MIGRANT COMMON LOONS AT WALKER LAKE, NEVADA: CHARACTERIZATION OF RANGE, SOURCE(S) AND EFFECTS OF MERCURY CONTAMINATION AND LOSS OF FISHERY

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Background and Methods

Each spring and fall as many as 1,400 common loons *(Gavia immer) have* staged during migration at Walker Lake, Nevada to rest and feed. Severe decreases in water levels and quality have raised concerns about the viability of the Walker Lake fishery and the consequences of its possible demise to the western loon population and populations of other wetland bird species that rely on the lake. The loss of the lake's fishery would eliminate the loons' resource base. The loons at Walker Lake may represent a significant percentage, if not the total sum, of a specific population of interior breeding loons. Therefore, the loss of Walker Lake's fishery could have a significant adverse effect on a regional or continental breeding population of loons.

The Walker River Basin covers more than 4,000 square miles in California and Nevada. Its origins are the Sierra Nevada Mountains in California's Mono County. Walker Lake is the terminal lake of the Walker River system, and is one of only two (with Pyramid Lake, NV) remaining major remnants of ancient Lake Lahontan. Due primarily to upstream water right diversions, evaporation, and periods of drought, the lake experienced a yearly average water budget deficit of 33,000 acre-feet during the years 1939-1993. In 1996 Walker Lake retained only 50% of its 1882 surface area and 28% of its 1882 volume. This resulted in high concentrations of total dissolved solids (TDS) consisting mostly of salt, along with low dissolved oxygen, relatively high temperatures, the presence of hydrogen sulfide, and large blooms of planktonic blue-green algae.

In April 1998 Boise State University, the University of Maryland-Baltimore County, U.S. Fish and Wildlife Service (FWS), the Nevada Department of Wildlife (NDOW), U.S. Geological Survey-Biological Resources Division (USGS-BRD), Great Basin Bird Observatory, BioDiversity Research Institute (BRI),

Earthspan, and the office of U.S. Senator Harry Reid launched a cooperative study to determine these loons' nesting and wintering locales by subcutaneously implanting satellite-received Platform Transmitter Terminals (PTTs).

Depending on weather conditions, we conducted fieldwork during nights near the new moon period of fall and spring migration. Loons were spotlighted from boats and captured by dip net. Subject loons were transported to a nearby facility onshore where measurement, blood and feather sampling, banding (USGS butt-end and alpha-numeric color plastic) and (in some cases) anesthesia and PTT implant surgery commenced immediately. Loons were released back into the lake as soon as they had been processed or had recovered from anesthesia. Blood and feather samples taken were for routine contaminant testing as part of a larger North American study on geographic trends of mercury (Hg). Satellite telemetry locations were distributed via computer every four days. Separate data files were maintained for each loon. Location data were analyzed to determine breeding areas and migratory pathways for the loons.

Results

We implanted PTTs in three spring 1998 and three spring 2000 migrants (figs. 1, 2), and successfully tracked four individuals to presumed breeding locales. All four subjects breed within a circle having a radius of just 75 miles in west central Saskatchewan. In addition, an adult we banded at Walker Lake in October of 2000 was recovered dead in June of 2001, apparently at its breeding locale. That took place in Saskatchewan as well, and widened the above referenced circle (now encompassing five Walker Lake migrants) to a radius of only 90 miles. Accordingly, evidence suggests that migratory loons staging at Walker Lake are a discrete geographic segment of the western North American population. PTT batteries did not last as long as expected and we were unable to track the loons until wintering areas could be determined. Five of six PTTs implanted in fall 2004 failed prematurely and we were unable to track subjects to wintering areas. The sixth individual wintered at Walker Lake and PTT batteries were expended in May 2005 as the loon was in Montana and on a course for Saskatchewan.

Analyses of 1998 blood samples surprisingly disclosed near lethal levels of blood Hg (range 6.49-8.65 ppm) in three of the six subjects and elevated levels (2.13 and 3.22 ppm) in two others. Levels exceeding 3.0 ppm place individuals in high risk categories, as designated by Evers et al. for loons and other piscivores in the Great Lakes and Northeast Regions of the United States and Canada. Loons exhibit strong philopatry to breeding and wintering areas and to migration routes, and are thus repeatedly exposed to the same sources of contamination.

