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SCIENCE

Biology Contravenes Taxonomy in the Myxozoa: New Discoveries Show Alternation of Invertebrate and Vertebrate Hosts

Ken Wolf and Maria E. Markiw

STATEMENT

Presented by: Harold K. Hagen, Ph.D

Subject: Issues related to Whirling Disease meeting, Denver, Colorado May 5, 1994.

It was suggested by an outdoors news editor that a study currently underway by the Colorado Division of Wildlife on the Colorado River, may be " the single most important fishery study ever undertaken by the Colorado Division of Wildlife." I agree, but not for the reasons suggested by the editor which is a determination whether or not Whirling Disease is the causation of an apparent disappearance of three age classes of rainbow trout.

I believe the importance of a study goes much deeper. It goes to re-examination of a policy established by the DOW wherein each regional office has the autonomy to establish its own agenda relative to investigations and the management of fishery resources within its jurisdictional boundaries. It is that autonomy that has led to this unnecessary meeting where subjective opinions have clouded the real issues and have divided the public, if not the DOW, as to what the real dangers of whirling disease are. Had the news releases about the mysterious disappearance of young of the year rainbow trout and the finding of a few Myxobolus cerabralis spores among survivors been cleared first through the top echelons of the state, but not hidden, I believe that the current investigation, which is at least partially justified, could have been devoted to biological fact and not political hysteria. I am not suggesting that regional biologists should be prohibited from expressing their own opinions but the ramifications of unguarded remarks are obvious. This is especially true in this situation where the division, among other interested parties, has been diligently gathering data needed to mitigate the whirling disease problems within their own facilities and to establish policy relative to the commercial sectors as well.

The advantages of being able to make a local decision are several. Not the least of these would be speed of action needed in response to emergency situations. That authority among others should, in my opinion, remain with regional entities. But most of the activities of regional biologists and managers involve long term projects and plans that should be coordinated and finalized at the state level. In this day and age of modern communications there is no need for regionalism in areas as important as biological research where all parts of the state may have a shared interest and a role to play. It is impossible to imagine a private corporation or even the federal bureaucracy functioning adequately where regional offices or managers could establish their own policy, make decisions that can affect the entire organization or communicate to the local public without going through a process of risk assessment. It is

the obsolescence of this policy that has caused this current fiasco and it will cause others. Individuals and organizations are demonstrably aware of the opportunities to gain an advantage for their particular agenda in the regional autonomy scenario. Individual biologists can be cultivated in many ways that a more solidified state hierarchy will not allow.

If anyone is to be embarrassed by this exercise it should be the state Wildlife Commissioners. They could have and should have recognized the explosive potentials of this latest whirling disease controversy. They should have remembered the damages that were caused by the 1987 and 1988 vacillations within the DOW when the disease was first encountered. Now they are faced with the unsavory task of either having to choose sides publicly with individuals from within their own organization who differ on the etiology of whirling disease, go along with one segment or another of a largely uninformed but vocal public, or sit on the fence.

It has been implied that my commentary on whirling disease is made from a biased view, in that we still have one hatchery in which Myxobolus cerebralis spores have been found, and that my full support of the recent DOW decision to stock Kokanee salmon and rainbow trout exposed to whirling disease is somehow unethical and self serving. Not only is this professionally insulting but it demonstrates the lack of basic knowledge shown by those people making such statements or writing news releases.

The very fact that we, along with state personnel, have a first hand set of experiences with the pathogen and have seen what it can and will do both in the hatchery and the wild over a span of more than six years, gives our opinion some degree of credibility. I have personally searched the literature very thoroughly in order to become familiar with the organism, its life history and the causation and effects of the disease. As a small business owner I would be stupid to have continued in business if those findings were other than what I have clearly stated before. Whirling disease is a minor but potential threat in hatcheries but of little concern in a wild population. The only major threat to our survival during the past few years has been the total befuddlement of the state bureaucracy in that initial period where their response was to take unwarranted actions including total quarantine under the cliche of " erring only on the side of caution? Incidentally, our production at the above mentioned small hatchery is nearly fully subscribed by loyal customers who perhaps see an extra bonus in stocking fish that have a demonstrated high genetic tolerance to this pathogen. I find it interesting that vocal experts make loud sucking noises as they condemn the DOW for their recent planting decisions, while at the same time they approve immunization of their own children through host tissue reaction technologies. Pathologists working on whirling disease report substantial disintegration by host tissue reaction in both primary and secondary cells from myxosporean infections. If this and other forms of genetic mutation and immunization were not functional both survival and evolution of a species would not be possible.

As a biologist, I am very much involved in developing and proposing methodology for moving the hatchery back into the wild. I am greatly concerned when DOW research biologists suggest that the much celebrated Colorado River strain of rainbow have and likely are suffering near total mortality in the wild from a pathogen that even under stress conditions of a hatchery rarely causes mortalities. I am now not sure that this strain is a good candidate for streams throughout the state, most of which are known to harbor spores of Myxobolus cerebralis. How will they respond to the host of other pathogens present in nearly all stream waters? Do the biologists really subscribe to the proposed hypothesis of near total mortalities from whirling disease in this one stream while at the same time they extol the fish as the salvation for nearly all Colorado streams? I think not. I believe the problem is now a colossal conundrum that will not be and can not be solved or concluded with the current study. The study must, however, be completed since the value will largely be a demonstration to the Wildlife Commission and hopefully the public that regional autonomy without risk assessments at the state level can lead to situations such as this one that become more an issue of personality and strong opinion than biological fact.

As far as the anomaly on the Colorado River is concerned, the least likely cause of the disappearance of young of the year rainbow, among the several causes considered by pathologists and others, is whirling disease. From both a biological view and a practical and logical view, it would be impossible for the change in numbers of young rainbow (a reported 30,000 in three miles of river) to be reduced to near zero, in no more than two months, from whirling disease, which is a chronic not an acute condition. Had the actinosporean stage spores, which is the infectious stage in fish, been high enough in number, in this case perhaps tens of billions, to infect almost every young of the year rainbow, let alone cause their mortality, most of the brown trout could not have escaped serious infection and mortalities either. There is nothing in the literature to support the media contention that brown trout are immune from the disease. It was endemic to the brown trout of Europe where an obvious tolerance or immunity developed. Robert Toth, reporting from California in 1988, did in fact report a higher infection in brown than in rainbow in seven waters planted with trout from the Mt. Whitney hatchery. Considering the total life cycle of Myxobolus cerebralis, the number of infected but surviving older trout required to shed enough spores to infect the necessary number of tubificid worms would be considerable. Most would be symptomatic of having had or continued to have the disease but this condition has not been reported. If an anaerobic sewer of the magnitude to cause this postulated devastation exists on the Colorado or its tributaries, it is obvious the State water pollution board or EPA should be notified.

The condemnation of the DOW in their decision to plant exposed kokanee and rainbow by Trout Unlimited is to be regretted. Sanctimonious statements by executives of this organization such as

" It (stocking) shows a total disregard for the natural ecosystem that makes recreation possible." or " it has become a question of ethics in resource management", does neither Trout Unlimited or the Division of Wildlife any good at this time. More importantly it distracts from a mutual concern that I believe both organizations have for the environment, and it sows distrust and suspicion.

The issue of whirling disease and wild rainbow trout of the Colorado River is only one of several contentious aquatic disputes that will arise in the very near future. The question of wading in streams or walking on banks of streams that pass through private property is one, for example, that might be far more divisive and destructive. This one is a statewide issue and unless there is more authority restored at the state level and less autonomy at the regional level, the opportunity for reasonable dispute resolution will likely be lost to endless litigation and with potential regional bias. I sincerely hope the real lesson from this exercise is a recognition that unbridled local power can quickly get out of hand. Considerable authority should remain at the regional level but there must be the power to override at the state level.

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13 July 1995

Hi Bob:

Thanks for your letter of early June and your "whirling disease update."

Things are going well at the Unit. However, Hiram's dad isn't doing so well, so Hi's been down to the Bay Area. We are glad that the health situation appears to be coming along for you.

You asked about drainages in Oregon with whirling disease. I've enclosed a reprint that may help. I guess that the Grande Rhonde basin is the "hot spot." However, the bug but not the symptoms of the disease have been detected elsewhere in the state. ODFW is in the midst of a new statewide survey for M. c. I will send it to you once a report exists.

Time for us to plan another road trip, isn't it? My hope was to make it back into the Kern sometime. Think there is any way we could pull it off next year?

I have only a couple of trivial comments on the "w.d. update". "Mucous" is an adjective; change it to "mucus", the noun on p.1, change "This data" to "These data ...." on p.3. On p.2.

you are probably right that there may not be either differences in strains of M. c. or differences in virulence even if there were different strains in the U.S. However, it is still an eventuality. Founder effect of M.c. in western waters is quite likely.

The idea of looking at Tubifex community ecology makes a lot of sense. A real remote possibility is that there are different genetic strains of the intermediate host, and that these differ in "hospitality" to the parasite.

Enjoy the Western. I just returned from the Internat. Symp. on Reproductive Physiology of Fish held at the U. Tx in Austin. It was an excellent meeting. There was lots of molecular stuff, but interest in life history aspects of physiology is starting to come into its own. The only good thing about the heat & humidity in Austin was the excuse it provided to sample large quantities of relatively good beer.

Say "Hi" to Sally,

Cheers,

Carl

P.S.- One other thought on M. c.. Skin mucus is a logical site for antibody blocks to invasion. However, the gut also contains lymphocytes and the gill has mucus. Both of these organ systems, particularly the gill, have a much larger surface area in contact with water than the skin. In relative importance as a barrier to bugs the gill & gut tend to be ignored while in fact they may be most important.

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Detection of *Myxobolus* (*Myxosoma*) *cerebralis* in Salmonid Fishes in Oregon

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Abstract.—*Myxobolus* (*Myxosoma*) *cerebralis,* the etiological agent of whirling disease, was detected in salmonid fish populations in northeastern Oregon. This is the first record of *M. cerebralis* in the Pacific Northwest of the USA. During an epizootiological survey for the parasite, two methods for spore detection were compared, and an efficient procedure for determining *M. cerebralis* infection in adult fish was developed. The enzyme digest method was more efficient than the plankton centrifuge procedure for examination of numerous individual lots of fish processed during the survey. Sampling only the area around the otoliths was at least as effective as sampling entire heads for detection of spores in infected fish.

Whirling disease, caused by *Myxobolus* (*Myxosoma*) *cerebralis,* infects all species of salmonid fish except lake trout *Salvelinus namaycush* (O'Grodnick 1979). The disease occurs in Europe, the United Kingdom, New Zealand, South Africa, the USSR, and the USA (Halliday 1976; Hoffman 1976; Hnath 1983). Within the USA, the geographic range includes several eastern states and, until recently, only California and Nevada in the West (Halliday 1976; Hnath 1983). *Myxobolus cerebralis* is one of two fish pathogens covered in laws regulating importation of fish into the country. The disease is also included as one of concern in the fish disease control policies of other international, national, regional, and state governments (Rohovec 1983). Because of importation regulations, efforts have been made to improve the efficiency and accuracy with which the presence of *M. cerebralis* can be detected in fish tissues (Landolt 1973; Contos and Rothenbacher 1974; Kozel et al. 1980; Markiw and Wolf 1980). The enzyme digest method (Markiw and Wolf 1974a) and the plankton centrifuge method (O'Grodnick 1975) are techniques currently used to diagnose whirling disease. Microscopic examination of preparations that reveals spores showing morphology similar to that of *M. cerebralis* provides presumptive diagnosis of whirling disease. Confirmation of parasitism by *M. cerebralis* is made either by detection of spores in histological preparations of cartilaginous tissue (Plehn 1904) or by specific fluorescent antibody techniques (Markiw and Wolf 1978). Previously described methods are for diagnosis of whirling disease in juvenile fish, and none have been tested with infected adults.

In late 1986, *M. cerebralis* was detected in populations of juvenile rainbow trout *Oncorhynchus mykiss* (formerly *Salmo gairdneri*) and brook trout *Salvelinus fontinalis* at a privately owned site in northeastern Oregon. This first observation was followed by detection of the parasite in feral populations of these two species and of chinook salmon *Oncorhynchus tshawytscha* in nearby areas. The discovery provided both an opportunity to test methodologies for detection of the parasite in adults and an impetus to broaden an epizootiological survey already in progress.

In this report, we document the presence of *M. cerebralis* in Oregon and describe our detection method. During an epizootiological study of whirling disease in the state, we compared modifications of the currently used diagnostic procedures and examined methods for detecting *M. cerebralis* in adult salmonids.

Methods

Detection of M. cerebralis in Oregon.—Feral fish, primarily juvenile rainbow trout, steelhead (anadromous rainbow trout), brook trout, cutthroat trout *Oncorhynchus clarki,* kokanee (lacustrine sockeye salmon *Oncorhynchus nerka*), and coho salmon

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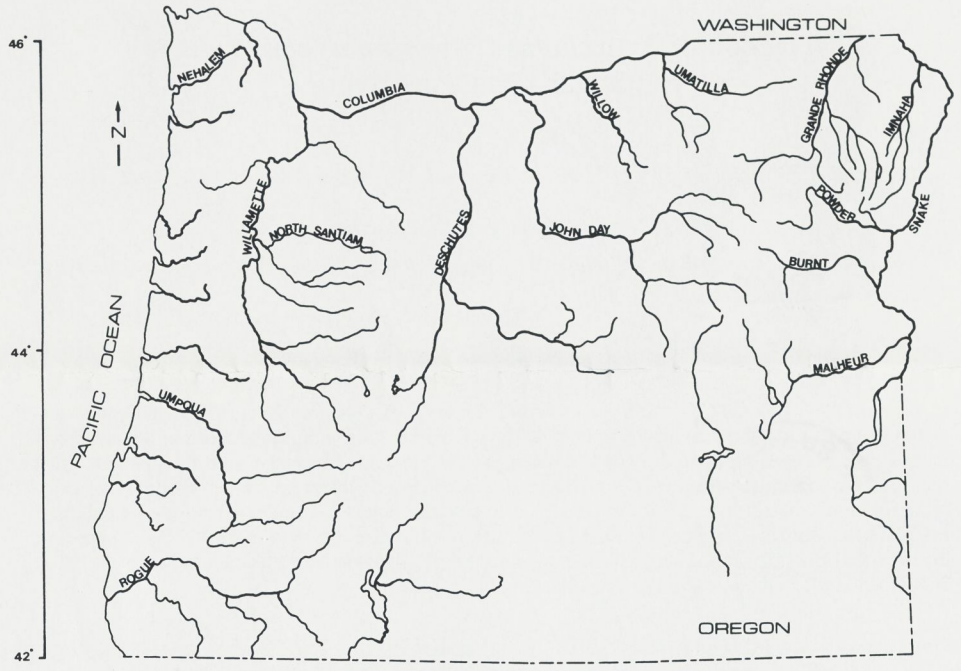

FIGURE 1.—Major watersheds in Oregon from which salmonid fish were collected for detection of *Myxobolus cerebralis.*

Oncorhynchus kisutch, were seined, angled, electrofished, and trapped from major watersheds throughout Oregon (Figure 1). Some samples were collected at state and private hatcheries. Adult steelhead and chinook salmon that had returned from the ocean to areas in northeastern Oregon were also examined for *M. cerebralis.*

In the epizootiological study, approximately 350 samples embracing more than 4,000 fish were collected. Entire fish or heads were frozen and delivered to the laboratory. At most sites, some heads were fixed in 10% buffered formalin, and these were included with many of the samples for histological examination. The frozen samples were processed and examined by methods similar to those in Amos (1985). Samples that contained spores of the size and shape typical of *M. cerebralis* were presumed positive; confirmation was made by histological examination. For histology, the portions of the preserved heads containing the semicircular canals and otoliths were decalcified for 3 d in CAL-EX II (Fisher Scientific, Pittsburgh, Pennsylvania) and then rinsed in flowing water for 3–4 h. Tissue samples were placed in 70% ethanol, processed in an ethanol–xylene series, and embedded in paraffin. Seven-micrometer-thick sections were cut, stained with May–Grünwald Giemsa, and observed microscopically.

