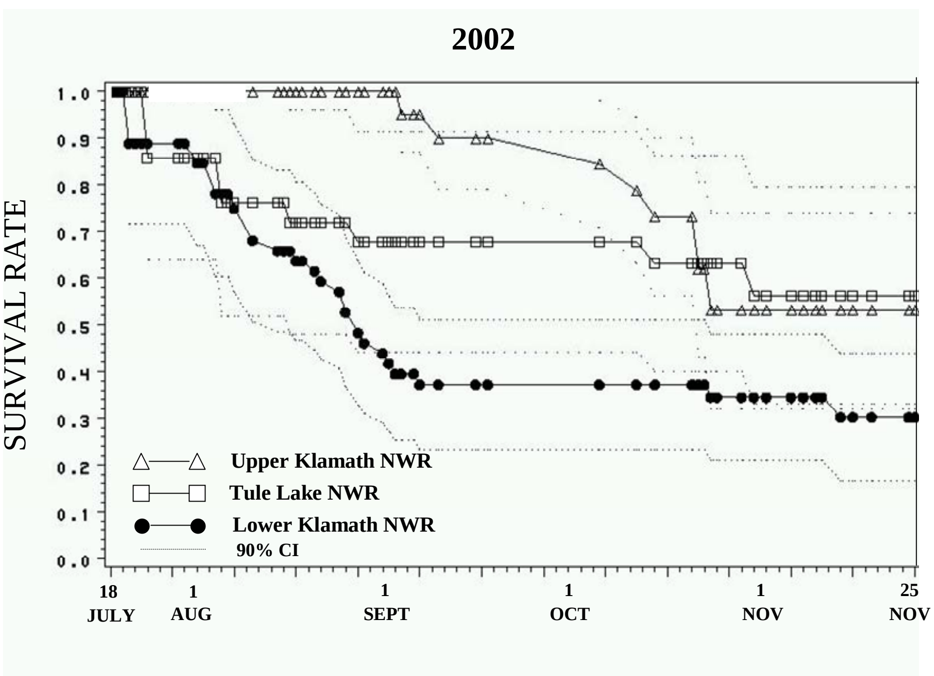

2001
SURVIVAL RATE
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Tule Lake NWR
Lower Klamath NWR
90% CI
18 JULY
1 AUG
1 SEPT
1 OCT
1 NOV
25 NOV


2002
SURVIVAL RATE
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Upper Klamath NWR
Tule Lake NWR
Lower Klamath NWR
90% CI
18 JULY
1 AUG
1 SEPT
1 OCT
1 NOV
25 NOV