We initially suspected these results to be reflective only of contaminants acquired on wintering grounds and brought along to Walker Lake. Subsequent investigation and literature review revealed elevated Hg levels in biota previously sampled at Walker Lake (table 1). In response to our concerns, NDOW sampled six Lahontan tui chub (*Gila bicolor obesus*) and six Lahontan cutthroat trout (*Salmo clarki henshawi*) from the lake in April 1999. Chub averaged 0.59 ppm Hg (table 1) and trout 0.68 ppm (M. Sevon, pers. comm.). Barr found reproductive impairment in common loons feeding on fish with 0.30 ppm Hg and no reproduction in those feeding on fish with 0.40 ppm. All levels herein cited are by wet weight unless otherwise specified. In addition, a 1996 Walker Lake chub sample was tested for methylmercury (MeHg, a more toxic organic form). That sample contained 2.4 ppm, dry weight of MeHg, or nearly five times the dietary effect level (about 0.5 ppm) in birds.

While analyses of the few samples of biota cited above proved nothing conclusive, the elevated Hg levels found in the chub and common loons indicated there is a threat to the survival, well being, and reproduction of fish and wildlife using Walker Lake. It became critical that we study the causes and degree of Hg contamination in the Walker River/Lake ecosystem, and the potential sources of contamination the staging loons might encounter elsewhere. We mounted a volunteer effort in April 1999 that resulted in our collecting samples from 20 more staging loons at Walker Lake. We recruited collaborators with the U.S. Fish and Wildlife Service and U.S. Geological Survey–Water Resources Division (USGS-WRD) and submitted cooperative proposals that were partially funded by FWS in FYs 2000 - 2002.

Our USGS-WRD partners extensively sampled sediments and water at stream sites, reservoirs, and the lake itself. Results showed generally low Hg concentrations in the upper basin, generally higher concentrations in the middle basin, and yet higher concentrations in the lower basin and lake. Their interpretation, bolstered by sediment core results, is that natural background Hg concentrations in sediments entering the lake (table 2) were ~30-40 ng/g (nanograms per gram-equivalent to parts per billion) prior to mining in the basin. During the late 1800s and early 1900s mining activities, especially in the Aurora and Bodie Districts, considerably increased the input of Hg to streams in the basin. Much of this Hg was transported into Walker Lake, resulting in concentrations >1,000 ng/g in sediments. Current Hg concentrations in sediments entering Walker Lake are between 100 and 400 ng/g.

The FWS found that aquatic invertebrates showed elevated Hg levels at some stream sites downstream of historic mining operations; no elevated levels were detected at similar sites where upstream mining was not documented. Wiemeyer (FWS) also sampled additional tui chub from Walker Lake and compiled his results and those available from previous efforts (table 1). Chub >20 cm in length showed a quantum increase in Hg level over those <20 cm in length, to levels that are demonstrated to affect loons adversely. We interpret this as an artifact of chub >20 cm beginning to feed on smaller individuals and thereby concentrating Hg more rapidly.

During additional capture efforts in spring and fall of 2000 and 2001, and in fall of 2004 we collected more loon blood and feather samples. In spring of 2001 our attempts to collect loon prey for analyses via gastric lavage were unsuccessful. During the two nights of field work high winds kept us off the lake until almost midnight. Since the loons we captured after that time had last fed before dark and metabolize rapidly, no stomach contents were still available to us.

We analyzed a total of 98 blood samples collected in 1998 - 2001 (table 3) from common loons at Walker Lake (61 spring, 37 fall). Mean total blood Hg was 3.0 ppm (range 0.15 - 9.46 ppm). Based on these results, blood Hg levels of Walker Lake migrant loons exceeded those documented anywhere else in the United States. Our mean level actually matched the 3.0 ppm high risk threshold, and 45% of our individuals met that criterion. Based on Wiemeyer's results, Hg levels in tui chub at Walker Lake generally increase with fish size. If loons are acquiring significant amounts of Hg from these chub, it would follow that larger loons (capable of consuming larger fish) would display higher Hg blood levels. In fact, that is the exact pattern our results showed. The blood Hg of smaller female loons (2,665-4,000g, n=46) was 2.11 ppm, and only 22% of individuals met the 3.0 ppm high risk level. Individuals of unknown sex (4,075-4,400g, n=28) had a mean blood Hg level of 3.72 ppm, and 61% were "high risk". Mean blood Hg of males (4,450-4,850g, n=24) was 3.84 ppm, and 71% met the high risk threshold.

