DEPARTMENT OF THE INTERIOR
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ENVIRONMENTAL CONTAMINANTS PROGRAM
OFF-REFUGE INVESTIGATIONS SUB-ACTIVITY

NV - Humboldt River Aquatic Biota Monitoring
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INTERIM REPORT

by

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INTRODUCTION

Background and Justification

Anthropogenic sources of contaminants in the Humboldt River and its terminal wetlands at the Humboldt Wildlife Management Area (WMA), Nevada, include irrigation drainage, livestock grazing, abandoned mines, mine dewatering, and municipal wastewater effluent. A better understanding of the relative sources of contaminants in the Humboldt River is needed. Several mining operations in Nevada have dewatered mine pits to facilitate mining below the water table. Three of these mines (i.e., Lone Tree and Gold Quarry, parent company Newmont Gold Company; Goldstrike, parent company Barrick Goldstrike Mines Inc.) have discharged water to the Humboldt River. Collectively, these mines are permitted to discharge 313,000 acre-feet per year, which exceeds the average annual flow of the main-stem Humboldt River; however, discharges have been lower than the maximum allowed. Additional mines could begin discharges within a few years, which could increase the magnitude and potential importance of future impacts. Sewage effluent from Lovelock is discharged to an agricultural drain which flows to the Toulon Drain, eventually reaching Toulon Lake in the Humboldt WMA.

Although mine dewatering discharges are required by regulation to be in compliance with State and Federal water quality standards, dissolved solids concentrations and several trace elements have exceeded concentrations currently existing in the Humboldt River near discharge points. Dissolved solids, arsenic, and selenium are of particular concern. Between 1982 and 1992, mean levels of dissolved solids and arsenic at a U.S. Geological Survey (USGS) gage near Carlin, Nevada (upstream of dewatering effluent discharges), were 293 mg/L (extremes 174 and 406 mg/L) and 6.9 Fg/L (extremes 3 and 12 Fg/L), respectively (USGS 1982-1992). During this same period, selenium was below a 1 Fg/L detection limit in 41 of 43 samples. The standards for discharge are 500 mg/L for dissolved solids, 50 Fg/L for arsenic, and 5 Fg/L for selenium. Because of the dewatering magnitude and permitted discharge standards, inorganic contaminant concentrations, including dissolved solids and trace elements, and loads in this closed basin may increase.

The Humboldt River, the largest watershed in Nevada, terminates in the Humboldt Sink in Pershing and Churchill Counties, except in years when the Humboldt Sink floods and discharges into the Carson Sink, such as in 1998. Wetlands in and near the Humboldt Sink provide important nesting, foraging, and resting habitat to large numbers of migratory birds. These wetlands, now contained within the Humboldt WMA, have been identified as one of the most important wildlife habitats in Nevada (Hallock et al. 1981). In unusual years, such as 1977, the Humboldt WMA may be the most important wetland in Nevada as determined by waterfowl-use days (Hallock et al. 1981). Shorebird use of the area is also important.

Wetlands near the terminus of the Humboldt River were investigated in 1990-1991 under the National Irrigation Water Quality Program (Seiler et al. 1993), followed by a field verification study in 1996 (Seiler and Tuttle 1997). The reconnaissance investigation in 1990-1991 found that irrigation drainage from the Lovelock area had caused harmful effects to fish and wildlife, and potential harmful effects on human health. Levels of arsenic, boron, chromium, copper, dissolved solids, lithium, mercury, molybdenum, selenium, uranium, and zinc in water, sediment, and/or biota exceeded geochemical baseline values, biological effect levels, and/or Nevada water quality standards for the protection of aquatic life or the propagation of

wildlife. Because of high concentrations in water and/or biological tissues, dissolved solids, arsenic, boron, mercury, and selenium were of primary concern. Dissolved solids in Toulon Lake of the Humboldt WMA were high enough to cause an adverse effect on duckling survival, based on other studies. Dissolved boron concentrations at sites receiving irrigation drainage were 2 to 18 times higher than the previous Nevada water quality standard for the protection of aquatic life. Selenium concentrations in drainwater met or exceeded levels causing food chain bioconcentration. Selenium biomagnification occurred, with the median concentration in livers of juvenile black-necked stilts (*Himantopus mexicanus*) being about three times higher than the effect level. Also, the public health advisory criterion for selenium in edible tissue was exceeded in one of three adult duck muscle samples.

