THE RIVER OTTER IN IDAHO: REPRODUCTIVE AND POPULATION PARAMETERS AND LIVER CONCENTRATIONS OF ENVIRONMENTAL CONTAMINANTS

by

Gina Diggs

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DEFENSE COMMITTEE AND FINAL READING APPROVALS

of the thesis submitted by

Gina Diggs

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The following individuals read and discussed the thesis submitted by student Gina Diggs, and they evaluated her presentation and response to questions during the final oral examination. They found that the student passed the final oral examination.

Jim Munger, Ph.D.	Chair, Supervisory Committee
Wayne Melquist, Ph.D.	Member, Supervisory Committee
Jesse Barber, Ph.D.	Member, Supervisory Committee

The final reading approval of the thesis was granted by Jim Munger, Ph.D., Chair of the Supervisory Committee. The thesis was approved for the Graduate College by John R. Pelton, Ph.D., Dean of the Graduate College.

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ABSTRACT

To obtain current data on the North American river otter (*Lontra canadensis*) population in Idaho, licensed trappers were mandated to surrender river otter carcasses through provisions of the Idaho Department of Fish and Game's mandatory harvest report. Throughout the 2002-2003 and 2003-2004 trapping seasons, 237 river otter carcasses were collected. Necropsies were performed to assess age and sex, general body condition, reproductive rates, and concentrations of environmental contaminants in the livers. Reproductive rates were determined by counting corpora lutea and blastocysts in female river otters. Livers were dissected and concentrations of environmental contaminants were determined for the following toxins: mercury and other heavy metals, organochlorine pesticides, and polychlorinated biphenyls (PCBs). No negative relationships were found between environmental concentrations and female reproductive rates or presence of sperm. The majority of otters had contaminant levels well within what is considered background levels. Data from the present study suggest the river otter population in Idaho is stable to increasing. Based on the results from the present study, I conclude that the Idaho Department of Fish and Game's current management of river otters, including the existing harvest season and quota, are not a detriment to the population.

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INTRODUCTION

The impetus for the present research arose from a need for current information on North American river otter (*Lontra canadensis*) populations in Idaho to assist in management decisions. Chapter 1, titled Reproductive Parameters and Population Characteristics of River Otters in Idaho, discusses sex ratio, age structure, body condition, and reproductive parameters of 237 otters harvested and collected throughout the state. I also sought to determine concentrations of the following environmental contaminants in river otter livers: heavy metals (including mercury, arsenic, cadmium, cobalt, copper, molybdenum, lead, and zinc), organochlorine pesticides (OCs), and polychlorinated biphenyls (PCBs). Chapter 2, titled Environmental Contaminant Concentrations in Livers of River Otters in Idaho, discusses these contaminants and correlations with body condition and reproductive rates.

CHAPTER 1: REPRODUCTIVE PARAMETERS AND POPULATION CHARACTERISTICS OF RIVER OTTERS IN IDAHO

Abstract

To obtain current data on the North American river otter (*Lontra canadensis*) population in Idaho, licensed trappers were mandated to surrender river otter carcasses through provisions of the Idaho Department of Fish and Game's mandatory harvest report. Throughout the 2002-2003 and 2003-2004 trapping seasons, 237 river otter carcasses were collected. Complete necropsies were conducted to determine sex ratio, age structure, body condition, and reproductive parameters. Data from both trapping seasons were pooled and the combined sex ratio was essentially 1:1; that is, 50.2% (n = 119) of the harvested otters were male and 49.8% (n= 118) of the harvested otters were female. Of the 226 individuals that could be aged, 61 were juveniles (26.9%) and 65 were yearlings (28.7%). This age structure is illustrative of an increasing population, based on previous studies that percentages of juveniles and yearlings combined exceeding 35% are indicative of an increasing population. Reproductive rates were determined by counting corpora lutea and blastocysts in female river otters. During the 2002-2003 season, the mean number of corpora lutea for pregnant adult female river otters was 1.6, and the mean number of blastocysts was 1.6. The respective means increased to 1.9 for the 2003-2004 season. Eighty-nine percent of female otters above 2 years of age were pregnant. A higher percentage of older (> 2 years) females versus younger females were pregnant, also indicative of a stable to increasing population. Data from the present study suggest

the river otter population in Idaho is stable to increasing. Based on the results from the present study, I conclude that the Idaho Department of Fish and Game's current management of river otters, including the existing harvest season and quota, are not a detriment to the population.

Key words: furbearer, Idaho, *Lontra canadensis*, reproduction, river otter

Background

The impetus for the present research arose from a need for current information on North American river otter (*Lontra canadensis*) populations in Idaho to assist in management decisions. Fluctuating otter harvests and subsequent declines in harvest during the period of 1945 through 1970 were interpreted as a decline in the river otter population, resulting in a 29-year closure of the legal harvest of river otters as a furbearer in Idaho. In 2000, the river otter season was reopened, despite the fact that approximately 66% of Idahoans were opposed to the harvest of river otters. Because many Idahoans were opposed to river otter harvest, the Idaho Department of Fish and Game (Department) decided to seek current information on the otter population so that they could assure concerned citizens that the harvest was not detrimental to the overall population. In addition, the Department petitioned the U.S. Fish and Wildlife Service (USFWS) for multi-year approval of Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) export tags. The USFWS denied the issuance of CITES export tags for river otters, pending the receipt from the Department of evidence that the harvest will not be detrimental to the population.

History of River Otters in Idaho

Even before 1945, declines in river otter populations were observed in Idaho. Dr. C. Hart Merriam (1891) reported the river otter as "common along most of the streams and lakes in Idaho" during his biological reconnaissance of south-central Idaho, conducted during August, September, and October 1890, for the U.S. Department of Agriculture (USDA) (Merriam 1891). Within just a few decades, however, trappers in Idaho were reporting low-to-no sign of river otters (Davis 1939). In 1934, a trapper from southwest Idaho reported only 1 river otter harvested from Grandview, along the Snake River in Owyhee County, within a 15-year period. In 1939, a trapper from south-central Idaho, who had trapped in the Big Wood River since 1923, reported no occurrence of otters (Davis 1939). W. B. Davis reported in his book, *The Recent Mammals of Idaho* (1939), "This interesting and valuable mammal now is greatly reduced in numbers." By 1942, William M. Rush reported in *Wildlife of Idaho*, "They are quite scarce in most parts of Idaho. A few may be found along the streams and lakes."

Responding to this apparent decline in the river otter population, the Idaho Fish and Game Commission (Commission) approved the first regulated river otter trapping season in 1945. This is important to note; prior to 1945, there were no regulations on harvesting. A peak in the harvest (Fig. 1.1) occurred in 1957 with 227 otters trapped, followed by a steady decline, and then another peak occurred in 1965 when 131 otters were trapped. After 1965, the harvest once again declined with a low of 40 otters harvested in 1970. It was this second decline that prompted the Commission to close the trapping season in 1971-1972.

Although the decline in harvest was interpreted as an indication of a decreased population, many other factors could have contributed to the decline. For example, fluctuations in the market value and weather constraints are known to affect overall trapper effort. Tabor (1974) reported that trappers from Oregon believe adverse weather conditions during the trapping seasons, primarily flooding and ice, influence trapping effort, trapping success, and, thereby, the number of otters trapped.

Research

Several years later, from 1976-1981, an ecological study of river otters was conducted in west-central Idaho by Melquist and Hornocker (1983). Population density estimates were established based on data collected from the North Fork Payette River drainage in the McCall area. Population density estimates ranged from 1 otter/2.7 km to 1 otter/5.8 km of waterway. For all study areas combined, the density was 1 river otter for every 3.9 km of waterway, based on a density estimate in the study area of 41 otters in 158 km of waterway.

In 1983, the Department mailed questionnaires to Department personnel regarding river otter sightings throughout the state. The locations of all river otter sightings were plotted on a map. The responses to these questionnaires indicated widespread distribution of otter. Concurrently, the Idaho Trapper's Association (ITA) petitioned the Commission to reopen the river otter and fisher (*Martes pennanti*) season.

These combined factors (i.e., the map indicating widespread distribution and the petition from the ITA to reopen the otter season) led the Department to conduct public opinion surveys on river otter trapping. In 1988, the Department solicited public comments on a possible river otter trapping season through notices in local newspapers,

radio, and television. The Department also contracted with the Idaho Department of Corrections to interview a random sample of 1,045 Idaho citizens by telephone. The Department reported to the Commission that an overwhelming majority of the individuals polled did not favor a river otter season. Based on telephone calls and letters received by the Department, 621 (94%) of 660 respondents were opposed to a river otter season. Results of the telephone public opinion survey showed that 294 (28%) favored a river otter season, 619 (59%) opposed a season, and 132 (13%) were undecided (Idaho Department of Fish and Game 1988). After hearing this report, the Commission decided not to open the season on river otters or fishers.

As part of the mandatory harvest reporting process, a survey was sent to trappers in 1996-1997. Trappers were asked a series of questions in an effort to help the Department better understand furbearer populations in Idaho and how best to manage them. Several questions focused on observations of otter sign, such as tracks, scat, and latrine sites. The survey consisted of a map illustrating the region's rivers and second-order and greater streams (Fig. 1.2). Trappers documented the number of river otters (single or families) sighted, numbers of river otters incidentally trapped along these waterways, and observations of otter sign, mentioned above. No random public survey was conducted by the Department this time.

Seventy percent of 524 respondents indicated on the provided map that they had seen river otter sign in the area they trapped. Of 401 respondents, 71% felt that river otter sign was either plentiful or common where they trapped, and 66% considered the amount of sign to have been increasing during the period between 1986 and 1996. Finally, 54% of 567 respondents indicated there should be a trapping season for river

otters (Idaho Department of Fish and Game 1988). These results suggested the river otter was widely distributed and relatively common throughout Idaho, a perception shared by many Department field personnel.

On March 10, 1998, the ITA sent a second proposal for Commission consideration to harvest river otters in Idaho. The factors described in previous paragraphs, coupled with the fact that an average of 30 incidentally captured river otters were turned in each year by trappers throughout the 29-year closure (Fig. 1.3), led the Commission to reopen the river otter season for the 2000-2001 trapping season. A statewide legal harvest quota was established based on extrapolated density estimates from data collected from the North Fork Payette River study (Melquist and Hornocker 1983). The total statewide harvest quota was divided among the administrative regions, and, in each administrative region the quota was set at 1.25% of the estimated river otter population (Table 1.1). Statewide, the resulting harvest quota was approximately 100 river otters.

In September 2000, the Department submitted a request to the USFWS Division of Scientific Authority (DSA) for a multi-year approval of CITES export tags. The DSA Guidelines on information required in order to conduct a review and required for consideration for State export programs indicate that the following must be provided: 1) information on the condition of the population, including trends and population estimates where such information is available; 2) information on total harvest of the species; 3) information on the distribution of harvest; and 4) an evaluation of habitat. It is important to note here that there are no known methods to accurately determine population trends with species such as the otter (Melquist et al. 2003). Therefore, what CITES was

requesting from Idaho was difficult to provide without information that would result from animals trapped during a regulated harvest (G. D. Patton and W. E. Melquist, Idaho Department of Fish and Game, unpublished data). DSA guidelines specify that the minimum requirements for a management program are (i) a controlled harvest, (ii) methods and seasons to be determined by the State or Indian Nation, (iii) all skins must be registered and tagged, and (iv) harvest levels must be determined annually by the State or Indian Nation.

The Department's request was initially denied because insufficient information was provided about Idaho's river otter population and its habitat status. Because river otters are listed on Appendix II of CITES (Bittner et al. 1977), member nations, including Canada and the United States, are (i) required to monitor or restrict trade (Melquist et al. 2003) and (ii) before export tags are granted by the USFWS, must show that harvest management does not detrimentally affect populations. The DSA also was concerned that the Department had based its harvest management strategy on population numbers extrapolated from 20-year-old data and that information, taken from only one region in Idaho, was used to determine the statewide strategy for harvest management. The DSA requested that it be provided with current information on distribution, density, and demographics of river otters in Idaho and suggested the Department record catch-per-unit effort (CPUE). CPUE measures the amount of time required to harvest an animal, and is one of the most effective indices of otter relative abundance (Chilleli et al. 1996, Gallagher 1999). With a constant reporting rate and continual collection of CPUE, these type of data can facilitate long-term trend analyses.

The Department submitted a second petition in 2002, providing the requested data and age and sex structure of river otters harvested during the previous two trapping seasons. Because the 1983 study was initiated only 4 years after the legal trapping season was closed, the Department also noted that the population density estimates from the 1983 study should be considered conservative. In addition, there was consideration of the results from earlier trapper surveys and otter sightings. Finally, the Department noted that a harvest of no more than 1.5 percent per year is very conservative in the context of current wildlife management programs (Table1.1). Harvest models developed in Minnesota indicate that river otter population stability can be maintained with a harvest of 15-17% of the available autumn otter population (B. Berg and D. Kuehn, Minnesota Department of Natural Resources, *in* Melquist et al. 2003).

During the process to obtain CITES tags, the Department decided that a current study of the river otter in Idaho was needed to provide additional information on its status, aid in management decisions, and supply the requested current data to the DSA. In November 2002, the Department mandated that for two consecutive trapping seasons, trappers would surrender river otter carcasses for use in the present study.

The research objectives of the present study were to: 1) determine population characteristics, specifically age structure, sex ratio, and general body condition, of river otters in Idaho; 2) determine reproductive parameters (corpora lutea and blastocysts provide estimates of ovulation rate and potential litter size, respectively) of river otters in Idaho; 3) determine the concentrations of mercury, other heavy metals, organochlorines, and polychlorinated biphenyls (PCBs) in the livers of river otters in Idaho, and to assess any potential correlations between environmental contaminant concentrations and

reproductive parameters; 4) identify populations that are subject to heavy concentrations of environmental contaminants, thus determining geographic areas of concern; and 5) provide the DSA and the Department with information on the current status of the river otter population in Idaho to provide a foundation for management decisions.

The Department also began to document reported CPUE from trappers submitting their furbearer harvest report forms. With (i) the collection of CPUE data, (ii) the proposal for the present study, (iii) the age and sex structure of the previous 2 trapping seasons' harvest, and (iv) the Department's opinion that the harvest quota is considered conservative, CITES authorities determined that Idaho had developed a management program that will provide for a sustainable population of river otters. In February 2003, CITES authorities approved the river otter export program for the 2002-2003 trapping season. In the fall of 2003, the DSA approved multi-year CITES tags for Idaho. However, to continue to receive CITES tags, the Department must provide an annual report to the DSA on the river otter harvest in Idaho and verify that continued harvest is not detrimental to the river otter population. Accordingly, this study was an important component of the Department's program to manage the river otter as a legally harvested furbearer.

Study Species

The North American river otter is a member of the family Mustelidae, which includes mink (*Mustela vison*), marten (*Martes americana*), wolverine (*Gulo gulo*), weasels (*Mustela sp.*), and others. The river otter is a medium-sized, semi-aquatic, opportunistic carnivore, with morphological adaptations for life in an aquatic ecosystem. Adult river otters are 890-1370 mm in length (Melquist and Hornocker 1983, Patton,

personal observation), with the tail accounting for 35-40% of the total (Melquist and Hornocker 1983, Patton, personal observation). Weight ranges from 3.4 to 15.4 kg for animals in the wild, with 6 adult females from central Idaho averaging 7.9 kg (Melquist et al. 2003). Sexual dimorphism in size occurs among most subspecies of the river otter (Harris 1968, van Zyll de Jong 1972 (both *in* Melquist et al. 2003). Melquist and Hornocker (1983) reported adult males were significantly larger than females. The authors reported that disparity was greatest for total length, and progressively less for tail length, hind foot length, and ear length.

The river otter's legs are short, with longer hind legs, and thus river otters exhibit the typical humped-back gait of mustelids (Melquist et al. 2003). The river otter pelt is characterized by short, dense, soft hair protected by longer, stiff guard hairs (Melquist et al. 2003). Color ranges from dark brown to a pale chestnut dorsally and light brown to silver gray ventrally (Obbard 1987). The river otter's diet consists of approximately 90% fish (Toweill and Tabor 1982), but this can vary by region and prey diversity. Other prey items include crayfish (*Cambarellas sp*., *Cambaras sp*.), aquatic invertebrates, frogs (*Rana sp*.), and, at times, injured birds and muskrats (*Ondatra zibethicus*) (Melquist and Dronkert 1987). River otters have an acute sense of hearing, smell, and touch. Long vibrissae assist in finding prey in murky waters, and plantar pads on the feet aid in traction and scent marking (Buskirk et al. 1986).

Once widespread in North America, populations of river otters decreased during the 19th and 20th centuries, due to overharvest, habitat loss, and pollution (Toweill and Tabor 1982, Melquist and Dronkert 1987). Overharvest may have been particularly detrimental during the 19th century (Armstrong 1972 *in* Melquist and Dronkert 1987).

Since the 1970s, reintroduction projects, wetlands preservation, and better wildlife management techniques have improved populations throughout the U. S. (Melquist et al. 2003).

Reproduction

The river otter is a seasonal breeder that exhibits delayed implantation (Hamilton and Eadie 1964) of the developing ball-shaped embryo, specifically known as arrested development of the blastocyst. Blastocysts are semitransparent spheres measuring about 1 mm in diameter (Hamilton and Eadie 1964; Polechla, personal communication; Patton, personal observation). The blastocysts float freely in the bicornuate uterus for 9-11 months before eventually implanting in the endometrium.

Females reach sexual maturity at 1 to 2 years of age, depending on geographic location. Studies from Arkansas and British Columbia reported river otters breed beginning at 1 year old (Melquist et al. 2003). Based on data from captive otters, Liers (1951) reported females do not breed until age 2 years. Hamilton and Eadie (1964) found female otters in New York probably did not mate until spring at the end of their second year. Hamilton and Eadie (1964) concluded from their data that otters in New York mate in March or April, and that the developing embryo remains in the unimplanted blastocyst stage until January or early February, when implantation takes place. Polechla (1987) reported that implantation occurred in December in 60% of the otters from his Arkansas study.

Parturition date is variable and depends, to some degree, on geographic area (Harris 1968 *in* Melquist and Hornocker 1983). Liers (1951) reported a variable period from first mating to birth of young of 9 months 18 days to 12 months 15 days in his

captive otters. A study in Oregon (Tabor 1974) documented otters giving birth in April. Melquist and Hornocker (1983) reported parturition in late March or early April, about 11 months after copulation. This information compares favorably to Hamilton and Eadie (1964) who reported the young born in March or April. Post-partum estrus is said to begin immediately after parturition and lasts 42-46 days (Hamilton and Eadie 1964, Lauhachinda 1978). Breeding occurs 3-4 weeks after parturition.

Sexual maturity in males occurs at 2 years of age, but reproductive success occurs later. Tabor (1974) reported that wild male river otters do not produce mature spermatozoa (hereafter referred to as sperm) as juveniles; however, Polechla (1987) reported 10.6% of juveniles (age 8-20 months) from a population in Arkansas with mature sperm. However, males may not become successful breeders until 3-5 years of age because of the shape of the baculum or os penis (Liers 1951, Hamilton and Eadie 1964). The baculum is the ossified structure inside the mature penis of the river otter. As the male river otter matures, the baculum changes from a J-shape, to a hockey-stick shape, with the final shape of the baculum approaching an S-shape (Melquist et al. 2003). Liers (1951) suggested that as the baculum reaches the more mature shape, it more readily stimulates the female to ovulate. Males are polygamous and do not help in the rearing of the pups.