Repeated migratory visits to Walker Lake could also result in cumulative increases in blood Hg for individual loons if, as we suspect, migrants are acquiring significant amounts during their stay. We captured a single individual during the springs of 2000 and 2001, and again during the fall of 2001. Over the course of roughly 18 months, this individual's blood Hg went from 1.74 to 4.72 to 8.15 ppm (table 4). During the fall of 2001 we also attempted to capture and sample migratory loons at Topaz Lake, far upriver in the basin but only 40 air miles to the west of Walker Lake. Topaz is connected to the river via canal. Because of the lakes' proximity we thought it useful to compare blood results among migrants. If Topaz migrants display similar blood Hg levels to those at Walker, the major source of acquisition is probably outside the Walker Basin. Although Topaz is much smaller than Walker and hosts far fewer loons during migration, we were able to sample two individuals. Although this comprises a wholly inadequate sample size, it must be noted that those two individuals had very low (mean = 0.66 ppm) blood Hg levels (table 3).

At issue also are the possible public health ramifications of consuming Lahontan cutthroat trout that are eating large numbers of Walker Lake chub. While the .68 ppm mean Hg level in the six trout analyzed by NDOW in 1999 is below the Food and Drug Administration's immediate action level of 1.0 ppm, it exceeds the recommended Environmental Protection Agency level. Accordingly, state health officials have considered the issuance of a human consumption advisory on Walker Lake fish (Associated Press 2001).

Results from the six blood samples collected at Walker Lake in fall 2004 were received in mid - September 2005, and blood Hg levels were lower than those from 1998-2001 (mean 2.26 ppm, range 1.87 - 2.46 ppm). This probably does not mean that the situation is improving. The lowest Walker Lake water level in recorded history occurred in May 2005, which should be concentrating Hg even more. Loon counts have been down from the high of 1,400 to the 200-300 range. Chub have had no recruitment to the population since marginal numbers in 2002. There are severely diminishing food resources and it is likely loons are no longer spending weeks at the lake during migration. They may arrive, forage for a few days, and then move on when their efforts are unrewarding. Thus, it is also likely the Hg uptake among those we captured was minimal since they were probably recent arrivals.

Conclusions and Recommendations

Inquiries to date suggest migratory loons staging at Walker Lake are a discrete geographic segment of the western North American population, and that mercury levels in fish at Walker Lake likely contribute to Hg contamination among these loons. It is also possible that the loons are exposed on their nesting or winter areas or on the migration route to Walker Lake. Considering the continued freefall of the ecology at Walker Lake and resulting decline in food resources available to migrating loons, the need to complete remaining inquiries from our original proposal becomes even more compelling. If the loons are reacting to a diminished and more contaminated food resource by leaving more quickly and foregoing their traditional staging during migration at Walker Lake, how is that affecting their prospects for successful completion of that migration? The staging phenomenon at Walker Lake suggests that, historically, adequate habitat and food resources were available at Walker to this migratory cohort that were not necessarily available to the immediate north or south.

Completion of the study would allow us to obtain additional samples (from loons, fish, water, sediments, etc.) at other identified locales to fully characterize the degree to which contamination within the Walker River Basin is responsible for high blood mercury levels among migrant loons and assess prospects for successful migration if Walker Lake is no longer a viable resource for them.

We propose to determine the yearly movement pattern and distribution of the migratory loons that use Walker Lake, and to determine the primary source of Hg contamination in this cohort. We will relate these findings to the threats posed by contamination of the loons and the potential loss of the Walker Lake fisheries. Specifically, we would:

- Capture and analyze blood samples from up to 30 more Walker Lake migrant common loons during an additional fall and spring effort, and radio mark 12 (6 fall, 6 spring) with satellite-received telemetry. We would either use units from Microwave Telemetry (as in 2000) or units from North Star (if successfully modified to match the thickness of Microwave's implantable PTTs).
- Track these individuals to lakes along migration routes, and to wintering and nesting areas using the Argos satellite system. Further sample subjects and/or associates, fish, water and sediments at these locales.
- Attempt to capture and analyze blood samples from an additional 10 Topaz Lake migrant common loons.
- Determine impacts of MeHg body burden for the common loon.
- Provide natural resources managers an appraisal of the Hg toxicity problem within the Walker River Basin and prospects for successful passage of Walker Lake migrant loons.

Results can be used to develop management plans assuring the Walker Basin's suitability for native and transient wildlife as well as humans. Partial funding of previous proposals has provided a firm foundation of knowledge and allowed development of the field techniques required to accomplish these objectives.

