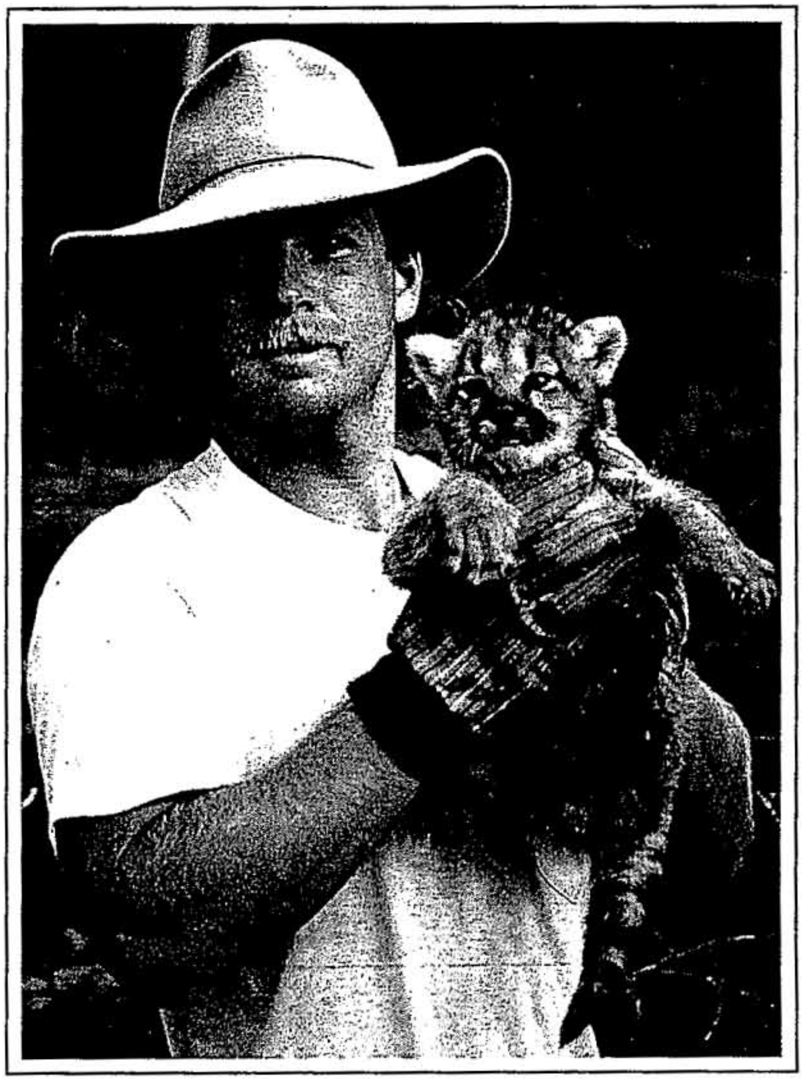
Yellowstone Science

A quarterly publication devoted to the natural and cultural sciences



Cutthroats and Parasites
The Yellowstone Lion
GYE Bald Eagles

Volume 2 Number 3

Risk and Research

The world of Yellowstone research is its own unusual community: fluid, seasonal, and as dynamic as the park's geothermal and ecological systems. Some researchers are here all year, or for many years, while others drop in once a year, or once in a career, for a grab sample or some other relatively quick gathering of information.

This makes for a disjointed sort of society, in which enduring friendships form based on infrequent but well-remembered encounters under all kinds of circumstances. Over the years, these friendships become more involved. Seasonals and graduate students finish projects, move on to jobs in new institutions and agencies, and begin to send their own students to Yellowstone for research. Over time, the community becomes "multi-generational" and relationships become traditions.

For all this diffusion, the sense of community is sometimes quite strong, so when a shock comes it is felt widely. The death of mountain lion researcher Greg Felzien in February of 1992 was one such shock. This tragedy was well covered in the media at the time, and there is no need to go into the details of the situation; Greg, a research associate of the Hornocker Wildlife Research Institute, was killed by an avalanche while tracking a lion in the park. Our interview in this issue, with Kerry Murphy, leader of the lion study and a friend of Greg's, deals at some length with the risks of research in wild country and what the loss of Greg meant to his friends and colleagues.

The photo of Greg on the cover of this issue of *Yellowstone Science* hangs in the entryway of the Yellowstone Center for Resources, with an appropriate tribute to his memory. We dedicate this issue of *Yellowstone Science* to his memory as well.

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On the cover: Greg Felzien, Yellowstone mountain lion researcher killed by an avalanche in 1992, with lion kitten. See previous page, and interview with Kerry Murphy beginning on page 8. Photo by Todd Fredricksen.

Yellowstone Science is published quarterly, and submissions are welcome from all investigators conducting formal research in the Yellowstone area. Editorial correspondence should be sent to the Editor, *Yellowstone Science*, Yellowstone Center for Resources, P.O. Box 168, Yellowstone National Park, WY 82190.

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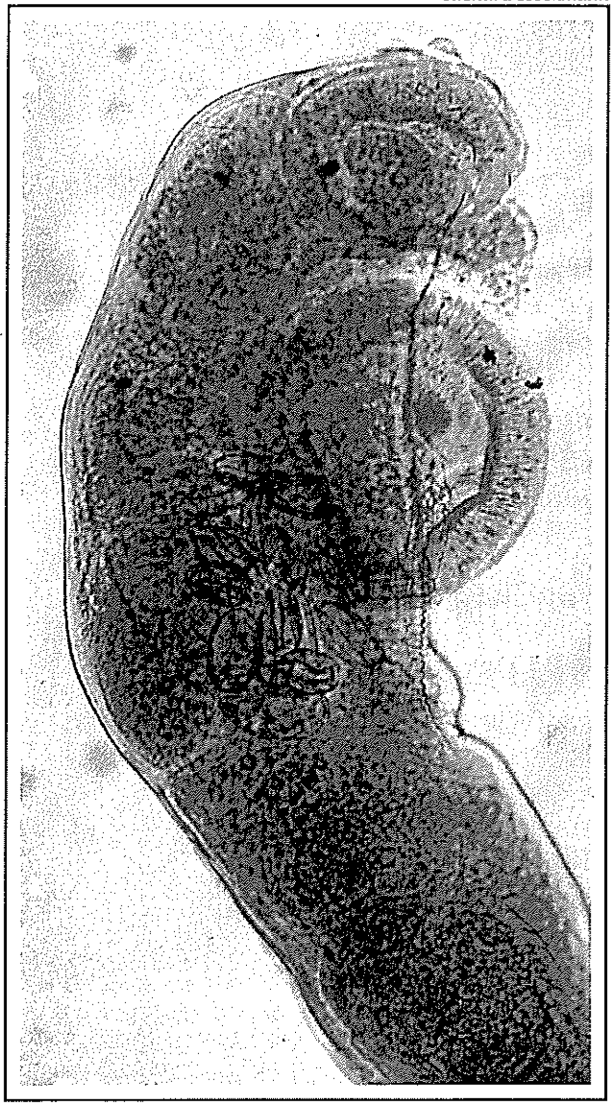
Cutthroats and Parasites

Yellowstone Lake's complex community of fish and companion organisms

Richard Heckmann



Crepidostomum farionis, *an adult trematode found in the intestine, bile duct, and gall bladder of Yellowstone Lake cutthroat trout, at 100X magnification.*

by Richard Heckmann

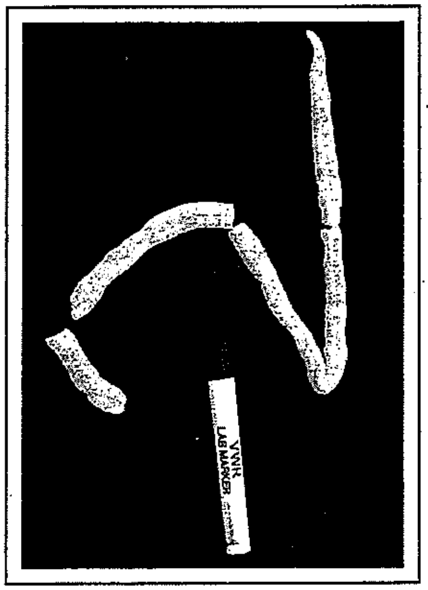
I was first introduced to Yellowstone Lake cutthroat trout and their close companions during a Boy Scout trip shortly after World War II. We rented a rowboat at West Thumb, rowed off shore, and fished with Colorado spinners. We all caught fish and cooked them over an open fire for dinner.

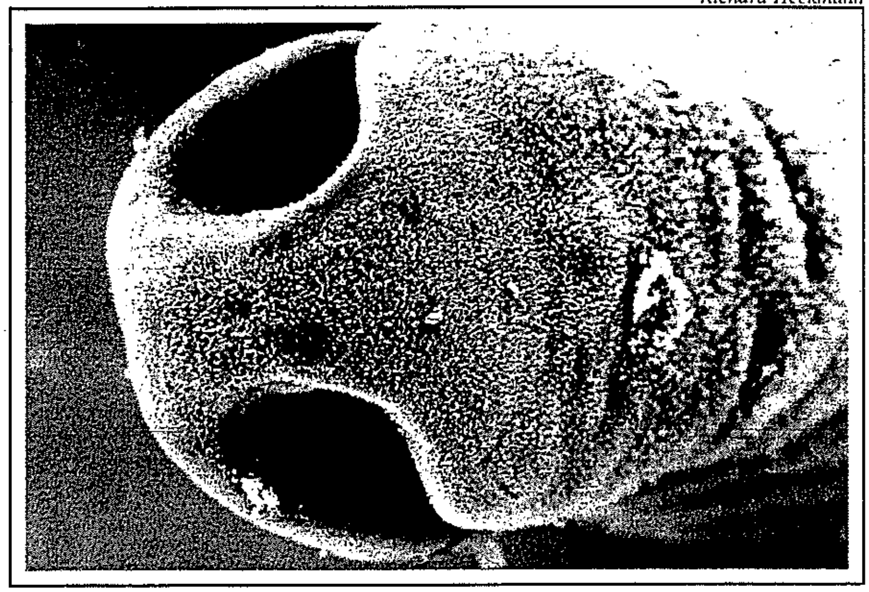
I asked my scoutmaster about the white, ribbon-like structures that crawled out of a blister area in the fish's muscle. He did not know what they were, but he said they would be no problem if we cooked the fish to where no blood or pink meat was visible. Welcome to the parasites of Yellowstone Lake cutthroat trout.