Habitat

Year-round habitat use by river otters generally has been associated with streams more than with lakes, reservoirs, and ponds (Melquist and Hornocker 1983). Otters occurring in mountain habitats predominately use valley habitat, especially favoring lowland marshes, swamps, and bogs interconnected with meandering streams and lakes

(Melquist and Hornocker 1983). Mack et al. (1994) reported that river otters along the Clearwater River in north-central Idaho preferred large riprap, natural rock, and sand substrates for latrine sites and for den sites.

River otters give birth in dens, often using beaver bank dens or lodges, natural rock formations, or man-made structures (Melquist and Hornocker 1983). Mack et al. (1994) reported 63% of river otters studied in the Clearwater River drainage used rock cavities as den sites; of those sites, 43% were manmade rock structures. Mack et al. (1994) reported railroad (24.2%) and highway (19.4%) riprap, natural rock (19.4%), and vegetation (12.9%) as the most common den sites. The same study reports that river otters along the Potlatch River, a tributary of the Clearwater River, tended to use dens more associated with denser vegetation, organic substrates, river eddies, and slough waterways. The authors attribute the difference in habitat use to a difference in available habitat.

River otters need riparian vegetation adjacent to wetlands for forage sites and cover. River otters tend to make only limited use of exposed areas with sloping shorelines, such as reservoirs (Melquist and Hornocker 1983). Logjams, also used frequently by river otters, serve as excellent forage, feeding, rest, and cover sites (Melquist and Hornocker 1983).

Many studies have reported the importance of beaver habitat and activities to river otters (Polechla 1987; Melquist and Hornocker 1983). In Idaho, there is much overlap between river otter habitat and beaver habitat. Melquist and Hornocker (1983) reported that 38% of resting sites used by instrumented otters were beaver bank dens and lodges. Mack et al. (1994) found beaver sign in 60% of river otter latrine sites and at 21% of den

sites. Polechla (1987) reported that 5 out of 6 radio contacts of otters were either in beaver lodges or in the immediate vicinity of beavers.

Home ranges of river otters are often described linearly, because of the otters' use of rivers and creeks. Melquist and Dronkert (1987) reported movements by mature males as great as 78 km with female river otters ranging less, up to 35 km in stream length. Mack et al. (1994) reported estimated annual home range lengths from 15.5-148.3 km, with mean estimates for males (106.3 km) greater than those of females (25.5 km). Male river otters tended to have larger spring and summer home range lengths while female river otters tended to have larger home range lengths during summer and fall (Mack et al. 1994). Erlinge (1968) reported that throughout the year, male European river otters (*Lutra lutra*) (with the exception of pups in family groups) travel longer distances than female river otters.

Bioindicator Species

The integrity of an ecosystem may be measured by the health of its vertebrate carnivore populations (Zielinski and Kucera 1995). Because of their trophic position and sensitivity to both availability and toxicity of certain environmental contaminants (Wren et al. 1986), the river otter is referred to as an indicator species of healthy aquatic ecosystems (Aulerich and Ringer 1979, Melquist and Dronkert 1987, Melquist et al. 2003). In fact, a group of scientists in British Columbia ranked the river otter as the top mammalian indicator species of chemical contamination in the aquatic component of the Fraser River Basin (Moul et al. 1996). Their study based this rank on the otters' ability to meet criteria linked to natural history, such as its habitat, home range size, and diet.

A bioindicator can reflect biological, chemical, or physical attributes of ecological condition, providing useful information on contaminant levels in organisms lower on the aquatic food chain. Otters are also referred to as a "flagship species" for wetlands and aquatic habitats (Foster-Turley 1996 *in* Melquist et al. 2003). Flagship species are species selected to act as a symbol for a specific habitat or represent an environmental cause. By conserving a flagship species, or its habitat, the status of other species that share the same habitat may be improved.

Materials and Methods

Study Area

River otter carcasses were collected statewide from every Departmental administrative region (Fig. 1.4); therefore, a brief description of the state of Idaho is provided.

Idaho comprises 3 principal ecoregions, described in McNab and Avers (1994) as follows. Sections are a further subdivision of the ecoregions.

Northern Rocky Mountain Forest-Steppe-Coniferous Forest-Alpine Meadow Sections: Okanogan Highlands, Flathead Valley, Bitterroot Mountains

Middle Rocky Mountain Steppe-Coniferous Forest-Alpine Meadow Sections: Idaho Batholith, Challis Volcanic, Beaverhead Mountains, Blue Mountains

Southern Rocky Mountain Steppe-Open Woodland-Coniferous Forest-Alpine Meadow Sections: Overthrust Mountains, Yellowstone Highlands

More than half of Idaho is mountainous, and much of the remainder is plateau, deeply incised by canyons. Elevations range from a low of 225 meters above sea level at Lewiston to 3860 meters at the summit of Mount Borah in the Lost River Range (Ross and Savage 1967). Figure 1.5 depicts the various land types and uses throughout Idaho.

The northern part of the state is influenced by wetter climates, grading into drier climates to the south. Extensive areas of southern Idaho average less than 200 millimeters of precipitation per year, whereas small areas in the higher portions of the Bitterroot Mountains are believed to receive nearly 1780 millimeters annually (Ross and Savage 1967).

Native vegetation zones of Idaho include the semi-arid sagebrush and prairie zone at the lowest elevation. Timbered zones predominate at intermediate elevations. And the alpine zone occurs at the very highest elevations. There are 11 major river drainage basins throughout Idaho. These basins are extremely variable in geology and geography.

Sample Collection

River otter carcasses were collected from licensed trappers during the 2002-2003 and 2003-2004 trapping seasons through regulations added by the Commission to the Department's mandatory furtaker harvest report. Legally harvested river otters (skinned) and incidentally captured river otters (not skinned) were surrendered. Carcasses were surrendered to Department personnel in the region in which the animal was taken.

Carcasses were frozen soon after surrender and stored at the regional office until I was able to coordinate the delivery of the carcasses to the State Wildlife Health Laboratory (hereafter referred to as Wildlife Laboratory) in Caldwell, Idaho. When the carcasses arrived at the Wildlife Laboratory, they were placed in large garbage bags, 1 specimen per bag, and were kept frozen until time of necropsy. Carcasses were labeled with the following information: date of harvest, location of harvest (administrative hunt unit and body of water), sex, and either the state tag number (prior to DSAs approval of Idaho's river otter export program in February 2003) or a CITES tag. Otter carcasses were also given a unique identification number and a laboratory necropsy number.

Carcass Analysis

Carcasses were thawed in a refrigerated cooler for approximately 2-3 days prior to the gross necropsy. Before each necropsy, all harvest and trapper data were recorded on a necropsy data sheet, including the trapper's name, whether the river otter was a target animal or a nontarget animal, harvest location, and harvest date. During the first year necropsies were conducted, training and assistance in necropsy procedures were provided by Dr. Paul Polechla, Jr. (University of New Mexico).

Upon removal of the carcass from the garbage bag, the river otter was laid on its sternum on top of a measure tape attached to the necropsy table. The carcass was placed carefully to align the vertebral column with the measure tape. Each river otter was measured from the tip of the nose to the tip of the last caudal vertebrae. The lengths of the total carcass, the tail, the right hind foot, and the right ear were measured in millimeters. Weights of carcasses were measured in pounds and then converted to kilograms. An external examination for gross abnormalities and ectoparasites was

performed on each carcass. The mouth and teeth were examined for wear and trauma. River otters were examined for scars or wounds, especially on the appendages. Toes, claws, and foot pads were closely examined, and conditions were noted.

The necropsy began with a mid-ventral incision through the abdominal wall along the linea alba, starting at the groin and extending upward to the tip of the sternum. The flaps of the abdominal wall were then retracted. Before removal of any samples from the carcass, the organs were observed *in situ*, enabling me to assess any gross abnormalities. If abnormalities were observed, the abnormal organs were preserved in 10% formalin and saved for histological examination. Histological procedures were conducted by Dr. Stewart Lincoln, DVM, at the University of Idaho's Caine Center in Caldwell, Idaho. Livers were frozen and shipped to the Analytical Sciences Laboratory at the University of Idaho, Moscow, Idaho, for toxicological procedures, discussed in Chapter 2.

Age Determination

To obtain teeth to determine age, river otter carcasses were decapitated and the heads were stored frozen. Entire skulls were later simmered in a hot water bath for at least 2 hours to soften the tissue and loosen the teeth to allow for extraction. One lower or upper canine tooth was extracted per river otter by using a dental extractor and dental elevator. Teeth were subsequently sent to Matson's Laboratory in Milltown, Montana for aging by cementum annuli analysis and an assignment of a confidence level of the age. Natural aging results in a cyclic nature of cementum growth, which results in an annular pattern of "rings" in the tooth, similar to what is seen in trees.

Stomach Contents

During the first season, stomach and gastrointestinal contents were emptied and stored in wide-mouth Nalgene specimen jars containing 10% formalin. General stomach contents were recorded, e.g. fish, bones, dirt, debris. Contents were not analyzed but were shipped to Washington State University (WSU) for a parasitological study. Beginning with the second season, entire stomachs, gastrointestinal tracts, and lungs were frozen in 1-gallon Ziploc bags. These samples were also provided to WSU for the same parasitological study. Most otters were free of parasites (W. J. Foreyt, Washington State University, personal communication).

Body Condition

River otter body fat was recorded primarily for descriptive purposes, but also to provide a general indication of health at the time of harvest. River otter body fat content was determined by a ranking system in which fat content was recorded as light, moderate, or heavy in the following physical locations: mesentery, adrenal glands, and kidneys (P. Polechla, University of New Mexico, personal communication). Fat is most prominent at the base of the tail and on the rear legs caudally. Photos were taken with a digital camera to document these rankings in an attempt to minimize subjectivity.

I used the methods of Kruuk et al. (1987) to estimate body condition index on 196 river otters. Kruuk et al. (1987) established a relationship of body condition (*K*) as a function of weight and length.

$$K = W/ (aL^n)$$

Kruuk et al. (1987) also estimated parameters for female river otters as being a = 5.02 and n = 2.33 and estimated parameters for male river otters as being a = 5.87 and n = 2.39. Using Kruuk's estimates for a and n, I calculated body condition index (K) for each of the 196 river otters. Forty-one river otters did not have either length or weight recorded, because of missing tails and/or heads and/or degradation of carcass.

Organ (spleen, heart, and lungs) weights in relation to overall body mass can also serve as an index of body condition. Organ weights were taken near the end of the 2nd season on approximately 30 river otters.

DNA Samples

Tissue samples, approximately 8 cubic mm from the spleen, kidneys, heart, lung, skeletal muscle, and liver, were excised with surgical scissors previously sanitized in Nolvasan, placed in a 1.5 ml cryovial, and stored in deep freeze at -77° F. The tissue samples were collected for future genetic studies and will not be discussed further in this paper.

Reproductive Tracts

Reproductive tracts from all individuals were completely excised and examined to determine reproductive status.

Males

Testes were excised from male river otters, and the epididymides were then dissected from the testes (P. Polechla, personal communication). Length and width of testes were measured to the nearest 0.1 mm. A longitudinal cut was made on both the left and right epididymis and a smear made from each. Smears were then examined at 400x

magnification for presence of mature spermatozoa (P. Polechla, personal communication). Testes were then stored in 10% formalin.

Females

Ovaries were excised from the ovarian bursa. Length of each ovary was recorded to the nearest 0.1 mm, and weight was recorded to the nearest 0.1 gram. Each ovary was sliced at 1 mm intervals along the long axis without severance so that the sections remain joined along the mesovarian edge (P. Polechla, personal communication). Ovaries were then examined under a dissecting scope so corpora lutea could be counted. Counts of corpora lutea provide counts of ova shed but cannot provide accurate counts of future embryos because of the possibility of intrauterine mortality.

Because implantation of the blastocyst is delayed in river otters, blastocysts will be present in the uteri of reproductively active females during the period that river otters are trapped in Idaho (November 1 – March 15). Blastocysts can easily be flushed from uteri and counted, providing a count of embryos harbored in each female.

After the ovaries were severed from each oviduct, a syringe was inserted into each uterine horn and blastocysts were flushed from the corresponding uterine horn with a 0.9% saline solution (P. Polechla, personal communication) and collected in a Petri dish. Prior to flushing, the opposite uterine horn was tied off with a piece of string to prevent flushing both horns at one time. The process of flushing was then repeated with the other uterine horn. Blastocysts are visible with the naked eye but were counted under a dissecting scope to distinguish them from possible debris. When swelling was observed in the uterus, each uterine horn was sliced open longitudinally and examined for the presence of embryos (M. Drew, Idaho Department of Fish and Game, Wildlife

Laboratory, personal communication). Embryos were removed and stored in 10% formalin. Sex was determined if the fetus was developed sufficiently; the gender of an embryo greater than 37 mm long can be identified by location of external genitalia and presence or absence of nipples (Melquist et al. 2003).

Results

Preliminary statistical analyses attempted to discern differences among administrative regions. However, because of small sample sizes at the level of some administrative regions, regions were pooled as follows: Northern Idaho (Panhandle and Clearwater administrative regions); Southwestern Idaho (McCall, Southwest, and Magic Valley administrative regions); and Eastern Idaho (Southeast, Upper Snake, and Salmon administrative regions).

For some of the river otters, complete data were not received or I was unable to collect all of the data from the carcasses. Therefore, the number of individuals in the various analyses or examinations varies.

The software package, STATISTICA (Tulsa, Oklahoma), was used for all statistical analyses.

Sex Ratio

During the 2002-2003 and 2003-2004 trapping seasons, 237 river otters were collected; 120 were collected the first season and 117 were collected the second season. Of the otters collected in 2002-2003, 59 (49.2%) were male, and 61 (50.8%) were female. In 2003-2004, 60 (51.3%) were males and 57 (48.7%) were females. No significant difference from a 1:1 sex ratio (x^2 Goodness of fit test; $P > 0.05$) existed within each year

or between the two trapping seasons. However, the sex ratio of collected individuals with known age for the combined 2002-2003 and 2003-2004 trapping seasons differed substantially among age classes. Among the 61 juveniles harvested, 42.6% were male and 57.3% were females. Among the 65 yearlings harvested, 53.8% were male and 46.2% were female. Among the 101 adults harvested, 53.5% were male and 46.5% were female.

Age Structure

The age structure of harvested otters did not differ significantly between the two trapping seasons ($P > 0.05$; Kolmogorov-Smirnovs test). Therefore, the following discussion will reflect the two years of combined data.

Of the individuals that could be aged, collected otters were primarily juveniles ($n = 61$ or 27%), yearlings ($n = 65$ or 29%), and 2-year-olds ($n = 38$ or 17%). Adults older than 2 years ($n = 63$) made up 27% of the harvest (Fig. 1.6). This compares favorably to previous trapping seasons in Idaho. During the 2001-2002 trapping season, juveniles constituted 35% of the harvest, while yearlings made up 21%. During the 2000-2001 trapping season, juveniles constituted 26% of the harvest, while yearlings made up 30%. During the 2002-2003 trapping season, 27 (22.5%) were juveniles, 38 (31.7%) were yearlings, and 19 (15.8%) were 2-year-olds. During the 2003-2004 trapping season, 34 (29.1%) were juveniles, 28 (23.9%) were yearlings, and 19 (16.2%) were 2-year-olds. Figure 7 depicts harvest by age in years.

General Morphology

Table 1.3 depicts standard measurements of collected river otters. Adult males were significantly larger than adult females in total length (t-test: $t = 3.85$, 81 df, $P < 0.01$) and foot length (t-test: $t = 4.07$, 59 df, $P < 0.01$) but not in tail length (t-test: $t = 1.69$, 82 df, $P > 0.05$) or ear length (t-test: $t = 1.56$, 9 df, $P > 0.05$). Yearling males were significantly larger than yearling females in total length (t-test: $t = 3.6$, 55 df, $P < 0.01$), tail length (t-test: $t = 2.7$, 55 df, $P < 0.01$), and hind foot length (t-test: $t = 2.6$, 40 df, $P < 0.05$), but not in ear length (t-test: $t = .01$, 12 df, $P > 0.05$). There were no significant differences between juvenile males and juvenile females in any of the standard body measurements.

Body mass of male and female juveniles is similar, but males are significantly heavier than females as yearlings (t-test: $t=-3.6$, 48 df, $P< 0.01$) and adults (t-test: $t=5.01$, 78 df, $P<0.01$) (Fig. 1.8).

Mean standard body measurements are comparable to results from a central Idaho study (Melquist and Hornocker 1983) for all age classes. Total body length from this study is comparable to results from previous studies (Hall 1981, Melquist and Hornocker 1983), with a range from 944.0 mm to 1352.0 mm. Overall weight is also comparable to previous studies (Hall 1981, Polechla 1987) with a mean skinned weight of 7.12 kg (3.24-11.15, s.d. $\pm$1.6) and a mean unskinned weight of 10.1 kg (6.67-13.35, s.d. $\pm$1.94).

Body Condition Index

The mean body condition index (K) for adult male river otters was 0.97 (n=44) and 1.0 (n=35) for adult female river otters. There was no significant difference in body condition between male and female adult river otters in K (t-test: $t=1.26$, 77 df, $P=0.2$).

There were significant differences in *K* between male and female juvenile otters (t-test: *t*=3.1, 52 df, P< 0.01), with the mean *K* for male juveniles being 0.82 (*n*=23) and the mean *K* for female juveniles being 0.93 (*n*=31). There were also significant differences between male and female yearling otters (t-test: *t*=2.6, 53 df, *P*=0.01), with the mean *K* for female yearling otters at 1.01 (*n*=25) and the mean *K* for male yearling otters at 0.92 (*n*=30). Overall (all age classes combined), female river otters had a significantly higher body index (*K=0*.99, *n*=96*)* than male river otters (*K*=0.92, n=99) (Fig. 1.9).

There is a significantly lower body condition index (*K*) in river otters harvested in the Clearwater region (*K* = 0.87, *P*=0.039, ANOVA). The range statewide is 0.87 – 1.01, with the highest body index in river otters harvested from the Salmon region. When compared on a geographic level, *K* is significantly less in the northern region of the state (*K* =0.89, *P*=0.0, ANOVA) than in the eastern region of Idaho (*K*=0.98, *P*=0.03, ANOVA) or the southwest region (*K*=0.96, *P*=0.047, ANOVA) (Fig.1.10).

Body condition index was significantly lower in juveniles from the northern region of Idaho (*K*=0.74, *P*<.01, ANOVA) than in juveniles from the eastern region (*K*=0.92) and the southwestern region (*K*=0.89) (Fig. 1.11).

Kruuk et al. (1987) reported *K* varying significantly from 1.05 in November-December to 0.77 in May-June, noting that otters were significantly lighter in summer. Because all of my samples were from the same period (November-March), a comparison of *K* among seasons is not possible. However, the range of *K* compares favorably to Kruuk et al. (1987) with a minimum *K* of 0.52 and a maximum body index of 1.46. The lowest *K* was from a juvenile female otter from the southwest region (Elmore County), and the highest *K* was from an adult male from the southwest region (Owyhee County).

Mean weights for the following river otter organs weighed are: spleens (*n*=33) 42.7 (22g – 75.6g); hearts (*n*=32) 141.8 (56.7g – 255.2g); and lungs (*n*=32) 227.2 (85.1g – 354.4 g). There were no significant differences between sexes or among age classes for any organ weights.