2011 Update

We submitted a proposal in 2006 to complete the study entitled “Assessment and monitoring of the ability of west central Nevada lakes to support migratory loons, and identification of wintering areas and annual range of loons using Walker Lake during migration.” In 2009 Senator Harry Reid had $300,000 transmitted to FWS via the Omnibus Appropriations Act with the purpose being the exact title of our proposal. They have neither contracted with us for the work nor expended the funds otherwise for that purpose. Water levels at Walker Lake have continued downward, TDS levels upward, and fish populations have crashed. NDOW loon counts during migration have been <100. Substantial resources have been dedicated to purchase of water rights for the lake, but willing sellers are in short supply.

Acknowledgments

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Selected Publications for Further Information

Evers, D.C. 2001. Common Loon population studies: Continental mercury patterns and breeding territory philopatry. Ph.D. dissertation, Univ. Minn., St. Paul.

Evers, D.C., J.D. Kaplan, M.W. Meyer, P. S. Reaman, W.E. Braselton, A. Major, N. Burgess, and A.M. Schuehammer. 1998. A geographic trend in mercury measured in Common Loon feathers and blood. Environ. Toxicol. Chem. 17(2):173-183.

Seiler, R.L., M.S. Lico, S.N. Wiemeyer, and D.C. Evers. 2004. Mercury in the Walker River Basin, Nevada and California - Sources, Distribution, and Potential Effects on the Ecosystem. USGS Scientific Investigations Report 2004-5147, Denver, CO. 24 pp.

Wiemeyer, Stanley N. 2002. Mercury in biota and sediment in the Walker River Basin, Nevada and California. FWS internal report, Nevada Fish and Wildlife Office, Reno, Nevada.

Yates, M.A., M.R. Fuller, D. Evers, J. Paruk and K. Kenow. 2005. Migrant Common Loons at Walker Lake, Nevada: Characterization of Range, Source(s) and Effects of Mercury Contamination and Loss of Fishery. Final report to USFWS, Reno, NV.

Figure 1
Northward migration of four common loons tracked from Walker Lake, Nevada