Approximately 25 years later, as a graduate student from Montana State University, I was completing research for my Ph.D. on the same host species, the cutthroat trout. Since my Boy Scout days, I had greatly expanded my knowledge of the symbionts (organisms that live in symbiotic relationships) inhabiting and attaching to cutthroat trout. I now knew that the white ribbon-like structures were tapeworms, one of many parasites I consistently found in Yellowstone cutthroat trout.

Many cutthroat trout are unnecessarily discarded each year in Yellowstone National Park due to the unsightly infections of parasites such as the cestode larvae (tapeworms). Cutthroat trout caught from Yellowstone Lake have ended up in trash cans or thrown into the trees due to parasites, especially the tapeworms. Until bearproof trash cans were installed, park bears had many free meals because fishermen were fearful of the effects of eating trout with such visible parasites. Recent "catch and release" policies for the trout in Yellowstone Lake have helped to alleviate the waste of fish.

Richard Heckmann





Above: Plerocercoid (larval stage) of Diphyllobothrium *tapeworm that infects many cutthroat trout. Right: Head of tapeworm at 50X magnification.*

Since 1891, when Linton published two papers pertaining to tapeworms he had observed in trout from Yellowstone Lake, there have been many articles published about this host and its "close companions." Larval tapeworms (*Diphyllobothrium*) present in most trout more than six inches in length, have been of great concern to many fishermen. The most current list (see table on page 5) includes 18 different species of parasites of the Yellowstone Lake cutthroat trout. This does not include bacteria and viruses that may be present. In 1964 it was estimated that 75 percent of the trout in Yellowstone Lake were infested or infected with parasites.

Most people are aware that all species of animals, including humans, harbor some form of parasite. Parasites often serve as a check for overpopulation numbers, culling out the weak and ultimately building a stronger population. All wild fish populations are hosts for parasites, from the tapeworms in bass in the southern United States to *Diphyllobothrium* in Yellowstone Lake cutthroat trout.

Published pamphlets and books on the fishes in Yellowstone Lake do not contain much information about the parasites and diseases of these fish; nor do the fishing regulations. In this article, I will discuss many of the most important or abundant parasites. If you would like more detailed information on these parasites and their ecology, some technical sources are listed in the box on page 7.

Protozoa

There have been six species of protozoan parasites reported for the trout from Yellowstone Lake. Microscopes are required to observe these parasites. None of them are dangerous to humans, and most have been found on or in other fish species as well.

A ciliate, *Trichophrya*, is common on the gills of the fish (cilia are fine, hairlike projections extending out from the surface of the organism—thus the name ciliate is applied to protozoans having cilia). It was found on the gills of all cutthroat trout examined by the author from all sites on Yellowstone Lake during collection trips beginning in 1969. This parasite does only limited damage to the host. *Trichophrya* commonly infests the gill surface of fishes, and apparently feeds on the gill mucus.

Blood parasites occupy either the blood cells or swim free in the fluid channeled through the cardiovascular system. For cutthroat trout, these parasitic protozoa are rare. Only one of approximately 300 Yellowstone Lake fish examined during several research trips contained red blood cells infected with the blood parasite *Hemogregarina*. The vector (that is, the organism that transports it to the host) for this parasite is usually a leech, and leeches are present in Yellowstone Lake. It is not a common parasite for trout in general and does not infect humans, but blood parasites are of interest to fish parasitologists, and are similar to the parasites that cause malaria in humans.

Trichodina is another common ciliated protozoan. It occurs in the gills of many species of fish, as well as in amphibians, crustaceans, mollusks, and even coelenterates (jellyfish, hydra, sea anenomes, and coral). *Trichodina* often results in diseases known as trichodiniasis, which are quite common in food and aquarium fish. It sometimes results in considerable mortality of fish, but is nonpathogenic (that is, nondisease-causing) in Yellowstone Lake cutthroat trout.

Tapeworms: *Diphyllobothrium* plerocercoids

One of the most interesting and visible parasites found in cutthroat trout is a white, flat, ribbon-like tapeworm. This cestode, or flatworm, is perhaps the most famous of Yellowstone's fish parasites, and is the reason many fish have been unnecessarily discarded. It is a plerocercoid, which is a larval form rather than an adult.

No study has been done on the effect of nonfatal infections of this parasite on the fish of Yellowstone Lake, and quite heavy loads of plerocercoids are sometimes carried by young, vigorous fish without visible harm. However, moderate loads of plerocercoids may be reducing the vitality of even the most vigorous fish. I examined a fish taken from the West Thumb of Yellowstone Lake that contained more than 400 plerocercoids.

This cestode has a complex life cycle; it spends parts of its life in three different hosts. The cestode occupies the first two, which are called the first intermediate host and second intermediate host, in its larval form. It then occupies the third host, called the natural definitive host, as an adult.

The first intermediate host for this common cestode remains unidentified, though several aquatic zooplanktonic species (very small crustaceans in this case) in Yellowstone Lake are strongly suspected to be hosts in the life cycle. Once an egg has been eaten by this host, it passes through the stomach wall and encysts in the host's body cavity tissues, where it enters its first larval form.

The parasite remains within this host until the crustacean is eaten by a trout, the second intermediate host. The larva is released when the trout digests the crustacean, and then migrates through the wall of the fish's alimentary tract, where it develops into its second larval form, called the plerocercoid.

The plerocercoid encysts in the trout's abdominal organs, and grows until it can break from the cyst and become free in the abdominal cavity of the fish. The plerocercoid may then migrate into the flesh and become encapsulated. In some cases, part of the plerocercoid remains in the body cavity and part is in the muscle.

A variety of animals, including pelicans, gulls, and bears, have been identified as the natural definitive hosts. When one of these hosts, usually a bird, eats and digests the fish, the plerocercoid is again released and develops into an adult cestode within the bird's intestine. It eventually produces eggs, which are released with the bird's feces into the lake, starting the cycle again.

The essential role of birds in the life cycle of this parasite has long been recognized. If water birds were somehow prevented from preying on the fish population, one effect might be the disappearance of *Diphyllobothrium*, which is directly dependent upon water birds for part of its life cycle. At one time, several decades ago, park managers even proposed to eliminate pelicans from Yellowstone Lake, thus eliminating the tapeworm.

Certainly a heavy tapeworm infection is harmful to some individual trout. Tapeworms can cause considerable damage to internal organs, lead to reduction of vigor of individual fish, and possibly affect reproduction. But control of the parasite would be extremely difficult. More important, removal of this natural element could lead to a disruption of Yellowstone's aquatic ecosystem.

The potential for human infection by plerocercoids in Yellowstone Lake cutthroat trout has long been of major concern. However, fisheries biologist Lowell Woodbury, writing in 1932, claimed that the plerocercoids of *D. cordiceps* were not infective to man. Late in the summer of 1931, Woodbury intentionally ate eight small plerocercoids, some free and some encapsulated, in order to test the potential for infection. He found no evidence of infection, and repeated the experiment the next year by eating six larger plerocercoids (20-70 mm in length) with the same negative results.

Another investigator, John W. Scott, also ate plerocercoids from Yellowstone Lake trout at various times with negative results, but a third, Rolf Vik, ingested plerocercoids and later passed adult worms, indicating that human infections are possible. In 1970, another researcher, C. W. Crosby, found that plerocercoids from Yellowstone Lake cutthroat trout fed to laboratory dogs resulted in viable, egg-producing adults.

NPS Photo Archives

Pelicans nesting on the Molly Islands in the Southeast Arm of Yellowstone Lake were long ago recognized as an important link in the life cycle of the trout tapeworm Diphyllobothrium. *Because of public distaste for the tapeworms, and because of the great popularity of trout fishing on Yellowstone Lake, early National Park Service managers actually planned the destruction of the pelican population in order to eliminate the tapeworm. Though some pelican eggs were destroyed, public opposition ended such activities. In the above photograph, taken by NPS naturalist George Bagley in 1932, park personnel band the young birds, one of which is pictured below.*

Known Parasites of Cutthroat Trout, *Onchorhynchus clarki*, from Yellowstone Lake, YNP

Name of Parasite	Location on or in host
Protozoa:	
Costia pyriformis	Gills
Haemogregarina sp.	Blood Stream Red Blood Cells
Myxosoma sp.	Skin & Muscle
Myxosporidan sp.	Gills & Skin
Trichophrya clarki	Gills
Trichodina truttae	Gills

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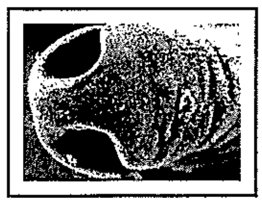
Myxosoma

Name of Parasite	Location on or in host
Cestoda: Tapeworms	
Diphyllobothrium cordiceps L	Muscle, Viscera
**Diphyllobothrium ditrenum* L	Muscle, Viscera
**Diphyllobothrium dendriticum* L	Muscle, Viscera
Diphyllobothrium sp.	Muscle, Viscera

*Recently described—replaced *Diphyllobothrium cordiceps*



Diphyllobothrium

Name of Parasite	Location on or in host
Acanthocephala: Spiny headed worms	
Neoechinorhynchus rutili	Intestine
Digenea: Trematodes—Flukes	
Crepidostomum farionis	Intestine, Gall Bladder, Bile Duct
Diplostomum spathaceum L	Eyes
Diplostomum baeri buccelentum L	Eyes
Nanophyetus salmincola	Intestine
Posthodiplostomum minimum L	Viscera

Diplostomum

Name of Parasite	Location on or in host
Nematoda: Roundworms	
Bulbodactnitis scotti	Intestine
Irudinea: Leeches	
Illinobdella sp.	Surface of fish, Gills, Fins
Piscicola salmositica	Surface of fish, Gills, Fins
Crustacea: Copepods (Lice)	
Salmincola sp.	Head region, Gills
Mollusca: Bivalves	
Glochidia L	Gills

L = larval stage

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Left: Gill filaments (200X mag.) from a cutthroat trout from Yellowstone Lake infested with Trichophrya clarki. *Below: A* Trichodina *sp. from the gills of cutthroat trout (1000X mag.).*

For the modern fisherman who may not care to repeat this experiment, my scoutmaster gave us the right advice when I first ate trout from Yellowstone Lake: they are not harmful to humans as long as the fish are cooked. Dislike of the parasite is purely psychological, and discarding parasitized fish is wasteful. Consider the additional protein you are ingesting when infected fish are eaten.