Reproductive Parameters

Males

Of the adult (> 2 years) male otters examined (*n* = 54), 68.5% (*n* = 37) contained mature sperm in their epididymides. Eight (14.8%) adult male otters did not contain sperm, and 9 (16.7%) were unknown. Degradation and decomposition of many specimens may have resulted in the loss of sperm or the inability to detect sperm. Even histological procedures could not detect sperm in some specimens, possibly because of the degree of decomposition prior to freezing of the carcass, or improper preservation of the carcass. Of the 35 yearling (1-2 years) male otters examined 88.6% (*n* = 31) contained sperm in their epididymides. Three (8.6%) yearling male otters did not contain sperm, and 1 (2.9%) was unknown. Of the 26 juvenile (< 1 year) male otters examined, 38.4% (*n* = 10) contained sperm in their epididymides. Nine (34.6%) did not contain sperm, and 7 (26.8%) were unknown.

Adult male otters had an average testis weight of 6.4 g (range =1.38 g to 17.42 g). Yearling male otters had an average testis weight of 4.6 g (range = 0.7 g to 12.2 g). Juvenile male otters had an average testis weight of 0.66 g (range = 0.3 g to 1.03 g). Average testes weight varied significantly among all age classes *(P* = 0.006, One-way ANOVA) (Fig. 1.12). The oldest male river otters harvested were 10 years old (n=3). Of

these, 1 had sperm present, and 2 did not. There were no significant differences in average testis weight among the same age classes between geographic regions.

Females

Of the total number of female otters with the presence of either corpora lutea (ovulation rate) or blastocysts (potential litter size), 88% were adults and 12% were yearlings. Of the adult (> 2 years) female otters (*n*=47), 76.6% (*n*=36) showed signs of ovulation based on evidence of corpora lutea on the ovaries (Table 1.4). Of these 36 ovulating females, 17 (47%) had 1 corpus luteum, 16 (44%) had 2 corpora lutea, and 3 (8.3%) had 3 corpora lutea. Ten adult female otters (21.3%) did not show evidence of ovulation. One otter was recorded as unknown because of desiccation of the ovaries to the degree that they could not be sliced open and examined.

Of the yearling female otters (*n*=30), 4 (13%) showed evidence of ovulation, 25 (83.3%) did not show evidence of ovulation, and 1 (3.3%) was undetermined. Of the 4 yearling female otters that had ovulated, 1 (3.3%) otter had 1 corpus luteum, 1 (3.3%) otter had 2 corpora lutea, and 3 (6.7%) had 3 corpora lutea. No corpora lutea or evidence of ovulation was found in any juvenile female otters (*n*=34), and no blastocysts were found in any juvenile female otters (*n*=33).

From the sample of adult female otters (*n*=47), 63.8% (*n*=30) had free-floating blastocysts, confirming they were pregnant. Of the 30 confirmed pregnant female otters, 12 (40%) were documented with 1 blastocysts, 10 (33.3%) were documented with 2 blastocysts, 7 (23.3%) were documented with 3 blastocysts, and 1 (3.3%) was documented with 4 blastocysts. Of the 30 yearling female river otters, 26 (86.7%) were documented with no blastocysts, and 2 otters (6.7%) were documented with 2 blastocysts.

Two yearling female otters were reported as undetermined due to both degradation and decomposition of the ovaries or lack of confidence by the author to report.

The mean number of corpora lutea for adult female river otters (*n*=47) was 1.6 (0-3.0, S.D. =.0.69). The mean number of blastocysts for adult female river otters (*n*=45) was 1.6 (0-4, S.D. = 1.08). The mean number of corpora lutea for yearling female river otters (*n*=29) was 0.31 (0-3, S.D. =0.85), and the mean number of blastocysts was 0.14 (0-2, S.D. = 0.52).

The mean ovulation rates for river otters, based on corpora lutea counts, have been reported as 2.4 (Hamilton and Eadie 1964), 3.05 (Tabor 1974), 3.02 (Tabor and Wight 1977), 2.9 (Lauhachinda 1978), 2.74 (Mowbray et al. 1979), and 3-3.67 (Polechla 1987). In the present study, the mean number of blastocysts for pregnant adults (>1 years) was 1.90. Again, when I included yearling female river otters, the mean number of blastocysts increased during both seasons from 1.87 to 1.88 (2002-2003) and from 1.93 to 2.0 (2003-2004). This number is less than results from Melquist and Hornocker (1983); these authors reported reproductive rate estimates at 2.4 pups per breeding female in their central Idaho study.

By using ANOVA and Tukey HSD, the mean number of corpora lutea was compared among age classes (juvenile, yearling, adult) with a significant difference between yearling female river otters (mean=0.25) and adult female river otters (mean=1.24, *P*=<.01). When mean number of blastocysts was compared among age classes, there was a significant difference between yearling female river otters (mean=0.14) and adult female river otters (mean=1.2, *P*=<.01). The discrepancy among years of reproductive rates could be attributed to factors such as degradation of ovaries

resulting in the inability to find corpora lutea, possible loss of blastocysts during the flushing process, degradation of the carcass, or my inexperience the first season.

Adult female river otters had significantly larger ovaries than juveniles in all categories of measurements: length ($P<0.001$), width ($P<0.001$), and weight ($P<0.05$) (Fig. 1.13). Adult female river otters also had larger ovaries than yearling female river otters; length and width were significantly different ($P<0.001$ for both), but weight was not significantly different ($P>0.05$). There were no significant differences in overall weight of all female otters' ovaries combined among geographic area ($P > 0.5$) (Fig. 1.14).

Discussion

The primary purpose of the present study was to collect data on Idaho's river otters in order to assist the Department with management decisions. My results suggest the population of river otters in Idaho is stable to increasing. This conclusion is based on two results. First, in the present study, of the river otters in which I was able to determine age, there existed an age structure typical of an increasing population. That is, 26.9% were juveniles and 28.7% were yearlings. Second, 63.8% of adult female otters were pregnant, which is also typical of an increasing population (Dixon 1981).

Earlier studies on river otters (Tabor 1974, Stephenson 1977, Lauhachinda 1978, Mowbray et al. 1979, Anderson and Scanlon 1981) conducted throughout the U. S. and Canada and a later study done in Arkansas (Polechla 1987) combined juveniles and yearlings harvested when reporting percent juvenile to percent adult to determine if populations were declining, stable, or increasing. When I combined the percent juveniles and percent yearlings harvested, an overall 54.2% juvenile to adults were harvested

during 2002-2003 and 53% juveniles to adults were harvested during 2003-2004. This percentage exceeds an Arkansas study (Polechla 1987) that interpreted an overall 44.3% juvenile harvest as indicative of a population that was increasing, and is in agreement with Melquist and Hornocker (1983). A previous study that interpreted juvenile harvest as indicative of a declining population had juvenile harvest levels of 8.2% (Lauhachinda 1978). Studies that reported a stable population documented juvenile harvest at 36.3% (Tabor 1974), 29.9% (Mombray et al. 1979), and 26.0% (Anderson and Scanlon 1981).

Frequency distributions can illustrate age distribution and characteristics of a population and can provide insight relative to the status of populations (Melquist and Hornocker 1983). Increasing populations tend to have a higher proportion of young animals, stable populations have a more even age distribution, and declining populations have a higher percentage of adults (Elseth and Baumgardner 1981). Based on previous studies, with percentages of combined juvenile and yearling otters exceeding 35% reported as indicative of an increasing population, the general pattern of age structure found in the present study is illustrative of an increasing population.

When age structure of harvested otters is compared among geographic areas, the combined percentage of juvenile and yearling age classes in the harvest was 58.5% in the eastern part of Idaho, 59.4% in the southwest, and 39% in the northern area of the state. These data further indicate an increasing population in both the eastern and southwest areas of Idaho, but the northern population is more illustrative of a stable population.

This age distribution compares favorably to previous trapping seasons (2000 – 2004) in Idaho.

Interestingly, four 10-year-old otters, and one 11-year-old otter were harvested during this study. Longevity records from other wild river otter studies vary from 6-7 years of age (Anderson and Scanlon 1981) to 13-14 years of age (Toweill and Tabor 1982). Tabor and Wight (1977) report two otters from Oregon at 11-12 years of age.

Although the results suggest an increasing population, it is important to note the potential for age and gender-bias with trapping. Trapping may under-represent older animals of both sexes (Harding 2002), and, can be biased towards young male otters. While Melquist and Hornocker (1983) suggested their data from central Idaho were indicative of an increasing population, the authors also report a trapping bias towards young male river otters.

Of the pregnant otters (all age groups combined), 88% were adults compared to 12% yearlings. The percentage of younger females pregnant will be lower than that of older females in a population near carrying capacity (Dixon 1981). Therefore, another factor that supports the notion that the population of river otters is stable to increasing is the percentage of pregnant adult females. As a population decreases and there is reduced competition for resources, an increase in younger females becoming pregnant may occur. Based on these assumptions, reproductive parameters from the present study further suggest that Idaho's overall river otter population is stable to increasing.

Sex ratio can have a significant impact on population growth (Elseth and Baumgardner 1981). For example, if male adults outnumber female adults there will be a tendency for population growth to decline because males would compete for resources instead of contributing to reproduction (Elseth and Baumgardner 1981). Despite the age-specific differences that exist in sex ratios of living species, the average ratio tends to

conform to the theoretical value of 1:1 expected on the basis of random chromosome segregation (Elseth and Baumgardner 1981). Other studies conducted throughout North America have found combined age class sex ratios favoring males while others report an overall 1:1 sex ratio. A study in Ontario, Canada, (Stephenson 1977) reported a ratio of 115:100 males to females. Likewise, another study conducted in the northwest region of the U. S. (Tabor 1974) found a sex ratio of 125:100.

The sex ratio of the entire sample found in the present study (all age classes combined) of river otters harvested from 2002-2004, was 100:99, or essentially 1:1. This overall ratio of 1:1 compares favorably to results from the earlier central Idaho study (Melquist and Hornocker 1983), where the authors found a combined sex ratio of 109:100. However, Melquist and Hornocker (1983) reported a sex ratio favoring males for juveniles (unlike my data) and yearlings (favorable to my data), and a greater abundance of females in the adult age class, also favorable to my data. One must consider, however, that Melquist and Hornocker were live-trapping otters rather than kill-trapping, which could account for variations in trap vulnerability.

Sex ratios in the present study varied among age classes. In the present study, male to female ratios in juveniles, yearlings, and adults were 43:57, 54:46, and 53:47, respectively. While numerous studies have reported higher proportions of males, most of these studies were conducted on carcasses turned in by trappers (Hamilton and Eadie 1964, Tabor 1974, Lauhachinda 1978). The higher preponderance of males to females may be attributed to the following factors: 1) males travel farther and have larger home ranges than females (Melquist and Hornocker 1983, Mack et al. 1994), and 2) females

may have a higher mortality rate during postnatal development (from birth to 1 year old) (Polechla 1987).

Management Implications

As previously discussed, based on age distribution and the percentage of juveniles and yearlings represented in the harvested otters, the data reported in the present study suggest river otter populations in Idaho are increasing in most regions and are stable in the northern region. However, an important aspect of obtaining carcasses from trappers is that trapping may under-represent females and older animals of both sexes (Harding 2002) and can be biased towards young male otters. Although Melquist and Hornocker (1983) suggested their data were indicative of an increasing population, the authors also report a trapping bias towards young male river otters. But, studies that I used for comparison were also studies conducted on otter carcasses obtained from trappers, so I can still conclude that river otter populations are stable to increasing, based on the present data.

Harvest data are often the only data many state agencies collect on furbearer species, including the river otter. However, year-to-year harvest data alone can be a poor short-term indicator of population status (Melquist et al. 2003). Harvest data collected over long periods of time are more reliable in depicting general trends in abundance and distribution (Melquist et al. 2003) of furbearer species. Dixon (1981) suggests that the following data are needed to provide accurate status indicators of furbearer species: harvest level, Catch Per Unit Effort (CPUE), age-specific pregnancy rates, litter size, and survival.

Currently, the Department collects only 2 of the above for river otters: harvest data and CPUE. The collection of otter teeth, for age analysis, was discontinued after the research presented here ended. Despite the fact that age distribution is not one of Dixon's indicators, I still encourage the Department to once again periodically collect jaws from otters so that age structure and distribution can be determined with a more accurate indication of the status of the otter population. These data can be important in providing justification for continued CITES export authorization.

Because harvest data and CPUE are currently the primary data collected to determine the status of Idaho's river otter population, I encourage the Department to continue long-term collection of these data to provide insights into river otter population status and trends. I encourage the Department to restart a voluntary surrender of otter jaws to enable the continuation of data collection of age distribution of harvested river otters. Periodic mandatory surrender of jaws should be required if a voluntary program proves futile.

I encourage carcass collection to continue at intermittent years to evaluate long-term trends in reproductive parameters and reproductive rates. Other potential low-cost survey methods could be incorporated into the Department's mandatory harvest report, such as bridge-sign surveys and latrine surveys, which could supplement the harvest data and provide additional data on the status of the river otter population.

Tables and Figures

Table 1.1. River otter population estimates and harvest quotas in Idaho.

Region	Population estimate	1.25% of population (harvest quota)	1.5% of population (maximum allowable harvest)
Panhandle	736	9	11
Clearwater	1,107	14	17
Southwest	2,181	27	33
Magic Valley	1,326	17	20
Southeast	791	10	12
Upper Snake	1,153	14	17
Salmon	753	9	11
Totals	8,047	100	121

Table 1.2. Sex and age structure of harvested river otters during the 2002-2004 trapping seasons in Idaho.

Age class	Males	Females	Male: female ratio
Juveniles	26	35	74:100
Yearlings	35	30	116:100
Adults	54	47	114:100
All age classes	118	119	99:100

Table 1.3. Mean standard measurements (mm) of juvenile, yearling, and adult otters harvested during the 2002-2003 and 2003-2004 trapping season in Idaho.

Age	*Sex*	*N*	*X*	*SD*	*Range*
Total Length					
Juvenile	M	24	1089.3	58.0	948.0-1,224.0
	F	31	1086.0	66.3	910.0-1,215.0
Yearling	M	31	1193.0	63.1	1025.0-1,325.0
	F	26	1130.5	66.7	944.0-1240.0
Adult	M	45	1190.3	74.2	1,060.0-1,352.0
	F	39	1135.1	46.6	1050.0-1265.0
Tail Length					
Juvenile	M	26	406.0	34.88	349.3-482.6
	F	30	409.1	32.9	344.4-463.6
Yearling	M	30	448.9	32.4	400.1-561.3
	F	27	421.4	42.8	289.6-541.5
Adult	M	47	443.1	40.2	342.9-567.0
	F	38	429.9	21.7	393.7-485.8
Hind Foot Length					
Juvenile	M	16	125.8	5.7	115.0-136.0
	F	21	122.6	6.3	107.0-131.0
Yearling	M	22	128.9	9.97	101.6-152.4
	F	20	121.5	7.9	104.8-133.0
Adult	M	37	129.2	7.5	114.0-150.1
	F	25	121.7	5.3	112.0-133.4
Ear Length					
Juvenile	M	2	21.0	0	21.0-21.0
	F	5	21.5	3.7	16.0-25.4
Yearling	M	9	21.8	1.9	20.0-25.0
	F	5	21.8	1.8	19.8-24.0
Adult	M	6	24.0	2.6	21.0-27.0
	F	5	22.0	1.4	21.0-24.0

Sample size varied because some otters were turned in to the Department without heads, tails, feet, or skinned; therefore, it was impossible to get complete measurements. If the head, tail, and/or feet were cut off, total body weight was not taken.

Table 1.4. Reproductive parameters by age class of female river otters harvested in Idaho during the 2002-2004 trapping seasons.

	Adults	**Yearlings**	**Juveniles**
Corpora Lutea	76.6% (n=47)	13% (n=30)	Zero (n=34)
Blastocysts	63.8% (n=47)	6.7% (n=30)	Zero (n=34)

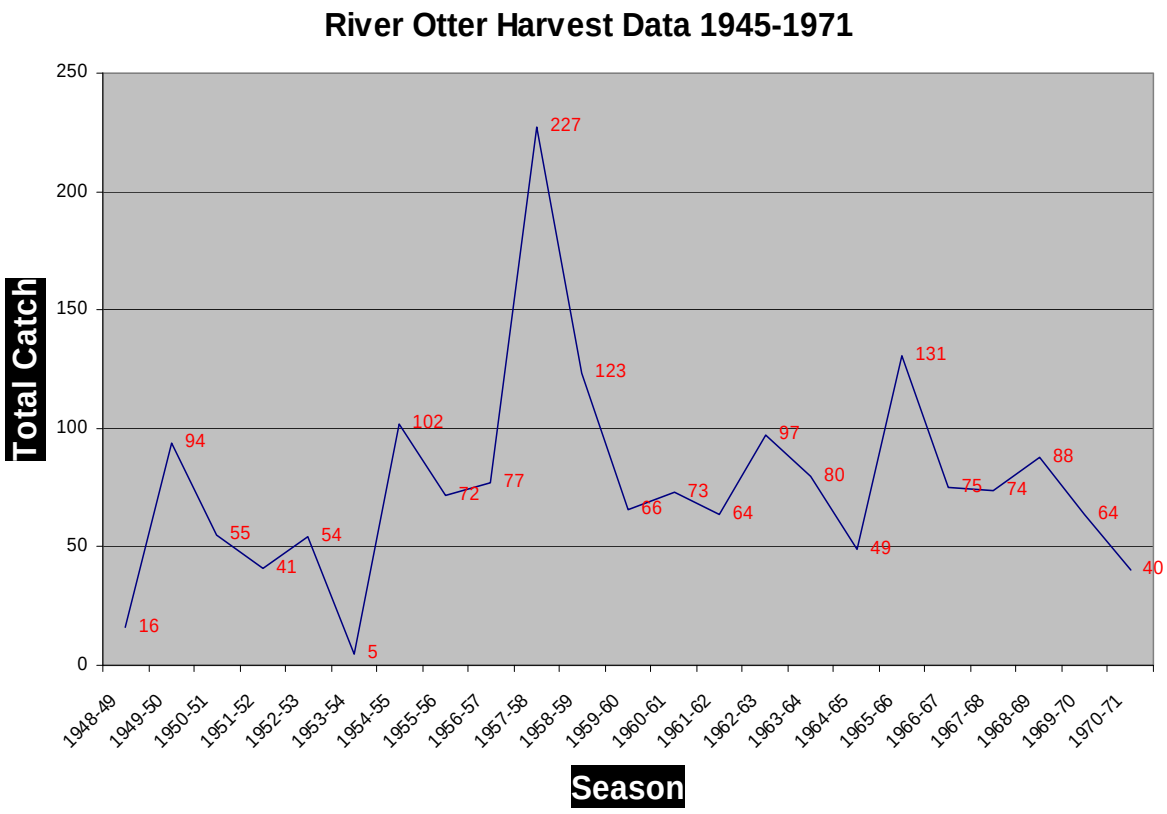

Figure 1.1 River otter harvest in Idaho from 1945-1971.