Comparison of detection methods.—Fifty juvenile rainbow trout averaging 179 mm in fork length were collected from a hatchery where whirling disease was confirmed. The heads were severed just behind the opercula. The gills were removed and each head was cut in half longitudinally to provide material for detection of *M. cerebralis* by the enzyme digest and plankton centrifuge methods. The tissue was pooled (50 halves) and heated at 50–60°C for 15 min. The heads were defleshed and approximately 30 g of material was processed by one or the other method as described in Amos (1985). We varied the procedure for the enzyme digest by using formalin instead of serum to stop

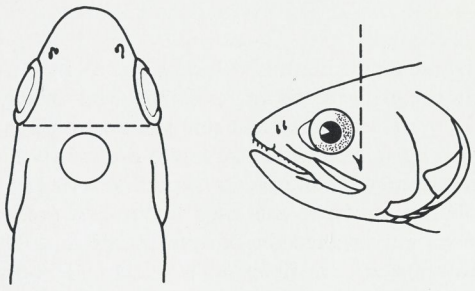

FIGURE 2.—Dorsal and lateral views of an adult salmon head, indicating the location for obtaining a core sample for examinations for *Myxobolus cerebralis.*

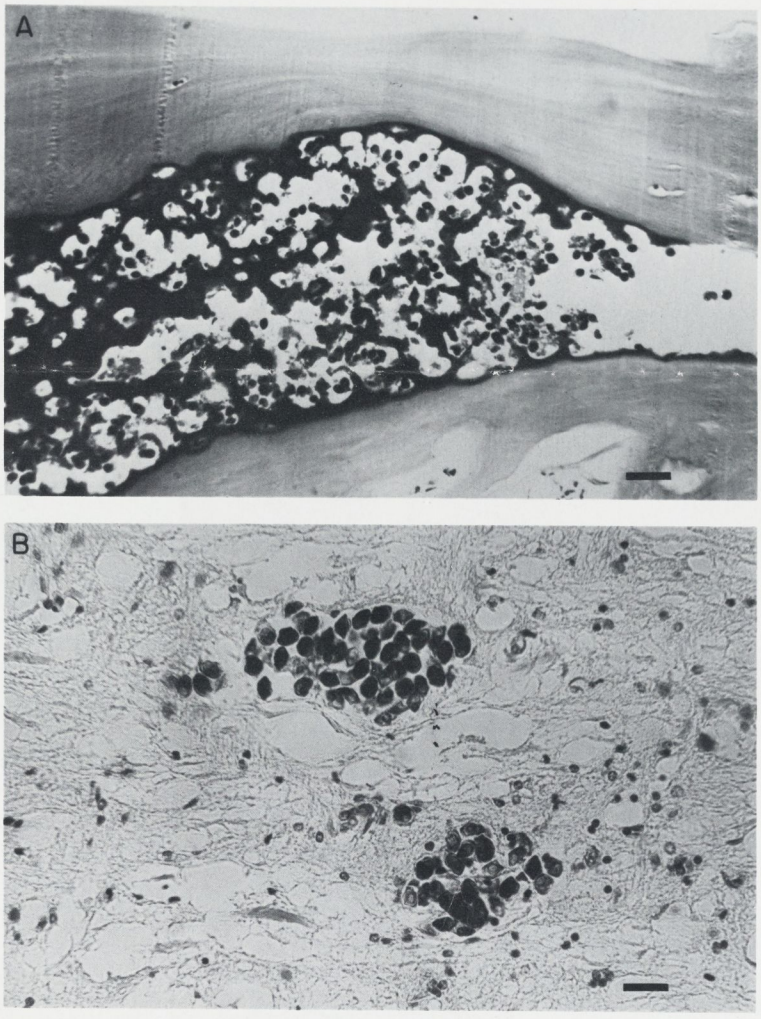

FIGURE 3.—Histological sections of salmonid heads. (**A**) Cartilage containing spores of *Myxobolus cerebralis*; bar = 36 μm. (**B**) Brain tissue containing spores of an unidentified species of *Myxobolus*; bar = 24 μm.

digestion and resuspend the pellets. The spores were counted with a hemocytometer.

Comparison of sampling methods.—To compare methods for sampling tissue to be screened for *M. cerebralis,* 40 adult chinook salmon were taken from a parasitized population returning to a northeastern Oregon hatchery. Twenty heads, some weighing as much as 1 kg, were used in each procedure and were processed individually.

The entire head was used in the first method. Heads were heated for 20 min at 121°C, cooled, and defleshed. The bone and cartilage (~18 g) were blended in 20 mL of pepsin and then processed by the enzyme digest method.

In the second method, a subsample was taken from each head with a cork borer 110 mm long and 19 mm in diameter. The borer was inserted into the head, dorsally and perpendicular to the long axis of the body, approximately 10 mm behind the eye and was pushed through the roof of the mouth (Figure 2). The sample contained the semicircular canals and, in the case of smaller fish, the otoliths. After the skin and some musculature were removed, each sample (~8 g) was blended in 10 mL of pepsin and processed by the enzyme digest method.

One milliliter of each sample was centrifuged through 5 mL of dextrose, resuspended in formalin, placed on a slide, and examined microscopically at 250× and 400× magnifications. The

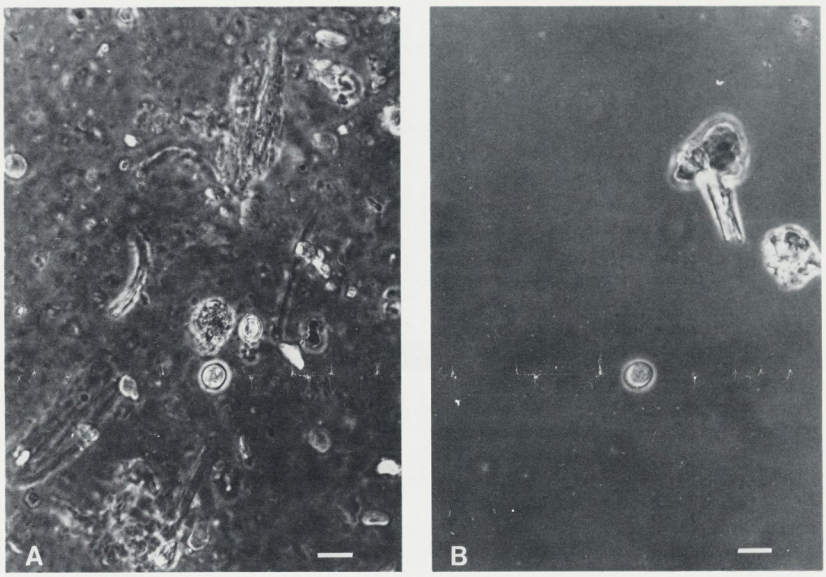

FIGURE 4.—Wet-mount preparations from juvenile rainbow trout containing spores of *Myxobolus cerebralis* obtained by (**A**) the plankton centrifuge method, and (**B**) the enzyme digest method. Bars = 10 μm.

slide was searched until *M. cerebralis* spores were detected or until an area of 22 mm^2 had been swept.

Results

Detection of M. cerebralis in Oregon

Spores of *M. cerebralis* were detected in feral fish collected in the Grande Ronde and Imnaha river systems. Furthermore, typical spores were found in captive fish that had been transferred from a single contaminated source into ponds in these two systems and in the John Day, Umatilla, Powder, and North Santiam systems. In some samples, two different sizes of spores with similar morphology were observed. When histological sections were examined, these spores could be differentiated by their tissue tropism (Figure 3). Spores parasitizing the nervous tissue of fish were from an unidentified species of *Myxobolus*.

Comparison of Detection Methods

Spores were easier to detect in the reduced level of background debris resulting from the enzyme digest method than they were after centrifugation (Figure 4). Averages of 12.5×10^2 and 3.75×10^2 spores/mL were detected in the enzyme digest and plankton centrifuge preparations, respectively.

Comparison of Sampling Methods

Two of 20 fish whose entire heads were processed were positive for *M. cerebralis*. The 20 fish from which cores were examined included 6 individuals positive for *M. cerebralis*.

Discussion

This report documents the occurrence of *M. cerebralis* in Oregon and the first observation of the parasite in the northwestern USA. An epizootiological survey indicated that *M. cerebralis* is confined to a relatively small area of Oregon, but has produced no indications of how introduction into Oregon occurred. Several possibilities exist. (1) The parasite may have been present for many years but was not detected until fish were reared in an environment ideal for development of clinical whirling disease (rainbow trout in earthen ponds with low water exchange). (2) The parasite may have been introduced with infected anadromous salmonids that strayed from regions where the disease is enzootic. (3) Contamination may have come from the Owyhee–Snake river system arising in Nevada, a state where *M. cerebralis* has been detected. (4) The disease may have been introduced with processed fish or (5) imported with fish that had been examined but in which the parasite went undetected. Epizootiological studies will continue to define the geographic range of the parasite more accurately.

During the epizootiological survey, we compared the efficiency of two different methods for detecting *M. cerebralis* in juvenile fish. Spores were easier to detect by the enzyme digest method be-

cause it produced a cleaner preparation than centrifugation. Digestion also was the more efficient method when several samples were processed simultaneously. The plankton centrifuge technique is faster when single samples are examined (Markiw and Wolf 1974b), but a time-consuming decontamination of equipment is required between samples. In addition, only the number of samples for which there are plankton centrifuges available (usually one) can be processed at one time.

Although we cored only 20 chinook salmon heads, the resulting data indicate that this subsampling technique may be appropriate for detection of *M. cerebralis* in large fish. Not only could the technique be used in epizootiological studies, it might also be useful for examination of fish for compliance with international trade laws.

Acknowledgments

We acknowledge the assistance of personnel of the Oregon Department of Fish and Wildlife (ODFW) who collected samples. We also acknowledge the cooperation of owners of private trout hatcheries. We thank P. Allison of the College of Veterinary Medicine, Oregon State University, for her help with the histology and C. Pelroy for typing the manuscript. This research was supported by grants from the U.S. Department of Agriculture, Animal Health and Disease Research Funds, and from the ODFW through a contract with the Bonneville Power Administration (agreement DE-A179-87BP 33823) and by funds from the Anadromous Fish Act (Public Law 89-304) under project AFS-78 administered by the U.S. Fish and Wildlife Service. This is Oregon Agricultural Experiment Station technical paper 8524.

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July 29, 1996

Mr. John Mumma
Director
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Dear John:

Thank you for the copy of -- An Assessment of Fishery Management and Fish Production Alternatives----with the request that comments be sent to Jim Bennett. I will send a copy of this letter to Mr. Bennett, but my comments concerning alternatives and redirection in relation to the catchable trout program should be brought to your attention.

The assumption that recreational days of angling are directly related to the numbers of catchable trout stocked requires much more in-depth analysis and thought than is evident in the report. It is unstated, but probably also assumed that angler days are directly related to license sales. That is, a 30% or 40% reduction in numbers of catchable stocked (in state or by region) will translate into 30% or 40% less angling licenses sold.

Last sentence on bottom p. 17, to top of p.18, reads: ". . .we assume there is a direct and equal correlation between the number of fish stocked and the number of recreational days generated." Since only the number of catchable trout will be reduced in 1997, "fish stocked" means catchable trout.

There is abundant data to dispute this assumption, much of it in DOW studies. For example, Mary McAfee conducted Federal Aid Project 7-59," Coldwater Lakes and Reservoirs" (I have a copy of the 1991 report). A few highlights from Mary's studies pertinent to any evaluation of DOW's catchable program are: Will anglers who fish in waters stocked with catchables continue to fish these waters if no catchables are stocked (only nonsalmonid fishes could be caught)? Anglers were interviewed in many "intensive use" waters of Denver, Grand Junction, Rifle, Craig, and Georgetown. From 88% to 97% of those anglers said they would continue to fish these waters (for nonsalmonid fishes) if catchable trout stocking ceased.

In regards to avoiding wasteful stocking and get the best mileage from catchable trout, her data from Rifle Gap Reservoir and Bear Lake are instructive. In 1984, 16,500 catchables were stocked in Rifle Gap and 58,000 angling hours (about 20,000 angler days) were "generated." In 1987, 61,500 catchable trout were stocked and 61,000 angler hours (ca.21,000 angler days) were "generated." In relation to the assumption of "a direct and

equal correlation between the number of fish stocked and recreational days generated," it can be seen that an increase of 45,000 catchable trout stocked, "generated" and additional 1,000 recreational days, with 45 additional catchable trout correlated to each additional recreational day, it is obvious such a "direct and equal correlation" assumption is wrong, and it can be very wasteful and costly.

In Bear Lake, 100 catchable trout per surface acre were stocked for four years and 400 per acre were stocked for three years. There was a "correlation" between angler days and numbers of catchables stocked, but it was not "direct and equal." An angler day was "generated" by 1.5 catchables with an annual stocking of 100 per acre. At a stocking rate of 400 per acre, seven catchable trout were necessary to "generate" an angler day.

Mary also compiled data pertinent to how hatchery trout stocked for "put and grow" fisheries can be more effective. She tested four "strains", two typical domesticated hatchery-selected strains of rainbow trout and two less domesticated strains, the Eagle Lake rainbow and Snake River cutthroat. Fingerlings of all four strains were stocked into Stillwater Lake and Bear Lake. Two years or more after stocking, survival of the less domesticated strains was 24:1 to 60:1 better than the domestic strains. When Mary requested increased production of Eagle Lake rainbows by DOW hatcheries, she was informed that there was no space; all facilities were geared to maximum production of catchable trout (which, in recent years has made up 90% to 94% of total hatchery production by weight).