Flukes: Blindness for Trout

If the lens of a cutthroat trout's eye appears opaque or cloudy, it may be due to a larval stage of a fluke. The larval stage has migrated into the orbit of the eye, causing blindness. Unsuccessful fishing trips may be partially due to this parasite.

The larvae of *Diplostomum* live in the eyes of Yellowstone Lake fishes and remain there until the fish die or the life span of the parasite has been reached. Some fish are probably blinded by Diplostomatosis, the disease caused by the parasite. For fish, this parasite is nonhost-specific (meaning it can live in a variety of hosts rather than in just one species) but has not been considered dangerous to humans. During recent surveys of fish parasites for cutthroat trout from Yellowstone Lake, cutthroat trout had a 100 percent incidence of the eye fluke, with some fish containing more than 100 larvae per eye.

Fish are the most common second intermediate hosts for *Diplostomum*; however, infections in amphibians, reptiles, and mammals have also been reported. Once the larvae are released from their primary host, snails, they penetrate the second intermediate host, lose their forked tails, and migrate to the tissue of the eye, where the metacercariae (or second larval stage) develops in 50-60 days.

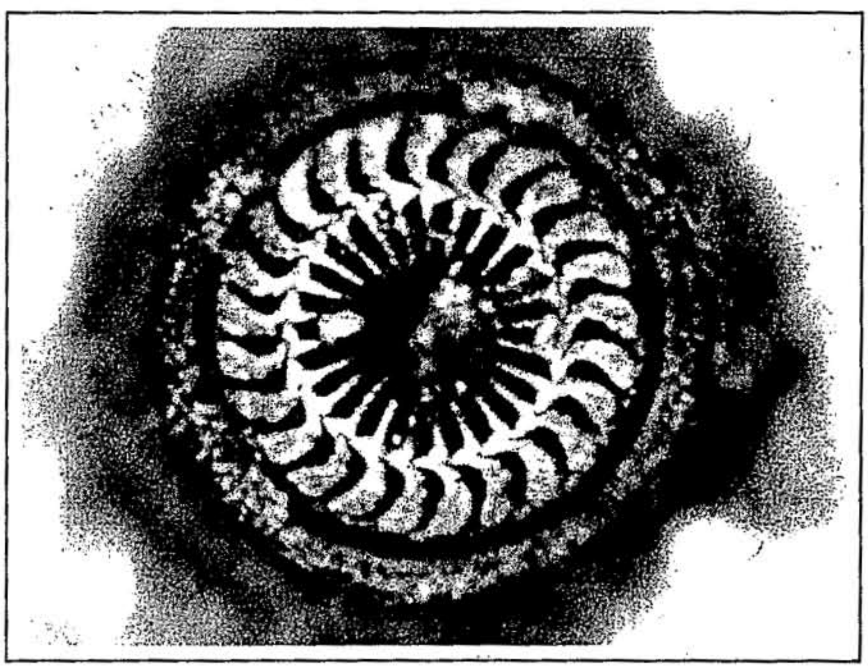
Diplostomatosis can cause cataracts of the lens tissue, due to the presence of the metacercaria stage of this parasite. Visual acuity for infected fish can be slightly hampered or lost, depending on the number of worms present. In addition to visual loss, fish show retarded growth and a change in food habits.

There is a small adult fluke found in many of the fish called *Crepidostomum farionis*. In my 1970 survey, 95 percent of the trout examined were infected with this fluke, which often occupied the lumen of the gall bladder.

Ectoparasites: Fish Louse and Leeches

The fish louse, or parasitic copepod, is a small crustacean usually found attached behind a trout's fins. It is common in June and eventually drops off after the fish has been removed from the water. Minimal damage is caused by the copepod to the host fish. Certain species of copepods, or fish louse, such as the genera *Argulus*, *Lernaea*, and *Ergasilus*, are very serious pests in fish culture and sometimes in nature.

The freshwater leech (*Piscicola salmonsitica*) is dark brown and about one inch long when extended. It attaches to the body of the trout by means



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As part of his research, the author captured Yellowstone Lake cutthroat trout and held them briefly in a live well (above) so examinations could be conducted (below). The fish were used for parasite identification and to test new pharmaceuticals against varous parasites.

of a suction-type mouth equipped with rasping mouth parts. The leech is most numerous during the cutthroat's June spawning run. It usually drops off shortly after the fish is removed from water.

Leeches were found on the gills and base of fins of 8 percent of the cutthroat trout checked for parasites during 1985.

Fish Parasites and the 1988 Fires

The last parasite survey of Yellowstone Lake cutthroat trout that I conducted was in 1990, two years after the fires of 1988. I discovered a remarkable drop in the number of tapeworm plerocercoids.

In the 1985 survey, 100 percent of the trout that were six inches or longer were infected. This dropped to 5 to 38 percent infected for the same size group for the 1990 survey, with lower numbers of plerocercoids per infected fish. I have hypothesized that the fires somehow interrupted the life cycle of the cestode so that fewer fish were infected.

Richard Heckmann, a Professor of Zoology at Brigham Young University, has been involved in research on the parasites of the cutthroat trout in Yellowstone Lake for more than two decades.

Suggested Readings

Heckmann, R.A. 1970. Comparative morphology and host-parasite studies of *Trichophrya clarki* (sp. n.) on cutthroat trout (*Salmo clarki*). Unpublished dissertation, Montana State University, Bozeman. 69 pp.

Heckmann, R.A. 1971. Parasites of cutthroat trout from Yellowstone Lake, Wyoming. *Prog. Fish. Cult.* 33:103-106.

Heckmann, R.A. and T. Carroll. 1985. Host-parasite studies of *Trichophrya* infesting cutthroat trout (*Salmo clarki*) and longnose suckers (*Catostomus catostomus*) from Yellowstone Lake, Wyoming. *Great Basin Nat.* 45:255-265.

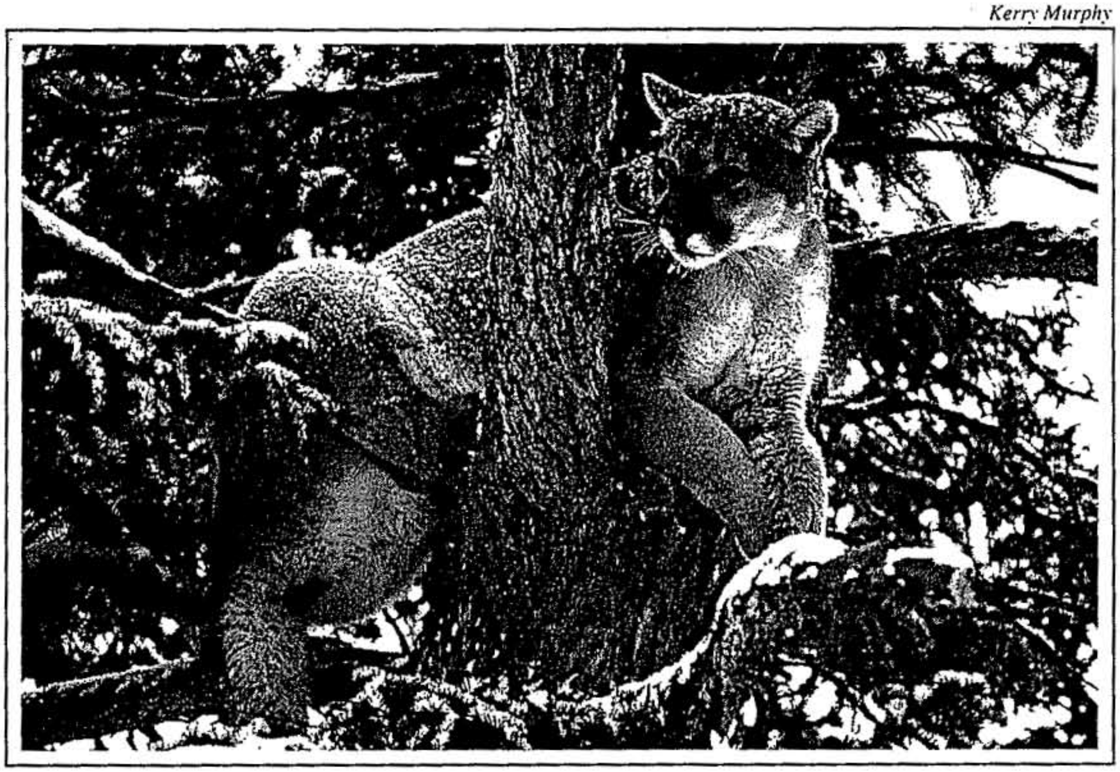
Heckmann, R.A. and H.L. Ching. 1987. Parasites of the cutthroat trout, *Salmo clarki*, and longnose suckers, *Catostomus catostomus*, from Yellowstone Lake, Wyoming. *Great Basin Nat.* 47:259-275.

Hoffman, G.L. 1967. *Parasites of North American freshwater fishes.* Univ. of California Press, Berkeley and Los Angeles. 486 pp.