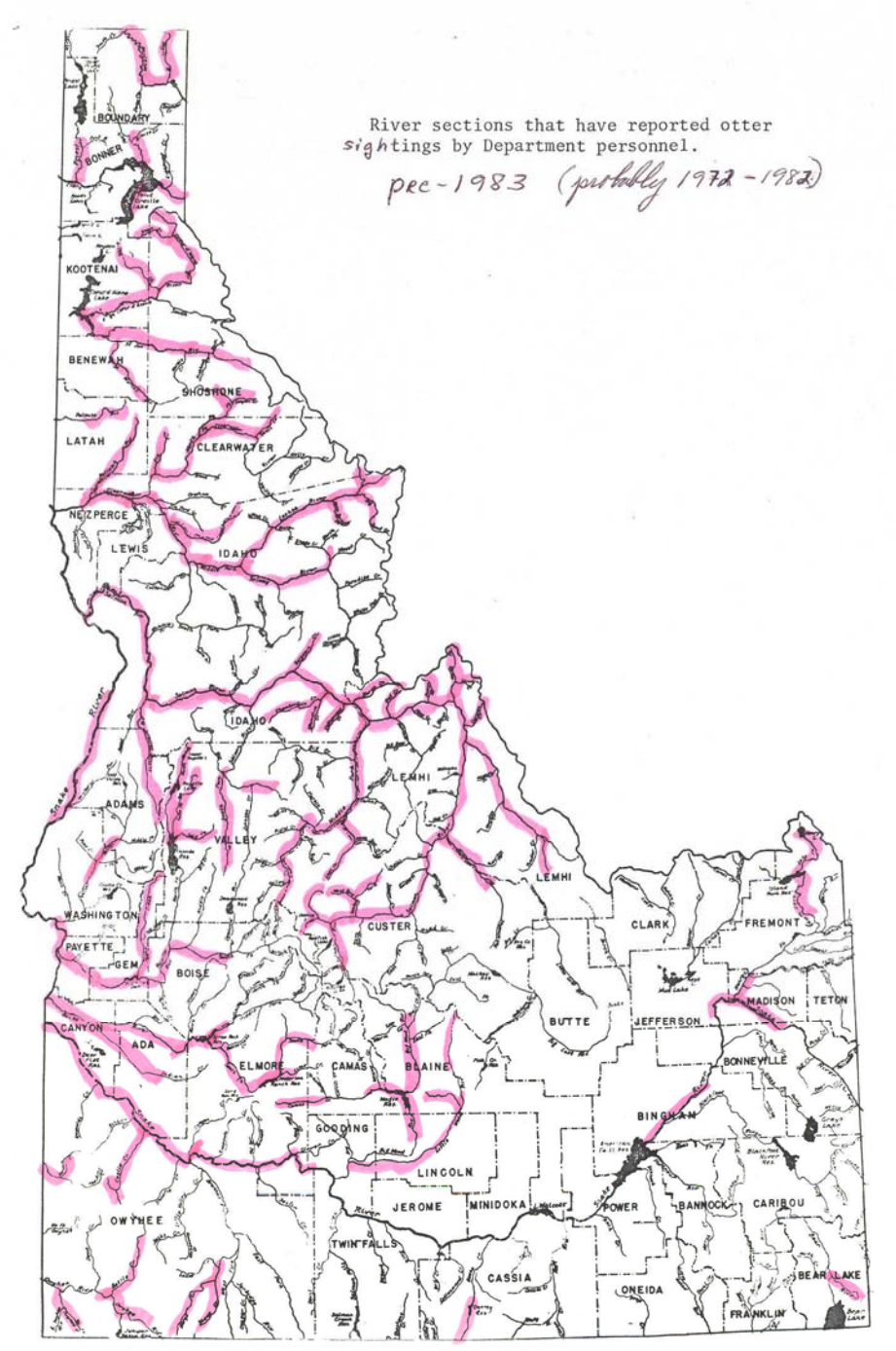

Figure 1.2. Map illustrating sightings of river otters by IDFG personnel pre-1983.

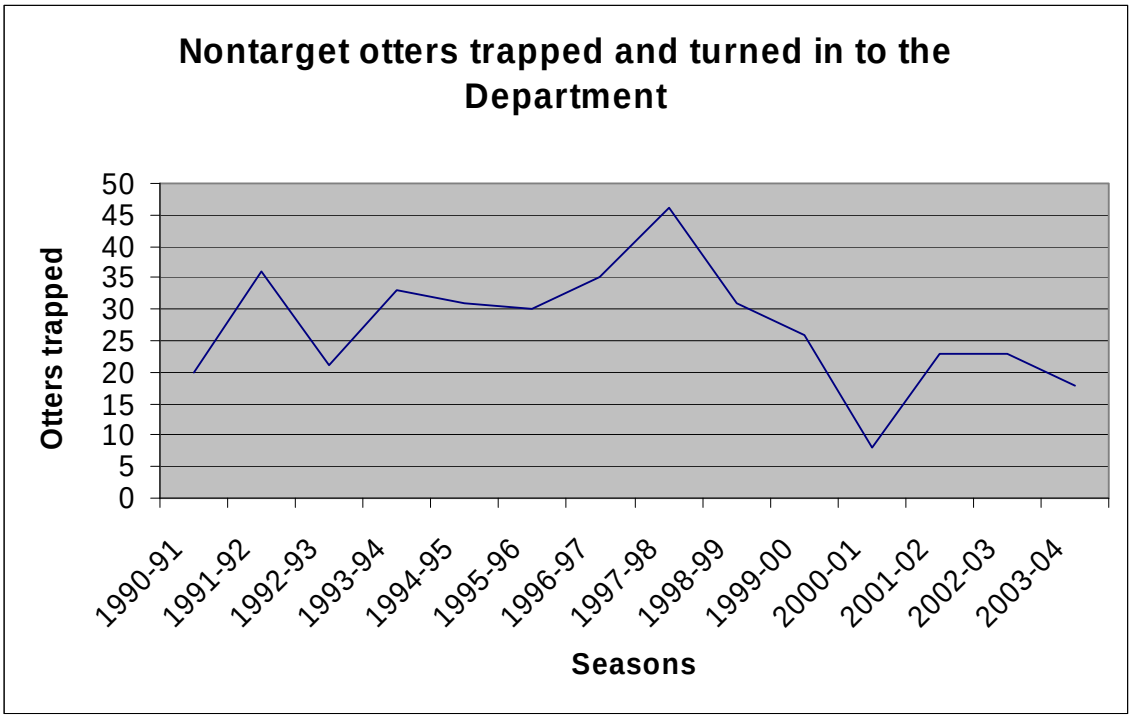

Figure 1.3. Nontarget otters trapped in Idaho from 1990-2004.

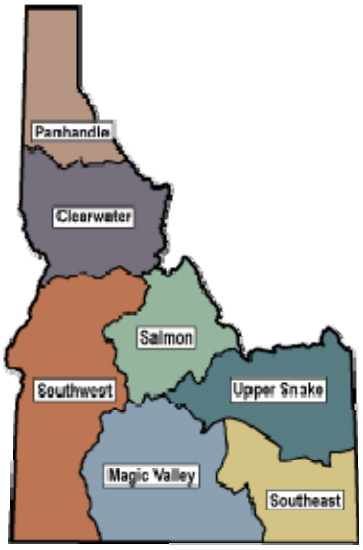

Figure 1.4. Map of Idaho Department of Fish and Game Administrative Regions. Source: Idaho Department of Fish and Game.

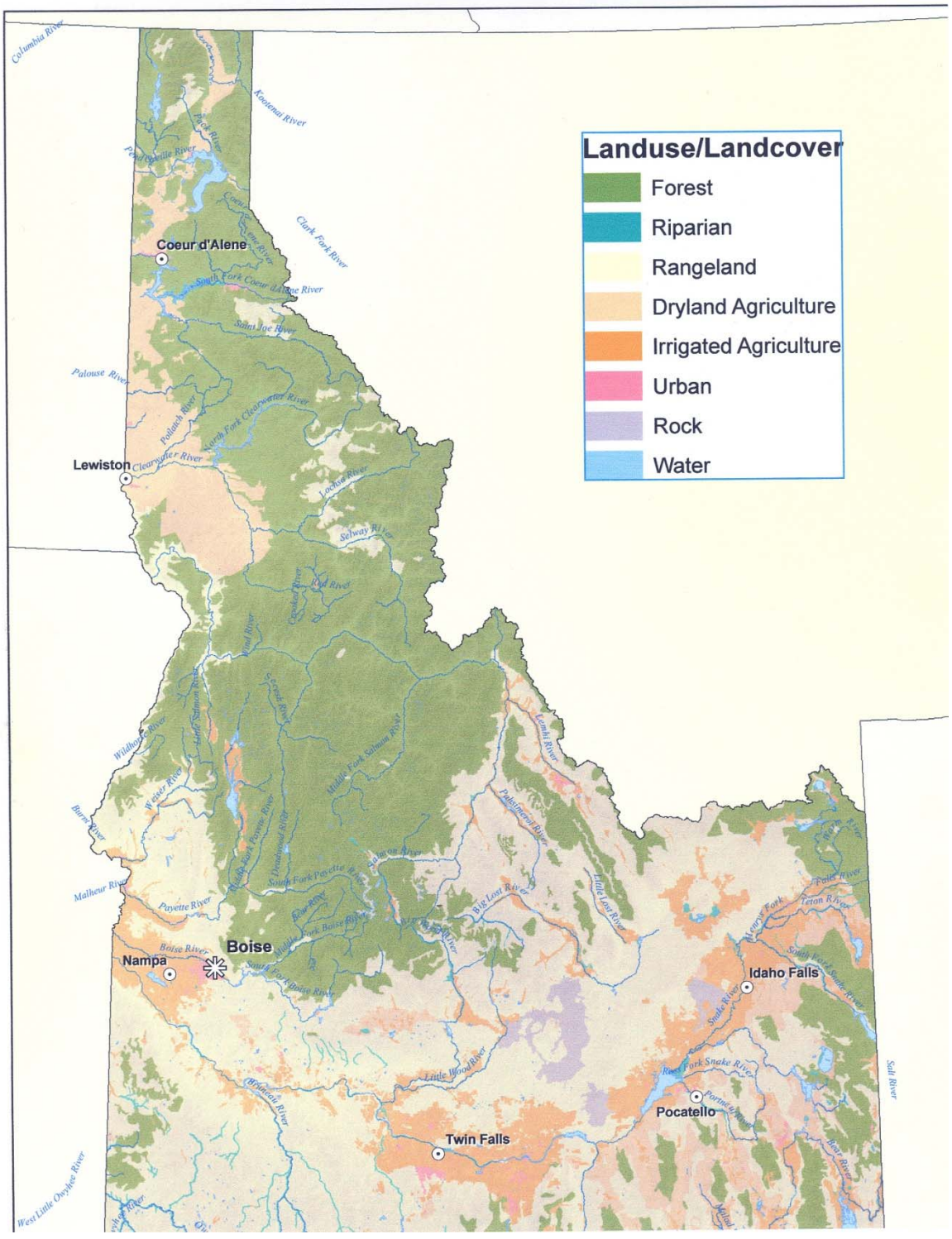

Figure. 1.5. Map of land use and land cover throughout Idaho. Source:Idaho Department of Fish and Game.

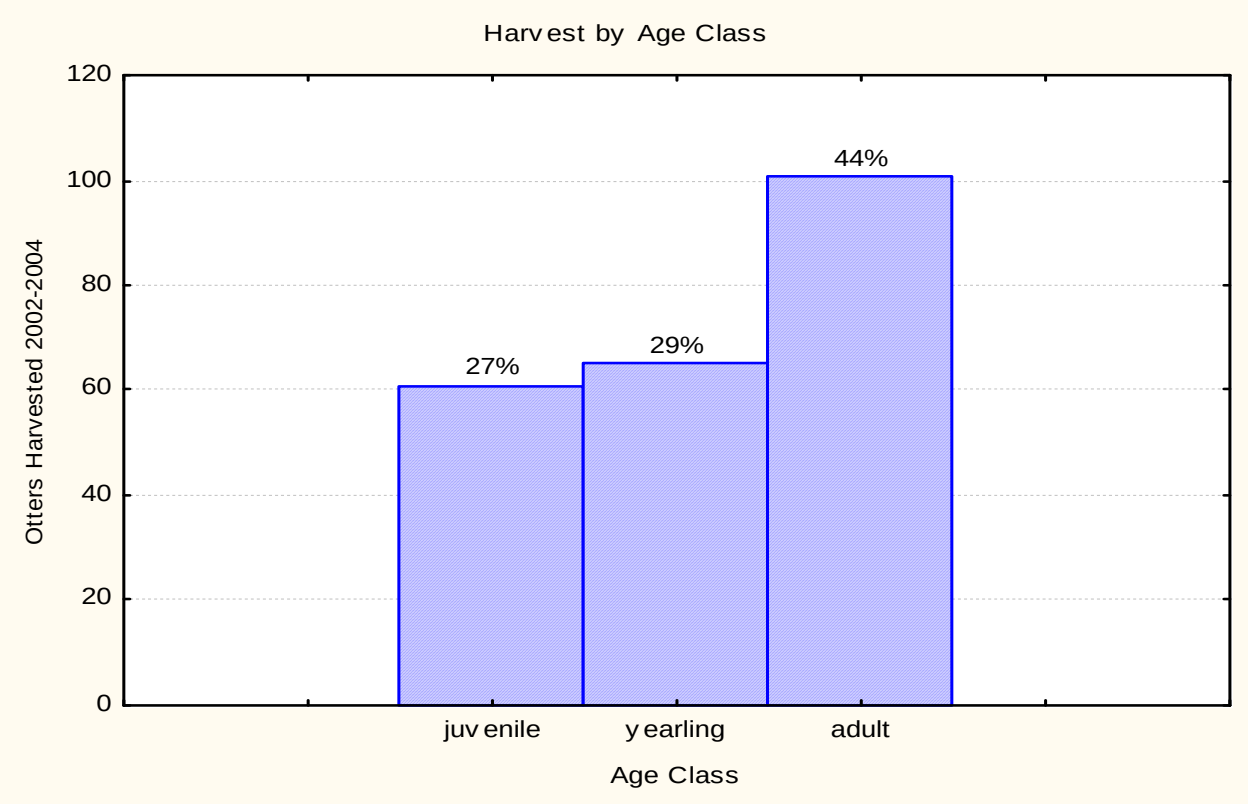

Figure 1.6. Age structure of river otters harvested during the combined 2002-2003 and 2003-2004 trapping seasons in Idaho.

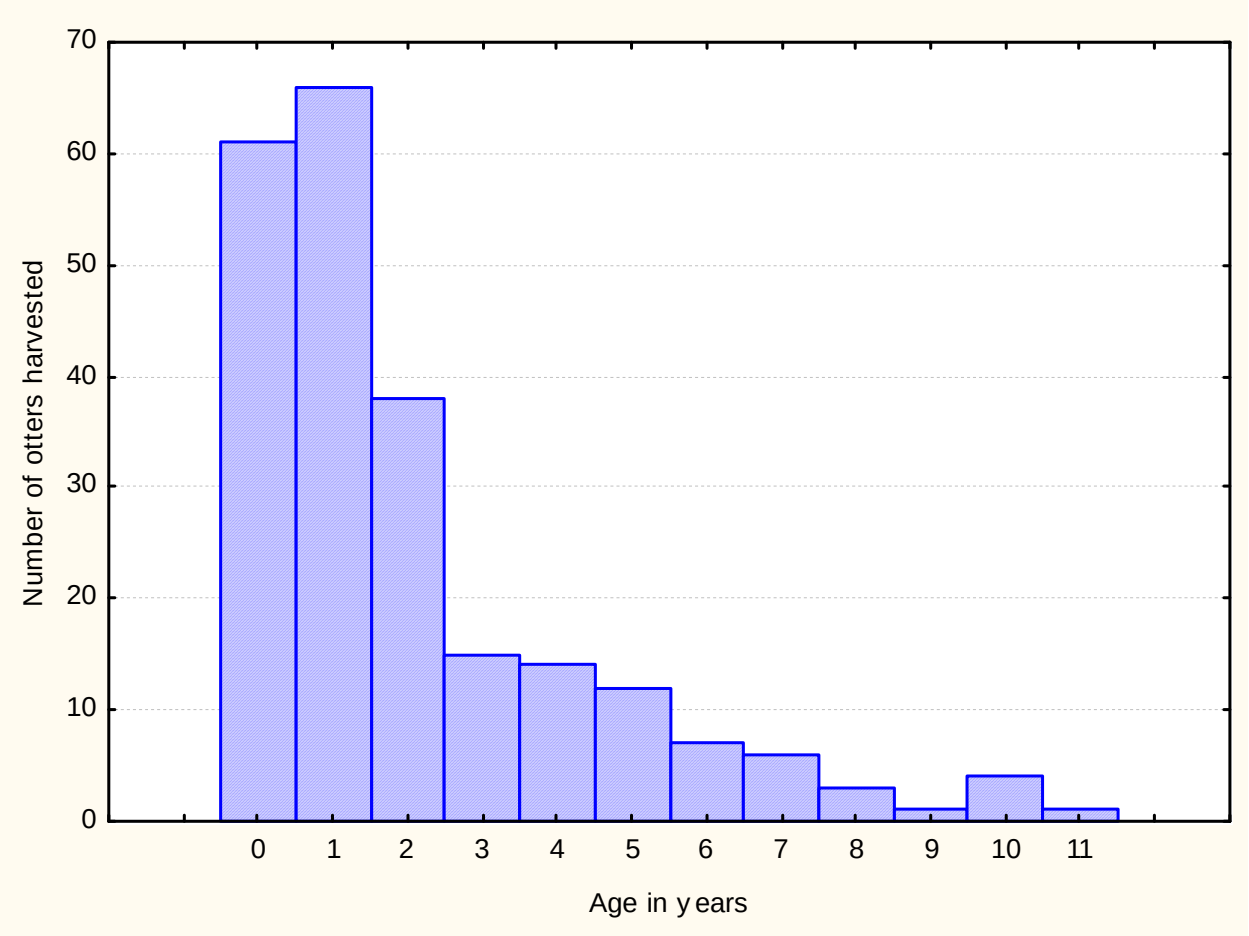

Figure 1.7. River otters harvested in Idaho by age in years during the combined 2002-2003 and 2003-2004 trapping seasons.

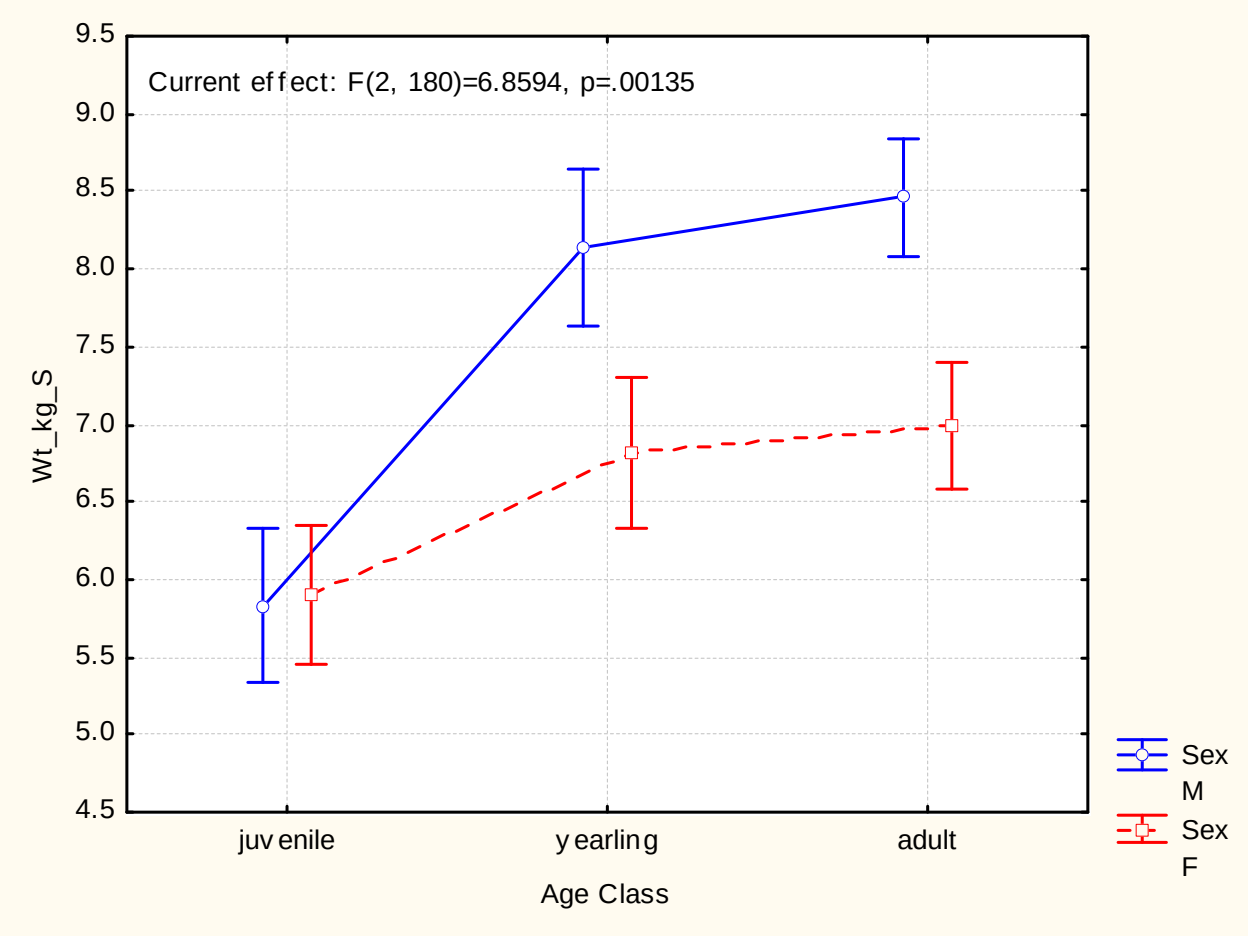

Figure 1.8. Weight by sex and age class of river otters harvested during the 2002-2004 trapping seasons in Idaho.