I see no mention of Mary McAfee's work in the assessment report. Are the author's unaware of this DOW data which bears directly on "direct and equal correlation between fish stocked and recreational days generated"? I assume Mary still works at the Grand Junction office. Was her input requested for the assessment report?

Table 9 in the report provides supporting evidence to the effect that the "direct and equal correlation" assumption is false. About 20-25 years ago, perhaps 40% of all catchable trout were stocked in streams (vs. lakes and reservoirs). The report mentions this ratio declined to 19% by 1992 and to 5% in 1996. There has been a steady decline in numbers of catchable stocked in streams. Therefore, we should expect a steady decline in anglers fishing streams. Table 9, shows no such decline. Consistently, 33% - 36% of statewide angler use occurred in coldwater streams from 1982 to 1994. Increased license sales during this period means that the actual numbers of anglers fishing coldwater streams increased during this period of continuing decrease in numbers of catchable trout stocked. Table 9 also indicates why there is no "equal and direct correlation" between angler use and number of catchables stocked in coldwater streams. Two figures of 11% and 12% are given for anglers "desiring" catchable trout. Two figures are also given for anglers "desiring" wild trout, 18% in 1982, 70% in 1994--times and desires are changing.

Table 9 also has a column, a very misleading column, percent of people fishing "put-and-take" waters, which is 78% for 1994. This is readily explained by the change to stocking most catchables in lakes and reservoirs; therefore, anglers fishing for bass or walleye in most Colorado lakes and reservoirs are fishing in "put-and-take" waters.

I would also point out that in California, which leads the nation in numbers of catchable trout stocked (Colorado leads nation in number per licensed angler), the sales of fishing licenses declined from 10% to 5% of the state's population during the 1980's. During this period of decline, catchable trout production remained stable or increased. It was obviously not a determining factor governing license sales.

Pennsylvania has stocked about the same number of catchable trout as Colorado during the past 10 years. There is considerably greater fishing pressure directed toward trout in Pennsylvania than in Colorado although the state has only 790 miles of class A streams (support 27 pounds per acre of brook trout or 36 pounds per acre of brown trout) for wild trout fishing. Pennsylvania has only 23,000 surface acres of lakes and reservoirs suitable for salmonid fish stocking. That is, Colorado has about five times more stream miles and lake and reservoir area for wild trout or put-and-grow type fisheries (non put-take catchable fisheries). Yet angler satisfaction in Pennsylvania is high. Data available in: 1991 Trout Angler Survey, and Management of Trout Fisheries in Pennsylvania (1987), published by Penn. Fish Comm.

I assume the Penn. Fish Comm. sends their publications to DOW library. They are highly pertinent for a new and improved DOW assessment report.

When I read, on p. 16, of the assessment report that. . ." DOW biologists estimate that 85% of the recreational days (of "intensive" use category) depend on catchable trout stocking," I must ask who are these biologists? On what basis do they make this estimate? Are they familiar with the facts and figures I cite above from other states and from DOW data? It comes down to a matter of credibility. The assessments and assumptions regarding catchable trout in the assessment report are not credible.

Sincerely,

Robert J. Behnke
Professor

RJB:dm

cc: Dr. James Bennett
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James R. Bennett
[1996]

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EXECUTIVE SUMMARY

The introduction and spread of whirling disease (WD) in Colorado has created widespread concern and controversy within scientific and public circles. In April 1996, Division Director John Mumma created a review panel of Division of Wildlife (DOW) staff to conduct an assessment of WD issues and impacts related to (1) the management of native cutthroat and wild trout; (2) the reliance of sportfishing recreation on trout stocking; (3) the role and operation of the state's hatchery system; and (4) the demand for hatchery-raised products like catchable trout. The Director asked this panel to develop alternative approaches to deal with each of these issues, and to provide preferred alternatives. The panel members came from a diversity of backgrounds: regional administration, fisheries research, sportfish management, state hatchery propagation, and native wildlife conservation.

The panel gathered data and information from a broad base of scientific literature, reports, unpublished data, and communications with staff and field personnel in DOW's Aquatic Wildlife Section. The panel was asked to build upon the assessments provided in previous reports prepared by Deloitte and Touche in July and November 1995. Taken together, all of this information contributed significantly to the panel's assessment of the major issues and development of alternative strategies. The first draft of this report received peer review from a select group of biologists and consultants from both inside and outside the DOW. Input from DOW Aquatic Wildlife Section personnel was also encouraged. The second draft received a broader technical peer review from scientists working for other state wildlife agencies, federal land management agencies, and universities. This final version of the document, which incorporates the thoughtful comments and concerns voiced by many scientists and other reviewers, represents our best current understanding of the WD issue in Colorado.

Overview

The DOW is mandated to manage Colorado's wildlife resources from both a conservation and recreational perspective. This dual mission is emphasized in the 1994 Long-range Plan, and it is central to the controversy surrounding WD as the DOW attempts to balance resource protection with fishing recreation. The 1994 Plan directs the DOW to protect and enhance the viability of all of Colorado's wildlife species, diversify fishing opportunities, increase participation in fishing in proportion with human population growth, increase angler satisfaction, stock fish as appropriate to maintain angler satisfaction, and protect and improve high-priority aquatic habitats. Further direction for DOW related to stocking fish comes from Commission Policies D-1, 2, 4, 6, and 9, and Administrative Directive F-1.

Currently, WD is known to exist in 1.3% of coldwater stream habitat and 9.1% of coldwater lake habitat. Since 1988, an estimated 2,550 stream miles have been exposed to the WD parasite. The trout populations in five major streams in Colorado demonstrate significant population level declines from WD infection. Evidence in Colorado and elsewhere now refutes the belief that WD does not negatively impact wild trout populations.

Whirling Disease

Myxobolus cerebralis (MC), the myxosporean fish pathogen that causes WD, was first detected in public and private fish culture facilities in Colorado in 1987. Between 1988 and 1991, despite massive field testing for the presence of MC, there was no evidence that the parasite impacted wild trout populations. Moreover, containment and control of the parasite at public and private fish culture facilities seemed to be working. However, beginning in 1992, additional state fish culture facilities began to test positive for the parasite.

In late 1993 and continuing into 1994, circumstantial evidence indicated that WD was potentially linked to serious declines in wild trout populations in the upper Colorado River. During 1994 and continuing through 1995, DOW researchers, fish health specialists, and biologists amassed significant evidence that exposure to MC was implicated in severe declines in wild rainbow trout populations in several Colorado trout streams, including the Colorado, Cache la Poudre, Gunnison, Rio Grande, and South Platte rivers. Moreover, sentinel fish tests in 1995 and 1996 demonstrated that Colorado River cutthroat trout and brook trout were even more severely affected by exposure to the pathogen in the Colorado River than rainbow trout and brown trout.

In response to the problem, the DOW has implemented steps on a number of fronts. These include (1) greatly expanding the WD testing program with a large research effort at both the field and laboratory level to assess the threat to wild trout populations; (2) determining the status and rate of expansion of the disease in the wild; (3) initiating major efforts to clean up fish culture facilities testing positive for the parasite as well as protecting the remaining negative units; (4) dramatically redirecting the use and stocking of cultured fish in natural environments to stem the spread of the parasite into presently negative habitats; (5) implementing long-term monitoring to determine if it is possible to reverse the serious effects of the pathogen among some wild trout populations presently being impacted severely by the disease; and (6) redirecting and reallocating human resources and equipment. More than $700,000 was spent during fiscal year 1995-96 to accomplish the above steps.

Protection

Native cutthroat and wild trout populations are a part of Colorado's natural wildlife heritage and provide a recreational fishing opportunity that is held in high esteem by the public. Protection of native species and self-sustaining wild trout fisheries from the adverse effects of WD is considered paramount and should not be compromised to sustain recreational use levels. The fact that two of the three native cutthroat species are declining or federally-listed due to other factors makes this protection from WD even more compelling. Since native trout appear at least as vulnerable to the pathogen as rainbow trout, lack of adequate protection would likely increase the risk of further decline and frustrate recovery and conservation efforts.

The habitat occupied by native cutthroat trout or officially designated as Gold Medal or Wild Trout fisheries is limited. Much of the current and potential stream and lake habitat for native cutthroats occurs in headwater drainages, and the use of native cutthroats as the primary trout species for management in these headwater drainages appears feasible from a conservation perspective. However, even with the expansion of native cutthroat waters to full potential, the resource base for these species would represent only 10% of the coldwater stream miles and 1% of the coldwater lake surface area available. Fisheries for these species should focus on catch-and-release and limited-harvest regulations.

Threats to native cutthroat from hybridization with nonnative salmonids, overharvesting from angling, and degradation of habitat can be dealt with using known fish management strategies, legal protection of instream flows, and water quality regulations. Protection from WD stocking has been provided through DOW policy, which defines native cutthroat habitat and high-quality wild trout fisheries, and through the immediate application of stocking restrictions to protect populations from exposure to the parasite. Continued establishment of new populations of native cutthroat trout provides insurance against potential losses to WD.

Recreation

Fishery resources in Colorado are characterized by their management type (using the DOW's Categorization System) into **Intensive Use** (catchable trout stocking), **Optimum Use** (no stocking, or cold- and warmwater fry, fingerling, or subcatchable hatchery fish), and **Special Use** (little or no stocking). Fishing recreation days, fish catch, and fish stocking requirements associated with each category were estimated for the base year 1992. More recently, trout stocking has been changed to prevent the spread of the WD parasite into protected habitats. As a result, estimated fishing recreation days and their statewide distribution have likely been significantly altered. This change, along with the decision to reduce WD+ catchable trout stocking by 1.3 million fish in 1997, could further reduce recreation days on the west slope by 500,000 recreation days as compared with 1992, while east slope recreation days could decline to 1992 levels. Because the state is perilously close to losing negative WD status on its remaining fry and fingerling production units, serious losses of fishing recreation could also occur in habitats managed for **Optimum Use**.

A number of options could be considered to mitigate the loss of recreation days resulting from reductions in WD+ stocking. Balancing the stocking of WD- and WD+ trout in 1997 can provide some short-term, but limited, relief to fishing recreation losses that the state is now experiencing. Increasing recreation in warmwater fisheries holds some promise through the acquisition of new access, improvement of angler facilities, enhancement of habitat at existing lakes, and an increase in the stocking levels of WD+ catchable trout in nontraditional warmwater habitats. Emphasizing wild trout management in coldwater lakes may have only limited potential because of the near total dependency on hatchery-reared trout to sustain fishing recreation in those habitats. On the other hand, there is some potential to switch to a greater reliance on wild trout management (including native cutthroats). The tradeoff is a loss of recreation days or some

reduction in the need for hatchery-reared trout, and further protection of these resources from WD. Enhancement and protection of coldwater resources through water quality/quantity programs and habitat improvement is a vital component of DOW programs, but increased efforts in these areas represent a long-term commitment. Habitat improvement cannot enhance the productive capacities of Colorado aquatic resources quickly enough to compensate for fishing recreation losses.

Demand

Natural reproduction from wild trout populations provides fish for anglers, but even with special angling regulations (catch-and-release, size limits, restricted bag limits, etc., which allow managers to recycle fish), the DOW is still not able to meet angler "demand" without supplemental hatchery production. Demand for hatchery-raised catchable trout cannot be estimated using an economic model because the public will "consume" all catchable trout under the current license fee, year-round season, and eight-fish bag limit. Demand for catchable trout will always exceed supply under these conditions.

Demand includes the desire for a commodity, as well as the ability or willingness to pay for it. A major premise of this report is that a true assessment of the demand for hatchery-reared fish should help determine the DOW's hatchery production goals. The DOW has tried various methods to estimate demand, including the present Categorization System.

Fishing recreation is important to local and state economies (more than $900 million annually), and it is estimated that hatchery-reared fish support 80% of the state's coldwater angling recreation days (Deloitte and Touche 1995). However, to manage our fisheries effectively, we need to know more about (1) what people want, and how much they are willing to pay (**demand**); (2) factors contributing to **angler satisfaction**; (3) management **program objectives**; and (4) interactions among **management variables** like catch rate, angler use, stocking rate, and regulations.

Hatchery Production

The hatchery system has operated with 89.4 permanent personnel and 14 temporary employees and an annual budget of $7.56 million, including capital construction projects. The system consists of 14 coldwater units, two warmwater facilities, one combination cold/warmwater hatchery, and a planting base. Support services include a fish health section and research hatchery. Eight of the 14 coldwater units have been found positive for WD.

Information is provided in Chapter VI for each individual hatchery concerning costs, potential to increase production of WD- fish, alternatives to rear different species, and opportunities to convert production units to other functions such as research or youth fishing areas. Most of the information was provided by the superintendents of the various hatcheries.

In the short term, recommendations include trading fish with the WD- federal fish hatchery at Hotchkiss, developing an increased water supply and production capacity at the Buena Vista Correctional Facility, increasing production at the Pitkin hatchery, leasing or purchasing WD-, private hatchery(s), and purchasing WD- trout from the private sector. Long-term alternatives (in addition to the short-term) include acquiring new (undeveloped) water sources and cleaning up and/or modifying existing facilities. However, before any expensive options are finalized, a thorough cost/benefit analysis (including risk assessment) should be performed by a consulting firm specializing in hatchery system analysis.

Alternatives

Twenty-two alternatives were identified from the assessment of the various issues. From this list, seven alternatives were identified as "assumed," meaning that, while they were considered appropriate by the Team, they were either already being implemented or certain to be implemented. These "assumed alternatives" are:

* Implement the WD Policy (D-9, May 1996) with respect to protection/stocking restrictions in native cutthroat trout and wild trout waters.

* Implement recovery, conservation, and management plans to expand the range of three native cutthroat trout, and restore them to a viable biological status.

* Use native cutthroat in their endemic drainages as the primary species for management in headwater drainages, providing catch-and-release and limited-harvest fishing opportunities.

* Investigate options for reducing the negative impacts of WD to stocked fish, and evaluate other species and strains of salmonids for resistance to WD; initiate research to determine the density, periodicity, and seasonality of waterborne spore production in infested waters.

* Conduct a research project to determine whether the continued stocking of trout from WD+ units into WD+ habitats increases or maintains WD spore levels above that produced by the alternative tubifex worm host.

* Buy WD- trout from the private sector.

* Trade for WD- trout from federal hatcheries.

Seven additional preferred alternatives were recommended:

* Balance the use of WD+ and WD- trout to protect resources while creating and directing fishing recreation.