Concentrations of arsenic, chromium, mercury, and selenium in aquatic vegetation, aquatic invertebrates, and avian eggs and livers were generally higher in the field verification study than in the reconnaissance study (Seiler and Tuttle 1997). Arsenic, boron, mercury, and selenium in one or more biological matrices exceeded concentrations associated with adverse effects to avian species. However, the causes of these changes are unknown. The mean arsenic concentration (28.7 Fg/g) in aquatic vegetation collected in 1996 approached a 30 Fg/g dietary concentration associated with effects to growth, development, and physiology of mallards (*Anas platyrhynchos*; Camardese et al. 1990). All vegetation samples exceeded a 100 Fg/g boron concentration associated with delayed growth and biochemical effects in mallards (Hoffman et al. 1990), with one sample exceeding a 1000 Fg/g concentration associated with reduced duck egg hatching success, hatch weight, duckling weight gain, and duckling survival (Smith and Anders 1989). Mercury concentrations in aquatic invertebrates were greater than dietary concentrations associated with reduced production and behavioral effects in mallards (Heinz 1979). The mean mercury concentration (0.89 Fg/g wet weight) in American coot *(Fulica americana*) eggs exceeded a 0.83 Fg/g egg concentration (wet weight) associated with reduced hatch rate and juvenile survival in mallards (Heinz 1979), with one of seven American avocet (*Recurvirostra americana*) eggs exceeding this effect concentration. Selenium in all invertebrate samples exceeded a 5 Fg/g critical avian dietary threshold identified by Skorupa et al. (1996). The mean selenium concentrations in coot (4.3 Fg/g) and avocet (8.2 Fg/g) eggs exceeded a 4.0 Fg/g concentration associated with increased susceptibility to duck hepatitis virus in mallards (Skorupa et al. 1996). During both the reconnaissance investigation and the field verification study, mean selenium concentrations in coot livers exceeded a 10 Fg/g concentration at which the possibility of reproductive impairment and sublethal effects increase (Heinz 1996). During both periods, juvenile shorebird hepatic concentrations of selenium were near a 30 Fg/g concentration indicative of an increased risk of adverse biological effects (Skorupa et al. 1996).

Seiler (1995) showed that the likelihood of a selenium problem at the Humboldt WMA would change from possible to probable with the addition of a major upstream source of selenium. A discharge containing selenium concentrations above historic levels could provide the upstream source of selenium for adverse effects on biota to occur at the Humboldt WMA. Even though the concentration of trace elements in water in the river may not increase with increased flows, the total loads will increase. Increased dissolved solids and trace element loading from mine dewatering discharges and other possible sources may exacerbate inorganic contamination existing in terminal wetlands at the Humboldt WMA, in part in relation to evapo-concentration of trace elements in the terminal wetlands. Problems may be further worsened if

the period of increased loading is followed by an extended period of decreased flows in the Humboldt River, such as that which may occur with the cessation of mine dewatering.

Objectives

There are three objectives to this study. First, the study was designed to obtain sufficient data to begin to assess trends in surface water quality and trace elements in aquatic vegetation, invertebrates, fish, and bird eggs and livers in the mid to lower Humboldt River basin. Second, the study will assess the adequacy of current State and Federal water quality standards for dissolved solids and trace elements to protect fish and wildlife resources in the lower Humboldt River basin, and the possible need for the establishment of total maximum daily loads. Early detection of potential biological effects is critical because of the terminal nature of the Humboldt River system, the persistence of trace elements in the environment, and the previous identification of adverse biological effects caused by inorganic contaminants in wetlands at the terminus of the river. Third, the study will attempt to determine the relative proportions of total dissolved solids and trace elements entering the Humboldt WMA that originate from mine dewatering and from agricultural drainwater in the Lovelock area.

METHODS

Data Collection and Analysis

An ecosystem approach will be used to determine impacts to biotic communities both in the Humboldt River and terminal wetlands at the Humboldt WMA. This includes information on interactions between trace element concentrations in water, aquatic vegetation and invertebrates, fish, and aquatic birds. Impacts to avian reproduction will also be assessed. The study involved the collection of a full set of field data during the first two years (i.e., 1998 and 1999), followed by collection of a limited set of field data from four sites on the Humboldt River in the third year (i.e., 2000; using left over analytical funds). Data analysis and report preparation are currently being conducted and should be completed by the end of 2001.