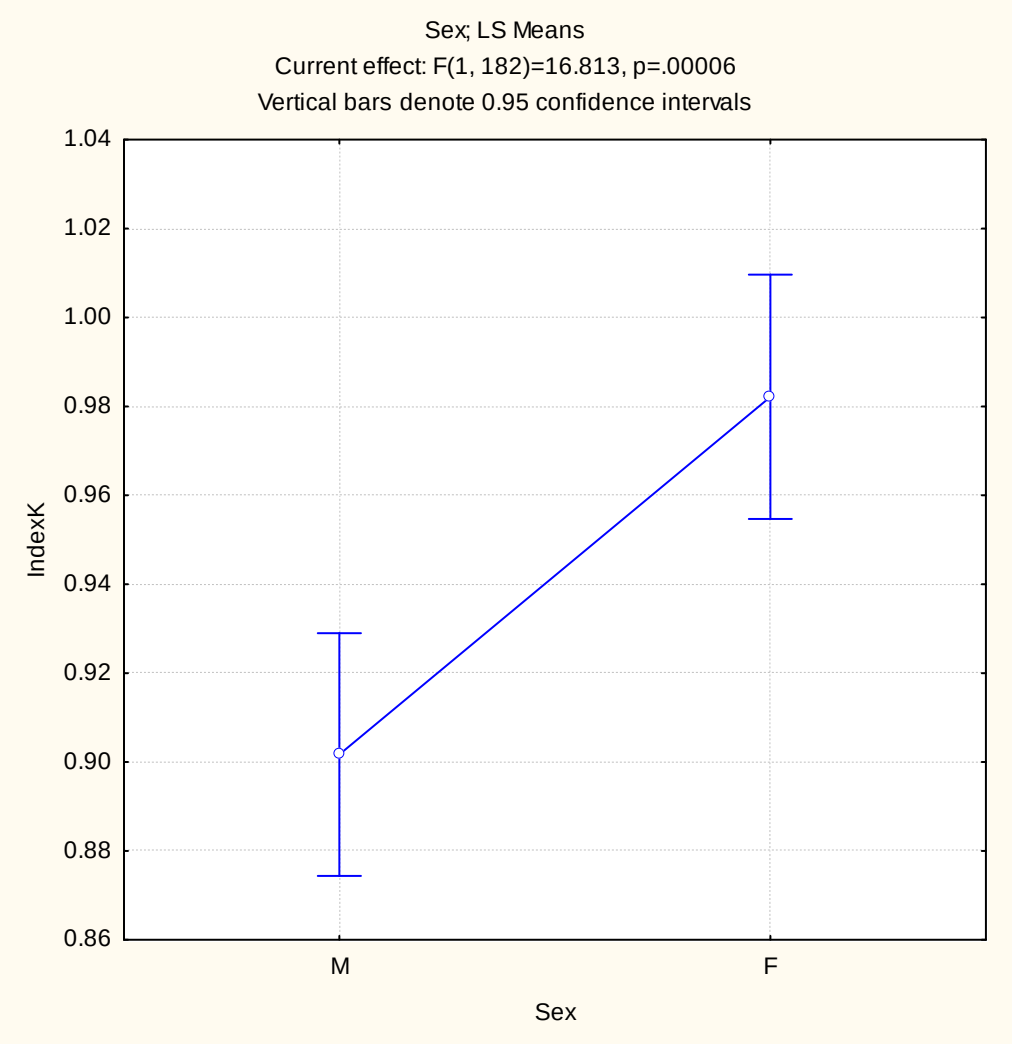

Figure.1.9. Body index (*K*) by sex of harvested river otters in Idaho (all age classes combined).

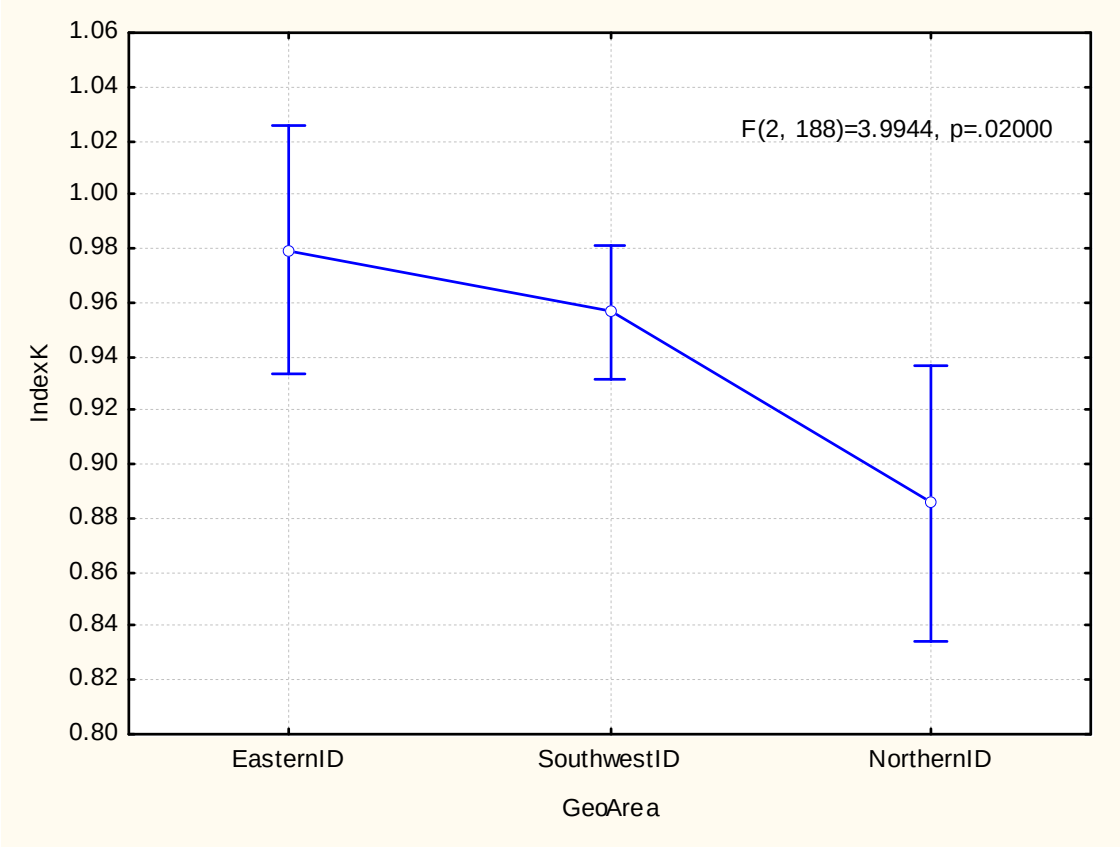

Figure 1.10. Body index (K) by geographic area of river otters harvested in Idaho during the 2002-2004 trapping seasons.

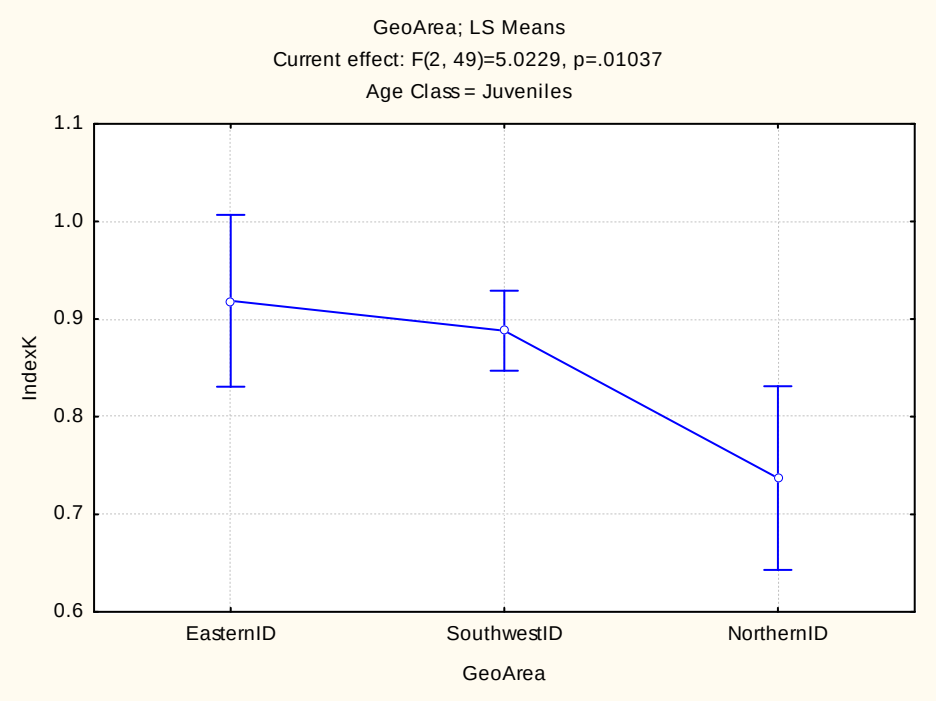

Figure 1.11. Body index (*K*) by geographic area among juvenile river otters.

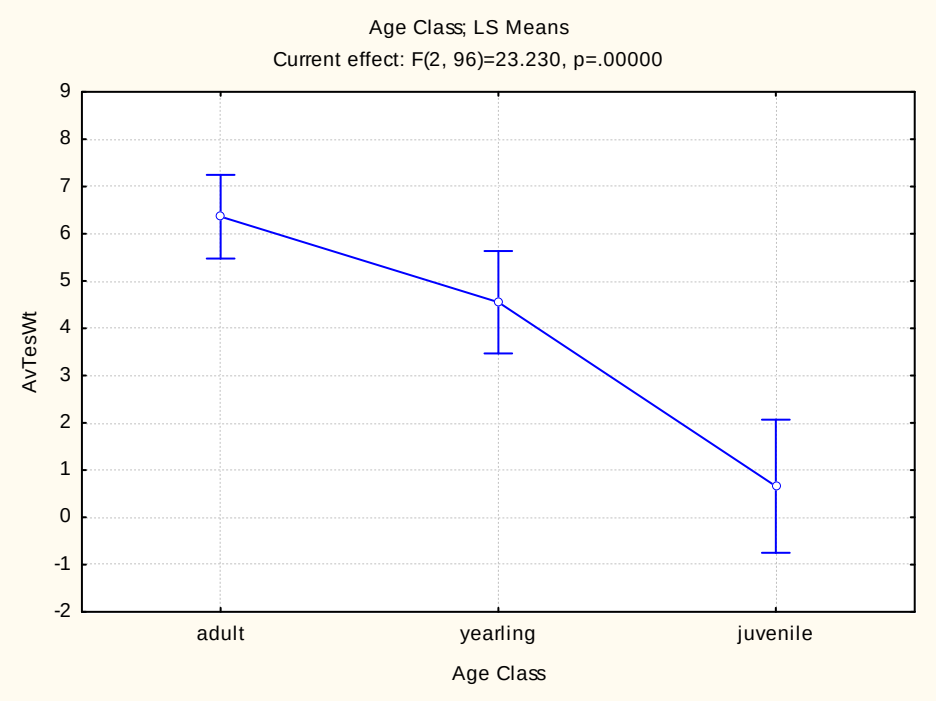

Fig. 1.12. Average testis weight among age class in river otters harvested in Idaho from 2002-2004.

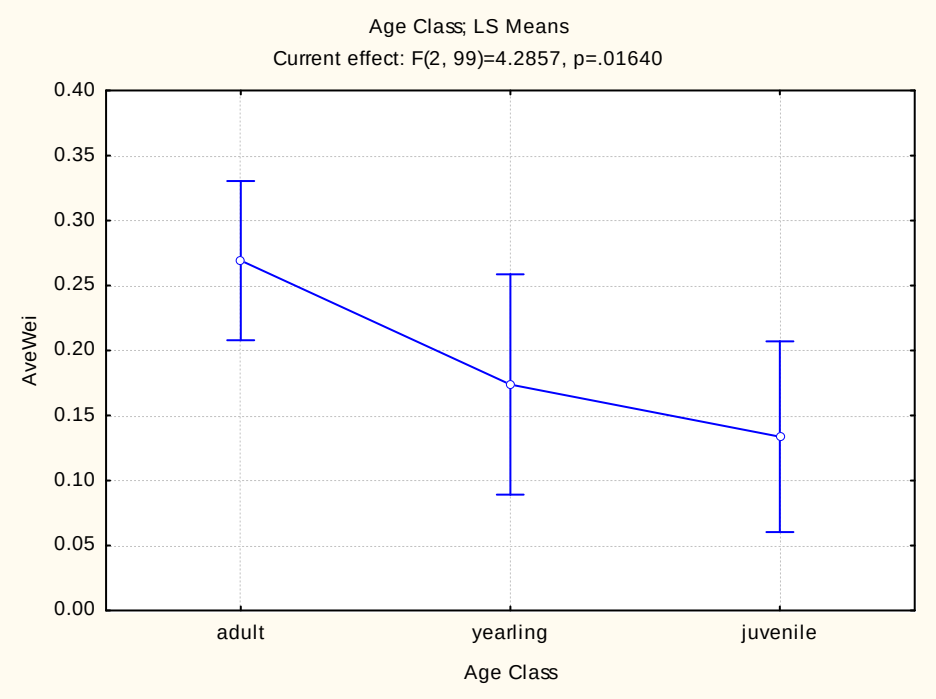

Figure 1.13. Average ovarian weight among age class in female river otters harvested in Idaho from 2002-2004.

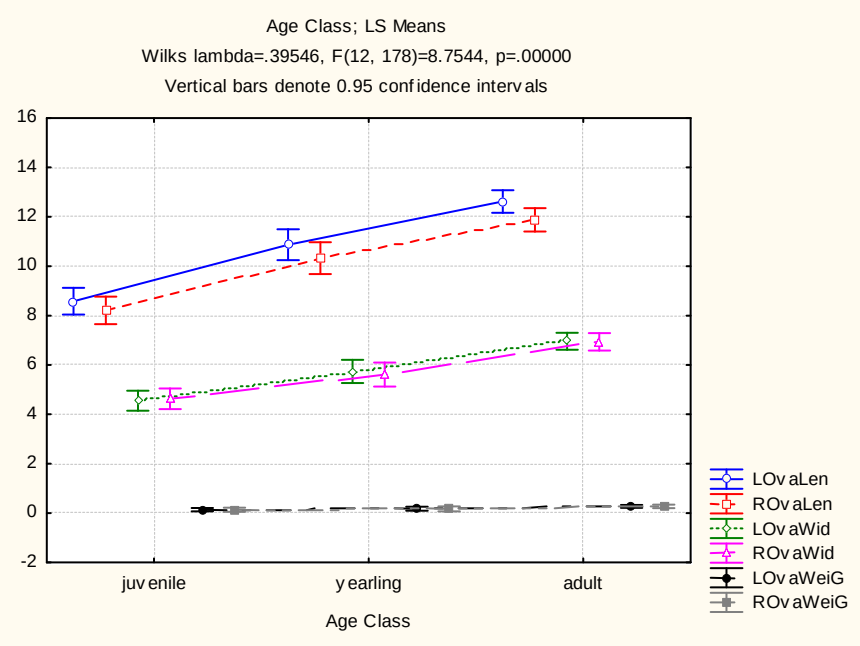

Figure 1.14. Mean ovarian measurements for all age classes of female river otters harvested in Idaho during the 2002-2003 and 2003-2004 trapping seasons.

CHAPTER 2: ENVIRONMENTAL CONTAMINANT CONCENTRATIONS IN LIVERS OF RIVER OTTERS IN IDAHO

Abstract

North American river otter (*Lontra canadensis*) carcasses were collected from trappers in Idaho throughout the 2002-2003 and 2003-2004 trapping seasons, and necropsies were conducted on 237 specimens. Necropsies were performed to assess age and sex, general body condition, reproductive rates, and concentrations of environmental contaminants in the livers. Livers were dissected and concentrations of environmental contaminants were determined for the following toxins: mercury and other heavy metals, organochlorine pesticides, and polychlorinated biphenyls (PCBs). The methodology of determining PCB concentrations differed between the 2 years in which research was conducted. Therefore, PCB concentrations are reported differently between each year. Of the 18 organochlorine pesticides tested for, only the following 5 were found: chlordane, DDE, DDD, DDT, and dieldrin. Concentrations were below threshold levels reported in the literature, except for 1 individual, which had a level of 17.6 ppm wet weight. Differences in environmental contaminants were determined among geographic areas, among age classes, and between sexes. ANOVA and regression analyses were used to determine differences and correlations in reproductive rates and body condition indices in relation to contaminant concentrations in the livers. Analyses conducted the first year found significantly lower concentrations of PCB1260 in livers from otters harvested in the southwestern region of Idaho when compared to other geographic areas

within the state. During the second year, there were significantly higher concentrations of total PCB concentrations in livers from otters harvested in the northern region of Idaho. Concentrations of cadmium and lead were higher in the northern region of Idaho, and concentrations of copper were higher in the southwestern region of Idaho. Cadmium levels were significantly higher in adults when compared to juveniles and yearlings. Mercury levels were significantly higher in males when compared to females. No negative relationships were found between environmental concentrations and female reproductive rates or presence of sperm. Manganese was the only heavy metal that correlated with a negative body condition index. The majority of otters had contaminant levels well within what is considered background levels. Nevertheless, some individuals do contain levels of mercury, DDE, or PCBs that approached concentrations of concern or are known to produce deleterious effects on health and reproduction.

Key words: body condition index, environmental contaminants, furbearer, Idaho, liver, *Lontra canadensis*, mercury, organochlorines, polychlorinated biphenyls, reproduction, river otter.