The Yellowstone Lion

The homecoming of a native predator: Part One

Kerry Murphy



Mountain lions were native to the Yellowstone region, and were often mentioned by early travelers, who either heard or saw them in the park. The federal predator control programs of the early twentieth century essentially eliminated them from Yellowstone; 121 were reported killed between 1904 and 1925, when the "last" one was taken. For many years after that, only occasional sightings were reported, and the belief that the mountain lion was gone was widespread. But in the past thirty years, sightings increased, and evidence grew that Yellowstone again had its own population of mountain lions.

Kerry Murphy, a wildlife biologist with the Hornocker Wildlife Research Institute in Moscow, Idaho, is now completing a five-year study of this "new" Yellowstone lion population. In this first part of a two-part interview, we asked Kerry about many aspects of the study and its results. In the second part, to appear in the next issue of Yellowstone Science, *we will follow Kerry through a typical day of tracking, in which a lion is treed by the dogs, radio-collared, and released.*

We look forward to hearing more from Kerry on the ecology of the Yellowstone lion as he completes his analysis of the data gathered during this important study.—Ed.

YS How did the lion study come about?
KM The Yellowstone lion study grew out of work that Maurice Hornocker, director of the Hornocker Wildlife Re-

search Institute, did with his colleagues in the Big Creek area in Idaho in the 1960s.
YS That was a landmark study, with lots of cutting-edge methodology.
KM Right. Maurice asked me to go back there as an assistant to Gary Koehler. The idea was to do another study because the prey distribution and density had changed. Because of the 1960s work, we would have reference information to compare the new findings with. We wanted to see if the lion population had changed in response to the changes in the prey population.

At the time that we went back into Big Creek, in the early 1980s, a lot of the science we used was changing. Researchers and managers were doing more direct manipulation with large carnivores.
YS You mean like capture and handling, and radiocollaring?
KM No. I mean removal experiments, in which lions were taken out of the area, to see how predator social organizations would change or how prey populations would respond to reduced numbers of predators. Lion removal wasn't envisioned for Big Creek right away, but Maurice eventually wanted to experimentally manipulate the population. So we thought we'd study the Big Creek situation for three or four years, and when we understood what was going on, we would take individual lions out, and see how remaining lions responded.

This brought up the obvious question of what to do with the lions we took out. The answer was, "Let's put them in Yellowstone, because the park doesn't have lions." Well, we knew we'd better go take a look.

That's when Maurice proposed to do the survey. The park was getting more sightings, and some park researchers thought there were more mountain lions around than commonly believed, but nobody knew how many or if they were resident.
YS Besides the sightings of individual lions, Doug Houston, one of the NPS biologists in the 1970s, was flying over the Black Canyon of the Yellowstone River in the northern part of the park and photographed a female with two kittens.

Gary Koehler

Kerry Murphy with "Spook" the redbone hound that Kerry claims could actually reason. The lion was a large kitten captured in Big Creek, Frank Church River-of-No-Return Wilderness, March 1987. This capture was part of Hornocker's second study in Big Creek.

KM That was a significant sighting. When reproduction occurs, there is a high probability that the family is resident. Family groups need predictable resources. For this reason, it would be very difficult for the mother to be unattached to a home range and still support a family. We could have guessed right there that resident individuals were present.

From January to April of 1986, Gary Koehler and Jay Tischendorf did the survey. They estimated that there were three to five resident lions on the northern range in the park. It's hard to document population size based only on a survey, but three to five was probably a reasonable estimate.
YS How do you make an initial estimate like that? How do you decide if lions will like a country and live in it?
KM The winter haunts of lions are pretty predictable. Gary and Jay looked on a map for areas where prey, rocks, and conifer cover occur together. They thought the Black Canyon would be great habitat. It had a lot of cover and was prime ungulate winter range. Of course, it did not support as many ungulates as other habitats on the northern range, but lions don't necessarily need high prey densities. Lions are morphologically equipped to find and kill prey efficiently.

Gary and Jay skied those likely areas and inevitably found tracks and other sign. The problem was not finding sign but deciding how many lions left it. That's why telemetry is usually needed for these secretive carnivores. Researchers have proposed using track counts to document population trends, but you really need to establish the relationship between the actual population size and the tracks seen.
YS Let's get back to the launching of

the study. What happened after the initial survey?

KM Well, we immediately recognized that lions were already here, so there was no need to pursue a population restoration using lions from Big Creek. But we had developed a strong interest in how lions affected the elk on the northern range. It was also a unique opportunity to study how the lion population was responding to a very high prey base.

YS Why would that be special?

KM Most of the lion research conducted previously in the western states was in situations where prey were at low or moderate levels. In Yellowstone, ungulate densities are among the highest in the world. We calculated 55 elk per square mile, based on some of Frank Singer's [*NPS ungulate ecologist—Ed.*] numbers. Maurice calls the park an elk supermarket. And that does not include the other lion prey that are present, such as deer, sheep, moose, or large rodents.

Maurice proposed a 5-year study. He put together funding from outside funding sources and the NPS, and away we went.

YS That's where you came in. What were your hopes for the study?

KM I thought I might be able to do my doctoral work here, but I was afraid I might end up writing a dissertation about only one or two individuals. There was some risk involved for Maurice and me. The funding wasn't secure in the long term. We just decided to go for it.

YS How did you start?

KM Jay Tischendorf and I began work right where we thought the best lion habitat was—in the Black Canyon, on lower Blacktail Deer Creek, and lower Hellroaring and Slough Creeks. We caught 10 or 11 individuals during the first winter.

YS That must have been an amazing start, to get so many right off.

KM It was a good winter to capture lions. They were reasonably concentrated. When we started, we caught lions that occurred predictably in the river corridors. But as the study evolved, we worked in areas where the lions occurred at lower densities, such as Pebble Creek. Many parts of the northern range are hard to get to, and so more time and energy is required to capture lions there than in the river corridors.

YS Mention of capturing lions brings up another subject. Many people are curious about the use of dogs in this project. Dogs have a long history of conflict with wildlife in many places, and unleashed pets are not allowed in national parks. In fact, for many years, dogs were absolutely forbidden in Yellowstone. Even in recent decades, residents were not allowed to own them in the park's interior. That must have required some careful diplomacy between you and the local people, to suddenly be running a wild animal in the backcountry with dogs. Was that a problem?

KM When I arrived here, I didn't appreciate how much opposition there might be against hounds. I had worked with lions and dogs in other places and it was not a problem. Dogs had been used in Yellowstone in the early 1900s to control lions. And Yellowstone was not the first national park to do lion studies with dogs. Everglades, Big Bend, and Guadalupe Mountains national parks had all used dogs, so precedents existed.

So we said, "Hey, what's all the concern? It's been demonstrated that dogs can be used effectively without disrupting ungulates, if you show common sense." Still, the opposition was there.

YS Some of the problem must have been misunderstanding of what your dogs would do. If you mention using dogs to catch lions, a lot of people would think of a string of twenty or so dogs out there, with lots of noise, and elk and deer being spooked in all directions. People picture the old fox hunt.

KM Exactly.

YS But that isn't how it works. If a hiker came along and saw you at work, they would see two fellows with heavy backpacks, and a couple of dogs on leashes.

KM Right. In the first three years of the study, we took out a lot of rangers and other park personnel. They saw the nature of the operation and its logistical difficulties. That was a big factor in reducing concern over the hounds.

The dogs were not allowed to bark when we hiked. After we released them to follow lion tracks, their barking was partly absorbed by the canyons and the forest.

Spook, the same redbone, early in the Yellowstone study, April 1988.

YS When were you in the field with the dogs? When did you catch lions?

KM Generally our capture season was from late October through March 30. We did it that way to avoid confrontations with bears.

YS So grizzly bear denning times dictated your field season?

KM Yes. We did immobilizations outside the park when bears were not denned, but only in areas that we thought supported few grizzlies.

YS Another time frame that you had to deal with was the lion-hunting season in Montana, north of the park. How did you work with that?

KM The lion-hunting season opens December 1 and closes when quotas are reached. That would often be in early January, but sometimes seasons wouldn't close until about February 15.

YS So you tried to do your work outside before and after the hunting season, and then work in the park during the hunting season?

KM Right.

YS What proportion of your work was outside the park?

KM Thirty to forty percent of our effort was expended outside the park. In the winter, the density of lions was greater there, maybe because the cats preferred deer, which were more abundant there than in the park. We tried not to work outside the park during the lion hunting season because we didn't want to alert the hunters to where radio-collared lions were.

YS Later we want to verbally travel with you through an entire tracking session. For now, how about some background on the process by which you gathered information on the lions once they were caught and collared? How many radio relocations did you need?

KM We might only get one radio location every two or three weeks, depending on the weather for flying or our objectives on the ground at the time. During spring, summer, and fall, we camped in the vicinity of some lions, and might have continuous radio contact with them from dawn until nine or ten o'clock at night. If necessary, we would get up in the middle of the night and use the telemetry equipment to see if a lion had moved from its previous position.

Our most intensive work occurred when we were attempting to document lion-prey relationships. This included estimating the rates at which lions took deer and elk.

YS How many days would you follow a lion to collect predation data?

KM Our advising statistician, Dr. Pat Munholland, from Montana State University, suggested that a monitoring sequence should last until it contained at least three ungulate kills. That period of time was variable, but it might be as long as 50 days.

YS During that time, how much of the cat's actual movements did you track?

KM During one sequence, Greg Felzien and Todd Fredricksen monitored a family group for 24 days and believed they had seen almost every footprint the cats made. Obviously that's very intensive effort, and we weren't able to achieve that level for many sequences, especially not in the summer when snow cover was absent. If we lost the telemetry signal of the lion, we would call Bill Chapman [*contracting pilot on the study—Ed.*] and he would use his airplane to locate the cat for us. Then we would have just one contact point for that day.

YS Was there a risk that your presence

Jana Mohrman

A lion track photographed on Soda Butte Creek in the Lamar River drainage, Yellowstone National Park.

on all those days would disturb the lion and influence your findings?