Water Quality and Quantity

As a condition of their National Pollutant Discharge Elimination System (NPDES) permits, mines and the city of Lovelock that discharge to the Humboldt River or an agricultural drain are required to monitor quantity and quality of effluent. Reports of these data are submitted quarterly to the Nevada Division of Environmental Protection (NDEP). Surface water quantity and quality, including dissolved solids and certain trace elements, are routinely monitored at several locations along the Humboldt River by USGS and NDEP. USGS sampling sites include those near Carlin and Battle Mountain, whereas NDEP sampling sites include those near Osino, Carlin, Palisades, Battle Mountain, Comus, Imlay, below Rye Patch Reservoir, above Humboldt Sink, and Toulon Drain. Appropriate water quality and quantity data will be obtained from these agencies. Effects of effluent discharge to surface water quantity and quality will be assessed annually.

In order to separate the relative inputs of agriculture drainwater discharges from mine dewatering discharges, additional monitoring of flow, specific conductance, and periodic

analysis of water samples were required. This task was conducted by USGS, with monetary support from the Fish and Wildlife Service, Barrick Goldstrike Mines Inc., and the Bureau of Reclamation. Specific conductance was monitored at two existing gaging stations on the Humboldt River, one at Imlay above Rye Patch Reservoir and one just downstream of Rye Patch Reservoir. Gaging stations were also be installed at three additional sites, namely Army Drain and the Humboldt River before discharging to Humboldt Lake on the Humboldt WMA, and Toulon Drain before discharging to Toulon Lake on the Humboldt WMA. Flow and specific conductance were monitored at these sites. At each of these five sites, water was collected approximately nine times per year for analysis of pH, total dissolved solids, major inorganic constituents, and selected trace elements (including those of concern identified above). USGS collected these data using their own protocols and quality assurance/quality control procedures.

Aquatic Community Structure

One existing program conducted limited monitoring of aquatic community structure in the mid and lower Humboldt River. Aquatic community structure and function was assessed under the Regional Environmental Monitoring and Assessment Program (REMAP), conducted by the University of Nevada, Reno, under contract from EPA. A number of REMAP sampling sites in the Humboldt River Basin were on the main-stem of the river, and should provide useful data to our study. JBR Environmental Consultants, Inc. (1997), under contract by Barrick Goldstrike Mines Inc., previously monitored the physical characteristics, aquatic habitat, macroinvertebrate communities, and the fish communities above and below Barrick's point of dewatering discharge on the Humboldt River. The Lone Tree Mine monitored macroinvertebrate abundance and diversity along the river upstream and downstream of their point of discharge. Data from ongoing programs, in conjunction with discharge quality data, will be used to assess effects of effluent discharges to aquatic communities of the Humboldt River.

Trace Elements in Biota and Their Effects

Biological samples were collected for trace element analyses to assess accumulation in organisms and concentrations in food chains.

Sampling Sites

Aquatic vegetation, invertebrates, and fish were collected annually in late summer of 1998 and 1999 from each of eight sites along the Humboldt River. The sites were located in the following areas: One each upstream and downstream of Elko (i.e., Osino and Carlin Canyon [= Carlin], respectively); one each downstream of the mine dewatering discharge sites (i.e., Palisades, TS Ranch bridge above Argenta [= Argenta], and Emigrant Canyon near Golconda [= Emigrant], respectively), for a total of three sites; one upstream of Rye Patch Reservoir (i.e., near Mill City [= Imlay]); one immediately downstream of Rye Patch Reservoir (just below the dam[= Rye Patch]); and one downstream of Rye Patch Reservoir, but upstream of agricultural drainage inputs (i.e., upstream of Lovelock [= Lovelock]). Up to five composite samples of each matrix (i.e., vegetation, invertebrates, and fish) were collected at each site. The minimum sample size for each of the three matrices exceeded 10 grams in nearly all cases. Samples were collected only from the Carlin, Palisades, Argenta and Emigrant sites in 2000.

Aquatic Vegetation and Invertebrates

Aquatic vegetation was collected with gloved hand, identified, placed in chemically clean glass jars with teflon-lined lids in the field, stored on ice until return to the laboratory, and frozen. Aquatic invertebrates (i.e., dragonfly larvae and crayfish) were collected with a kick net and/or by hand (i.e., crayfish). For riverine sites, dragonfly larvae were removed from the net with gloved hand, sorted in clean stainless steel pans from debris, and placed in clean jars. Crayfish were handled with gloved hand, placed in clean plastic bags in the field, sorted by size, and weighed in the lab and placed in clean jars. Samples were placed on ice in the field, transported to the laboratory, and frozen until chemical analysis. Invertebrates collected at the Humboldt WMA were obtained with a kicknet, sorted from debris in clean stainless steel pans in the field, placed on ice in the field, and transported to the laboratory where they were frozen. A limited number of taxa of both vegetation and invertebrates that were common among most sampling sites were submitted for trace element analysis.