Background

Current information on North American river otter (*Lontra canadensis*) populations in Idaho is needed to assist in management decisions. The Idaho Department of Fish and Game (Department) interpreted fluctuating otter harvests and subsequent declines in harvest from 1945 through 1970 as a decline in the river otter population, resulting in a 29-year closure of the legal harvest of river otters as a furbearer in Idaho. In 2000, the river otter season was reopened, despite the fact that approximately 66% of

Idahoans were opposed to the harvest of river otters. Because many Idahoans were opposed to river otter harvest, the Department decided to seek current information on the otter population to assure concerned citizens that the harvest was not detrimental to the overall population.

The Department also petitioned the U.S. Fish and Wildlife Service (USFWS) in 2000 for multi-year approval of Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) export tags. The USFWS denied the issuance of CITES export tags for river otters, pending the receipt from the Department of proof that the harvest would not be a detriment to the population.

Because of their trophic position and sensitivity to both availability and toxicity of certain environmental contaminants (Wren et al. 1986), the river otter is referred to as an indicator species of healthy aquatic ecosystems. Therefore, I also sought to determine concentrations of the following environmental contaminants in river otter livers: heavy metals (including mercury, arsenic, cadmium, cobalt, copper, molybdenum, lead, and zinc), organochlorine pesticides (OCs), and polychlorinated biphenyls (PCBs). Because of the river otter's role as a bioindicator species (Aulerich and Ringer 1979; Melquist and Dronkert 1987), the present study provides data about the health of some of Idaho's aquatic ecosystems.

The research objectives of the present study were to: 1) determine population characteristics (age structure, sex ratio, and general body condition of river otters in Idaho); 2) determine reproductive parameters of the Idaho river otter population; 3) determine liver concentrations of persistent contaminants in the livers of river otters in Idaho, and assess any potential correlations between environmental contaminant

concentrations, reproductive parameters, and body condition indices; 4) identify populations subject to heavy concentrations of environmental contaminants, thus determining geographic areas of concern; and 5) provide the USFWS Department of Scientific Authority (DSA) and the Department information on the current status of the Idaho river otter population to assist in management decisions of the river otter as a furbearer.

The present chapter addresses the latter three objectives, focusing on environmental contaminants and possible correlations to reproductive rates, population characteristics, and body condition indices. Chapter 1 addressed the first two objectives.

History of River Otters in Idaho

Even before 1945, declines in river otter populations were observed in Idaho. In 1891, Dr. C. Hart Merriam (Merriam 1891) reported the river otter as "common along most of the streams and lakes in Idaho." That report resulted from his biological reconnaissance of south-central Idaho, conducted during August, September, and October 1890, for the U.S. Department of Agriculture (USDA). Within just a few decades, however, trappers in Idaho reported low-to-no sign of river otters (Davis 1939). In 1934, a trapper from southwest Idaho reported only 1 river otter harvested from Grand View, along the Snake River in Owyhee County, within a 15-year period. In 1939, a trapper from south-central Idaho, who had trapped in the Big Wood River since 1923, reported no occurrence of otters (Davis 1939). W. B. Davis reports in his book, *The Recent Mammals of Idaho* (1939), "This interesting and valuable mammal now is greatly reduced in numbers." By 1942, William M. Rush reports in *Wildlife of Idaho* (Rush

1942), “They are quite scarce in most parts of Idaho. A few may be found along the streams and lakes.”

Responding to this apparent decline in the river otter population, the Idaho Fish and Game Commission (Commission) approved the first regulated river otter trapping season in 1945. A peak in the harvest (Fig. 2.1) occurred in 1957 with 227 otters trapped, followed by a steady decline, and then another peak occurred in 1965 when 131 otters were trapped. After 1965, the harvest once again declined with a low of 40 otters harvested in 1970. It was this second decline that prompted the Commission to close the trapping season in 1971-1972.

The decline in harvest was interpreted as an indication that populations were also in decline. However, many factors could have contributed to the decline in harvest. For example, factors such as market value fluctuations and weather constraints are known to affect overall trapper effort. Tabor (1974) reported that trappers from Oregon believe adverse weather conditions (e.g., flooding and ice) influence trapping effort, trapping success, and, therefore, the number of otters trapped.

Research

Pollution is considered an important factor leading to declines of the North American river otter (Serfass et al. 1993) and the Eurasian otter (*Lutra lutra*) in Europe (Gutleb 2000). Although researchers began to recognize that environmental pollutants were hazardous to fauna as early as the 1950s (Nelson et al. 1971), it was not until the early 1970s that research focused on toxins and their effects on aquatic furbearers in North America (Cumbie 1975). During the early 1970s, mink (*Mustela vison*) ranchers around the Great Lakes began to notice severe reproductive failure and high kit mortality

in their animals (Wren 1986). Aulerich et al. (1973) soon linked this reproductive failure and mortality to the Great Lakes fish fed to the captive mink. Laboratory tests revealed that PCBs were the primary pollutant in the fish. Mink fed diets containing as little as 0.64 parts per million (ppm) PCBs experienced both reproductive failure and high kit mortality. Shortly after these results were published, elevated levels of PCBs were also reported in wild mink from Maryland (O'Shea et al. 1981) and Oregon (Henny et al. 1981), raising concern about the sensitivity of aquatic carnivores to persistent environmental contaminants.

Populations of Eurasian otters suffered serious declines during the past decades in many parts of Western Europe, and in some areas the species has become extinct (Gutleb 2000). The first evidence that toxic chemicals might be responsible for the decline in Britain came from an analysis of hunting records (Chanin and Jeffries 1978). The authors reported the decline was most likely due to the introduction of OCs such as dieldrin. The disappearance of otters in waterways throughout Europe coincided with a massive increase in the use of OCs as insecticides in agriculture, and several of these substances have been found in damaging concentrations in the tissues of dead otters (Kruuk 1995). Macdonald and Mason (1994) claim that in addition to OCs, PCBs and heavy metals, particularly mercury, are responsible for population declines. Mercury is widespread throughout the environment, and the organic form, methylmercury, is extremely toxic to mammals (Wren 1986). Bioaccumulation of methylmercury can have far-reaching consequences for river otter individuals and populations (Ben-David et al. 2001).

One of the first studies to determine mercury burdens in aquatic furbearers (Sheffy and St. Amant 1982) suggested that piscivorous furbearers had higher mercury levels than the herbivorous species. Based on the mean concentration of mercury in 5 tissues, Sheffy and St. Amant (1982) found river otters had the highest mercury burden followed by mink, raccoon (*Procyon lotor*), fox (*Vulpes vulpes*), muskrat (*Ondatra zibethica*), and beaver (*Castor canadensis).* Later studies reported reproductive organ hypoplasia of young male river otters from the lower Columbia River in the Pacific Northwest of the United States. These abnormalities were correlated with 29 congeners of PCBs, 2 congeners of polychlorinated dibenzo-p-dioxins (PCDDs), 4 congeners of polychlorinated dibenzofurans (PCDFs), and 6 organochlorines, (Henny et al. 2003).

In summary, there is substantial evidence that pollution has had major effects on the distribution and abundance of river otters (Macdonald and Mason 1990), and those effects have been both indirect and direct. Indirect effects include damage to the food supply or habitat (Macdonald and Mason 1990). Direct effects result either in death (acute toxicity), or in a lowered fitness (sub-lethal toxicity) by reducing the river otter's ability to reproduce successfully (Macdonald and Mason 1990). There is evidence that the North American river otter suffers a similar fate.

Primary Toxins Found in Otters

I analyzed mercury, 16 other metals, PCBs, and OCPs in river otter livers. As indicated earlier, mercury, PCBs, and OCs are especially common in the environment, and therefore are described in detail here. PCBs and OCs are considered persistent organic pollutants (POPs). POPs are toxic and persistent environmental contaminants that share several characteristics. POPs are resistant to normal processes that break down

contaminants. They travel great distances on wind and water currents, thus circulating globally and therefore remain intact in the environment for long periods (Stockholm Convention on Persistent Organic Pollutants 2001). POPs accumulate in body fat of humans and other animals and are passed from the mother to the fetus. A brief description of the primary toxins found in otters in this study follows.

Mercury

Mercury in the environment is derived from both natural sources and human activities. Mercury in Idaho is a naturally occurring ore, typically associated with geothermal areas such as high temperature gold deposits and hot springs (Idaho Department of Environmental Quality website) and is prevalent throughout central and northern Idaho.

Mercury can adversely affect both humans and wildlife that have consumed contaminated fish. Several areas in Idaho have been subjected to severe contamination from lead, mercury, and other metals from mining and smelting since the 1880s (Blus et al. 1993). The release of mercury into the environment from a variety of industrial, agricultural, and mining activities, especially Idaho's historical mining, has resulted in highly polluted local areas. For example, the Coeur d' Alene River, in northern Idaho, has received metals contamination from mining operations and smelting since 1885 (Ellis 1940 *in* Farag et al. 1998).

Excess mercury in fish tissue occurs in a number of areas in Idaho (Essig and Kosterman, 2008). Mercury is at such levels that Idahoans have been advised of the hazards of eating fish caught in several local reservoirs and lakes. In February 2004, advisories in Idaho were in place for 5 water bodies: Brownlee Reservoir, C. J. Strike

Reservoir, Lake Coeur d'Alene, Lake Lowell, and Salmon Falls Creek Reservoir. In 2006, 4 water bodies were added to this list: Priest Lake, Lake Pend Oreille, American Falls Reservoir, and East Mill Creek. In a 2007 study conducted by the Idaho Department of Environmental Quality, 40% of the lakes sampled (20 out of 50) in Idaho contained at least 1 species of fish with methylmercury levels above the criterion (0.3 mg/kg) considered safe for human consumption. As of 2009, the Idaho Department of Health and Welfare has a statewide total of 16 bodies of water with fish advisories.

Polychlorinated Biphenyls

PCBs were widely used in the electrical industry due to their ability to resist degradation. PCBs are normally found in the environment as mixtures of several components, referred to as congeners, with differing levels of toxicity. Environmental concerns resulted in restrictions on their use and manufacturing during the 1970s. However, because of their persistence and ability to travel easily by wind and water, PCBs are still present in many areas of the environment. PCBs cause a wide range of toxic effects in vertebrates although the level at which PCBs can affect reproduction in otters is disputed. PCB alters the metabolism of vitamin A in the body, causing developmental irregularities, including fetal resorption and abortion, and increases the risk of infections and cancer (Kruuk 2006).

Organochlorines

Throughout the 20th century, OCs were used worldwide as agricultural pesticides and industrial agents. Although most have been banned in the U. S., OCs still persist in the environment and may adversely affect endocrine functions in exposed individuals.

One of the best known OCs is the pesticide DDT, a common household word after the publication of Silent Spring (Carson 1962). During the 1950s more than 100 million pounds of DDT were produced annually in the U. S. It soon became apparent that the application of DDT to large areas resulted in fish kills and caused reproductive failure in birds, particularly predatory species (Carson 1962). Environmental concerns resulted in a general ban on the use of DDT in the U. S. in 1974. However, its export was not banned, and it continues to pollute the earth's atmosphere, oceans, and wildlife. DDT is found in the livers of birds and fish on every oceanic island on the planet. DDT breaks down into several different toxic metabolites, of which DDE is the most stable.

Study Species

The North American river otter is a member of the family Mustelidae, which includes mink, marten (*Martes americana*), wolverine (*Gulo gulo*), and weasels (*Mustela spp*.). The river otter is a medium-sized, semi-aquatic, opportunistic carnivore, with morphological adaptations for life in an aquatic ecosystem. The river otter's diet consists of approximately 79 -100% fish (Toweill and Tabor 1982, Melquist and Hornocker 1983, Serfass et al. 1990, Mack et al. 1994). Other prey items include crayfish, aquatic invertebrates, frogs, and, at times, injured birds and muskrats (*Ondatra zibethicus*) (Melquist and Dronkert 1987).

Habitat

Because the river otter is non-migratory, they can serve as important bioindicators, providing information about our aquatic ecosystems. Home range for the river otter is often described linearly, because of their use of rivers and streams. Melquist

and Hornocker (1983) reported home ranges of 8-78 km of shoreline along streams and lakes in Idaho. Mack et al. (1994) reported estimated annual home range lengths from 15.5-148.3 km, with mean estimates for males (106.3 km) greater than those of female river otters (25.5 km). Male river otters tended to have larger spring and summer home range lengths while female river otters had larger home range lengths during summer and fall (Mack et al. 1994). Erlinge (1968) reported the male European river otter (with the exception of male pups in family groups) to travel longer distances than female river otters throughout the year.

Generally, year-round habitat use by otters in Idaho has been associated with streams and stream-associated habitat as opposed to lakes, reservoirs, and ponds and valley as opposed to mountain habitats (Melquist and Hornocker 1983). The authors also determined that river otters favor lowland marshes, swamps, and bogs interconnected with meandering streams and lakes. Mack et al. (1994) reported that river otters along the Clearwater River, in north-central Idaho, preferred large riprap, natural rock, and sand substrates for latrine sites and den sites. To some extent, habitat use is influenced by habitat availability, as long as it provides adequate shelter, security, and a source of food.

The river otter needs riparian vegetation adjacent to wetlands, which provides cover and foraging areas. River otters tend to limit use of areas with sloping shorelines (e.g., shallow reservoirs) that are exposed when water levels are drawn down (Melquist and Hornocker 1983). Logjams were also used frequently by river otters in Idaho (Melquist and Hornocker 1983); logjams serve as excellent forage, feeding, and rest and cover sites for river otters.

Many studies have reported the importance of beaver habitat and activities to river otters (Polechla 1987; Melquist and Hornocker 1983). In Idaho, there is much overlap between river otter habitat and beaver habitat. Melquist and Hornocker (1983) reported 38% of resting sites used by instrumented otters were beaver bank dens and lodges. Mack et al. (1994) found beaver sign in 60% of river otter latrine sites compared to 21% of den sites. Polechla (1987) reported 5 out of 6 radio contacts with otters were in beaver lodges.

Bioindicator Species

The integrity of an ecosystem may be measured by the health of its vertebrate carnivore populations (Zielinski and Kucera 1995). Because of their trophic position and sensitivity to both availability and toxicity of certain environmental contaminants (Wren et al. 1986), the river otter is referred to as an indicator species of healthy aquatic ecosystems (Aulerich and Ringer 1979, Melquist and Dronkert 1987, Melquist et al. 2003). As piscivorous (fish-eating) predators foraging near the apex of the trophic pyramid and feeding primarily on aquatic prey, the river otter is especially susceptible to contaminated aquatic habitats (Halbrook et al. 1996). The river otter readily accumulates high levels of pollutants (Halbrook et al. 1996; Ben-David et al. 2001). Therefore, the river otter is considered to be a bioindicator species. A bioindicator species can reflect biological, chemical, or physical attributes of ecological condition, providing useful information on contaminant levels in organisms lower on the aquatic food chain. In fact, a group of scientists in British Columbia ranked the river otter as the top mammalian indicator species of chemical contamination in the aquatic component of the Fraser River

Basin (Moul et al. 1996). Their study based this rank on the otters' ability to meet criteria linked to natural history such as its habitat, home range size, and diet.

Methods

Study Area

River otter carcasses were collected statewide from every Departmental administrative region (Fig. 2.2). A brief description of the ecological regions of the state of Idaho is provided; administrative regions are identified in the appropriate ecogregion.

Idaho comprises 3 principal ecoregions, described in McNab and Avers (1994) as follows (sections are a further subdivision of the ecoregions):

Northern Rocky Mountain Forest-Steppe-Coniferous Forest-Alpine Meadow Sections: Okanogan Highlands, Flathead Valley, Bitterroot Mountains

Middle Rocky Mountain Steppe-Coniferous Forest-Alpine Meadow Sections: Idaho Batholith, Challis Volcanic, Beaverhead Mountains, Blue Mountains

Southern Rocky Mountain Steppe-Open Woodland-Coniferous Forest-Alpine Meadow Sections: Overthrust Mountains, Yellowstone Highlands

More than half of Idaho is mountainous and much of the remainder is plateau that is deeply incised by canyons. Elevations range from a low of 225 meters above sea level

at Lewiston to 3860 meters at the summit of Mount Borah in the Lost River Range (Ross and Savage 1967).

Native vegetation zones of Idaho include the semi-arid sagebrush and prairie zone at the lowest elevation; at intermediate elevations, the timbered zones predominate; and at the very highest elevations, the alpine zone occurs (Fig. 2.3). There are 11 major river drainage basins throughout Idaho.

Sample Collection

During the 2002-2003 and 2003-2004 trapping seasons, river otter carcasses were collected from licensed trappers because of regulations added by the Commission to the Department's mandatory furtaker harvest report. Legally harvested river otters (skinned) and incidentally captured river otters (not skinned) must be surrendered. Carcasses were surrendered to regional office Department personnel at the region in which the animal was taken.

Carcasses were frozen soon after surrender and stored at the regional office until I was able to coordinate the delivery of the carcasses to the State Wildlife Health Laboratory (hereafter referred to as Wildlife Laboratory) in Caldwell, Idaho. Upon arrival at the Wildlife Laboratory, carcasses were placed in large garbage bags, 1 specimen per bag, until time of necropsy. Carcasses were labeled with date of harvest, location of harvest (administrative hunt unit and body of water), sex, and either the state tag number (prior to DSAs approval of Idaho's river otter export program in February 2003) or a CITES tag. Otter carcasses were also given a unique identification number and a laboratory necropsy number.

Carcass Analysis

During the first year that necropsies were conducted, training and assistance in necropsy procedures were provided by Dr. Paul Polechla, Jr., University of New Mexico.

Carcasses were thawed in a refrigerated cooler for 2 to 3 days prior to gross necropsy. Before each necropsy, all harvest and trapper data were recorded on a necropsy data sheet, including the trapper's name, whether the river otter was a target animal or a nontarget animal, harvest location, and harvest date. Upon removal of the carcass from the garbage bag, the river otter was placed on its sternum on top of a measuring tape attached to the necropsy table. The carcass was placed carefully to align the vertebral column with the measuring tape. Each river otter was measured from the tip of the nose to the tip of the last caudal vertebrae. The lengths of the total carcass, tail, right hind foot, and right ear were measured in millimeters (Table 2.1). Weights of carcasses were measured in pounds and then converted to kilograms. An external examination for gross abnormalities and ectoparasites was performed on each carcass. The mouth and teeth were examined for wear or trauma. Carcasses were examined for scars or wounds, especially on the appendages, and the condition of toes, claws, and foot pads was noted.

The necropsy was begun with a mid-ventral incision through the abdominal wall along the linea alba, starting at the groin and extending anteriorly to the tip of the sternum. The flaps of the abdominal wall were then retracted. Prior to removal of any samples from the carcass, the organs were observed *in situ* to assess any gross abnormalities. Organs with abnormalities were preserved in 10% formalin for histological examination. Histological procedures were conducted by Dr. Stewart

Lincoln, DVM, at the University of Idaho's Caine Center in Caldwell, Idaho. Livers were excised and shipped to the Analytical Sciences Laboratory at the University of Idaho, Moscow, Idaho, for environmental contaminants testing procedures. Contaminants screened for included mercury and other heavy metals (listed previously), OCs, and PCBs.

Environmental Contaminants

Because of the expense of toxicological procedures, a sub sample of animals was initially chosen for each toxin with measureable levels, initially based on the primary economic activity (e.g., mining, agriculture, paper mills) in the area where the river otter was harvested. To provide a control, the same toxin screens were also performed on a similar number of animals harvested from areas without such activity. Additional funding was later received from the Idaho Fish and Wildlife Foundation and from the Department, which allowed all female river otters to be screened for any additional toxins not previously screened for. Females were chosen so any potential correlations to reproductive parameters could be determined.