KM Our objectives were to not let the lion know that we were actually in the area. We obtained a preliminary radio location from a distance, using triangulation, then moved closer. Eventually, we circled the lion and obtained a precise location by triangulating every 50 yards or so. We used available cover as a screen, but occasionally the lion detected our presence and ran off. It didn't appear that it significantly affected their movement patterns.

It was surprising how well we could sneak up on a sleeping lion, which happened if their hearing was blocked by rocks or vegetation. Of course, if they were in open country, they would hear us. Scott Relyea was able to get within 15 or 20 yards several times without being detected. On separate occasions, Greg and Todd saw a male and female mating.

YS How often has that been seen?

KM To my knowledge, these were the first times that has been observed in the wild.

YS Is there something that made such sightings more likely here, or was it just happenstance?

KM It's partly the openness of Yellowstone landscape, which tends to have sparse understories. You wouldn't be likely to see that over on the Olympic Peninsula.

YS You've concluded from your study that the lion population on the northern range has been increasing.

KM It looks like the population in the park *and* the population down the Yellowstone Valley increased during the study. People often believe that lion populations can't increase very rapidly, but lions have a high reproductive potential. In fact, it exceeds that of mule deer. Lion populations can respond quickly if sport harvests are reduced.

YS How significant was the sport harvest north of the park?

KM Very significant. And this is not unique to our particular study; it's been observed repeatedly. Sport harvests among hunted lion populations are usually the single most important source of mortality of adults and subadults. That excludes kittens, who tend to die of natural causes such as disease, predation, and natural accidents.

Another important observation related to management was dispersal from our study area and how it may have affected subpopulations in other watersheds. Our radio-collared subadults dispersed to the Clark's Fork of the Yellowstone River, and to the Stillwater, Boulder, and Gallatin River drainages north and west of the park. I think lions on the northern range constituted one subpopulation that was well-linked to other major drainages in the greater Yellowstone ecosystem. The Yellowstone River watershed appears to trade dispersers with these peripheral areas.

About two-thirds of the kittens that survived to dispersal age (11 to 14 months) left the study area. Conversely, about two-thirds of the yearlings present on the study area were born outside.

YS Is that significant?

KM Yes, because it implies that emigration and immigration of dispersing lions may "rescue" over-harvested subpopulations by continuing to add new individuals. It also points out how adversely interstate highways and human developments might affect local populations if they block exchange.

YS Are you implying that travel corridors are important to dispersing lions?

Greg Zopetti

Three lion kittens hiding at their den site near Grizzly Creek in Tom Miner Basin in August 1989. Dealing with mother lions was sometimes quite exciting. As Kerry explained this episode, "Later that summer, we saw their mother thump a black bear that got too close. She was not too happy about having us around either."

KM I don't think "corridors" are necessarily important to dispersing lions if cover and prey are adequate. For example, one of our dispersers left Quadrant Mountain and travelled almost a straight line to Yellowstone Lake. He then changed direction and went to the vicinity of Shoshone Lake. It appeared that he moved as if on a compass bearing, at least in the early weeks of dispersal. We saw this behavior in other situations too. The point is that they don't always follow what we think of as a travel corridor. They seem to travel without regard to topography. There may be some genetic control over the process.

YS What happens after the initial period of dispersal? How do they go about settling into an area?

KM They leave their natal ranges and remain in "dispersal" mode for a couple or three months. Then suddenly, they switch into a normal movement pattern much like a resident. They generally disperse during summer.

Typically by September or early October, the snow is accumulating and the cats have to figure out where to make a living for the winter. And if they're on the Yellowstone Plateau, it may not be obvious where to go to find deer or elk winter range. That probably puts some of them in a bit of a crunch.

YS Lion population size has always been something of a mystery in Yellowstone. Some of the turn-of-the-century accounts from the park suggested huge numbers of lions. Some of the observers weren't trustworthy, but others were pretty sharp, and they seemed to believe there were much larger numbers of lions around than now. What do you make of all that?

KM I haven't studied the historical literature in detail, but I have a couple thoughts. One is that the folks who noted the high numbers of lions were right. Lion populations may be able to build to levels much higher than we have seen in our lifetimes. Maybe we incorrectly discount those early reports because we're predisposed to think that lions can't reach such high densities.

We should also consider that the human-use patterns in Yellowstone have changed significantly since the park was established. What was suitable habitat when the historical reports were made may not be useful to lions today. For example, take the Lava Creek area, on the road east of Mammoth Hot Springs. Disturbance to lions there was probably low before the road was paved. The cats probably felt comfortable with the noise level and freely used the rocky rims across the canyon from Undine Falls. Today, the traffic and human activity may be so great that lions avoid the area. I was always surprised at how few times we located lions there during late fall, winter, and early spring, considering the prey and rocky cover that are present in the area. The net effect may be that less habitat is now available to lions, which leads to lower lion numbers than in the past.

The second possible explanation is, of course, that the folks who wrote the historical reports did overestimate the numbers of lion present. When they saw a lot of tracks, they naturally concluded that lions were very abundant. But as I said before, it is difficult to know how many lions correspond to multiple sets of tracks seen over a large area. I once heard a credible wildlife professional confidently estimate the number of lions in an area that I had worked intensively. My estimates were three-fold less. This person assumed each set of tracks he saw represented a different lion.

Another frequent mistake is to observe tracks of female lions with their large offspring, then count each of those lions as a breeding individual. Lion kittens have rates of mortality as high as 66 percent, and many disperse long

NPS Photo Archives

Chief Ranger Sam Woodring (left) and another man with a large lion killed in the park in the mid-1920s four miles north of Tower Fall.

distances from their natal area anyway. With respect to the immediate area, their abundance doesn't matter much. Most wild cat populations limit their numbers through their social organizations, which tend not to tolerate stockpiling.

YS One subject of continual interest around Yellowstone is wolves. What does your study tell us about how lions will do if wolves are restored to the park?

KM Remember that lions evolved in the presence of wolves. In fact, they evolved in the presence of several physically stronger or numerically more abundant carnivores, including grizzly and black bears, wolves, and coyotes. When a lion opens up the body cavity of an ungulate he kills, a lot of scent is released. These other carnivores are naturally attracted to it. Lions obviously had to develop correct behavioral responses when confronted by scavengers. I expect that lions will be displaced from carcasses by wolves. If this happens frequently, lions may have to travel and kill more often. These behaviors carry risk that might reduce the lion's survival.

Keep in mind that the lion is a supercapable predator, fully equipped to consistently provide for itself. In Yellowstone, adult lions seldom need to scavenge because of their predatory skill and the abundant prey. Even if scavenging is necessary, a lion would probably not be competitive at it because other scavengers usually get to the food source sooner using their superior noses. So scavenging is not much of an option. The effect of wolves on lions could be significant, because they would have little alternative but to kill again and potentially face the same problem.

Based on sign and telemetry observations, we observed that black bears displaced lions from their kills at least 4 times. We directly or indirectly observed coyotes do this, or at least try to, 3 times. In fact, we documented 13 coyotes killed by lions. About half of those were in the vicinity of ungulates killed by lions.

In Glacier National Park, researchers have documented at least two occasions where mountain lions were killed by wolves. Think of a pack of five to twelve wolves trotting in on a carcass and finding a female lion and two small kittens. You can imagine what kind of things could happen in that situation.

YS One of the most difficult realities of research in a setting like Yellowstone is the risk to human safety, not so much from the animals but just from the setting. A study like yours, which depends so much upon data gathered in winter, has even more hazards. The death of one of your team members, Greg Felzien, in an avalanche in February 1992, was a great tragedy in Yellowstone research, one you and your colleagues felt keenly. What can we learn from it?

KM If you are going to do lion research and expect to be successful at it, there are risks. It's almost impossible to do the work well and not occasionally find yourself, your partner, or the dogs, in a bad position. We try to instill a safety ethic in everyone and recognize that lion studies come and go, but we keep our injuries when done with the project.

I believe the order of priorities should be yourself, your partner, the lion, then the dogs. Obviously, you are not much good to your partner if you are hurt, so keeping the old number one healthy is a pretty good idea. Unfortunately, you are almost always at the mercy of some force such as gravity, the terrain, or cold weather. There's not much getting away from it. These forces can be pretty unpredictable, and being physically tired doesn't help.

I am still intimidated by the big country in Yellowstone: the steepness of many parts of the northern range, the rocks, the big rivers, and the work late at night. I try never to put myself at excessive risk. That has always been a comfort to me as we turned the dogs loose in potentially dangerous terrain. As I felt my fear go up, I told myself, "I just won't put myself in a bad spot."

YS You have choices.

KM I have the choice, and I hope that my partner is just as careful.

You will never be 100 percent proficient at predicting situations that might get you into trouble, but you can learn to avoid the obvious ones. You can predict what footing is poor, and what temperature conditions and personal energy levels lead to hypothermia. Ultimately, you and your partner determine if it's possible to do the job and get out safely. You just hope that you have enough sense to know when to head for home and forget the work. I remember lots of cold nights in wet clothes when the best part of the day was just the sight of the truck or hearing the voice of 700 dispatch on our park radio. I guess those nights have to be considered as part of the fun too.

Yellowstone's Bald Eagles

Is the park a "black hole" for the national symbol?

by Al Harmata

To most of us, the term "black hole" conjures up images of celestial vacuums sucking all matter into dense, dark oblivion. In the early days of bald eagle research and management in the greater Yellowstone ecosystem (GYE), those of us involved often referred to Yellowstone National Park (YNP) as a black hole for the population. Little did we know.

In the 1950s and early 1960s, investigations quickly identified 10 to 13 resident pairs in the park each year. During population lows of the 1960s and 1970s, researchers determined that breeding bald eagles needed to produce a minimum of 0.7 young per pair each year in order to maintain at least a stable number of adult pairs in a population. Further investigation revealed that the park's eagle pairs were not producing enough young to maintain adult population levels.