Fish

Fish samples which were obtained with a beach seine, each consisted of composites of whole similar sized individuals of a single species. Fish that had been sorted by species in the field were placed in chemically clean glass jars with teflon lined lids in the field, placed on ice in the field, and frozen upon return to the laboratory until chemical analysis. Weight and length of individual fish in each sample were recorded. The same species of fish could not be obtained at all sites.

Aquatic Birds

Aquatic bird eggs were collected for residue analysis, with one egg from each nest sampled. We attempted to monitor nest success of American coot nests at the Humboldt WMA in 1998; however, we were unable to determine the outcome in a great majority of cases. Therefore, no attempt was made to monitor success in 1999. The primary emphasis at this site was on American coots, as nests of this species were abundant in 1996. Coots are relatively sensitive to the effects of selenium (J. P. Skorupa, pers. comm.). Secondary emphasis was on black-necked stilts, which are highly sensitive to selenium (J. P. Skorupa, pers. comm.), but were scarce at the Humboldt WMA in 1996. Coot nests were marked with a numbered piece of flagging in nearby vegetation (e.g., tamarisk or cattail). One egg selected at random from each coot nest was floated in clean non-chilled water in to determine stage of incubation during the first visit to each nest. After 10 days of incubation (eggs float to the surface at this stage) one egg was collected at random from each monitored nest for residue analysis. Eggs from coot nests at two additional sites (i.e., upstream portion of Rye Patch Reservoir and near Emigrant) were sampled in 1998. No coot nests were present at these sites in 1999.

All eggs that were collected were stored on ice in the field. Egg length, breadth, volume, and weight were determined in the laboratory. Eggs were opened using stainless steel instruments that had been cleaned with detergent and rinsed with nitric acid followed by distilled deionized water. Embryos were be aged and grossly examined for external deformities. Entire egg contents were be placed in glass jars with teflon-lined lids and frozen until chemical analysis. Each egg was analyzed separately.

Juvenile (pre-flight) American coots and American avocets were collected, using steel

shot, in 1998 and 1999 at the Humboldt WMA. A number of adults of these species were also collected due to difficulty in determining ages prior to shooting. Birds were placed on ice in the field and returned to the laboratory. Livers were removed with stainless steel instruments that had been cleaned with detergent and rinsed with nitric acid followed by distilled deionized water. Livers were placed in chemically clean jars with teflon-lined lids and frozen prior to chemical analysis. Livers were analyzed separately. Several moribund birds suffering from botulism were also collected in 1999 and their livers were removed for residue analysis.

Sediment

Sediment samples were collected at the Humboldt WMA in 1998 and 1999. A composite sample from each location was taken from at least three cores with a core sampler. The top 2-3 cm of sediment was retained, placed in a clean jar, placed on ice in the field, and frozen upon return to the laboratory.

Chemical Analysis

All samples were submitted to a laboratory (i.e., Research Triangle Institute) under contract with the Fish and Wildlife Service Patuxent Analytical Control Facility (PACF), Laurel, Maryland. All biological and sediment samples were analyzed for metals and trace elements (Al, As, B, Ba, Be, Cd, Cr, Cu, Fe, Hg, Mg, Mn, Mo, Ni, Pb, Se, Sr, V, and Zn) using inductively coupled plasma (ICP) scans, except for arsenic, selenium, and mercury. Arsenic and selenium were analyzed either by graphite furnace atomic absorption or hydride generation atomic absorption, whereas total mercury was analyzed by cold vapor atomic absorption. Analytical quality assurance/quality control procedures were given in PACF (1990). Analytical detection limits for given elements varied among years.

Data Analysis

For all residue data, concentrations will likely be $\log_{10}$ transformed to equalize variances. Two-way ANOVA will likely be used to examine differences among sites and years. An appropriate multiple comparison procedure will be used to determine which sites and/or years are significantly different from one another. Relationships between discharge quality, surface water quality, and trace element concentrations in biological tissues will be examined as appropriate. Data will also be evaluated to determine the contribution of agricultural drainwater flows to trace element concentrations in biota in the Humboldt Sink.

Residue data will be compared with established concern and effect levels from the literature. Data from bird eggs and livers collected from the Humboldt WMA will be compared with those collected during the irrigation drainwater reconnaissance study (Seiler et al. 1993) and field verification study (Seiler and Tuttle 1997).