Livers were stored at the Scientific Analytical Laboratory after the initial screen so that subsequent and alternate screens could be performed if deemed necessary. The liver was chosen because it accumulates some of the highest levels of both organic and inorganic contaminants, and is actively involved with toxin metabolism. It is also one of the most widely used organs for toxicological procedures, and thus cross-study comparisons are available.

Reporting Results

During the 1960s, most researchers reported the levels of environmental contaminants in wildlife in terms of parts per million (ppm) or mg/g wet weight of tissue (Jeffries and Hanson 2000). It then became more commonly expressed as mg/g of extractable lipids (Jeffries and Hanson 2000). However, because the amount of extractable lipid in an organ such as the liver is relatively small, calculation of a per-lipid concentration magnifies the concentration, thus making the toxin concentration appear much greater than it really is (Jeffries and Hanson 2000). Also, amounts of organ lipids may vary greatly due to the nutritional state and/or health of the individual, or with age of the individual (Jeffries and Hanson 2000). Because of these problems with organ per-lipid concentrations, Jeffries and Hanson (1987) calculated a conversion factor from a sample of 26 otters to convert wet weight toxin concentrations to per-lipid concentrations for the otter liver. The authors concluded that the conversion factor varied from 13.56 to 72.99 depending on the body fat level of the otter. For example, if an otter had normally high levels of body fat, the wet weight was multiplied by 13.56, and if the otter was emaciated, the wet weight was multiplied by 72.99.

For cross-study comparisons, and to allow me to report results of PCB concentrations following the criteria of Leonards et al. (1994) and Smit et al. (1996), I converted PCB concentrations from ppm wet weight in the liver to ppm in the lipids. I did the conversion by multiplying the original PCB concentration in the liver by 14. Because I did not have overall body fat levels, and in order to have conservative levels of wet weight concentrations, I chose the lowest multiplier factor of 13.56 and then rounded

to 14 to simplify the equation. However, all analyses were performed with the liver toxin concentrations as provided by the Analytical Sciences Laboratory, Moscow, Idaho.

The following criteria for PCB per-lipid levels were applied (EC_1 = 1% effect concentration, EC_{50} = 50% effect concentration, and EC_{90} = 90% effect concentration):

1) Less than 9 mg total PCB/g lipid is considered a proposed safe level for otters based on an EC_1 body burden in European otter affecting hepatic retinol (Vitamin A) level.

2) Equal to or greater than 21 mg total PCB/g lipid is considered a critical level for health impairment in otters based on an EC_{90} for body burdens in European otter affecting hepatic retinol level.

3) Equal to or greater than 50 mg total PCB/g lipid is considered a critical level for reproductive impairment in otters based on EC_{50} for reduction in litter size in mink.

Results of concentrations for mercury, other heavy metals, and OCs were reported as liver concentrations in ppm wet weight, as provided by the Analytical Sciences Laboratory, Moscow, Idaho.

Mercury

Mercury analysis was conducted with cold vapor atomic fluorescence spectrometry (Analytical Sciences Laboratory Standard Methods 2005). Equipment used included a Leeman HYDRA AF automated mercury analyzer, and a Tecator DS-40 digestor block and controller. A 0.5 g dried sample or a 1.0 g wet sample of liver tissue was digested in a 75 ml volumetric digestion tube on a heating block with trace metal grade nitric acid and hydrochloric acid. After the mercury was reduced to the elemental

state, it was separated by using pure argon or nitrogen in liquid-gas separation chambers. The mercury level was then quantified by cold vapor atomic fluorescence. The detection limit for this method is determined to be about 3.75 ppm for a 1 g sample and 7.5 ppm for a 0.5 g sample (Analytical Sciences Laboratory Standard Methods 2005).

Additional Heavy Metals

Livers were also analyzed for the following additional metals: arsenic, calcium, cadmium, cobalt, chromium, copper, iron, potassium, manganese, magnesium, molybdenum, sodium, phosphorous, lead, sulfur, and zinc. These metals were analyzed by inductively coupled plasma (ICP) atomic emission (Analytical Sciences Laboratory Standard Methods 2005). Samples were digested in a concentrated trace metal grade GFS nitric acid at approximately 115° Celsius. A Leeman 2000 or a Perkin Elmer Optima 3200 RL were used in addition to a Tecator Digestion Block (Analytical Sciences Laboratory Standard Methods 2005).

Organochlorine Pesticides

Liver samples were screened for OCs by a modified Environmental Protection Agency (EPA) 8081 method (Analytical Sciences Laboratory Standard Method 2005). Average spike recovery was 79.25 ±10.56. Tissues were ground in a Robot Coupe food processor or Waring blender and a sub-sample dried with sodium sulfate. The dried sample was extracted with 5% ethanol/ethyl acetate using a Tekmar homogenizer. The extract was cleaned using both Gel Permeation Chromatography and silica gel solid phase extraction (SPE) columns, followed by an additional clean-up using Florisil SPE

cartridges. The final extract was analyzed with Agilent 6890 Gas Chromatography (Analytical Sciences Laboratory Standard Methods 2005).

Polychlorinated Biphenyls

Samples were screened for PCB congeners by a modified EPA 8081 method. Liver samples were extracted in the same method as the organochlorine pesticides. The average spike recovery was 80.09 $\pm$20.04 (Analytical Sciences Laboratory Standard Methods 2005).

Statistical Analysis

Prior to analysis, administrative regions were grouped into the following geographical areas: Northern Idaho (Panhandle and Clearwater Departmental administrative regions), Southwest Idaho (McCall, Southwest, and Magic Valley Departmental administrative regions), and Eastern Idaho (Pocatello, Upper Snake, and Salmon Departmental administrative regions). I used Analysis of Variance (ANOVA) with Tukey's Honestly Significantly Different (HSD) test to compare environmental contaminant concentrations among geographic areas, among otter age groups, and between sexes. I assessed correlations between environmental contaminant concentrations, and used simple and multiple regression analyses to assess the effects of toxins on reproductive parameters and other physical characteristics. Multiple regression models and best subsets were used for predictive modeling to determine which toxins and other factors may influence reproductive rates in female otters. Best subsets were used to determine the most likely variables that contribute to the body condition (*K*) of the

harvested otters. The software package STATISTICA (Tulsa, Oklahoma) was used for all statistical analyses.

Results

During the 2002–2003 and 2003–2004 Idaho trapping seasons (November 1 through March 15), 237 otters were collected; 120 in the first season and 117 in the second season. Forty-one otter carcasses were collected from the northern region of Idaho, 41 from the eastern region of Idaho, and 149 carcasses from the southwest region of Idaho. The harvest locations of 6 otters were unknown.

Environmental Contaminants

Mercury

Overall Concentrations. Mercury was detected in all otters that were tested for the heavy metal (n =170). Mercury concentrations detected in the livers were generally low, and for the most part are considered to be representative of the range of background levels. Mercury concentrations ranged from 0.09-17.0 ppm, with a mean concentration of 1.6 ppm. Of the 170 otters tested for mercury, 95% had concentrations less than 5.0 ppm; well within reported background levels (O'Connor and Neilsen 1981). However, 8 otters had mercury concentrations above 5 ppm with the highest concentration of 17 ppm in 1 individual.

Mean mercury concentrations of 1.5 ppm in 2002-2003 and 1.7 ppm in 2003-2004 were not significantly different (t-test; $P = 0.58$). Overall, mercury concentrations ranged from 0.09-17.0 ppm, with a mean concentration of 1.6 ppm.

Geographic areas. The mean concentrations of mercury in the livers of otters from the 3 geographic areas of the state were 1.15 ppm in eastern Idaho, 1.59 ppm in southwestern Idaho, and 2.19 ppm in northern Idaho. These concentrations were not significantly different ($P>.05$).

Although no significant differences were found among geographic areas and mercury, there were significant differences among counties. Significantly higher concentrations of mercury were found in livers of otters harvested from Boise County in southwest Idaho (mean = 7.5 ppm), and Bonner County in north Idaho (mean = 5.7 ppm), (ANOVA, Tukey's HSD, $P<.05$).

Concentration comparisons between genders. Mean mercury concentrations were significantly higher in male otters (mean = 2.2 ppm, n = 56) than in female otters (mean = 1.3 ppm, n = 114) (t= 2.87, $P=0.004$).

Concentration comparisons among age classes. There were no significant differences in mercury concentrations in livers among age classes (ANOVA, Tukey's HSD, $P=0.13$, df 2). The mean concentrations of mercury in each age class were 1.1 ppm (juveniles), 1.7 ppm (yearlings), and 1.9 ppm (adults).

Reproductive parameters. Simple regression analyses found no statistically significant relationship between the numbers of corpora lutea ($R^2=0.026$, $P=0.16$) and blastocysts ($R^2 = 0.027$, $P=0.11$) and the concentrations of mercury found in otters.

Body condition index. Simple regression analyses found no statistically significant relationship between concentrations of mercury and body condition indices of river otters ($R^2 = 0.005$, $P = 0.38$).

Additional Heavy Metals

Overall concentrations. Table 2.2 shows concentrations of additional heavy metals that were included in the toxicological analyses.

Geographic areas. Concentrations differed significantly among geographic areas for cadmium, copper, and lead. Cadmium and lead concentrations were significantly higher in the northern region of Idaho ($P = 0.003$, $P = 0.004$, respectively). The mean cadmium level for the northern region was 0.09 ppm compared to 0.02 ppm for both the southwestern and eastern regions. Lead was present in 5 of 140 individuals, and only detected in individuals from the northern region, with a mean concentration of 0.45 ppm, and a range of 0.56-6.1 ppm.

Copper concentrations were significantly higher in the southwestern region of Idaho ($P = 0.005$), with a mean concentration of 8.8 ppm, compared to a mean of 7.0 ppm and 7.2 ppm in the eastern and northern regions of Idaho, respectively.

There were no significant differences in contaminant concentrations among geographic regions for arsenic, cobalt, manganese, molybdenum, and zinc.

Concentration comparisons between gender. No significant differences were found in contaminant concentrations between genders of otters.

Concentration comparisons among age classes. Cadmium and copper were the only heavy metals found to differ significantly among age classes. Cadmium concentrations were significantly higher in adult otters than juveniles or yearlings ($P<.05$). The mean concentration level in adults was 0.08 ppm compared to 0.01 ppm and 0.02 ppm for juveniles and yearlings, respectively. Copper concentrations were

significantly higher in juvenile otters than yearlings or adults (P<.05). The mean concentration level in juveniles was 8.96 ppm compared to 8.8 ppm and 7.26 ppm for yearlings and adults, respectively.

Reproductive parameters. Simple regression analyses found no statistically significant relationships between heavy metal concentrations and female reproductive parameters.

Body condition indices (K). Simple regression analyses were used to determine if any relationships existed between heavy metal concentrations and K. Manganese was the only heavy metal with a significant relationship with K; the higher the manganese concentration the lower the K ($r^2 = 0.04$, $P < 0.05$).

Organochlorine Pesticides

Overall concentrations. Toxicological procedures were conducted to determine liver concentrations for aldrin, alphaHCH, betaHCH, deltaHCH, lindane, chlordane, DDE, DDD, DDT, dieldrin, endosulfan 1, endosulfan 2, endrin, aldehyde, e. ketone, heptachlor, h. epoxide, and oxychlor. Only 5 pesticides were detected in the otters. DDE was detected in 84 otters, and chlordan, DDD, DDT, and dieldrin were detected in 1 otter each.

Geographic areas. No significant differences in concentrations of DDE were found among geographic areas (P= 0.72).

Concentration comparisons between gender. No significant differences between genders were found in concentrations of DDE (P= 0.57).

Concentration comparisons among age classes. No significant differences were found among age classes in concentrations of DDE (P= 0.55).

Reproductive parameters. No significant relationships were found between concentrations of DDE and reproductive parameters. The individual otter with the highest concentration of DDE (17.6 ppm wet weight) showed signs of ovulation, with 2 corpora lutea found on the ovaries.

Body condition indices (K). No significant relationships were found between concentrations of DDE and K in the otters ($R^2 = 0.0018$, $P = 0.63$).

Polychlorinated Biphenyls

Overall concentrations. The toxicological procedures conducted on PCB congeners differed between the 2 research years because researchers at Analytical Sciences Laboratory developed a more refined procedure for the second year. Therefore, PCB concentrations for each year are reported separately.

For the research year 2002–2003, concentrations of the following PCB congeners were measured: PCB1016, PCB1221, PCB1232, PCB1242, PCB1248, PCB1254, and PCB1260. Only congener PCB1260 was detected. Fifty-four otters were tested for PCBs during the first year of the present study; the mean concentration of PCB1260 was 0.32 ppm wet weight, with a maximum concentration of 4.8 ppm. As discussed under the Methods section, I converted wet weight to lipid weight in order to compare my results to the criteria established by Leonards et al. (1994) and Smit et al. (1996). .

For research year 2003-2004, PCB congeners were reported based on the chlorination levels, and fully half of the congeners were detected in the 106 otters tested.

The PCB congeners detected were: 2_2_4_5_5_PentaCBP, 2_2_4_4_5_5_HexaCBP, 2_2_3_4_4_5_HexaCBP, 2_2_3_4_5_5_6_Hepta, 2_2_3_4_4_5_6_Hepta, 2_2_3_4_4_5_5_Hepta, and _2_2_3_3_4_4_5_Hepta. Congener concentrations were summed to report total PCB concentrations. Concentrations of total PCB in the livers of otters harvested in 2003-2004 ranged from 0.011 ppm to a maximum of 2.3 ppm.

Geographic areas. Concentrations of PCB 1260 in the livers were significantly lower in the southwestern region of Idaho (mean = 0.13 ppm) than in the eastern or northern regions of Idaho (mean = 0.98 ppm and 0.60 ppm, respectively, P= 0.01). There were 5 river otters with lipid levels above 9 mg total PCB/g lipid, which places them above levels considered safe for otters, based on the criteria established by Leonards et al. (1994) and Smit et al. (1996). In addition, there were 2 river otters with levels above 21 mg total PCB/g lipid, considered a critical level for health impairment. One of these individuals had a PCB lipid level of 67.2 mg total PCB/g lipid, which is well above the 50 mg total PCB/g lipid threshold considered to be a critical level for reproductive impairment for otters.

Results of PCBs for the second year (2003-2004) differed from the first year. Total PCB concentrations were significantly higher in the northern region of Idaho (P = 0.03). The mean concentrations of total PCBs for the northern region were 0.31 ppm while the eastern and southwestern regions had mean concentrations of 0.03 ppm and 0.09 ppm, respectively. When converted to lipid concentrations, the northern region had a mean concentration of 4.4 mg total PCB/ g lipids, still considered within the range of safe levels. The southwestern region of Idaho had a mean concentration of 1.3 mg total PCB/g lipids and the eastern region had a mean concentration of 0.47 mg total PCB/g

lipids. Only 3 otters had levels above the 9 mg total PCB/ g lipid considered to be a safe level for river otters. Two of these otters were above the 21 mg total PCB/ g lipid threshold considered to be a critical level for health impairment.

Concentration comparisons between genders. Concentrations of PCB 1260 were significantly higher in male otters than in female otters ($P = 0.03$) collected during the first year of the study, with mean concentrations of 0.55 ppm for males ($n = 27$) and 0.10 ppm ($n=27$) for females. I found no significant difference in total PCB concentrations between males and females collected during the second year of the study, with a mean concentration of 0.08 ppm for males ($n=17$) and 0.11 ppm for females ($n = 88$).

Concentration comparisons among age classes and age in years. There was a significant increase in PCB 1260 concentrations as otters aged ($P = 0.02$). However, no significant differences in PCB 1260 concentrations among age classes were detected ($P = 0.14$). The mean concentrations by age classes were 0.20 ppm in juveniles, 0.04 ppm in yearlings, and 0.55 ppm in adults.

Reproductive parameters. I used simple regression analyses to determine if any relationships existed between PCB concentrations and reproductive parameters. I found no significant relationships during the first year of the study between number of corpora lutea and PCB 1260 concentrations ($P=0.75$, $R^2=0.004$) or between number of blastocysts and PCB 1260 concentrations ($P=0.14$, $R^2=0.09$). Similarly, I did not find any significant relationships the second year between total PCB congeners and number of corpora lutea ($P=0.32$ $R^2=0.01$). However, there was a significant relationship between number of blastocysts and total PCB congeners ($P=0.05$, $R^2=0.005$). Two adult female otters had concentrations of PCB1260 that, when converted to lipid levels, were above the

established threshold considered a critical level for reproductive impairment. Of these 2 females, 1 was pregnant and 1 was not. For animals collected in the second season, 2 individuals, both adult males, had concentrations of total PCBs that, when converted to lipid levels, were above the established threshold considered a critical level for reproductive impairment. Of these, 1 had detectable sperm in the epididymides while the other, a 4-year-old, did not have detectable sperm.

Body condition indices (K). I used a simple regression analysis to determine if relationships existed between PCB concentrations and *K* in the otters. No relationship was found the first year with PCB 1260 (P=0.66, R^2 = 0.004) or the second year with total PCBs (P=0.29, R^2=0.013).

Discussion

I conducted necropsies on otters harvested throughout Idaho in order to (i) determine concentrations of environmental contaminants in the livers of the otters; (ii) assess any potential relationships between contaminant concentrations, reproductive parameters, and body condition indices; (iii) identify populations subject to heavy concentrations of environmental contaminants; and (iv) provide the DSA and the Department information on the current status of the Idaho river otter population.

Does Exposure Occur?

Results from the present study suggest that exposure to environmental contaminants does occur, however, for the majority of the otters, concentrations compare favorably to background levels (levels considered safe). Nevertheless, some individuals

do contain levels of mercury, DDE, or PCBs that approach concentrations of concern or are known to produce deleterious effects on health and reproduction.

Results from the study also suggest that mercury is consistently found throughout the aquatic ecosystems of Idaho, as evidenced by its presence in every otter tested. A study done by the Idaho Department of Environmental Quality (Essig and Kosterman 2008) supports this conclusion. Their study on fish tissue found that mercury was widespread throughout the water bodies in Idaho.

Even though mercury was present in every otter tested, mercury concentration ranges reported in the present study are comparable to those in many studies done throughout North America and Europe. Wren et al. (1986) found ranges of 0.71 – 17.4 ppm, 1.18 – 2.60 ppm, 0.20 – 2.46 ppm, and 0.00 – 4.14 ppm in 4 locations throughout Ontario, Canada. Studies conducted in Connecticut and Massachusetts reported ranges from 2.8 - 16.3 ppm, with no known mercury pollution (Organ and Griffin 2004). Liver concentrations in Eurasian otters have been reported from Sweden (4.1 – 30.7 ppm), Finland (0.05 – 31.0 ppm), Spain (3.92 – 17.48), and Ireland (0.15 – 17.03 ppm) (Gutleb 2000), among others. Mean mercury concentrations reported in the present study are less than those from otters collected in Wisconsin (mean = 3.34 ppm) reported by Sheffy and St. Amant (1982), and from otters collected in Georgia (mean = 9.16 for Ware Co. and mean = 5.11 for Echols Co.) reported by Halbrook et al. (1996). Likewise, Fortin et al. (2001) reported a mean liver concentration of 4.1 ppm in otters from Quebec, Canada.

Mercury and PCB1260 were the only contaminants found at significantly higher concentrations in males when compared with females. The significantly higher concentration of mercury in males compares positively with O'Connor and Nielsen

(1981). However, although Kucera (1983) found significantly higher mercury concentrations in male mink when compared with female mink, he found no differences between sexes in river otters. The higher concentrations of PCB compares favorably to studies conducted in Oregon, where otters from the lower Columbia River had mean PCB levels of 9.3 ppm for males and 3.5 ppm for females (Henny et al. 1981). In contrast, studies done in Denmark found no significant differences in PCB levels among sexes (Madsen and Gaardmand 2000).