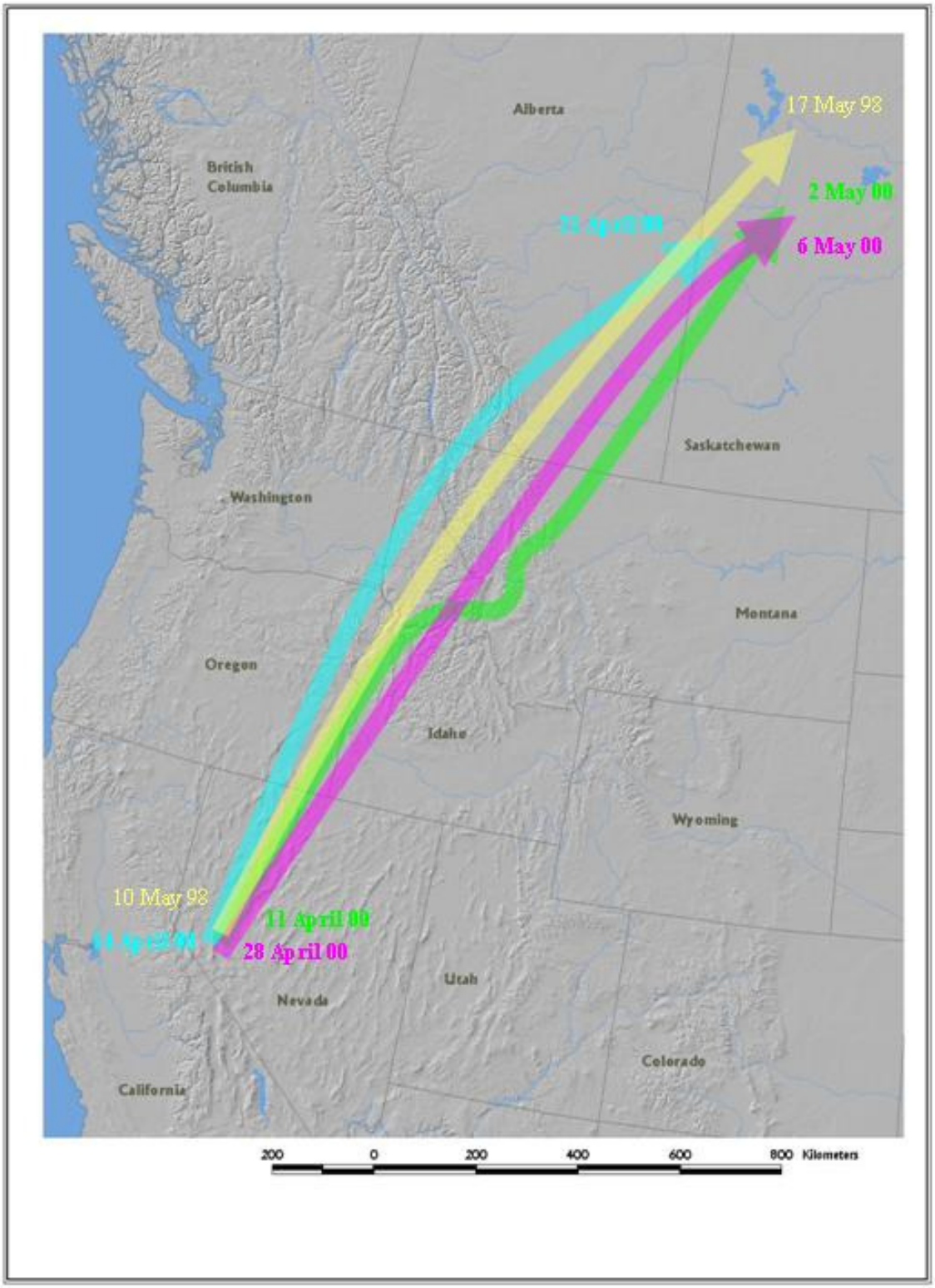

Figure 2
Summer locations of loons from Walker Lake, Nevada study

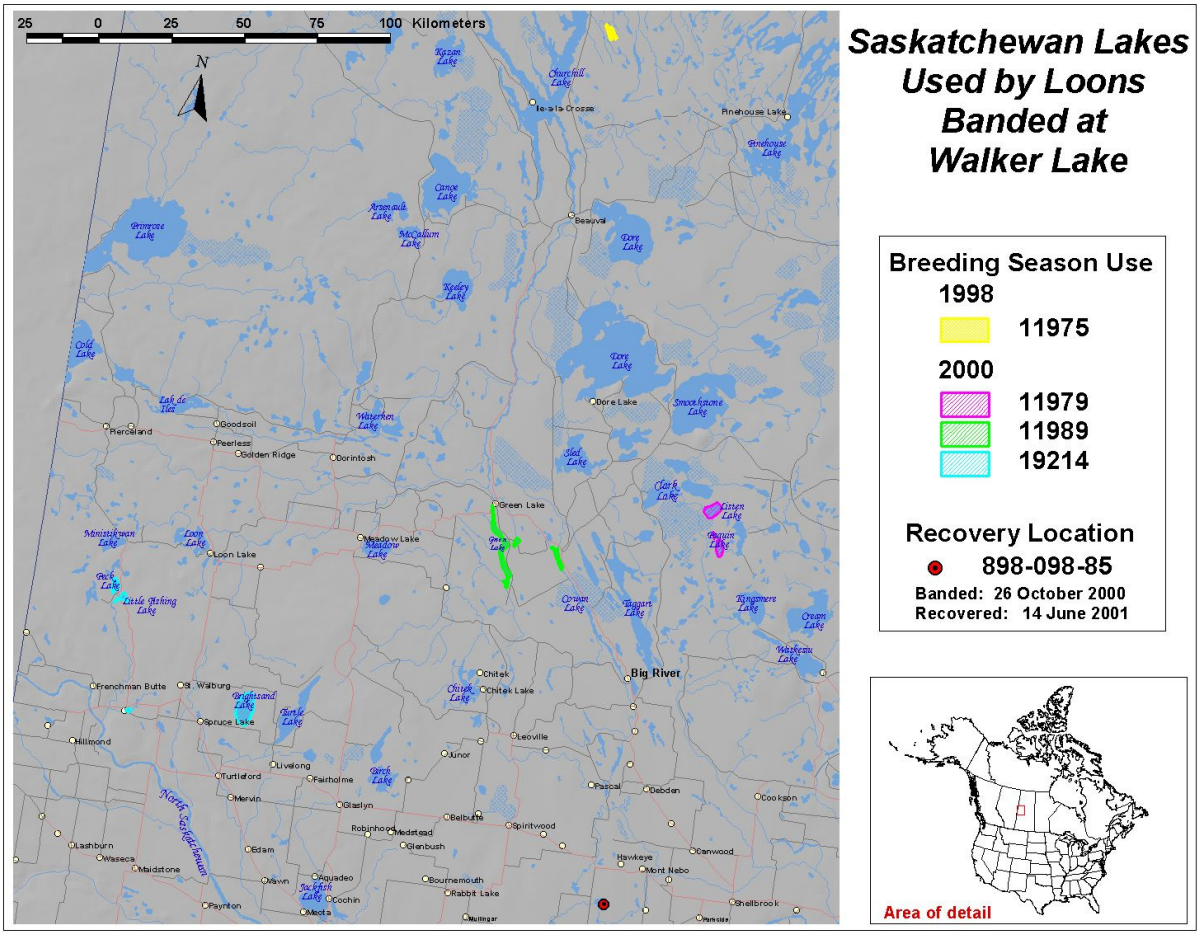

Table 1

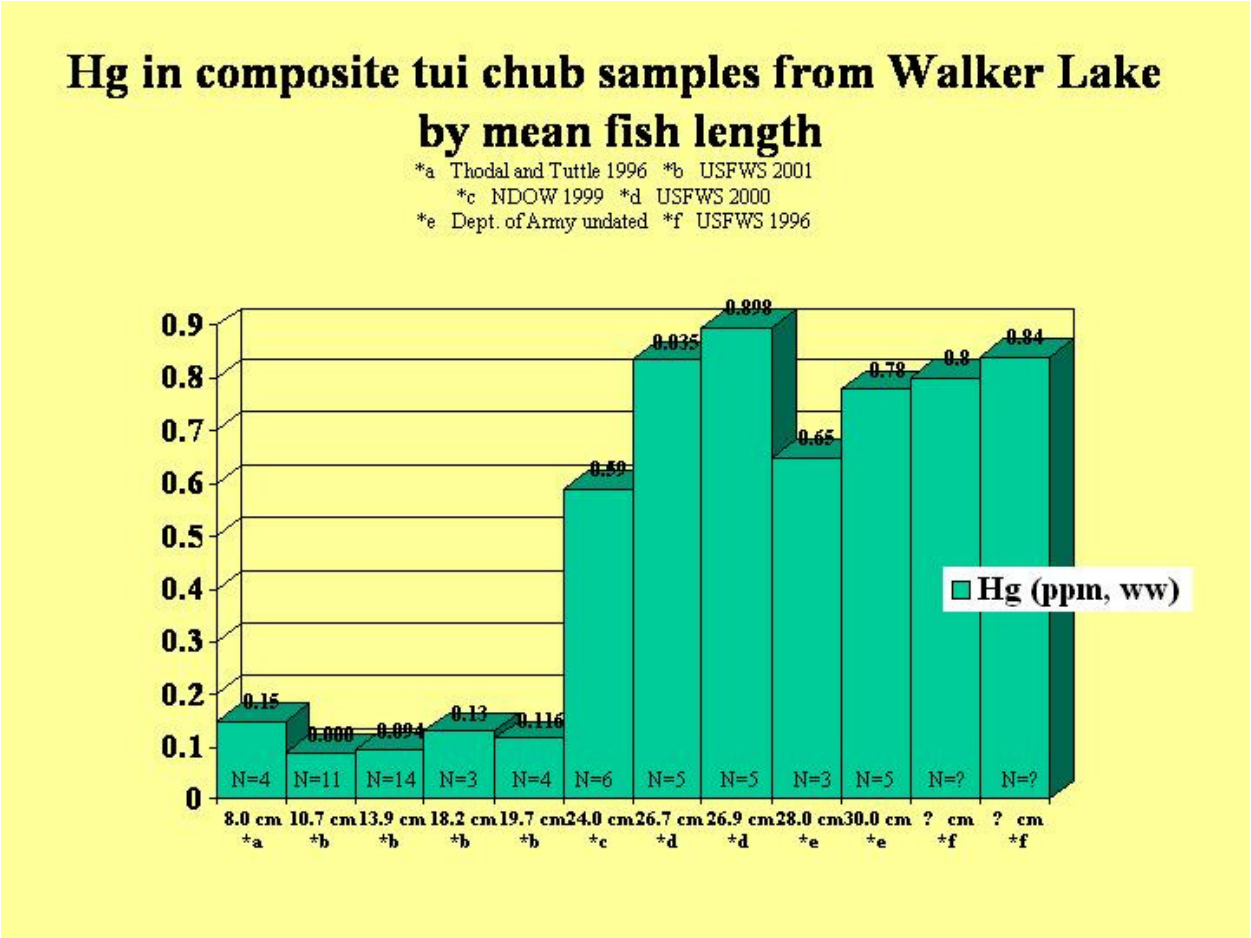
Hg in composite tui chub samples from Walker Lake by mean fish length
*a Thodal and Tuttle 1996 *b USFWS 2001
*c NDOW 1999 *d USFWS 2000
*e Dept. of Army undated *f USFWS 1996
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.15
0.000
0.094
0.13
0.116
0.59
0.835
0.898
0.65
0.78
0.8
0.84
N=4
N=11
N=14
N=3
N=4
N=6
N=5
N=5
N=3
N=5
N=?
N=?
8.0 cm *a
10.7 cm *b
13.9 cm *b
18.2 cm *b
19.7 cm *b
24.0 cm *c
26.7 cm *d
26.9 cm *d
28.0 cm *e
30.0 cm *e
? cm *f
? cm *f
Hg (ppm, ww)