* Undertake an economics-based study that examines the cost, benefits, and anglers' willingness to pay for hatchery-reared fish in Colorado. This should also incorporate results to enable an understanding of "angler satisfaction" and the estimation of angler success and demand by category. The study should be done on a broad scale so that the results can be applied to the entire hatchery system.

* Implement user pay mechanisms to determine the demand for catchable trout and to enable DOW to index hatchery production.

* Initiate research to determine if UV light, sand filtration, or other screening materials provide a viable methodology for eliminating WD spores from hatchery supply waters.

* Eliminate or reduce the WD pathogen from existing state production facilities.

* Lease or buy new WD- hatcheries.

* Modify existing negative hatcheries to produce more fish.

It is recommended that action on these alternatives be considered by the DOW Director, the Leadership Team, and the Aquatic Wildlife Section to help minimize the impacts of WD on Colorado's aquatic resources.

INTRODUCTION

This report dated September 23, 1996, supersedes all previous drafts. It is intended to guide Director Mumma and the Colorado Wildlife Commission in decisions related to hatchery production, aquatic resources, species protection, angling recreation, and containment of whirling disease (WD).

The mission of the Division of Wildlife (DOW) is to perpetuate the wildlife resources of the state and provide the public the opportunity to enjoy them. Inherent in this mission is a duality that can sometimes be cause for frustration and consternation as we attempt to carry out our responsibilities. This has never been more difficult than with the policy and management issues surrounding WD. For the most part, the "friction" between resource protection and fishing recreation goals is confined to certain geographical areas of the state, notably those areas that contain self-reproducing salmonids, native species, and WD- coldwater hatcheries.

The level of risk associated with the spread and establishment of WD varies with distance to protected habitats, as well as a number of little-known and poorly-understood parameters. Although we are well invested in research with other agencies, we do not currently have the information necessary to manage the disease without incurring some level of risk. It may be several years before this vital knowledge is available to guide our fishery program. In the short term, the DOW has been directed by Colorado Department of Natural Resources Executive Director James Lochhead to proceed with utmost caution and, when in doubt, to consider the needs of resource protection of paramount importance. Furthermore, the Colorado Wildlife Commission (CWC) in its WD Policy passed in May 1996 stated, "The primary objective of the Division of Wildlife . . . is the continued protection of the health of the aquatic resources of the state when the stocking of fish exposed to the WD parasite is considered."

The **goal** of this assessment is to define the role of Colorado's hatcheries in meeting the DOW dual mission for aquatic resource protection and fishing recreation as well as the "demand" for hatchery-reared fish. The authors will examine the factors that contribute to the demand for fish and fishing in Colorado. We will characterize what we have learned about "demand" and offer options for aligning hatchery production with the demand for fish. Finally, we will highlight work that remains to be done, identify assumptions that should be verified, and propose strategies we believe will assist the DOW in meeting reasonable requests for fish stocking, while effectively dealing with WD.

I. OVERVIEW OF COLORADO'S AQUATIC RESOURCES

The DOW is involved in wildlife management based on the mandate in the Colorado Revised Statutes, Title 33, which declares that it is the policy of the state of Colorado that wildlife and their environment be protected, preserved, enhanced, and managed for the use, benefit, and enjoyment of the people of the state and its visitors. While the DOW is encouraged to offer the

greatest possible variety of wildlife-related recreational opportunities (CRS, 33-1-101 [1]), we are also expected to ensure the perpetuation of nongame/nonsport species as members of ecosystems (CRS, 33-2-102).

This "dual mission" is underscored by the DOW's 1994 Long Range Plan (LRP), which states, "The Division's foremost aim for the future will be to protect and enhance the viability of all Colorado's wildlife species." In that same LRP, goal #12 calls for the DOW to diversify fishing opportunities, and increase participation in fishing as the state's population grows, while simultaneously increasing the level of angler satisfaction. Sub-goal 12.3 directs the DOW to stock fish as appropriate to maintain angler satisfaction. Sub-goal 12.4 charges the agency to protect and improve high-priority aquatic habitats. To accomplish these tasks, DOW management programs must balance our recreation-based programs with protective components for all of the state's wildlife species.

Along with the guidance from the LRP, DOW's direction for stocking fish comes from CWC Policy and Administrative Directives, specifically:

>Commission Policy D-1 *Management of Aquatic Wildlife* (1975);
>Commission Policy D-2 *Fish Stocking* (1975);
>Commission Policy D-4 *High Lake Management* (1975);
>Commission Policy D-6 *Wild Trout and Gold Medal Trout Mgt.* (1992);
>Commission Policy D-9 *The Stocking and Use of Fish Tested Positive for, or Exposed to, the Whirling Disease Parasite, Myxobolus cerebralis* (1996); and
>Administrative Directive F-1 *Fish Management and Stocking* (1976).

Colorado's surface acreage encompasses about 104,000 square miles, with some 54,000 linear miles of stream habitat, 24,000 miles of which are perennial; 15,000 surface acres of natural lakes; and 250,000 acres of constructed ponds and reservoirs. These waters are inhabited by 112 species of fish--9 native sport species, 33 nonnative sport species, and 70 either native or introduced nonsport species.

The state's aquatic habitats, categorized as coldwater streams (miles) or impoundments (surface acres), and warmwater streams (miles) or impoundments (surface acres) are listed in Table 1, along with the WD status of each category. As shown, WD is not a concern in warmwater habitats. However, in the coldwater habitat that the DOW manages, 670 coldwater stream miles (1.3% of available habitat), and 10,400 coldwater surface acres (9.1% of available habitat) now contain fish populations testing positive for *Myxobolus cerebralis* (MC), the myxosporean parasite that can cause WD. A total of 2,550 stream miles has been exposed to the WD parasite through stocking since 1988, but only 670 miles (26%) have tested positive. Some exposed habitats have also been tested but have received negative test results, either because of statistically invalid sample levels or because feral fish were not infected. More than 200 miles of major trout streams, including the Colorado, Gunnison, Poudre, South Platte, and Rio Grande rivers, are suffering significant rainbow trout population declines because of WD infection (Nehring 1996). However, there are some stream segments (Elevenmile Canyon--S. Platte, Big

Thompson, Fryingpan, and Dolores rivers) which have tested positive yet have shown no significant population impacts. DOW's Aquatic Resources/Hatchery personnel estimate that the range of the parasite may be expanding by about 5% per year (in Deloitte & Touche 1995).

Over the years, Colorado's hatchery system has had to deal with potentially devastating problems such as diseases, water quality and quantity issues, and parasitic infestations. Until recently, most fish pathologists believed WD would not negatively impact wild trout populations (Anonymous 1988). This belief was based mainly on hatchery experience and the fact that there were no published studies indicating otherwise. Results of the first study documenting the impacts of a controlled quantitative exposure of very young rainbow trout to a very low dose of the MC pathogen were published by Markiw in 1991. In hatcheries, WD is a malady that rarely causes mortalities or leaves trout permanently impaired (Markiw 1992). Many fish pathologists and fishery managers assumed if trout survived infections of the WD parasite in a hatchery, the disease would not affect trout in the wild. This assumption was based on the belief that hatchery conditions were undoubtedly more stressful than what exists in the wild environment. However, the results in a recently completed study on the Colorado River (Walker and Nehring 1995; Nehring and Walker 1996), as well as results of other investigations in Montana (Vincent 1996) and Utah, clearly demonstrate that WD in the wild is a reality in the intermountain west.

Table 1. Approximate warmwater stream miles and surface acres, and coldwater stream miles and surface acres in Colorado, and their "whirling disease" status.

	WARMWATER				COLDWATER			
	STREAMS		LAKES		STREAMS		LAKES	
	N	MILES	N	ACRES	N	MILES	N	ACRES
WD+[1]	na		na		44	670[3]	21	10,400
Other[2]	16	529	437	116,300	8,857	53,230	3,046	103,900
Total	16	529[4]	437	116,300	8,901	53,900[4]	3,067	114,300

[1]Waters where the presence of WD has been confirmed by statistically-valid testing.
[2]These numbers were obtained by subtracting WD+ data from the total. This group includes untested waters and a small number of stream miles (<100) testing negative.
[3]A total of 2,550 miles have been exposed to WD by stocking; 670 miles have tested positive.
[4]Represents perennial and ephemeral streams.

II. WHIRLING DISEASE

History of *Myxobolus cerebralis* in Colorado

On November 25, 1987, ***Myxobolus cerebralis*** (MC) was found for the first time in Colorado at a private facility and a nearby state fish hatchery (Mt. Shavano) close to Salida in the Arkansas River drainage. In the two weeks that followed, the organism was also found at a private facility near Creede in the Rio Grande River drainage and at another private fish culture site on Trout Creek, a tributary of the South Platte River in south central Douglas County. Trout collected at a private hatchery north of Fort Collins tested positive for WD on December 15, 1987. On February 15, 1988, MC was detected at the Chalk Cliffs Rearing Unit in the Arkansas drainage. By May 1988, the pathogen had been found at 12 locations in Colorado. The list included two state facilities, nine private commercial fish farms, and one private pond on the Air Force Academy. Within a year (1989) 26,262 fish had been sampled for WD from 48 fish culture sites and 182 free-ranging populations. Eleven fish culture sites and 40 free-ranging trout populations (Appendix A) found in 11 of the 15 major drainages tested positive (Appendix B). All fish culture sites found positive for WD were immediately quarantined by order of the director. Presently, the DOW categorizes the WD status of the state's waters using "water codes" (DOW identification system for lake and stream segments).

In November 1987, the DOW employed one full-time fish pathologist and received assistance from the U.S. Fish and Wildlife Service's (USFWS) Fish Health Laboratory in Ft. Morgan, Colorado. After WD was found in Colorado, the DOW immediately rented laboratory space to start a WD diagnostic center and hired three temporary employees under the direction of the state fish pathologist to staff the facility. The USFWS provided the services of a certified fish pathologist for one year to assist in determining how widespread WD was in Colorado. The Director of the DOW also initiated a task force to guide the program. The task force consisted of one lawyer from the attorney general's office, a DOW fish pathologist, one person from the Law Enforcement Section, two fish researchers, a USFWS fish pathologist, one employee from the Public Affairs Section; and other individuals from within and outside the DOW, as needed. The whole group was under the direction of the state fish manager. Also, as required by regulation, other government agencies were consulted in the decision-making process. Total effort, minus legal services, on WD in Colorado from November 24, 1987, to July 31, 1988, amounted to 7,600 hours of labor and an expenditure of $172,000.

An emergency conference on WD held in Denver on April 12-14, 1988, was attended by approximately 70 people representing university and agency research communities, as well as a variety of state, federal, and private fishery programs. The Colorado River Fish and Wildlife Council (CRFWC) fish disease subcommittee conducted the meeting and, with the information generated, developed a conference statement that was presented to all fish health representatives of the member states for discussion as well as the entire assembled group. Minor changes were suggested and incorporated by the committee.

FINAL CONFERENCE STATEMENT: "The fish disease subcommittee for the CRFWC, having reviewed information presented at the WD conference, has determined that the status of the disease should be reevaluated and reassigned. The considerable expertise at the conference represented both historic and current perspectives pertaining to WD (*Myxobolus cerebralis*). The fish disease subcommittee recommended that whirling disease be included in the "notifiable pathogen" category (removing it as an emergency prohibitive disease) of the fish disease control policy of the CRFWC." The subcommittee further concluded that "fish with confirmed presence of WD should be liberated only in waters where there is confirmed presence of the pathogen. It is important that infected fish not be released where the spores may become established in the wild."

In 1988 the only authority the Director had was to quarantine hatcheries found positive for WD. Beginning with the first discovery of WD in Colorado, all WD+ hatcheries (state and private) were immediately quarantined. No fish or eggs were allowed to be removed from any facility found positive for MC. Criteria were eventually developed by the DOW's task force to allow limited removal of fish from quarantined hatcheries. Other concerned and involved agencies were also contacted. At the time (1988), regulation required approval by other government agencies in writing before stocking any fish from a WD-positive hatchery on the land(s) under their control. The DOW considered the appropriate resource agencies to include the Bureau of Land Management, Colorado Department of Park and Outdoor Recreations, U.S. Department of Defense, U.S. Fish and Wildlife Service, and U.S. Forest Service. The proposed criteria and an overview of the entire WD situation were presented in a public meeting at DOW headquarters on January 22, 1988. Input from the private sector was received at that time. Following additional review and revision, the first criteria for fish removal were approved by the Director on March 4, 1988 and the CWC on March 11, 1988, and were put into effect beginning March 14, 1988.

A new WD policy was put into effect on July 1, 1988, and continued through November 30, 1988. The policy was the result of new information obtained from the WD conference previously discussed, consultation with other agencies, and a public meeting on June 22, 1988. The amended policy was very similar to the policy that expired on June 30, 1988. Changes in the new policy addressed misinterpretations, clerical issues, and simplifying the total process. On July 11, 1988, as a result of the CRFWC decision to downlist WD to the "notifiable" category, the stocking criteria for the new policy were modified; stocking of fish from quarantined hatcheries would be allowed on the west slope. However, protected sites were established for Colorado River cutthroat trout and Rio Grande cutthroat trout. Self-sustaining populations of rainbow and brook trout were dropped from the protected criteria. All other stocking criteria remained in effect. As a DOW internal policy, stocking of fish from DOW WD-positive facilities on the west slope did not start until the spring of 1992. In addition, regional biologists were instructed not to request fish from quarantined DOW hatcheries in or near sites where spawn-taking operations were conducted.

In November of 1988 an Environmental Assessment (EA) was completed on stocking fish from WD-positive hatcheries on federal government lands. After a public comment period, the EA was approved.

Based on both public and government input and available scientific information, the WD policy was modified again on December 1, 1988. A major change was to give the managers of quarantined facilities the responsibility to complete their own forms without DOW inspection. A training session was conducted in November 1988 to prepare private hatchery managers for assuming this responsibility. Regional biologists were still responsible for approving DOW stocking locations. Other changes included reducing the stocking criteria for WD- fish to three specific areas: negative river drainages; negative fish culture locations; and protection of cutthroat trout habitat. The December 1988 WD policy and corresponding quarantines remained in effect until January 1992, when the quarantines were removed and procedures for management of WD-positive hatcheries were placed in DOW regulations. In June 1991 the legislature passed the "Colorado Aquaculture Act," which created the Fish Health Board. The Board consisted of five members: two members from the private aquaculture community appointed by the Colorado Dept. of Agriculture; one member from the Colorado Dept. of Agriculture; one member from the USFWS; and one representative from the DOW. The primary duty of this Board was to advise the CWC on matters concerning fish health. One of the first official acts of the Board was to come before the CWC to present an argument that the WD quarantines should be removed and the organism managed through regulations. The CWC agreed; consequently, the quarantines were removed and management of WD was placed in the General Provisions, Article IX, #009, G, which stated, "No live salmonid fish originating from a facility that has been diagnosed positive for *Myxobolus cerebralis* (whirling disease) may be stocked (A) in water within ten (10) miles of and within the same drainage as any state, federal, or permitted aquaculture facility unless the owners of all such facilities grant written permission to allow such stocking, or (B) within the protected habitat of Type A greenback, Colorado River, or Rio Grande cutthroat trout. Maps indicating the locations of state, federal, and permitted aquaculture facilities and known protected habitat of Type A greenback, Colorado River, or Rio Grande cutthroats are available from the manager of Aquatic Resources Section of the DOW, 6060 Broadway, Denver, CO 80216."