The higher levels of mercury and PCB could be attributed to the fact that male otters typically have larger home ranges, and could be more exposed to contaminated areas or a differing prey base composition. Another factor could be that females void part of their body burden during parturition and lactation.

Although the threshold level of 50 mg total PCB/g lipid is accepted as the damaging concentration in European otters (Jensen et al. 1977, Leonards et al. 1994, Smit et al. 1996), researchers in the Shetland area of Scotland found no such correlation, where an apparently healthy population of otters had a mean of 210 mg total PCB/g lipid, which compares to 5.5 ppm wet weight (Kruuk and Conroy 1996). However, European otter researchers have found negative correlations between PCB levels and *K* (Kruuk et al. 1987). I found no relationship between the levels of PCB (both PCB 1260 and total PCB) and *K*, given that 8 otters had levels above 50 mg total PCB/g lipid.

Concentrations for the remaining heavy metals tested for were generally at background or safe levels. Although a few specimens had notably higher levels of lead and arsenic, these levels were still below threshold levels reported in the literature. Toxic levels of lead are reported as 10 ppm (Buck et al. 1969). Heavy metal concentrations also

compared favorably to previous work done on river otters and mink from the Fraser and Columbia Rivers, which are large, complex systems in British Columbia and Washington and Oregon, respectively (Henny et al. 1981).

Although I found very few relationships among the remaining heavy metals and population or reproductive characteristics, I did find a significantly higher reproductive rate among individuals with a higher level of cadmium. Studies suggest that low levels of cadmium have beneficial effects on reproduction. In low dosages, cadmium may actually enhance the synthesis of progesterone, thus having significant effects on ovarian and reproductive tract morphology (Henson and Chedrese 2004). I also found a significantly higher concentration of cadmium among adults when compared to juveniles and yearlings. Cadmium, like mercury, is known to bioaccumulate, thus providing the potential for concentrations to increase with age.

Of the organochlorine pesticides for which I tested, only 5 were detected. The percentage of individuals with detectable levels was low, usually less than 1%. Concentrations were below those reported as having detrimental effects on reproduction or populations. Although DDE was found in over 50 percent of the otters tested for the OC, levels were comparable to those found in the Columbia River in Oregon (Henny et al. 1981), with the exception of the specimen with 17.6 ppm. Many organochlorines, including DDT, its metabolites, chlordane, and dieldrin, have been banned in the U.S. since the 1970s. However, these toxins and metabolites break down slowly and persist within our environment years after their use. They are also transported long distances in the atmosphere, thus contributing to their presence in environments where there is no known source of the pollutant.

Are There Areas of Concern?

The results suggest that otter populations in the northern region of the state are exposed to higher levels of some contaminants than other populations. Lead, cadmium, and total PCBs were found to be significantly higher in the northern region. Although lead was present in only 5 out of 140 otters tested, with ranges from 0.56-6.1 ppm, all 5 of these otters were harvested in the northern region of the state. These heavy metals originate from mines, mine tailings, and smelters, many of which lie at the head waters of the Coeur d' Alene River in the Silver Valley of northern Idaho. Interestingly, *K* was significantly lower in the northern region, yet reproductive rates were significantly higher. Again this could be attributed to the higher level of cadmium, as mentioned above.

PCBs were tested using methodologies that differed between years. The only congener detected during the first year was PCB1260. There was a significantly lower level of PCB1260 in the southwestern region of Idaho. PCB levels during the second year were reported as to the amount of chlorination (i.e., numbers of chlorine rings). Seven of 14 congeners were detected, but in very low concentrations. Three of these 7 were significantly higher in the northern region of Idaho.

I found mercury in otters to be widespread throughout the state. And, although there were no significant differences found in concentration levels of mercury among the geographic areas, it is revealing that the 2 counties with highest levels are those that have a long history of gold mining. I found a mean of 5.7 ppm and 7.5 ppm in Bonner County and in Boise County, respectively. These levels are above those considered to be background levels.

Although only 5% of the otters tested for mercury had levels above what is considered to represent background levels, these data suggest that there are areas of concern in Idaho. And although I did not observe any deleterious effects or find any correlations between mercury levels and *K* or reproductive rates, I do believe these data depict that Idaho has areas that need continued monitoring for environmental contaminants.

What Does It Mean?

Many of the major sources of the environmental contaminants discussed here have been eliminated; nonetheless, their persistence is undeniable. Although most of the concentrations of contaminants found in the otters' livers were below reported threshold levels that may have lethal effects on them, the current impacts on their prey and habitat are still unclear. And, because Idaho does not have current data on actual river otter population numbers, we still do not know the effects of these pollutants locally, or the significance in population terms.

Although river otters are indicators of the health of their aquatic ecosystem, and much research has been conducted on the chronic effects of pollution and otters, more work still needs to be done. Halbrook et al. (1996) reported that the assessment of negative effects on an individual organism or a population, based on tissue concentrations, is hindered by limited tissue concentration data from either acute or chronic laboratory studies. Although many studies have focused on furbearers, the comparison of data is seldom straightforward. Methodologies often vary (e.g., the variety of tissues used for sampling) and the way in which the data are reported (e.g., wet weight versus dry weight) can also vary. Samples have often gone through a freeze/thaw cycle

prior to necropsy, which expedites degradation of the carcass and also hinders the interpretation of data from field-collected specimens. In addition, adverse biological effects can seldom be attributed to a single contaminant when a river otter is exposed to several toxins simultaneously (Wren 1986). This situation, compounded with natural stresses, may lead to misinterpretations of the adverse effects of environmental contaminants on river otters. In fact, Kruuk (2006) reports that we still do not have good evidence that present-day otter populations are diminished by any specific contaminant.

Management Implications

Mercury contamination was detected in every otter specimen that was tested for the heavy metal, and it remains a serious threat to Idaho's natural resources. As of 2007, mercury advisories had been issued for Brownlee Reservoir, Lake Lowell, C.J. Strike Reservoir, Salmon Falls Reservoir, American Falls Reservoir, Priest Lake, Lake Pend Oreille, and Lake Coeur d'Alene (Idaho Department of Health and Welfare 2007).

Although the concentrations of OCs reported in the present study are below threshold levels, the potential threats these toxins could have on otter populations cannot be ignored. During the 1990s, the Department of Environmental Quality reported concentrations of PCBs and OCs within various species of fish (e.g., suckers (*Catostomus sp*.), whitefish (*Coregonus sp*.), and sculpins (*Cottus sp*.)) throughout many of Idaho's creeks and rivers exceeded wildlife guidelines. These fish species are important prey for river otters. Although PCB levels were below threshold levels for 88 percent of the harvested otters, there was a small sample of otters with levels considered critical for health and reproduction impairment.

Otters have low reproductive rates; they care for their young for a relatively long time, and invest a great deal of energy raising them. And, with otters occurring in low numbers, a small increase in adult mortality, or a decrease in pup recruitment, could have serious effects on the long-term viability of the entire population. Even more importantly, the long-term effects of environmental contaminants on prey could have detrimental effects on the whole population. Considering the fact that toxins, such as mercury, are more likely to accumulate in their aquatic prey and ultimately in them, otters are still quite vulnerable.

Recommendations

Based on the results from the present study, I recommend the Department: 1) continue including catch-per-unit data within the mandatory trapper harvest report; 2) periodically require forfeiture of skulls or a tooth, in order to look at age distribution of the harvest; 3) encourage wildlife managers to consider the threats that still exist to the otter's prey and habitat when discussing harvest quotas; 4) continue to recognize the otter's susceptibility to the long-term effects of environmental contaminants in their aquatic environment, and manage accordingly; 5) continue to collaborate with other land resource agencies in order to obtain data on pollutant levels in the otter's prey and the water bodies they inhabit; and, 6) maintain a conservative harvest quota.

Tables and Figures

Table 2.1. Mean standard measurements (mm) of juvenile, yearling, and adult otters harvested during the 2002-2003 and 2003-2004 trapping season in Idaho.

Age	*Sex*	*N*	*X*	*SD*	*Range*
Total Length					
Juvenile	M	24	1089.3	58.0	948.0-1,224.0
	F	31	1086.0	66.3	910.0-1,215.0
Yearling	M	31	1193.0	63.1	1025.0-1,325.0
	F	26	1130.5	66.7	944.0-1240.0
Adult	M	45	1190.3	74.2	1,060.0-1,352.0
	F	39	1135.1	46.6	1050.0-1265.0
Tail Length					
Juvenile	M	26	406.0	34.88	349.3-482.6
	F	30	409.1	32.9	344.4-463.6
Yearling	M	30	448.9	32.4	400.1-561.3
	F	27	421.4	42.8	289.6-541.5
Adult	M	47	443.1	40.2	342.9-567.0
	F	38	429.9	21.7	393.7-485.8
Hind Foot Length					
Juvenile	M	16	125.8	5.7	115.0-136.0
	F	21	122.6	6.3	107.0-131.0
Yearling	M	22	128.9	9.97	101.6-152.4
	F	20	121.5	7.9	104.8-133.0
Adult	M	37	129.2	7.5	114.0-150.1
	F	25	121.7	5.3	112.0-133.4
Ear Length					
Juvenile	M	2	21.0	0	21.0-21.0
	F	5	21.5	3.7	16.0-25.4
Yearling	M	9	21.8	1.9	20.0-25.0
	F	5	21.8	1.8	19.8-24.0
Adult	M	6	24.0	2.6	21.0-27.0
	F	5	22.0	1.4	21.0-24.0

Sample size varied because some otters were turned in to the Department without heads, tails, feet, or skinned; therefore, it was impossible to get complete measurements. If the head, tail, and/or feet were cut off, total body weight was not taken.

Table 2.2. Concentrations (ppm wet weight, liver) of heavy metals in river otters harvested in Idaho during 2002-2004.

Heavy Metal	Mean (ppm)	StdDv	Maximum (ppm)	Minimum (ppm)
Arsenic (n=127)	0.04	0.22	1.30	0
Cadmium (n=140)	0.03	0.09	0.43	0
Calcium (n=140)	78.95	78.8	770	32
Cobalt (n=139)	0.07	0.52	6.2	0
Chromium (n=140)	0.02	0.16	1.8	0
Copper (n=140)	8.16	3.23	21	2.8
Iron (n=140)	284.89	106.45	900	84
Potassium (n=140)	2325.71	373.27	3200	1300
Magnesium (n=140)	195.71	60.72	590	100
Manganese (n=140)	3.27	1.26	9.7	1.2
Molybdenum (n=140)	0.90	4.7	56	0
Sodium (n=140)	1430.64	190.26	1900	780
Phosphorus (n=140)	2941.43	469.35	4100	1800
Lead (n=140)	0.095	0.66	6.1	0
Sulfur (n=139)	2566.19	316.81	3400	1600
Zinc (n=139)	25.41	7.64	65	13

Table 2.3 Concentrations (ppm wet weight) of organochlorines in livers of Idaho river otters, 2002 indicates no organochlorine was detected.

	n	Mean	Minimum	Maximum	Std.Dev.
Aldrin	161	-	-	-	-
alphaHCH	161	-	-	-	-
betaHCH	161	-	-	-	-
deltaHCH	161	-	-	-	-
Lindane	161	-	-	-	-
Chlordan	2	0.07	0.0	0.14	0.099
DDE	159	0.15	0.0	17.6	1.39
DDD	156	0.002	0.0	0.25	0.02
DDT	159	0.0006	0.0	0.095	0.008
Dieldrin	4	0.024	0.0	0.094	0.047
Endosul1	160	-	-	-	-
Endosul2	160	-	-	-	-
Endrin	160	-	-	-	-
Aldehyde	160	-	-	-	-
E. ketone	160	-	-	-	-
Heptachlor	160	-	-	-	-
H. epoxide	160	-	-	-	-
oxychlor	160	-	-	-	-

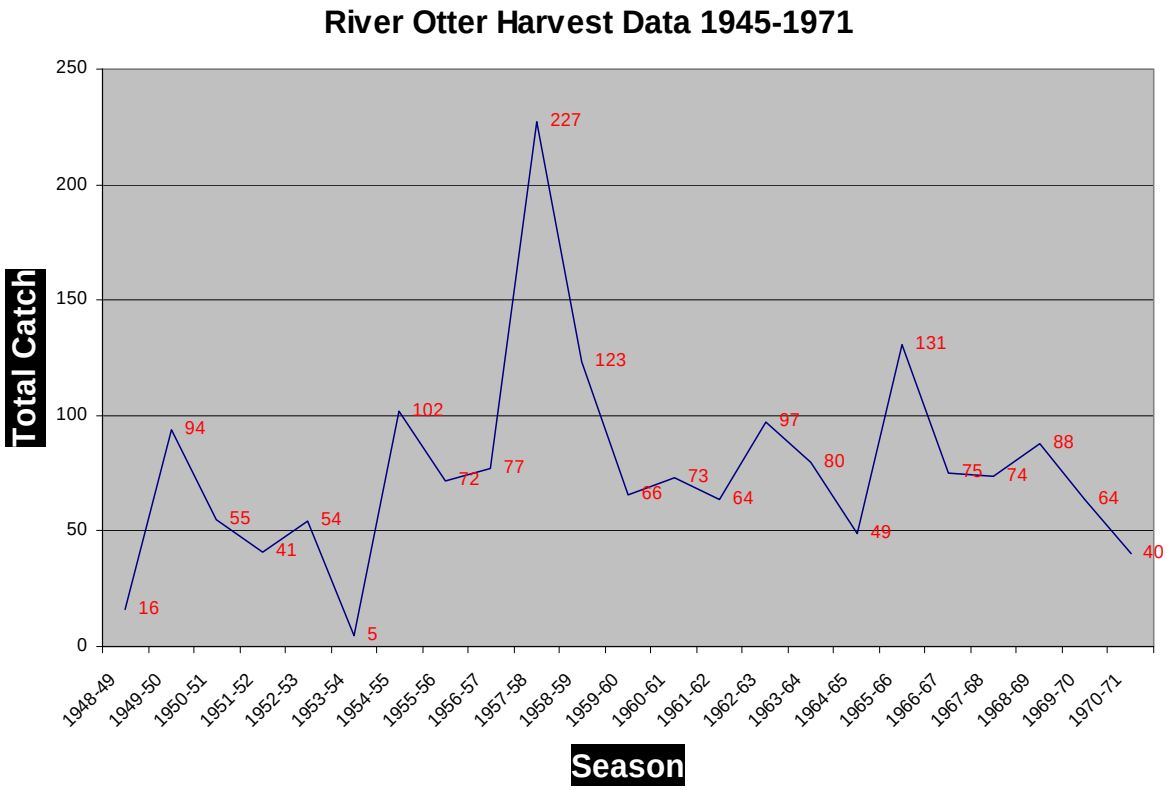

Figure 2.1 River otter harvest in Idaho from 1945-1971.

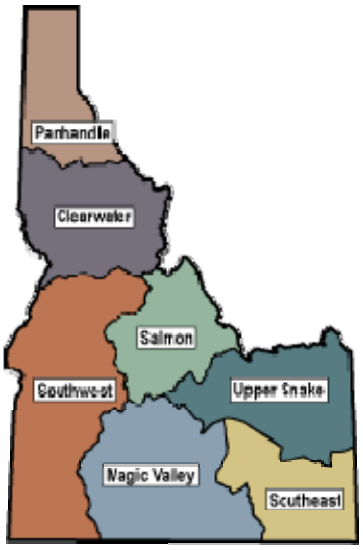

Figure 2.2. Map of Idaho Department of Fish and Game Administrative Regions. Source: Idaho Department of Fish and Game.

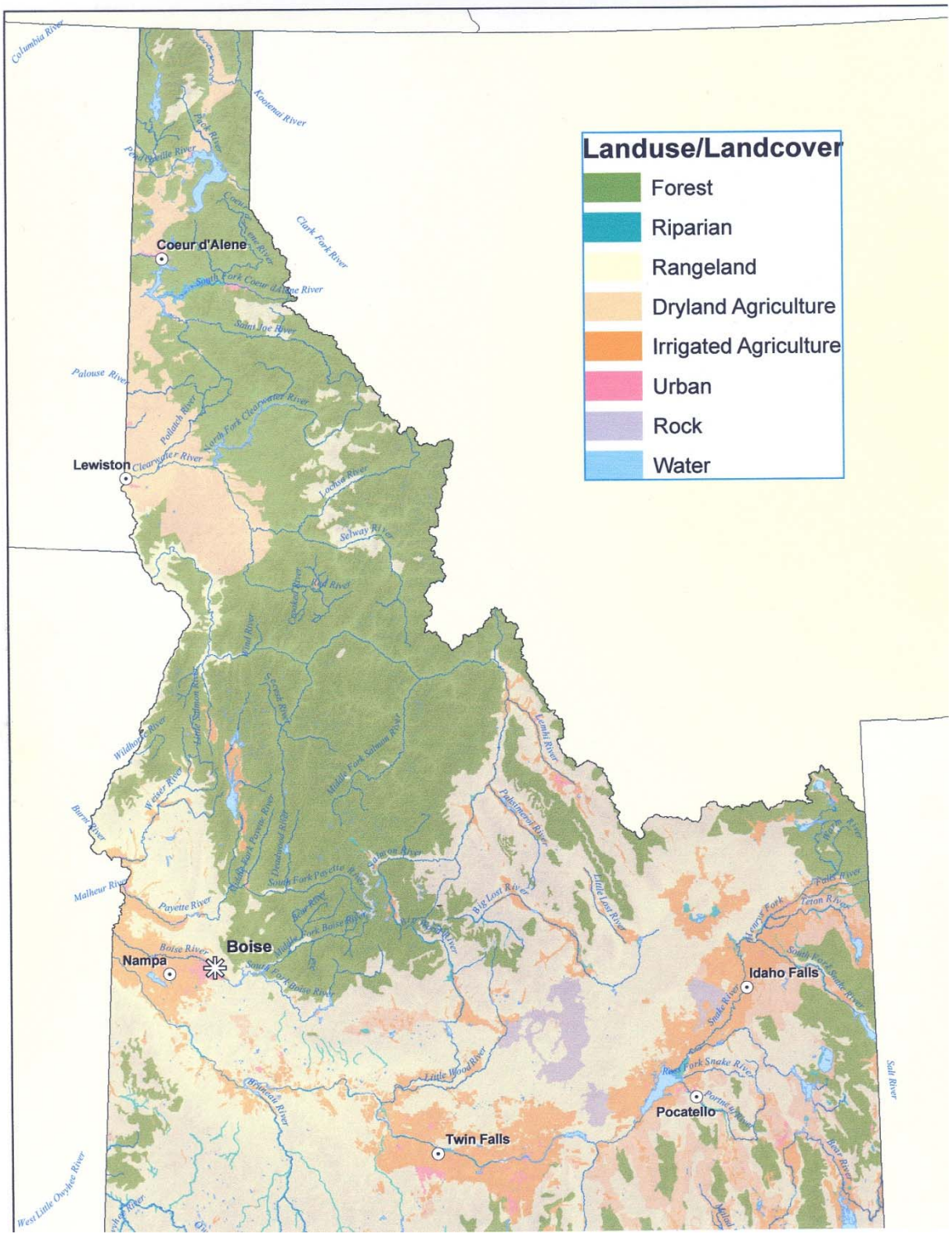

Figure 2.3. Map of Idaho illustrating land use and land cover. Source: Idaho Department of Fish and Game.

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