Table 2

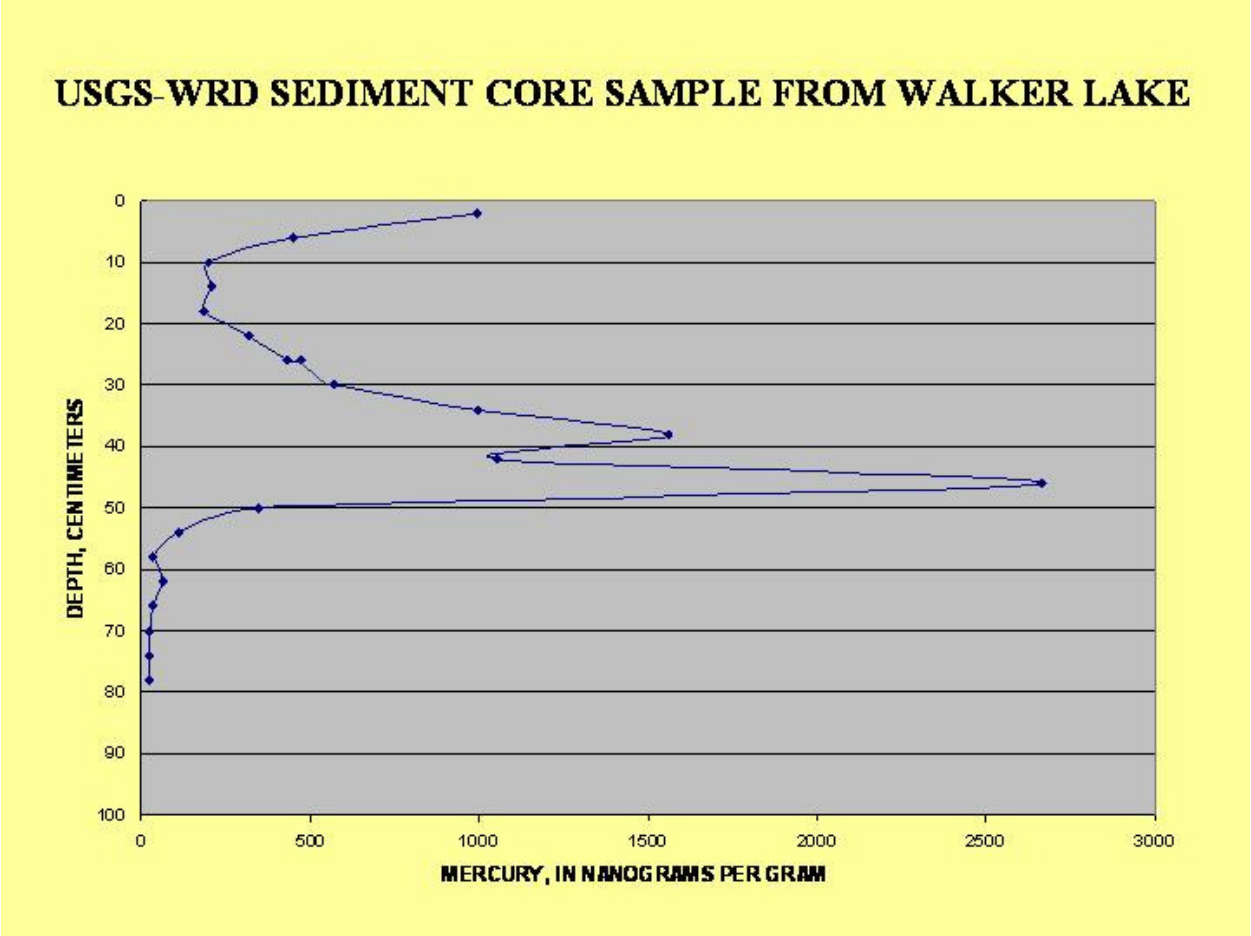
USGS-WRD SEDIMENT CORE SAMPLE FROM WALKER LAKE
DEPTH, CENTIMETERS
0
10
20
30
40
50
60
70
80
90
100
0
500
1000
1500
2000
2500
3000
MERCURY, IN NANOGRAMS PER GRAM