The regulation remained in place until September 1993, when the Fish Health Board again petitioned the CWC to change the wording of the regulation. The new proposed regulation would simplify the language and could also be used to expand the protected areas, if necessary. In December 1993, the CWC approved the new wording. General Provisions Article IX, #009, G, now reads, "No live salmonid fish originating from a facility that has been diagnosed positive for *Myxobolus cerebralis* (WD) may be stocked in protected habitat as defined in CWC regulation #001 V.5. Maps showing the locations of approved protected habitats are available from the manager of the Aquatic Resources Section of the DOW, 6060 Broadway, Denver, CO 80216." The corresponding regulation, Article #001, V. 5, defines protected habitat as "Specific areas determined by the Director, after consultation with the Fish Health Board, to be of special importance to Colorado's fishery resource. Protected habitat evaluation criteria will include uniqueness of the resource (species, habitat, or facilities), potential for use as a source of brood fish or gametes, potential for use in recovering threatened or endangered species, and significance of the threat of introducing certain pathogens or diseases. Maps showing the locations of approved protected habitats are available from the manager of the Aquatic Resources Sections of the DOW, 6060 Broadway, Denver, CO 80216."

Whirling Disease-Positive Fish Production Facilities

From 1988 until the passage of Senate Bill 90-67 in 1990, anyone who had a commercial lake license could sell and transport live fish and was therefore considered a fish hatchery. A commercial lake license holder was immediately quarantined if they became positive for WD. Senate Bill 90-67 separated a commercial lake license from an aquaculture license (fish hatchery). A commercial lake license permittee could no longer sell or transport live fish and, consequently, did not pose a threat of spreading the disease. After 1990 (creation of the aquaculture license), the number of permitted people selling and transporting live fish dropped from approximately 140 to 37. As a result, the number of WD-quarantined facilities dropped dramatically. Today there are five private hatcheries, one non-profit club, eight state hatcheries (Mt. Ouray became negative in June 1996), and one federal hatchery considered positive for WD (Appendix C).

Costs

Beginning in 1988, the DOW fish health program expanded rapidly. Much of this expansion can be attributed to the WD issue. Before 1988, the DOW had one fish pathologist working in office space donated by the USFWS at the Fish Health Laboratory in Ft. Morgan, Colorado. In 1988, noted previously, the DOW leased space for its own WD laboratory and hired two temporary employees. In February 1989, the DOW put together a Colorado Aquaculture Advisory Committee composed of three members from the private aquaculture community, one employee from the USFWS, and two representatives from the DOW. After several meetings, the committee produced a final report that dealt with fish health regulations, legislation, compliance, indemnification, inspection costs, and future committees. The Director agreed with the recommendations and signed the document on October 13, 1989. For the first time in the history of the DOW, the Fish Health Section had an opportunity to become proactive rather than reactive to fish health issues. As a result of this committee's efforts, and with support from the private aquaculture sector, Senate Bill 90-67, which provided personnel and funding for fish health programs and stiff penalties for the illegal movement of fish, was passed into law in 1990. As a result of this legislation, the DOW was able to hire two more full-time employees for the fish health program. The bill also provided for yearly funding to rent laboratory space, carry out fish health-related activities, and pay part of a compliance officer's wages.

In late 1993, biologists observed that the wild rainbow trout population in the upper Colorado River had apparently suffered three successive years of recruitment failure. Studies conducted on the Colorado River during 1994 implicated WD as a significant factor and perhaps the decisive factor in the loss of these year classes (Walker and Nehring 1995; Nehring and Walker 1996). Additional studies throughout the summer and fall of 1994 and 1995 implicated WD in similar year-class failures among wild rainbow trout populations in the Cache la Poudre, Gunnison, Rio Grande, and South Platte rivers (Nehring 1996).

To deal with this situation, a major redirection of staff time and monetary resources within the DOW began in 1994. Early in 1995, efforts at the Fish Health Lab were expanded with the

addition of another full-time pathologist and 70 months of temporary time. The Aquatic Wildlife Section redirected $550,000 to study WD and state hatchery cleanup. Another $155,000 was allocated toward WD research out of discretionary funds (Appendix D). These efforts are ongoing and will continue for at least the next 3 or 4 years.

Management and control of WD is an exceedingly difficult task for many reasons. Failure to recognize the potential threat to wild trout early in the process undoubtedly facilitated the spread in the wild. The extreme complexity of the life cycle of the parasite and its dynamic interaction with environmental factors make documenting effects very difficult. These characteristics of the parasite pose daunting problems for containment and control with existing technologies. Extensive dependence upon stocked trout for fishing recreation in Colorado has become a complicated issue as more of the state's fish culture facilities have tested positive for the MC pathogen.

Protection of the aquatic resources of the state from the potential effects of WD should be concentrated on two fronts. First, we must do everything we can to stop unwittingly exposing native cutthroat and wild trout populations and habitats to the MC parasite. Second, we must attempt to eliminate this fish pathogen in fish culture facilities. Research in Colorado over the past 8 years suggests that the stocking of WD+ salmonids from fish culture facilities has been the primary mode of exposure and contamination of wild trout habitats. If we are successful in eliminating the human-related transmission of WD, and do the best possible job of containing and eliminating the pathogen from public and private fish culture facilities, we will have made considerable progress in reducing the threat of WD to Colorado's native cutthroat and wild trout.

Accomplishments and Recommendations Related to Whirling Disease

Much has been accomplished since 1994, but much more remains to be done. Based on current knowledge, WD is likely to persist in aquatic environments already compromised by the MC pathogen. We are assuming it is unlikely the parasite will disappear on its own. We are also assuming it is unlikely in the short-term that fish species known to be susceptible to WD will adapt and become resistant to the parasite. We will probably have to learn to live with and manage around WD as another environmental constraint, and try to minimize the debilitating effects of the parasite on wild salmonid populations. To do this effectively, we will need to continue and expand the research efforts that have been ongoing since 1994.

Since January 1994, the DOW Aquatic Research Section, fish management biologists, and the staff at the Fish Health Lab have undertaken and/or accomplished a number of major tasks, including:

1. Extensive testing for the presence of the parasite in wild trout populations all across the state. To date, we have sampled only a small percent of the state's salmonid habitats, but have tested all of the state's major trout fisheries. Our goal is to have statistically valid samples completed on all Colorado streams by 1999. To date, all major trout streams and most large cold- and coolwater impoundments have been tested. Areas still needing testing are largely confined to small streams and remote high mountain lakes.

2. Monitoring the level of virulence and infectivity of the disease in most major streams in the state that are currently affected at the population level (loss of year classes), including, but not limited to, the Arkansas, Big Thompson, Blue, Cache la Poudre, Colorado, Dolores, Fryingpan, Gunnison, Rio Grande, Roaring Fork, South Fork of the Rio Grande, South Platte, and Taylor rivers.

3. Susceptibility testing of many strains and species of salmonids to determine their vulnerability to the WD pathogen, including brown trout, brook trout, A+ Colorado River cutthroat trout, Trappers Lake cutthroat trout, Colorado River rainbow trout, and Tasmanian rainbow trout. This effort will be continued in 1996 and will include tests on the Rio Grande and greenback cutthroat trout and the Snake River cutthroat trout, along with other salmonids.

4. Annual population-level monitoring as to the status of wild rainbow and brown trout populations in the streams in #2 (above) to assess whether or not there is a change in the effects of WD on wild salmonid populations.

5. Collection and testing of Colorado River cutthroat trout populations from 17 streams on the west slope during 1995. Encouragingly, all populations tested negative for WD. This effort is being continued and expanded in 1996.

6. Conducting a research project to answer the question of whether the continued stocking of trout from WD+ units into WD+ habitats increases or maintains WD spore levels above that produced by the alternative tubifex worm host.

7. Collection and preservation of aquatic oligochaete worms from the same streams where Colorado River cutthroat trout were captured and tested in 1995 to determine if the alternate host of the pathogen occurs in cutthroat trout habitats.

We recommend that DOW biologists cooperate and share knowledge with other scientists and agencies involved in WD research. If this is done, everyone will benefit. As the magazine **Fisheries** recently noted, "A coordinated approach to investigating whirling disease across the country would shorten the learning curve, thereby benefitting public resource stewards and the private sector. It is time to search for answers and knowledge, not scapegoats." (Hulbert 1996).

III. PROTECTION OF NATIVE AND WILD TROUT

The primary management goal in dealing with WD in Colorado is to maintain the long-term integrity of naturally-reproducing populations of native cutthroat trout and wild trout. Two management programs associated with these trout populations include Wild Trout and Gold Medal fisheries. The three native subspecies of cutthroat trout are a resource unique to Colorado, with the greenback being found nowhere else. Populations of these trout found in adjoining river basins offer unique recreational fishing opportunities. From the conservation perspective, the greenback cutthroat is federally and state listed as threatened, and the Colorado River cutthroat has declined and is a likely candidate for federal listing. Rio Grande cutthroat are considered a "species of special concern."

Recent research into WD effects on trout have demonstrated an equal or greater vulnerability of the Colorado River cutthroat compared with other salmonids. In 1995, brook trout and native Colorado River cutthroat trout were found to suffer far greater mortality than wild Colorado River rainbow trout when exposed to the same conditions in tests in the Colorado River. This vulnerability may be translated into potential impacts to self-sustaining populations of cutthroat trout that are similar to those documented for rainbow trout, i.e., failure of recruitment and greatly diminished, or lost, year classes. Already in a precarious ecological status, further spread of the WD parasite into Colorado's native cutthroat trout habitats will put these subspecies at greater risk and further jeopardize their potential for recovery. In some sections of the upper Colorado River, negative population level effects have been documented on brown trout (Walker and Nehring 1995; Nehring 1996), although in other sections containing WD, biomass of brown trout showed increases.

Wild Trout and Gold Medal trout fisheries that are officially designated by the CWC represent quality fishing experiences that are highly desired by the public for their environmental setting, high quality and productive habitat, and availability of large- to trophy-size trout. These fisheries are sustained by introduced populations of primarily rainbow and brown trout, but they also include nonnative cutthroat trout, brook trout, and other gamefish species. Catch-and-release and limited harvest regulations are used to maintain these trout populations. Before the spread of WD, most trout populations under Gold Medal and Wild Trout management were largely self-sustaining.

Dimensions of the Native Cutthroat/Wild Trout Resource

The habitat occupied by native cutthroat trout is limited. Right now, 137 populations of native cutthroat are found in 11 of the 15 major watersheds in Colorado. They occupy 96 streams totaling almost 600 stream miles and 41 lakes encompassing 450 surface acres (Table 2). Under the most optimistic conditions, 296 streams totaling almost 1,600 miles and 61 lakes encompassing 1,000 surface acres (current plus potential habitat) might be suitable for native cutthroat restoration. This expansion is implied in the recovery and conservation plans and would have to be accomplished over many years.

Opportunities to expand into potentially restorable habitats appear greatest for the Colorado River cutthroat on the west slope with an almost threefold potential increase in stream miles and an increase in lake surface acres by a factor of 2.5. Opportunities to expand habitat for the greenback cutthroat trout would occur on the east slope, but the full extent of potential restorable habitat is unknown at this time. The potential greenback expansion described in Table 2 represents potential habitats needing restoration to meet recovery goals before delisting. Expanded use of greenback cutthroat trout in suitable habitats on the east slope is likely more limited due to a smaller resource base on the Front Range. Expansion into new habitats is also presently constrained by its federal "threatened" status, which creates added concern from landowners and water resource users over the Endangered Species Act (ESA) restrictions on "take," and Section 7 consultations. Opportunities to expand the habitat for Rio Grande cutthroat are limited by its relatively smaller range within the state and the fact that many recovery efforts have already been completed, leaving fewer options.

Much of the current and potential stream and lake habitat for native cutthroats exists in the headwaters of each river drainage, where protection from negative interactions with introduced salmonids via instream barriers is most feasible. **Even with the assumption that this expanded resource base for the native cutthroat trout would be realized, their combined habitat would represent only 10% of the coldwater stream miles available and 1% of the coldwater lake surface area available.**

Our ability to expand the aquatic resources for native cutthroat beyond these boundaries is limited by an inability to adequately isolate their populations from other salmonid species. The most likely avenue for native cutthroat trout in conservation management will be to establish these species as the primary trout species in headwater drainages. Restoration of native cutthroat to more productive, lower elevation waters will be conducted where appropriate and biologically feasible. The predominant use of native cutthroat trout in fisheries management will likely focus on catch-and-release and limited harvest fisheries in more pristine and hard-to-access high mountain stream and lake systems.

Wild Trout and Gold Medal waters occur in 9 of the 15 major watersheds in Colorado, occupying 254 stream miles and 4,360 lake surface acres (Table 3). Opportunities to expand Gold Medal waters are largely nonexistent since the designation is based on habitat productivity and trout size criteria. Most, if not all, of the suitable habitat is already included in this program. Many existing officially-designated Wild Trout waters are already protected by special regulations.

Many streams in Colorado, besides those listed in Table 3, support wild populations of brown, brook, and rainbow/cutthroat hybrid trout that are not officially designated as Wild Trout waters. Some of these waters are currently managed using catchable or subcatchable trout stocking to supplement the fishery provided by the wild populations. It is possible that some of these waters could be managed as wild trout waters with little or no supplemental trout stocking, and protected with a reduced bag limit/size limit/terminal tackle restrictions. The magnitude of

this option, and its ramifications for recreation are examined in more detail in the **Recreation Section** of this report.

Table 2. Estimated aquatic habitat resources associated with native cutthroat in Colorado.

CUTTHROAT SPECIES	HABITAT	STREAM MILES	LAKE ACRES	NO. OF STREAMS	NO. OF LAKES
Greenback	Current	35	120	18	13
	% w/Angling[1]	51%	91%	--	--
	Potential	60	110	27	12
Rio Grande	Current	210	174	33	21
	% w/Angling	50%	79%	--	--
	Potential	30	0	2	0
Colorado River	Current	350	151	45	7
	% w/Angling	100%	99%	--	--
	Potential	900	400	171	8
Total for native cutthroat waters[2]	**all**	**1,600**	**1,000**	**296**	**61**

[1] Percent of current habitat open for angling.