RESULTS

Data collection by the U.S. Geological Survey (water flows and quality) was completed and a draft report is being revised for Fish and Wildlife Service review prior to being finalized. Additional funding by the Bureau of Reclamation, Lahontan Basin Area Office ($20,000 in FY 1998) and by the National Irrigation Water Quality Program ($20,000 each in FY 1999 and 2000) allowed for collection of additional water quality data by USGS that will aid in a better understanding of agricultural drainwater inputs to the Humboldt WMA and discharges of water from the Humboldt WMA to the Carson Sink. The original proposal did not provide funds to USGS for data analysis and support in preparation of a final report in FY 2000; funds (i.e., $13,500) were added to the FY 2000 budget for that purpose.

A summary of the number of samples that were analyzed, including their type and source, is provided in Tables 1, 2 and 3.

Data on water quality of the mine discharges to the Humboldt River and water quality in the river has been obtained from NDEP and has been, for the most part, placed in spread sheet files for later analysis.

Residue concentrations (geometric means and extremes) in biota and sediment have been summarized by sample type, site, and year in a series of tables which are available upon request.

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Table 1. Number of samples collected as part of the Humboldt River Aquatic Biota Monitoring study, 1998-2000 - fish.

Site	Lahontan redside			Carp			Tahoe sucker		Walleye		Mosquito-fish		Other fish	
	98	99	00	98	99	00	98	99	98	99	98	99	98	99
Osino	3	3	–	0	0	–	2	3	0	0	0	0	0	0
Carlin	5	5	2	0	0	1	0	0	0	0	0	0	0	0
Palisades	3	3	3	0	0	0	2	1	0	0	0	0	0	0
Argenta	5	5	3	0	0	0	0	0	0	0	0	0	0	0
Emigrant	3	3	3	2	0	0	0	0	0	0	0	0	0	0
Imlay	4	1	–	3	1	–	1	0	0	0	0	0	0	2[a]
Rye Patch	0	0	–	3	2	–	0	3	2	3	0	0	0	3[b]
Lovelock	1	0	–	0	0	–	0	2	4	0	0	0	0	0
HWMA	0	0	–	0	0	–	0	0	0	0	3	1	1[c]	0
Totals	24	20	11	8	3	1	5	9	6	3	3	1	1	5

[a] 1 Sacramento blackfish; 1 bluegill.
[b] 3 Sacramento blackfish.
[c] 1 Pumpkinseed.

Table 2. Number of samples collected as part of the Humboldt River Aquatic Biota Monitoring study, 1998-2000 - vegetation and invertebrates.

	Algae			Pondweed		Chara		Dragonfly larvae			Crayfish			Corixids		Other
Site	98	99	00	98	99	98	99	98	99	00	98	99	00	98	99	98
Osino	2	3	–	0	0	3	3	2	3	–	3	3	–			
Carlin	4	5	3	0	0	1	0	1	3	3	3	3	3			
Palisades	5	3	3	0	0	0	0	2	3	3	3	3	3			
Argenta	5	5	3	0	0	0	0	3	3	3	1	0	0			
Emigrant	5	3	3	0	0	0	0	2	0	3	3	3	2			
Imlay	0	0	–	0	0	0	0	2	1	–	0	1	–			
Rye Patch	3	3	–	2	3	0	0	0	0	–	3	3	–			
Lovelock	3	3	–	0	3	0	0	2	2	–	3	3	–			
HWMA	2	1	–	2	2	0	0	0	0	–	0	0	–	4	3	1[a]
Totals	29	26	12	4	8	4	3	14	15	12	19	19	8	4	3	1

[a] 1 notonectid

Table 3. Number of samples collected as part of the Humboldt River Aquatic Biota Monitoring study, 1998-2000 - bird eggs and livers and sediment.

	Eggs			Livers						
	Coot		Stilt	Coot				Avocet		
				Adult		Juvenile		Ad.	Juv.	Stilt
Site	98	99	99	98	99	98	99	99	99	99
Humboldt Wildlife Management Area										
Hum. Lake	19	12	0	2	8	6	6	3	3	1
Toulon Lake	0	10	2	0	0	0	0	1	0	0
Other areas										
Emigrant	5	0	0							
Rye Patch	3	0	0							
Totals	27	22	2	2	8	6	6	4	3	1

	Sediment	
Site	98	99
Humboldt Lake	5	3