Interestingly, the number of breeding pairs did not decline during the "DDT era" (the 1950s and 1960s), when bald eagle numbers across the continent declined so drastically due to the chemical's effects on eagle reproduction. How could Yellowstone eagles have maintained their population for over 30 years and through the DDT era if they didn't produce enough young?

One answer may be that resident adults lived a *very* long life. In fact, some North American eagles are known to have lived at least 17 years; one lived more than 22 years, and one 28 years. But recent data suggest that longevity of GYE bald eagles is considerably less.

Another possible explanation was that the Yellowstone Park population was bolstered by birds from other areas of the GYE or farther away. But significant differences existed among the three population units of greater Yellowstone eagles. They were different in time of breeding, preferred nest trees, food habits, and productivity. Based on these criteria, the three population units (the Continental Unit to the west and north of the park, the Snake Unit to the south and southwest, and the Yellowstone Unit in the park and east of the park) were thought to be distinct entities, and we suspected that little interchange occurred among them. So the question was, how did they survive so well? That was the objective of this study, and other recent studies.

Tracking Eagles

Back in 1979, Kurt Alt (now a biologist with Montana Department of Fish, Wildlife & Parks) and I initiated an extensive eagle leg-banding program in the GYE, including Yellowstone Park. We put U.S. Fish & Wildlife Service (USFWS) aluminum bands around the lower legs of nestling eagles. The birds wear these bands like loosely fitting bracelets for their entire life. Each leg band has a number unique to the individual, much like a Social Security number, and a brief instruction to the finder to "avise" (*sic.*) the USFWS, Bird Banding Laboratory (BBL) in Washington, D.C. of the circumstances of the "encounter" (the term "encounter" involves a variety of experiences; banded eagles may have been observed dead or alive, captured, or had their band number observed at a distance). Through this

Aluminum leg bands in place on an eagle banded in Grand Teton National Park. All photos courtesy of the author.

Eagles were fitted with solar-powered "backpack" transmitters that did not interfere with flight or other activities.

technique, we hoped to answer basic questions about bald eagles in the GYE, such as how long do they live, where do they winter, what kills them, and where and at what age do they tend to breed. Answers to these questions would then give us insight on how population stability in Yellowstone was achieved.

In 1985, through the visionary impetus of Bob Oakleaf, Nongame Coordinator of the Wyoming Game & Fish Department, a research project was arranged with the Fish & Wildlife Program in the Biology Department at Montana State University. This intensive study focused on bald eagles breeding along the Snake River in Wyoming, but also included, almost by accident, Yellowstone.

In addition to continued banding, this study employed radio transmitters on eagles between 1985 and 1989, and colorbands from 1985 to present. Young bald eagles were banded and radio-tagged in their nest before they could fly. Nests in trees, some more than 52 meters (170 feet) high, were reached using modified mountaineering techniques developed by Dr. George Montopoli, a climbing ranger in Grand Teton National Park (GTNP).

If the nest was big enough and eagles were only to be banded, George or Kurt performed those duties in the nest. If the eagle was to be radiotagged, it was lowered to the ground in a large canvas bag with a rigid, soft floor to prevent injury and minimize stress. There the eagle was fitted with a solar-powered transmitter "backpack," measured, and photographed. The procedure took between 20 and 40 minutes, depending on cooperation level of the eagle, and then the bird was hoisted back into the nest.

In banding more than 500 nestling bald and golden eagles between 1972 and present, only one was injured. That was due to a suspected genetic condition that resulted in abnormally thin long bone cortices. This bird did not behave normally and probably would not have survived in the wild, so it was remanded to captivity.

Banding Results

With little funding or support from managing agencies, we banded nine eagles the first year, including four in Yellowstone Park. By August 1993, 316 eagles had been banded, 287 as nestlings. Only 12 percent of nestlings were banded in Yellowstone Park itself, mostly because relatively few were produced there, but also because of logistics and weather problems.

Slightly less than 15 percent of all eagles banded in the GYE were subsequently encountered. Those encountered outside of the GYE were in five western states, and revealed various causes of death. Locations of encounters revealed a generally westward movement of immature eagles in autumn and return during spring.

Only one Yellowstone Park eagle was encountered outside the GYE, but the oldest bird encountered had been banded as a nestling near Eagle Bay on Yellowstone Lake. It was a 12-year-old male, whose death was possibly the

Dr. George Montopoli developed modified mountaineering techniques to safely reach eagle nestlings in trees as much as 170 feet high.

Dr. Montopoli banding a nestling from a precarious perch high above the ground.

Eagle 700 exhibited an unusual "pied" plumage pattern when compared to her sibling.

result of secondary organophosphate poison used for control of ground squirrels. He was found near Molheron Creek just off the Yellowstone River near Corwin Springs, Montana. Sadly, his sister had been found dead in May 1983 near Elk Creek in Island Park, Idaho, an apparent victim of a leg-hold trap set for furbearers or coyotes.

Eagles colorbanded in the GYE were observed alive in six western states and one Canadian Province. The GYE eagles seem to like to winter in California. In February 1992, we captured a GYE eagle at Big Bear Lake, less than 30 miles from the Los Angeles Basin. He was radio-tagged there and next located back in the GYE in summer 1992 at Cliff Lake in southwestern Montana (along with another immature eagle we radio-tagged at Big Bear). We found him again in southern California in January 1993 *and* 1994!

Eagles colorbanded in Yellowstone Park were observed mostly in the GYE, but only one in the park. Three were seen on the Snake River near Jackson, Wyoming, and one was seen at Cliff Lake in southwestern Montana. The lack of sightings in the park was mostly due to the small number of birds colorbanded, limited search effort (researchers were only in the park while banding birds or when flying over on radiotracking flights), and relative remoteness of areas frequented by bald eagles in the park. But we did learn that Yellowstone eagles, at least immatures, visited other population units when in the GYE. A sighting of a Yellowstone eagle, banded in summer 1993, near Bakersfield, California, in February 1994, further showed the propensity of GYE eagles to winter in California.

Radiotracking

Radio-tracking young bald eagles provided much more information on movements in a much shorter period than banding, but was much more expensive. Generally, tracking data showed that eagles stayed near their natal nests until early their first autumn.

About mid-September to mid-October, the eagles began moving west-southwest, mostly along major river drainages but often directly cross-country and over mountain ranges. They moved as far west as northcentral California and came back to the GYE as early as mid-March, but most returned in April and May. Then, they wandered the ecosystem for the summer, often covering more than 100 miles (161 kilometers) in a day. Movements of two of the 21 young bald eagles radio-tagged illustrate typical movements of juvenile and immature bald eagles produced in the GYE.

Eagle 700

On June 11, 1985, a nestling female bald eagle, produced at the Butler Creek site on the Snake River, southwest of Jackson, Wyoming, was fitted with a solar-powered transmitter. She was designated 700 because of her transmitter frequency, 148.700 mHz. She exhibited a previously unrecorded plumage coloration in bald eagles. From the time 700 fledged (left the nest for the first time) on June 26 until she left the GYE on her first autumnal migration in mid-September, she remained within 2,600 feet (800 meters) of her natal nest. She was away all winter because we periodically searched for all radio-tagged eagles throughout the GYE by aircraft and she wasn't located.

We next located 700 on April 30, 1986 on Palisades Reservoir in eastern Idaho. She had survived her first winter and returned to the ecosystem of her birth. She stayed on the reservoir until late May. More exciting, and indicative of things to come, we next detected her radio signal on Yellowstone Lake and triangulated her location to the Eagle Bay area, a minimum of 82 miles (132 km) from her last location!

Over the next 4 years, 700 was often located in Yellowstone, the alleged "black hole," mostly in association with Yellowstone Lake. In spring 1987, she was at South Arm and again at Eagle Bay. In summer 1988, she was on the Flat Mountain Arm and Heart Lake. And in 1989, an adult bald eagle wearing a transmitter and colorband was seen near LeHardy Rapids on the Yellowstone River. Could it have been 700?

923, A Yellowstone Eagle

On July 15, 1987, the male of two siblings produced at the Eagle Bay nest site on Yellowstone Lake was tagged with a transmitter frequency 148.923 mHz. He was intermittently monitored during summer from Lake Butte, 10 miles (15.5 km) northeast of the nest. By early August, 923 was traveling as far as 5.5 miles (9 km) from the nest, possibly as far as Flat Mountain Arm and The Promontory. On September 7, he was still on Yellowstone Lake near the nest site, but on October 10, he was located near Soda Springs in eastern Idaho. Obviously, he was beginning his first autumnal migration.

On the first aerial survey in spring of 1988, 923 was located on Upper Red Rocks Lake in southwestern Montana. By May 6, he had moved to Henry's Lake, Idaho, and by mid-June was back in Yellowstone. When first located on Yellowstone Lake, he was in the company of 944, another eagle that had been radio-tagged in a nest on Yellowstone Lake.

As Al Bath, the tracker, carefully worked his way through the thick lodgepole pine near Lake Lodge, he was startled to meet, in the dense, dark forest—another radio tracker! The other tracker was following grizzly bears. After introductions, they followed their respective signals, and were surprised when they found their animals together. Along a small stream known for spawning cutthroat trout, the bear was snagging spawning trout, opening the gut, and eating the roe. She then discarded the carcasses.

When the bear moved off about 10 feet (3 meters) both eagles pounced on the carcasses. The bear and eagles remained in the vicinity about one week, but discretion dictated minimizing observation time. The grizzly then moved to Pelican Valley, again visiting streams full of spawning cutthroat. Within one day, the eagles were there too. During subsequent aerial and ground surveys, 923 was located mostly in the Southeast and South Arms of Yellowstone Lake. He was last located in the GYE on October 21, 1988, on the west shore of the West Thumb of Yellowstone Lake.