[2] Includes both current plus potential, rounded to the nearest 100 miles/acre.

Table 3. Designated Wild Trout and Gold Medal waters in Colorado.

WATER	MILES	ACRES
WILD TROUT WATERS		
Poudre	10.9	
Cascade	2.5	
Cochetopa	4.5	
Conejos	4.0	
East River	1.0	
Gunnison River	26.0	
Lake Fork Conejos	3.0	
Laramie River	2.5	
Los Pinos Ck.	2.0	
Middle Fork South Platte	3.0	
North Platte	5.3	
North St. Vrain Creek	8.5	
Osier Creek	2.0	
Roaring Fork River	7.0	
South Platte	12.0	
Tarryall Ck.	2.0	
Emerald Lakes		270
Trappers Lake		290
TOTAL	96.2	560.0
GOLD MEDAL WATERS		
Blue River -	34.0	
Colorado River -	20.0	
Fryingpan River -	14.0	
Gore Creek -	4.5	
Gunnison River -	26.0	
North Platte River -	5.3	
Rio Grande -	22.5	
Roaring Fork -	12.0	
South Platte, Middle and South Forks -	19.5	
N. Delaney Butte Lake -		200
Spinney Mtn. Reservoir -		2,500
Steamboat Lake -		1,100
TOTAL	157.8	3,800

Threats and Protection Options

Populations of native cutthroat trout, Wild Trout fisheries, and Gold Medal fisheries are protected by stocking restrictions, fishing closures, harvest and gear restrictions, and stream barriers to fish passage. These approaches have proven effective in reducing the threat of hybridization in native cutthroat populations, and overharvest from angling. Threats due to depletion of the instream flow regime are reduced through filings for minimum instream flow rights with the Colorado Water Conservation Board (CWCB 1996). Currently, 7,255 stream miles in 1,222 stream segments are protected by decree over the seven water divisions (S. Platte/Republican, Arkansas, Rio Grande, Gunnison/San Miguel, Colorado, Yampa/White, and San Juan/Dolores). An additional 727 stream miles in 104 stream segments are not yet decreed. State water quality standards exist to protect coldwater fishery resources from pollution and degradation. Many of these potential threats are dealt with by DOW using either formal protocols in state law or established management solutions to maintain the integrity of these fishery resources. Further protection for native cutthroats is contained in the Endangered Species Act, Clean Water Act, NEPA, and other federal mandates such as the U.S. Forest Service Sensitive Species Program.

Unlike the threats and protection options just discussed, the threat of WD to native cutthroat and wild trout populations seems less amenable to solutions since it is perceived as a pathogen "on the loose" in Colorado waters that is not readily controlled by conventional or existing approaches. The first step in the protection of native and wild trout from WD is appropriately found among the stocking restrictions in the DOW WD Policy. Even during the development phase of the policy, delineation of native cutthroat habitat and high quality wild trout fisheries to be protected, and immediate implementation of stocking restrictions to protect these waters by DOW biologists occurred. At the end of 1995, no cutthroat trout population had tested positive for the MC pathogen. However, subsequent monitoring of protected waters is required to evaluate the effectiveness of this approach.

Further restrictions in stocking have been proposed as a desirable protective measure for existing trout fisheries and as a containment measure to minimize the spread of WD. The most extreme, short-term protective/containment measure available to DOW is to eliminate all production of WD+ trout from state hatcheries. This would dramatically decrease stocking options and associated recreation days. The impact would be abrupt and certain to create negative reaction among potentially affected interests. This alternative, therefore, is considered inadvisable. The consequences of less severe stocking restrictions and the use of WD+ hatchery production for recreation opportunities are discussed in the **Recreation Section**.

IV. RECREATION

Categorization of State Fishery Resources

Because aquatic resources in Colorado vary in their physical/chemical/biological attributes, they have widely varying potential as fisheries. Historically, fishery managers have taken advantage of the natural productivity of the state's waters to manage for wild trout or unique native trout fisheries. Besides the protection benefits, these high quality resources can produce fishing recreation at lower cost because stocking needs are minimal. However, many waters in the state have limited capacity to support natural reproduction, have poor habitat quality, or otherwise cannot maintain a recreational fishery. Maintaining fisheries under these circumstances requires a greater use of stocked fish and habitat enhancement.

Colorado has approximately 185,700 acres of public water managed as fisheries by the DOW. Fifty-one percent of the state's aquatic resources are in coldwater lakes (95,000 ac), 17% in coldwater streams (30,500 acres), 29% in warmwater lakes (54,000 acres), and 3% in warmwater streams (6200 acres).

In 1992, the Statewide Fisheries Management Categorization System was developed to describe the various options used by the DOW to manage the state's fishery resources. The water-specific fish management scenarios were grouped into three general categories, which were further divided into 33 definitive categories. It is important to note that the Categorization System describes waters by their *management objectives* rather than their *physical or biological capabilities*. Although there is often a link between the two, the inclusion into a specific category is based on a management strategy that is largely at the discretion of the fishery manager. The three general categories (**Intensive**, **Optimum**, and **Special Use**) and the recreation days associated with each are shown in Table 4.

Intensive Use Category

Intensive Use management provides the greatest possible amount of fishing recreation within the limits of the facilities and physical environment to support such use at the least cost. The primary objectives are to provide fish for anglers to catch and keep and to maximize return to the creel. Waters are managed under this concept when existing angling demand is difficult to meet using other management options.

Common to many of the waters in this category is a lack of physical and biological attributes needed for natural perpetuation of coldwater fish. This is particularly true for the standing-water habitats in this category. In addition, there are a number of waters (primarily streams or warmwater lakes) where self-sustaining populations of fish do not provide adequate numbers or sizes to meet the demands of existing angling pressure.

In 1992, 75,185 acres (41% of state waters) were in the managed **Intensive Use** category. At that time, 98% of total statewide production of catchable trout (4,700,000), and 48% of fry, fingerling, and subcatchable trout (5,900,000 fish) were stocked in **Intensive Use** waters.

It is estimated that 62% of the 1992 statewide recreation days occurred in the **Intensive Use** category, varying from a high of 75% of the recreation days in the CE Region to a low of 48% in the SW Region (Table 4). DOW's cost per recreation day was estimated at **$1.53**. In 1992, the **Intensive Use** category statewide generated 45 recreation days per acre, with DOW biologists estimating that approximately 85% of the recreation days in this category depended on the stocking of catchable trout.

Table 4. Total (coldwater and warmwater) 1992 recreation days by category for each region ("old" regional boundaries) from the 1992 Categorization System, DOW.

REGION	INTENSIVE		OPTIMUM		SPECIAL	
	REC. DAYS	PERCENT	REC. DAYS	PERCENT	REC. DAYS	PERCENT
NE	545,000	66	251,700	31	22,400	3
CE	1,017,000	75	238,000	17	110,200	8
SE	712,900	55	434,000	34	141,000	11
NW	425,200	67	132,000	21	72,000	11
SW	442,300	48	427,500	46	58,000	6
TOTAL	3,142,400	62.5	1,483,200	29.5	403,600	8

Optimum Use Category

Optimum Use management is designed to provide fishing recreation within the limits of the habitat to produce fish at the least cost, while allowing anglers to catch and keep fish within the water's natural productivity. Stocking, when necessary, is at a level similar to what would be produced naturally if all habitat requirements were satisfied. Regulations that encourage limiting fish harvest to the natural productive capability of the habitat are imposed. Some of the state's designated wild trout waters are in the **Optimum Use** category.

Waters in this category have physical and biological characteristics that support more viable and robust fish populations than those found in the **Intensive Use** category waters. **Optimum Use** waters include high lakes, headwater streams, wild trout streams, nonurban warmwater lakes, and more productive mountain lakes and reservoirs. Although these waters have adequate to excellent potential in producing fish populations that are attractive to anglers, some do not have

the capability for natural reproduction (most notably high lakes) or cannot produce enough fish to keep up with angler harvest (drive-to small mountain lakes and streams). Therefore, many of these waters receive supplemental stocking of fry or fingerling fish and may be under harvest restrictions.

Most of the state's aquatic resources (53%) are in the 99,362 acres that occur in the **Optimum Use** category. Only 1% of total statewide production (51,000 fish) of catchable trout were stocked in these waters in 1992, while 49% of all coldwater fry, fingerling and subcatchables (6,000,000) were stocked into **Optimum Use** category waters. DOW's cost per recreation day in the **Optimum Use** category was **$1.24** in 1992, and 17 recreation days were generated by each acre of habitat.

It is estimated that the **Optimum Use** waters produce 30% of statewide recreation days (Table 4). The catch in lakes (and associated recreation days) in this category definitely depends upon fry and fingerling stocking, while the contribution to the catch in streams from stocked fish varies significantly by region.

Special Use Category

Special Use management is designed to preserve and enhance selected species or to provide specialized fishing recreation within the biological and physical capability of the environment to support the designated use at the least cost. The primary management objective is to preserve and enhance selected species (including those listed as special concern, threatened, or endangered) or to provide anglers the opportunity to catch but not always harvest either wild fish, large fish, or unique species. Stocking, if necessary, is at a level similar to what would be produced naturally. Special harvest regulations are frequently used to meet management objectives.

The waters in this category include native cutthroat habitats and Gold Medal designated streams and lakes. Most have good potential for natural reproduction and are not stocked, but harvest restrictions are imposed on many of them.

Only 11,012 acres (6% of public waters) in Colorado are managed for **Special Use** objectives. The **Special Use** waters were stocked in 1992 with 1% of statewide production of catchable trout and only 3% of fry, fingerling, and subcatchable trout production. This category of waters accounted for 8% of total fishing recreation days in 1992 (Table 4). Catch rates and recreation days vary among areas, while trout density and biomass are dependent upon natural reproduction. The cost per recreation day in this category was **$0.19** in 1992 with 37 recreation days generated by each acre of habitat.

Whirling Disease Impacts to Fishing Recreation

The Categorization System can be used to estimate the potential impact of our current and future fish stocking decisions on fishing recreation days. However, in doing so, we assume that

there is a *direct and equal* correlation between the number of fish stocked and the number of recreation days generated. This assumption is an oversimplification and may lack validity as it does not account for factors, besides stocking level, which can affect fishing recreation use. Some of these factors include proximity to population centers, campgrounds or other accommodations, roads, scenic attributes, and other fishing opportunities available in the immediate area. It should also be reiterated that the Categorization System is not based on biological or physical attributes of fish habitats. We are aware that all of these factors likely influence the level of fishing, but we have not been able to quantify those relationships.

One should also realize that the Categorization System provides a "snapshot" of how we were managing our fishing resources as of 1992. It illustrates what our management *is*, rather than what it *could or should be*. The system is based on a given level of fish production in 1992 and the recreation days that also occurred at that time. It does not suggest the appropriate level of fish production, or dictate any management decision.

Nonetheless, the Categorization System is one of the few available tools that can be used to define the use of fish stocking and its role in meeting DOW fishing recreation goals. Since 1992, fishery management and the aquatic resource base has changed considerably. New access, regulation changes, changes in species management, and the level of fish production have all been dynamic. The most critical change, particularly in the past couple of years, has been in alterations of stocking management to decrease the spread of WD. It is helpful to examine these stocking changes by the two major components of fish production--catchable-size trout and fry/fingerling trout.

Catchable Trout Stocking

WD in Colorado's fish production facilities and changes in stocking deemed necessary by the CWC to contain the spread of the disease have drastically altered fishery management and have impacted the distribution of recreation days throughout the state. Given its dependency on catchable trout, the fishing associated with waters in the **Intensive Use** category is most affected.

The CWC WD policy (May 1996), along with the availability of both WD- and WD+ fish at state and federal hatcheries, has altered historical stocking programs. As seen in Table 5, this shift has led to an increase in stocking and estimated recreation days (+1,036,000) on the east slope, and a decrease in fish stocking and resulting loss of 394,000 recreation days on the west slope.

The CWC decision to reduce production of WD+ catchable trout by approximately 1.3 million in 1997 will also have major ramifications for stocking and recreation days in the **Intensive Use** category waters (Table 6). If 1.1 million catchables are cut from east slope waters and 0.2 million are cut from west slope waters, the west slope will likely experience a further decrease in recreation days from 1996 levels. Recreation days for the west slope in 1997 could decline by about 500,000 days, which represents about a 57% reduction, as compared with the

1992 base year. The east slope may lose substantial recreation days (-953,000) from 1996 to 1997; this loss would reduce estimated recreation days to the levels seen in 1992.

Table 5. Estimated changes in Intensive Use recreation days from 1992 to 1996 with the current 1996 stocking schedule.

REGION[1]	1992 CATCHABLES	1996 EST. CATCHABLES	1992 RECREATION DAYS[2]	1996 EST. RECREATION DAYS	PERCENT CHANGE
NE	798,159	1,037,690	545,000	692,139	+27
CE	794,446	1,302,657	1,017,000	1,632,880	+61
SE	1,045,037	1,479,047	712,900	986,524	+38
NW	1,434,198	503,759	425,200	144,831	-66
SW	642,754	492,960	442,300	328,805	-26

[1]Uses "old" regional boundaries.
[2]Assumes 85% of recreation days derived from catchable plants.

Table 6. Estimated changes in Intensive Use recreation days from 1992 to 1997 with reduction of 1.3 million WD positive catchables.

REGION[1]	1992 CATCHABLES	1997 EST. CATCHABLES	1992 RECREATION DAYS[2]	1997 EST. RECREATION DAYS	PERCENT CHANGE
NE	798,159	729,690	545,000	486,703	-11
CE	794,446	928,657	1,017,000	1,164,071	+14
SE	1,045,037	1,016,047	712,900	707,718	-1
NW	1,434,198	427,759	425,200	122,981	-71
SW	642,754	368,900	442,300	246,056	-44

[1]Uses "old" regional boundaries.
[2]Assumes 85% of recreation days derived from catchable plants.

To provide these analyses, we have assumed that there is a direct correlation between the number of fish stocked and recreation days. In most cases, the **loss** in one region would not be mitigated by a possible **gain** in another (McAfee 1993). In other words, anglers (and corresponding recreation days) would not "follow" any shifts in stocking. Anglers in isolated areas on the west slope where catchable trout were no longer stocked could have fewer options to find similar fishing experiences within an hour's drive and may elect to not fish. As a result, the recreation days that have been historically produced by an equitable allocation of fish would be disrupted and unequally distributed across the state. This could have extensive impacts on communities and counties, and at those waters where infrastructure (resorts, campgrounds, roads, concessions) exists. Again, it must be remembered that these projections are estimates, not givens. License sales and angler attitudes (as determined in scientific surveys) are the best barometers of angler satisfaction.