Table 3
Mercury level in 100 common loon blood samples collected 1998 - 2001

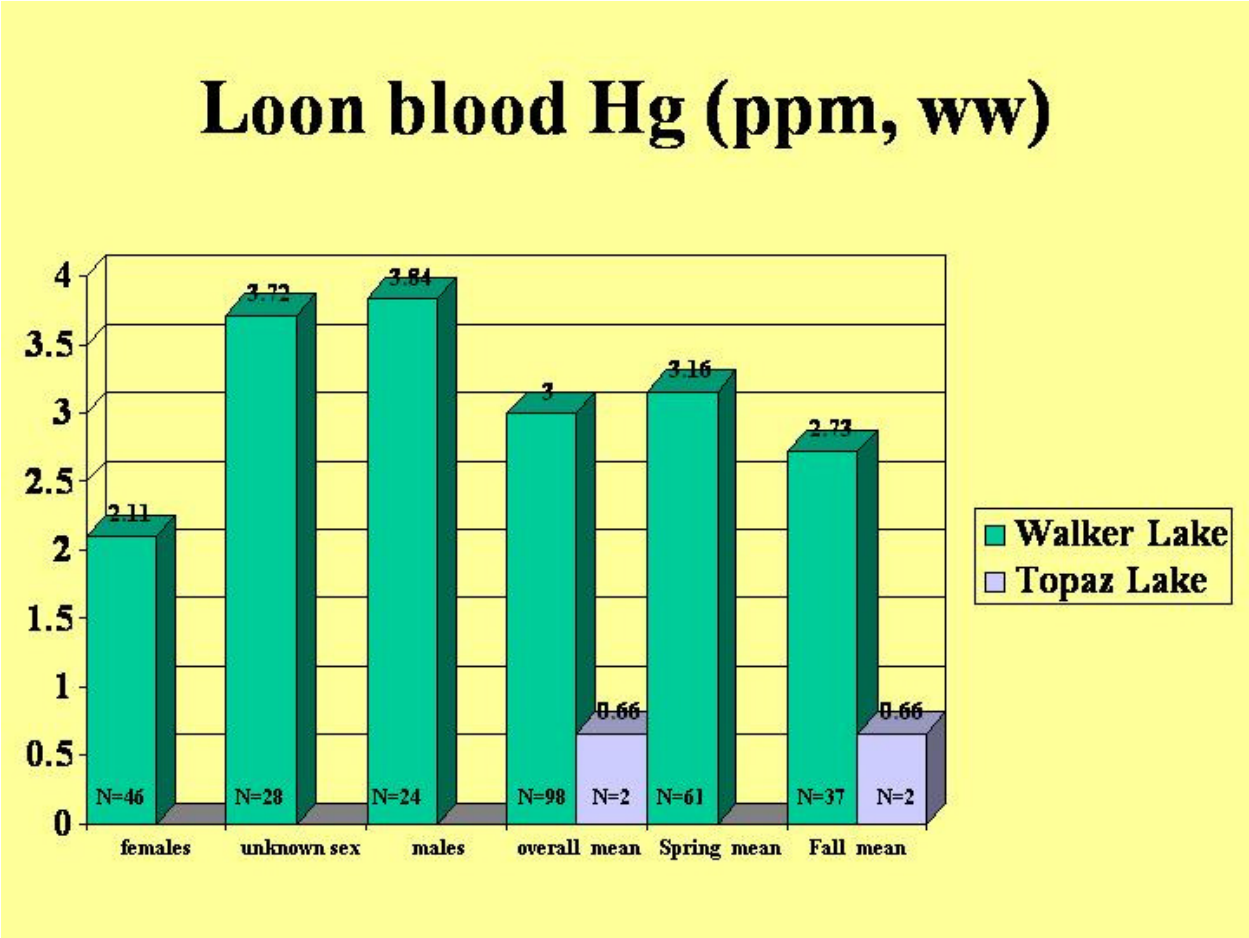

Table 4
Increase in one common loon's blood mercury in subsequent encounters at Walker Lake, Nevada