Late in 1987, during a trip to California, I detected a signal from another young GYE eagle, 827, from a hill 13 miles (21 km) west of Canby, 31 miles (50 km) south of Tule Lake Sump. I eventually located 827 on the southern end of Klamath Basin National Wildlife Refuges (KBNWRs), which span the Oregon-California border. He was there with nearly 600 other bald eagles, feeding on waterfowl killed by an outbreak of avian cholera. This established KBNWRs as a place to search for GYE eagles in ensuing years.

In November 1988, a receiver was sent to KBNWRs and personnel scanned for GYE eagles. This time, 923 was located on Tule and Klamath Lakes in northern California and southern Oregon, along with 827! They remained in the Klamath Basin until mid-December.

On March 30, 1989, 923 was located near Fishing Bridge in the park, and on April 14, he was seen by Terry McEneaney, Yellowstone Park Resouce Management Biologist, farther downstream on the Yellowstone River near LeHardy Rapids. Cutthroat trout are abundant in this section of the Yellowstone, and 923 was undoubtedly exploiting this blue ribbon fishery. By April 24, 923 was on the south shore of Yellowstone Lake near Breeze Point, and on May 12 was observed on Holmes Point on the southeast corner of Mary Bay. Proximity allowed close inspection of plumage, bands, and transmitter package. All were in excellent condition.

As in 1988, 923 spent most of the summer on Yellowstone Lake, at the mouth of the Yellowstone River on the Southeast Arm, and at Outlet Creek on the South Arm. On October 5, he was at West Thumb, indicating he may have been in the initial stages of his second autumnal migration. Subsequent ground checks around Yellowstone Lake failed to detect 923.

On February 25 to 28, 1990, 923 again was located in the Klamath Basin area, roosting 2 miles (3.2 km) southeast of Worden in southern Oregon. Monitoring then ceased, and when it resumed on March 4, no signals were detected. Timing of locations suggest 923 may not have wintered in the Klamath Basin but only visited there during migration.

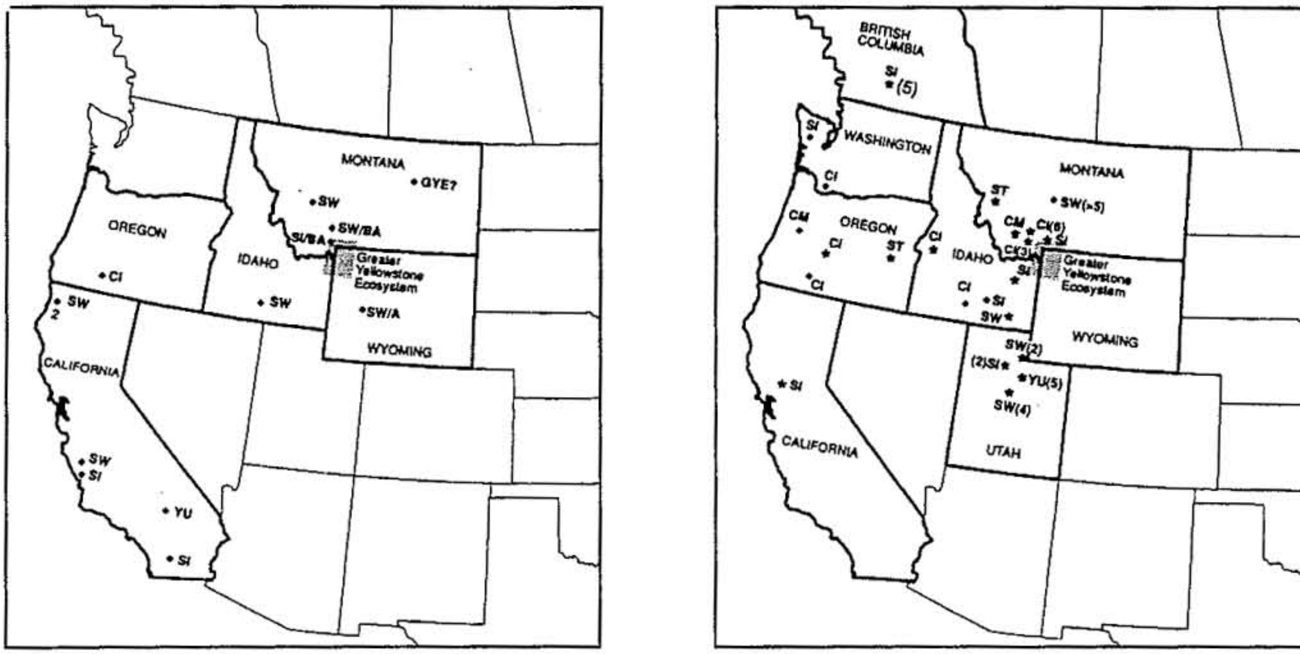
Long-range, migratory movements of 923 and other GYE eagles are shown in the maps on page 18. Funding ran out in early 1990, and we could no longer track radio-tagged eagles, despite functioning transmitters. Pleas for continued funding fell on deaf ears. Reluctantly, we relinquished contact with the young eagles we knew so well, and left them to wander the west unmonitored.

On January 17, 1994, I received a call from the Utah Division of Wildlife in Ogden. An adult bald eagle wearing a backpack transmitter had been found dead near the Weber River, about 12 miles (20 km) east of the Great Salt Lake. The band number revealed it was 923, who died of unknown causes about January 5, 1994. His peregrinations throughout the west have ended, but he will continue to contribute to the conservation of his species for years. He will be mounted with radio and bands intact, and exhibited along with an account of his life at the Fishing Bridge Visitor Center.

Survival

Survival of GYE juvenile and immature bald eagles radiotagged as nestlings or recent fledglings was high. Of 17 bald eagles with functioning radio transmitters, a remarkable 82.5 percent were alive in April after their first winter. After two winters, 58.8 percent were still alive. Nearly 77 percent of the birds that survived their first winter also survived their second. Fifty percent of those surviving their second winter and 42.9 percent of those surviving their first winter also survived their third winter. A third of the eagles were still alive after four winters.

A decrease in survival was evident in



Left: Extra-regional sightings of GYE colorbanded eagles. Letters indicate which population unit they originated in: SW=Snake Unit, Wyoming; SI=Snake Unit, Idaho; YU=Yellowstone Unit; CI=Continental Unit, Idaho. BA stands for breeding adult. Right: Extra-regional locations of leg-banded GYE eagles. Additional abbreviations: CM=Continental Unit, Montana; ST=Snake Unit, Tetons. Diamonds indicate direct encounters; stars indicate indirect encounters. Numbers in parantheses indicate age of eagle at time of encounter.

the third year and probably reflected actual phenomena rather than any problems with equipment or data. All young eagles radiotagged in Yellowstone survived at least four years, but lack of detections afterwards was most likely the result of transmitter failure rather than eagle deaths. We've seen at least three GYE eagles that were wearing our radios that we couldn't detect with a receiver and one that shed his transmitter after four and a half years.

Movements of Immature Bald Eagles

The GYE eagles showed a unique movement away from natal areas (home nests). The traditional popular view was that most birds move north and south during migration. Unlike Canadian-born bald eagles, which move south in autumn, or Florida eagles which move north, immature GYE eagles move *west*. Band encounters suggested and radiotracking verified that GYE eagles (such as 700, 827, and 923, discussed earlier) went to coastal and interior Oregon, Washington, and California as far south as Los Angeles.

Virtually all young eagles left the GYE their first autumn, departing between mid-September and mid-October. Juveniles apparently did not need to leave the GYE; juvenile eagles from Canada spend the winter in the GYE, indicating that requisites for survival are present. Competition with Canadian migrants was probably not a factor in causing local juveniles to migrate from the GYE, because most GYE eagles were gone before the Canadian birds arrived. Regardless, survival of immature eagles leaving the GYE during winter has probably been higher than those that did not, resulting in a population with a genetic propensity to migrate west as immature birds. The GYE eagles left their natal areas well before food resources dwindled or became unavailable due to snow cover or ice. In fact, waterfowl (a favored prey for eagles) numbers in the GYE actually may have been at peak when young eagles departed.

Migration was primarily southwest to the Snake River plain in Idaho and northern Utah, then west to the Pacific coast states. Traveling without parental guidance, the eagles moved alone. The exact route was influenced by topography and weather, while rate of travel may have been dictated by chance encounters with locally abundant food, adequate roost sites, and flying conditions.

The somewhat unusual east-west bald eagle migration pattern between the GYE and the west coast also is consistent with the theory of "genetic memory"; when they left the GYE, eagles possibly went to regions of historical abundant salmon runs of the Pacific coast. Dates and locations of band encounters on the west coast suggest that juvenile eagles wandered from Los Angeles in the south to Puget Sound in the north, where their genetics "told" them to look for salmon runs that are either greatly reduced or extinct.

Immature eagles returning from the west coast may search for vacant nest sites or available mates. Virtually all radiotagged immatures visited their natal nest areas and then dispersed throughout the ecosystem and, in some cases, beyond.

Young eagles were radiotagged in all population units, and each was detected in every other population unit at least once, seasonally exploiting fish spawning runs or waterfowl concentrations. Immature eagles also seemed to move freely among territories of nesting and non-nesting adult bald eagles throughout the ecosystem without eliciting aggression from resident adults. As autumn approached, immature eagles moved gradually back toward their parent's territories, often as close as a few hundred yards from their natal nest. Such movements may suggest that recruitment and pioneering of bald eagles occur primarily in spring and fall.

Immature eagles were found primarily on lakes within the GYE although the Snake River as well as smaller rivers and creeks throughout the ecosystem received periodic use by concentrations of immatures. Young eagles seemed to quickly key in on temporal concentrations of prey and carrion and regularly were found either along water bodies where fish were spawning (i.e., cutthroat trout in YNP and Henry's Lake, Idaho, in spring and whitefish in Cottonwood Creek in GTNP in autumn) or areas where ungulate viscera piles left by hunters were available (early elk hunts in Jackson Hole and late elk hunts in GTNP and near Gardiner, Montana). Some areas previously overlooked as important bald eagle habitat because of lack of breeding adults may be of critical importance to these "floating" immatures that move great distances from one food source to another.