Fry and Fingerling Trout Stocking

As noted previously, 62% of statewide fishing recreation days are produced by management in **Intensive Use** waters (largely with catchable trout) and 30% of Colorado's fishing recreation days come from waters managed under the **Optimum Use** category (Table 4). Many streams in the **Optimum Use** category are supported by wild trout and do not require stocking. Although the lake habitats within the **Optimum Use** category have outstanding physical characteristics, most do not have the necessary biological capabilities to maintain natural reproduction (with the exception of some brook trout fisheries). DOW biologists recognize that most of the lakes in this category (drive-to and high lakes) would not contain fish without stocking fry or fingerling trout. Fry are less than 2 inches long, and fingerling are 2-4 inches long.

Because most of these **Optimum Use** category resources are in protected habitat, the west slope is particularly dependent upon the use of WD- fish for stocking needs. Currently 92% of trout fry and 62% of fingerlings scheduled for the west slope are WD-.

On the east slope, only about 53% of **Optimum Use** category recreation days come from coldwater resources. About 58% of scheduled fry are WD-, while only 25% of scheduled fingerlings are WD-.

Because of the large proportion of coldwater resources on the west slope and the need for WD- fry and fingerlings to support recreation, the impacts of WD on stocking could be much more pronounced west of the Continental Divide--perhaps as many as 500,000 recreation days are at stake. Although the east slope is much less dependent upon WD- fry and fingerlings, there are still several popular "types" of waters (small drive-to lakes, high lakes) which are protected habitats that cannot be stocked if negative fish are not available. Over the past couple of years the hatchery system has accommodated the need for WD- fry and fingerlings statewide, but that situation is rapidly changing as the number of hatcheries exposed to WD that produce fry and fingerlings increases. The state is perilously close to losing negative WD status on much of the fry/fingerling trout needed for stocking in protected habitats. This will likely impact our abilities

to manage **Optimum Use** waters, particularly on the west slope, where serious losses to recreation may occur. In the short-term, the DOW needs to prepare its constituents for the anticipated loss of angling recreation opportunity as part of our consent building programs **(Public Education, Page 35)**.

Options to Increase Recreation Days

Balance stocking of WD+ and WD- trout

An option to ameliorate the estimated loss of recreation days in the state from WD stocking restrictions would be to stock a greater share of WD- trout to those areas (primarily on the west slope) that have the greatest amount of protected habitat. Approximately 900,000 WD- catchable trout available in 1997 would then be used in the short term to provide immediate relief by sustaining fishing recreation in protected habitat. All of the 1997 WD- production could be stocked on the west slope. This would increase recreation days on the west slope by about 178,000 recreation days, which is 37% below 1992 levels, instead of the 57% decrease as noted previously (Table 7). However, this stocking option may merely "shift" the problem elsewhere by creating some serious recreation losses in specific areas of the east slope. Although it is not feasible to recommend such a stocking allocation in this report without further DOW biologist input, it is *critical* that the DOW allocate 1997 production in a way that reflects a sensitivity to both our goal for resource protection and the current public expectations for statewide fishing recreation.

Table 7. Estimated changes in Intensive Use recreation days from 1992 to 1997 with 1.3 million WD positive catchable reduction and all WD negative catchables to west slope.

REGION[1]	1992 CATCHABLES	1997 EST. CATCHABLES	1992 RECREATION DAYS[2]	1997 EST. RECREATION DAYS	PERCENT CHANGE
NE	798,159	644,890	545,000	430,142	-21
CE	794,446	810,921	1,017,000	1,016,489	-1
SE	1,045,037	889,718	712,900	593,442	-17
NW	1,434,198	614,691	425,200	176,724	-58
SW	642,754	555,833	442,300	370,740	-16

[1]Uses "old" regional boundaries.
[2]Assumes 85% of recreation days derived from catchable plants.

It should be recognized that the WD- catchable trout available constitutes only 26% of the projected 1997 total production of catchable trout, and this supply will fall significantly short of projected needs. As a result, many areas of the state will not receive the number (if any) of fish they have received in the past. DOW's capacity to provide fishing recreation is also vulnerable to further, critical losses if additional hatcheries that produce fry and fingerling fish become positive (as Bellvue did in June 1996). In the short term, fine-tuning of stocking schedules will only bring minor relief for losses to fishing recreation. Our best hope for *long term* solutions to our dilemma rests in emphasizing research and enhancing supply side options for WD- fish.

Increase Warmwater Fishing

Some resident anglers have come from other states where warmwater fishing is prevalent and may want a similar experience in Colorado. Many of the state's warmwater fishing opportunities did not exist 20 years ago. Warmwater management intensified in the state when a number of biologists were hired specifically for that task in the late 1970s. Our warmwater hatcheries, with some out-of-state trades, are very efficient and meet the needs of the warmwater stocking schedule. Because of this aggressive management program, the DOW's productivity from existing waters in the warmwater management arena is good.

The options for shifting fishing recreation to warmwater species are to increase access, improve current facilities, improve habitat, and change species management. When total warmwater recreation days are considered, most of the potential for improvement in warmwater fishing occurs on the east slope. However, if progress can be made on some key issues, significant increases of recreation days to specific warmwater fisheries are possible on the west slope. The constraints of warmwater fish stocking in the Colorado River drainage due to the potential for nonnative sportfish impacts on the recovery of endangered native species, and the lack of adequate warmwater habitat, currently limits the potential for additional warmwater recreation days on the west slope.

1. Increase access -- Opportunities for acquisition exist by entering into agreements with municipalities or counties, typically at low or no cost to the DOW. The DOW has entered into lease agreements with private irrigation companies for fishing easements. Those leases have usually been affordable options, as the companies seek formal recreation management, enforcement, and liability protection. There are still some resources that can be leased (e.g., Douglas Reservoir in the NE Region); however, the DOW is facing stiff competition from other recreational groups (windsurfers and water skiers). The DOW should expect to pay $20-$50/acre per year for new recreation leases from private entities.

2. Improve existing facilities -- Many of our warmwater fishery resources are part of our State Wildlife Areas. Angler dollars have been used to establish attractive fisheries rather than recreational facilities and amenities; however, some anglers are deterred from using state wildlife areas (SWA) due to this lack of amenities. This is particularly true in the SE region, where some resources are underutilized. Capital expenditures for paved parking,

better restroom facilities, picnic tables/shelters, water pumps, and other amenities could be expected to increase recreation days (currently about 11% of statewide total recreation days) by 15-30%.

3. Improve habitat -- The greatest limiting factor for our larger and most productive warmwater habitats is water quantity. Inconsistent and generally low water conditions characterized by high fluctuation and high turnover have been identified by our warmwater biologists as the most detrimental attributes in the establishment of multispecies warmwater fisheries. The costs and politics of acquiring water rights or use agreements are difficult obstacles, as evidenced by the great plains reservoirs on the lower Arkansas River drainage. Without significant reallocation of financial resources, the DOW will not be competitive in the water acquisition arena.

4. Change species management -- A reasonable option for some lakes may be a change in management from catchable trout to warmwater species. This option has worked well in a number of warmwater/coolwater habitats across the state. Most notable are Pueblo Reservoir, Horsetooth Reservoir, Cherry Creek, and Rifle Gap, where dependency on catchable trout has been reduced by the establishment of excellent warmwater fish populations. However, these types of habitats may again become more important for stocking catchable trout and maintaining recreation days if catchable stocking in mountainous areas is reduced or eliminated.

5. Increase participation via information and education programs -- It is thought that the DOW could influence angler use of warmwater habitats by providing information on the productivity of these waters, and educating anglers about the "what's, when's and how's" of these fishing experiences

Promote Seasonal Use of Catchable Trout in Warmwater Habitats

Most of Colorado's "warmwater" fishing recreation waters are manmade reservoirs developed over the last century to supply water for a wide array of beneficial uses across the state. Warmwater fishing recreation, managed as a secondary use in most reservoirs, is produced during the late spring and summer months in these waters as warmwater species of fish become active and vulnerable to angling. During cooler months of the year (September - March), "warmwater" impoundments produce only limited fishing recreation. In the fall of the year, reservoirs are at minimum water levels and water temperatures begin to cool, creating "coldwater" environments capable of supporting coldwater species of fish.

DOW fishery managers, stocking catchable trout in the early fall in selected impoundments across the state, have successfully created **new** fishing opportunities for fall/spring trout and icefishing. These opportunities have been particularly popular and well received in low-elevation plains areas, where anglers can enjoy trout fishing without the expense and time required to travel to mountainous locations.

A large amount of reservoir habitat (perhaps as much as 32,000 acres statewide) could potentially support coldwater species on a seasonal basis. As our supply of WD- fish declines and stocking restrictions to protect fishery resources are applied, part of the "lost" recreation days could be replaced by using seasonal catchable trout stocking in these nontraditional waters. Furthermore, the DOW may be able to achieve Long Range Plan fishing recreation goals (increase recreation days and satisfaction), **as well as** decrease the risk to protected habitat, by stocking WD+ catchable trout into waters that are far removed from the state's significant trout resources. In this manner, WD+ catchable production could be considered as a potential successful alternative in redistributing fishing pressure and thereby protect resources, but this would need to be a policy decision.

Increased Emphasis on Wild Trout Management

In this section, wild trout refers to those resources where self-sustaining salmonid populations are the primary fishery and where no stocking occurs. These include most headwater streams and many of Colorado's larger trout streams. The vast majority of these stream miles are not officially designated as Wild Trout waters.

According to the 1992 Categorization System, there were approximately 377,000 coldwater recreation days (about 8% of the statewide total) in **Optimum Use** management. This compares with about 2 million coldwater recreation days in the **Intensive Use** category, or about 40% of statewide recreation days. With the goal of reducing the risk of WD exposure to protected habitats, one option would be to shift management emphasis from catchable (**Intensive Use**) or even fry or fingerling (**Optimum Use**) stocking to wild trout management, where very little stocking would occur.

However, based on discussions with DOW fishery biologists, there may be very limited opportunity to increase wild trout management in coldwater lakes, since most fish caught from these habitats are stocked. In some cases, brown trout, kokanee salmon, brook trout, or cutthroat can reproduce, but the potential is largely dependent upon suitable upstream habitat that is usually insufficient to maintain a self-sufficient fishery, even if special regulations were applied.

Switching to wild trout management in coldwater stream environments may be effective in reducing the risk of WD in protected habitats. The amount of coldwater stream habitat that provides average to excellent fishing in Colorado was estimated to be slightly more than 9,300 miles (Table 8). The west slope provides 69% of this stream fishery resource, which represents 56% of the available public coldwater stream miles in the state. Compared with the east slope, the west slope has four times the stream habitat rated excellent and twice the amount rated average to above average. Streams included in this average to excellent fishery category were presumed to have habitat of suitable quality to support a trout population and fishery using special regulations and no stocking (Nehring 1990). Given the almost 2,000 stream miles currently or potentially useful to native cutthroat and wild trout, an additional 7,300 stream miles would thus appear to be suitable for management as wild trout fisheries.

Table 8. Amount of stream habitat in Colorado providing average to excellent fisheries.

Region	Stream miles	Open to fishing	Rating[1]	River basins
Southwest	862	72%	EX	Dolores Gunnison Rio Grande San Juan
	772	61%	AA	
	1503	65%	AV	
Northwest	339	85%	EX	Colorado Yampa White Gunnison
	1320	71%	AA	
	1614	69%	AV	
West Slope (NW+SW)	1201	76%	EX	All of above
	2092	67%	AA	
	3117	67%	AV	
Northeast (+Central)	226	69%	EX	N. Platte S. Platte Republican
	571	50%	AA	
	1380	58%	AV	
Southeast	67	85%	EX	S. Platte Arkansas
	236	64%	AA	
	424	63%	AV	
Statewide	Excellent	Above average	Average	Total
Stream miles	1,494	2,899	4,921	9,314
West %	13	22	34	69
East %	3	9	19	31
% Coldwater + Public[2]	9	17	30	56

[1] EX=excellent; AA=above average; AV=average

[2] Public coldwater stream miles = 16,702

There are currently about 12,500 acres of coldwater stream habitat (actual miles not available, but estimated to be about 3,000) that are stocked with trout. The balance of the stream miles would be unstocked, less accessible waters. Stocked streams produced about 697,000 recreation days in 1992, or about 14% of total statewide fishing recreation days. It is assumed that current (1996) recreation days would be much less than this as catchable trout stocking in streams is now about 70% less than in 1992. Because fish stocking in streams, particularly with catchable trout, maintains a fish density above the level of natural productivity of that habitat, the resulting fishing pressure is also "artificially" high as compared with anticipated pressure under wild trout management. As a result, a change to wild trout management in these waters would probably result in a *decrease* of recreation days. A reasonable estimate of this loss based on the Categorization System would be about 100,000 recreation days.

In some of Colorado's higher quality trout streams, wild trout management with the addition of special regulations has produced exceptionally good trout populations. These fisheries are recognized for their quality and fishing pressure that meets or exceeds the fishing pressure found on heavily stocked streams. Some of the 3,000 miles of currently-stocked streams might be appropriate candidates for special regulations and could support fishing pressure similar to that experienced with stocking; however, the actual number of these waters was not determined for this report.

Although intensive fishery population monitoring would be needed to justify the addition of new quality fishing in streams using special regulations, *the general assessment of DOW biologists (based on adequate knowledge of their streams' potential) is that we have already established quality regulations on the vast majority of potential stream segments in the state.* Unless the DOW acquires access to substantial amounts of new private water, there is not likely much new potential for high quality wild trout habitat present in the state. Therefore, given existing resources, a switch to wild trout management in streams will generally mean a net loss of recreation. Further loss to recreation could occur if special regulations were broadly applied to streams to protect the wild trout (regardless of their quality) from harvest.

It should be recognized that regardless of the actual changes to fishing recreation days that might occur with a change to wild trout management in streams, currently these streams only support an estimated 14% of the statewide recreation days. Therefore, *any* changes to the management of coldwater streams will not have a large impact on *statewide* fishing recreation; however, there will likely be some recognized and contentious disruption of fishing in isolated areas of the state that are particularly dependent upon stream fishing for stocked trout (Poudre, Rio Grande, etc.).

Another impact of changing to wild trout management in streams would be the potential reduction or redirection of hatchery fish that are currently produced to support the existing stream stocking program. In 1992, streams received most of the statewide trout production--fry (1%), fingerling (22%), subcatchable (15%) and catchable (19%). However, because of stocking changes mandated by WD stocking guidelines in the past couple of years, these percentages

changed in 1996 to fry (34%), fingerling (13%), subcatchable (2%), catchable (5%). *From these data it is evident that, at this time, changing to total wild trout management in streams would not provide substantial opportunities to forego or redistribute hatchery-reared fish.* The greatest "savings" would be realized from the 2.3 million trout fry (34% of statewide fry production). However, because of their small size, production of trout fry has limited requirements for hatchery space and costs (food, feeding, and transportation).