As eagles age, the timing of their movements may change; there may be a tendency for them to leave the GYE later in fall and return earlier in spring. Juveniles almost all left the GYE in mid-September, returning in mid-April to early May. Two-year-olds and older birds tended to leave in middle to late October, returning from middle to late March. Some eagles may have remained as late as mid-January, leaving the GYE for only one month. Decreasing time away from the GYE was probably facilitated by increasing knowledge of routes and terrain as eagles grew older.

The patterns of their movements may also change as they age. Though basic movement patterns remained the same, variability in both extent and frequency of long-range movements increased as eagles grew older. Movements of older immatures suggest increased wandering outside of the GYE in summer, especially north into Montana and possibly Canada. Indeed, when eagle 827 was four years old, he was located with a mate and young at a nest site on the Missouri River near Helena, Montana, in 1991, 208 miles (335 km) due north of his natal nest, 114 miles (184 km) outside of the GYE.

In addition, the male of a productive pair nesting on the Madison River in southwestern Montana since 1989 was banded as a nestling in the GYE (colorband sighting). Clearly, the highly productive GYE population has provided recruits to expanding populations outside of the GYE. That more recently banded eagles are being found outside of the GYE may indicate all available breeding habitat is filled. The number of breeding areas in the GYE in recent years is leveling off, and instances of combat between adults are increasing.

Yellowstone Park's role in GYE eagle ecology

The value of Yellowstone to GYE bald eagles is in its importance as an area that enhances survival of young eagles produced throughout the GYE. The diverse, abundant, and unpolluted food base in Yellowstone contributes significantly to the fitness of young eagles. The more eagles that survive, the healthier the populations and the more resilience they have to rebound from natural environmental catastrophes like earthquakes, fire, volcanic eruptions, and severe human-caused contamination. High survival more than offsets the low production in Yellowstone and even provides a surplus to bolster eagle numbers in areas outside of the GYE.

Though more than two million people visit the Park each year, vast areas of eagle habitat are left undisturbed during important times of the year. These areas of the park are functional refuges, where immature eagles can feed, bathe, pair bond, play, loaf, and sleep without human disturbance. The freedom to just be eagles in prime habitat, without wasting valuable energy avoiding humans and their activities is relatively rare in the United States, and conditions that promote that freedom should be protected with fervor.

Al Harmata, a long-time eagle researcher in the greater Yellowstone area, is a research professor in the Biology Department at Montana State University.

There were fears that GYE bald eagles eventually would become extinct because they didn't produce enough young. Thanks to the broader view provided by movement data from this and other studies, it has become obvious that Yellowstone is not an ecological island, and that areas outside the GYE, such as the west coast, are also important for maintaining a viable population of bald eagles.

Movements of bald eagles also showed us something profound. Their summer wanderings essentially defined the limits of the GYE, indicating that there is in fact an ecosystem out there, not just some ethereal, academic concept with no basis in reality. If one species is dependent on an intact ecosystem, must there not be a multitude of others that also are? In pursuit of everyday survival, the young eagles have provided justification and even impetus to conserve and protect large areas of the GYE in order to maintain the biological integrity of Yellowstone National Park.

So is Yellowstone a black hole for bald eagles? The resounding answer is "NO," but the rest of the world is. We must be vigilant in our care for the global ecosystem if we wish to ensure the continued existence of the Yellowstone eagles.

Superintendent Bob Barbee Leaving Yellowstone

Our more distant readers, who do not routinely see the headlines in regional newspapers, will be interested to learn that Yellowstone Superintendent Robert Barbee is moving on to a new assignment. As part of what NPS Director Roger Kennedy describes as "a nationwide effort to diversify the senior management of the NPS," Barbee will become the Regional Director of the Alaska Regional Office, moving to Anchorage in September.

Barbee's move was part of a major shift of top NPS personnel announced in late May, in which half a dozen superintendencies and other key positions changed hands. This promotion moves him into a resource-management arena that is perhaps more complex and controversial than that of Yellowstone.

Science in Yellowstone changed dramatically during Barbee's 11-year term, which was characterized by a steady heightening of public interest in management issues. Greater Yellowstone ecosystem coordination, wolf restoration, grizzly bear recovery, geothermal resource protection, fire management, ungulate-range management, and visitor-use management were among the issues elevated to higher levels of public attention and concern, with corresponding growth in scientific research both by the NPS and by numerous other investigators. Major research initiatives on wolf restoration (resulting in two large reports to Congress), grazing-related issues (resulting in one soon-to-be-published report to Congress), geothermal development near the park, and other subjects were carried out during Barbee's term here.

In 1983, when Barbee arrived, Yellowstone hosted 90 research projects; that number had tripled by 1993. He also established the park's biennial scientific conference series, and led the park through the recent reorganization of research and resource management functions that resulted in the Yellowstone Center for Resources.

Barbee's previous assignments in his 34-year NPS career included superintendencies at Redwood National Park, Hawaii Volcanoes National Park, and Cape Hatteras National Seashore, as well as other assignments at Yosemite, Big Bend, Carlsbad Caverns, and Rocky Mountain National Parks, and Point Reyes National Seashore.

Michael Finley, current superintendent of Yosemite National Park, will become Yellowstone's new superintendent in October. Finley, 47, has also served as superintendent of Everglades National Park and Assateague Island National Seashore, and Associate Regional Director, Management, in the Alaska Regional Office.

Brucellosis Symposium September 26-28

A "National Symposium on Brucellosis in the Greater Yellowstone Area" will be held September 26-28, 1994 in Jackson, Wyoming. The symposium will be hosted by Governors Sullivan (Wyoming), Racicot (Montana), and Andrus (Idaho) along with Secretary of Interior Babbitt, and Secretary of Agriculture Espy. The symposium will serve as a forum and educational meeting for the public, including members of conservation and livestock organizations, wildlife and land managers, veterinarians, stockgrowers, agency and animal health regulatory officials, and members of the newly established Greater Yellowstone Interagency Brucellosis Committee. Invited experts and agency officials will explain issues and policies regarding problems associated with brucellosis in bison and elk of the greater Yellowstone area. The Greater Yellowstone Interagency Brucellosis Committee was formed by the state and federal agencies to solve the problems of brucellosis in greater Yellowstone while protecting the integrity of the region's elk, bison, and cattle populations. For further details on the symposium, contact Becky Russell, Wyoming Game and Fish Laboratory, P.O. Box 3312, University Station, Laramie, Wyoming 82071, 1-307-766-5616, FAX 307-766-5630.

Hydrothermal Monitoring Weir Vandalized

On April 3, NPS Research Geologist Rick Hutchinson discovered that the park's main hydrothermal monitoring apparatus in the Norris Geyser Basin had been vandalized during late winter or early spring. This monitoring weir is a deeply notched steel plate set across a stream. A float, placed upstream from the plate, electronically tracks water level, allowing for a continuous record of total stream flow. The weir plate and float assembly were intentionally torn out, resulting in collapse of the structure. A nearby vent pipe for an underground instrument vault was also broken off.

The monitoring weir has been operating since 1987, to gather baseline data on variations in water and heat flow through the Norris Basin. It is a joint project of the NPS and the U.S. Geological Survey. Water flow data collected at the weir is being used to clarify the relationship of regional and local seismic activity to changes in Norris thermal features. The data may also help to explain the mysterious alterations in pool levels, water temperature, turbidity, and geyser activity around the basin that often occur in the fall (these clusters of changes have been dubbed "the Norris fall disturbance"). Water flow information is combined with measurements of chloride concentrations taken at the weir to estimate heat flow in the area. Estimates made using this methodology indicate that Norris is the hottest thermal basin in the world.

Because prior research has shown a high probability that Mammoth and Norris share an underground source for thermal fluids, water and heat flow data from Norris are critical to understanding hydrological connections between Norris, Mammoth, and proposed geothermal wells outside the park. Rick Hutchinson has ordered repair parts for the weir and hopes to have it back in working order this summer.

USGS Research Well Update


Jim Peaco/NPS

Yellowstone Science readers may recall our report (Winter 1993) on the U.S. Geological Survey (USGS) research well whose valve failed in November of 1992, resulting in a spectacular steam "leak." The sealing of the well required a specially constructed valve assembly, and the USGS decided to check all the other research wells in the park. This is a report on that process.

As background, we will explain that in 1967 and 1968, the USGS drilled 13 research holes in various park geothermal areas. These wells, named Y-1 through Y-13, were created to study geothermal dynamics of aquifers in the park. Six of the wells were plugged after data collection was completed, in the 1960s. The well that leaked in 1992, Y-8, was sealed in late November of 1992.

An examination of the remaining six unplugged wellheads has since revealed that significant deterioration had occurred in three. Because of the expense of mobilizing the equipment to seal the old wells, and because of the inevitability of repairs, the USGS decided to permanently seal five of the remaining holes. This work was completed in October, 1993, using a bentonite and concrete slurry. Only Y-7, in Biscuit Basin was left unplugged; it currently has no well-head pressure and does not flow water when left open. Y-7 is currently being used by microbiologists as a source of moderate-temperature water samples.

Call for Species Occurrences

The Greater Yellowstone Conservation Data Center, in the Yellowstone Center for Resources, is developing a Natural Heritage Program database on the status and distribution of rare plant and native animal species in the Greater Yellowstone Ecosystem. In the process, they are compiling a species list, including all organisms (procaryotes and eucaryotes) found in Yellowstone and Grand Teton National Parks and the John D. Rockefeller, Jr. Memorial Parkway. They would appreciate submissions of species lists from researchers working in or near any of those areas.

Lists should be sent to Pete Feigley, Greater Yellowstone CDC, P.O. Box 168, Yellowstone National Park, Wyoming 82190, (307) 344-2157. Please include your name, address, phone number, and research interest or research project title.

For more information about the Greater Yellowstone Conservation Data Center, see the *Yellowstone Science* interview in the Spring 1993 issue.