It should be noted that this situation could change if the DOW increased its capability to produce more WD- trout, some of which might be scheduled for additional stream stocking. This situation might again encourage stocking plans that would more closely reflect 1992 stocking numbers, where a much greater proportion of the state's fish production was used in streams. Use of stocked trout to meet fishing pressure in certain high-use stream segments in populated corridors would make wild trout management a more viable option in surrounding stream habitat areas. Conversion of all suitable coldwater stream habitat to wild trout management may be a desirable and appropriate objective in and of itself, and would contribute toward less dependency on fish stocking and the risk of exposure to WD. If maintaining fishing recreation at or near the 1992 level (6+ million recreation days) is also a management objective (as suggested in the LRP), then an alternate strategy that exploits the recreation potential of WD+ fish in low-risk waters until they can be replaced by WD- fish during a transition period would be warranted. If not, then fish recreation goals in the LRP should be reevaluated with respect to increased participation in fishing, increased angler satisfaction, and stocking to maintain angler satisfaction.

Management of the native cutthroat species encompasses both conservation and recreation elements. Given the declining status of these species, the conservation objectives must take precedence over recreation opportunities or demand. Restoration and long-term management of the native cutthroats have the best prospects for success if they are managed as the exclusive salmonid species in the headwaters of their respective drainages. This is consistent with existing restoration management plans for each species, which emphasizes the need to isolate their habitat from other salmonids to minimize hybridization and other negative interactions. The implementation of this management alternative for Colorado River and greenback cutthroat will require at least a 10-year time frame.

Recreational benefits provided by self-sustaining native cutthroat populations are similar to other wild trout. Catch-and-release and limited-harvest regulations will be required to protect them from overfishing, to which they are very susceptible. As unique native gamefish, the attractiveness and desirability of these limited cutthroat fisheries to the public may enhance their recreation potential. However, management for native species (within the **Special Use** category) provided only 9,800 recreation days in 1992, or about 0.2% of the statewide recreation days. Even a doubling of waters managed for native species would do little to increase recreation days due to greater difficulty of reaching the remote waters targeted for restoration actions. Expansion of native species management that may take place over the next decade is unlikely to decrease the need for fish production or to increase recreation days, given that those potential waters now receive little management or fishery pressure.

Some potential exists to switch management strategies away from **Intensive Use** (put/take catchable trout) to **Optimum Use** (put-grow-take). In all waters, such a management strategy would probably have to incorporate reduced bag and size limits with terminal tackle restrictions. If this alternative is chosen, implementing it over time with a significant public education effort to gain understanding and acceptance of this alternative would be best. The switch of management strategies away from put/take to put-grow-take in standing waters may not require changes in regulations, particularly on the west slope, where angling pressure is much lower.

Enhance and Protect Coldwater Habitat

Protection and improvement of Colorado's aquatic resources have been a high priority for some time. Water quality research and investigations in support of appropriate stream standards, DOW involvement with nonpoint discharge projects, public education and water testing through the Riverwatch Program, water quality control at our production units, instream appropriations through the CWCB, forest and land use plan review, EIS preparation, and review and habitat manipulations on state and federal lands, all contribute to ensuring high water quality. Nonetheless, with increasing pressures placed on our aquatic environments, there is a need to increase and broaden our efforts.

Part of the debate in Colorado over the use of angler dollars involves what we are **not** doing with the funds spent on fish production. The concern typically addresses the question as to the appropriate allocation of funds between various DOW activities. Frequently, funding levels for fish production and habitat protection/enhancement are compared.

Many aquatic habitat issues are not under the jurisdiction of the DOW, but with other federal (USFS, BLM, EPA, Corps of Engineers) or state (Colo. Water Conservancy Board, Department of Health) agencies. Nonetheless, the DOW is an active participant to the extent that we are authorized to do so. DOW's lack of staffing for field investigations, data analysis, negotiations, and review is likely limiting our (and other agencies') abilities to solve aquatic habitat problems.

Becoming more aggressive in aquatic habitat protection and enhancement would require the reprioritization of permanent FTE, some of which is currently occurring, as well as capital expenditures for actual enhancement projects. Given the limited time and scope of this report, any quantification of benefits (increased biomass of wild trout, recreation days) was impossible.

Acquire New Coldwater Access

A preliminary assessment of this option involved asking DOW senior fishery biologists for their appraisal of potential new areas for acquisition. Although predicting options for new acquisition or leases always involves guesswork, the prospects for significant new access are not considered promising. Much of the high-quality stream access has already been acquired by the DOW, with most recent purchases/leases coming in at considerable cost. An example was the

acquisition of the Kemp/Breeze SWA, which included approximately 2.1 miles of Gold Medal trout water on the Colorado River, at an approximate cost of $2 million in 1993.

V. DEMAND

Background

The term "demand" is used, and commonly misused, by the public and fishery professionals alike. It has meant "projected use" of the resource, the quantity of fish needed to maintain some level of **angling success** (e.g., catch-per-hour), and likewise the quantity of fish necessary to maintain or improve **angler satisfaction**. In this document, demand will have an economic slant that embodies two characteristics: 1) the desire for a commodity and 2) the ability or willingness to pay for it.

In the past, "projected use" was derived by plotting historic trends in human population growth and license sales on the same graph, and then extrapolating into the future using population predictions. This "projected use" was then linked to fish production through the Angler Survey, which showed that the average angler caught "x" fish per day. Production goals were then obtained by multiplying "projected use" by "x" fish/day. This method proved unreliable--our own research showed that fishing participation, rather than increasing as a function of population growth, could actually decline. We also learned that there are several variables, besides the number of fish stocked, that affect catch rate.

Later, the DOW's Categorization System was promoted as a way to better understand the variables contributing to angler "demand," and, therefore, was seen as a useful tool in setting fish stocking levels. "According to information obtained from the DOW and other sources, two main tasks must be completed to ensure stocking levels and hatchery productions are appropriate . . . categorizing the waters managed . . . [with] the Division's Fisheries Management Categorization Model and performing underlying data collection to identify and gauge supply and demand." (Colorado State Auditor 1995). While the Categorization System does a good job in characterizing the state's waters (by size, elevation and use levels), it has limitations. The primary limitation is that it reflects the supply of hatchery fish rather than the demand for those fish.

Demand for hatchery production also includes **nonrecreational uses**. Uses of fish maintained in our hatchery system include domestic brood stocks, special strains for research programs, information and education programs, trading/bartering with other states and producers, and threatened, endangered, or special concern species recovery programs. Though the quantity of fish requested of our hatchery system for these nonrecreational purposes might seem relatively insignificant, providing fish for these purposes often ties up substantial space and human resources. Rearing these small lots of fish often takes as much hatchery space as raising a large cohort.

The other source of demand, of course, is **angling recreation**. DOW's sportfishing programs have benefitted from maximizing hatchery production over the years. For example, during 1992-94, our hatchery system produced an average of 4.87 million catchable trout and 10.3 million subcatchable trout per year. An annual average of 13.8% of catchable production and 50% of subcatchable production was free of WD during this time.

Demand for Native Cutthroat and Wild Trout Fisheries

Six surveys were conducted from 1982 through 1995 to determine public and angler opinions, preferences, and use patterns concerning fishing recreation in Colorado. It is difficult to make direct comparisons between these surveys since questions were not standardized, but it is instructive to examine the results for those questions of a similar nature to assess possible trends (Table 9). Fishing in coldwater lakes and streams, with a preference for trout, characterized more than 80% of the angler days over five surveys in a 13-year period. Much of the fluctuation observed in angler use of coldwater fisheries was due to coldwater lake fishing. A preference for catch-and-release fishing appears to have increased dramatically since 1982. In 1990, 87% surveyed wanted the DOW to continue this management strategy; while in 1994, 68% indicated they wanted to see more catch-and-release opportunities. The preference for wild trout fishing increased from 18% in 1982 to 70% in 1994, while the preference for catchable trout fishing appeared to remain constant between 1982 and 1994. It also appears that recreation days spent fishing for catchable trout has increased, or at least that the number of participants in this type of fishing has increased from 1982 to 1994, while participation in wild trout fishing has not changed as much. There was a strong increase in support for reduction in the bag limit to four fish in the 1980s, which was still apparent in 1995. Reduction in the bag limit below four fish was opposed in 1982. Anglers using primarily bait appear to have decreased steadily from 47% in 1986 to 15% in 1994. Participation in warmwater fishing appears to have increased twofold from 1982 to 1994, but a preference for warmwater fishing has dropped from 24% to 9% over the same period.

Table 9. Summary of public opinion and use surveys concerning wild trout in Colorado, 1982-1994.

Survey question topic	1982[a]	1986[b]	1989[c]	1990[d]	1994[e]
% angler days in coldwater streams	36%	33%		36%	33%
% angler days in coldwater lakes	45%	58%		52%	50%
% anglers desiring trout	87%	81%		87%	82%
Catch-and release fishing; cont=continue	32%			87%-cont.	68%-more
Catchable trout fishing desired	11%				12%
Wild Trout fishing desired	18%				70%
Put-and-take fishing % of days/people fished	27%-days	36%-people			78%-people
Wild Trout fishing % of days fished	42%-days				41%-people
Reduce bag limit to 4 trout - level of support	10%	59%			61% (1995)
Reduce bag limit to 2 trout - level of support	19% opposed				
Catch and release only	31% opposed		20%		
Anglers using primarily bait		47%	30%	14%	15%
Increase Wild Trout waters					81%
Increase use of stocked trout					59%
Warmwater fishing % of days/people	6%-days			10%-people	13%-people
Warmwater fishing preference	23.7%				9%

[a]Bergersen et al. 1982.
[b]Galloway et al. 1986.
[c]Standage Accureach 1989.
[d]Standage Accureach 1990.
[e]Standage Market Research 1994.

These results suggest that most anglers in Colorado fish for trout in coldwater lakes. Coldwater stream fishing has remained relatively stable, and warmwater fishing participation has doubled in the last decade. The drop in warmwater preference may indicate that opportunities for warmwater fishing are meeting the demand. There is an increasing preference, or "demand," for catch-and-release and wild trout fishing opportunities, and anglers appear to be switching from natural baits to artificial tackle as the primary approach to take advantage of this desired fishing opportunity. It is apparent from the previous assessment of resources available, however, that the proportion of public coldwater habitat available to support catch-and-release fishing for wild trout (or native cutthroat trout) is much more limited than the apparent public demand. This also suggests that the angling public would accept a conversion of coldwater streams to wild trout management, and perhaps a greater use of catch-and-release or limited-harvest regulations in coldwater lakes to sustain the recreational potential of fisheries managed and stocked as **Optimal Use** waters. Another important factor in assessing public preference is that 59% of the respondents in 1994 also indicated a preference for an increased use of stocked trout. Noting the apparent contradiction in preference versus use in the 1994 survey results is also important. While 12% desired put-and-take, catchable trout fishing, 78% of the survey participants fished in put-and-take waters; and while 70% desired wild trout fishing, only 41% of the participants fished wild trout waters.

Demand and Supply Aspects of Hatchery Production

While coldwater fishing recreation days have increased fourfold since the 1940's (Walsh et al. 1988), such fishing pressure is not spread uniformly across all habitat types. Some waters have experienced even greater increases in fishing pressure and could not maintain any reasonable level of angler satisfaction without supplemental stocking. However, we have become so reliant on supplements from our hatcheries that stocked fish now support an estimated 80% of Colorado's coldwater recreation days (Deloitte & Touche 1995).

Not only have our recreation programs grown more reliant on hatchery production, but indirectly, so have some local communities and businesses. Deloitte & Touche (1995) estimated the economic impact from fishing in Colorado to be about $900 million annually. Wildlife-related recreation has significant economic impact in Colorado. Within this assessment, we are ill-equipped to do more than acknowledge that such economic benefits and relationships exist. However, as the decision-making process proceeds, the political ramifications affecting local economies or businesses should be considered in concert with the technical information from this report.

Closely related to the direct and indirect economic impacts are social and moral issues. We should learn how the social good would be affected by our decisions to stock WD+ fish (Rolston 1988); there are people who believe that stocking unhealthy fish is wrong, or not to verify key assumptions about the productivity or limits of the waters we manage.

Ideally, we would prefer to have definitive information for preparing hatchery production schedules--creel census data estimating angler use and demand (by water "category") and measures of angler "satisfaction," all with reasonable statistical confidence limits. Satisfaction is some measure of the difference between what an angler expected from a fishing experience and what was actually experienced. Even the Colorado State Auditor's report (1995) concluded that stocking levels should be set using comprehensive empirical data. In reality, DOW data is lacking in some areas, so we have been forced to use some estimates and assumptions in making hatchery production decisions.

Deloitte & Touche (1995), Johnson et al. (1995), and others make explicit disclaimers that the information and assumptions forming the basis of their analyses came from DOW personnel. The credibility of any assessment we might undertake depends on solid information from the referenced sources. It is therefore unfortunate to encounter discrepancies involving the DOW over very basic issues. For example, while Deloitte & Touche (1995) state that, ". . . production shortfalls will decrease angler opportunity." Others, including Johnson et al. (1995), from an economic perspective, conclude that the DOW is stocking too many fish in some locales. The comments made by Deloitte & Touche (1995) are probably based on input they received from DOW employees (according to their disclaimer). It would be instructive to examine the assumptions and information provided by the DOW and to learn the basis for them.

While some would contend that recreational angling can always be improved, and that the ultimate strategy is to maximize DOW's hatchery production and stock them into the state's waters (Standage Market Research 1994), others are not convinced. This approach overlooks the fact that we do not have enough information to estimate demand accurately and, therefore, production. Historically, hatchery production has responded to requests from biologists for fry, fingerling, and subcatchable fish that were based on a given water's productivity and meeting perceived angler demand. Catchable trout production, on the other hand, has been driven by a desire to maximize the productivity and efficiency of the remaining hatchery system potential. What we would prefer is an objective decision-making process founded on empirical data and robust estimates of other key variables. Until the DOW has confidence in data describing anglers' demand and willingness to pay (by water category), and some insight into what comprises angler satisfaction and preference, we will not be able to manage our hatcheries proactively. An updated study similar to Bergersen et al. (1982) should be designed to address these parameters, and to help us understand the factors contributing to angler satisfaction, which is vital for efficient fisheries management. After that point, we would be able to more accurately predict the effects of varying stocking rates. We could also design a program that balances the demands of our diverse constituents with other DOW management objectives, and to adjust hatchery production accordingly. We need more information to guide good decisions.

It is important to reemphasize that there are several key variables involved in DOW's fishery management programs and our hatchery production system. They are 1) **demand**, which is characterized by what people want, and how much money they are willing to pay for that experience/opportunity; 2) angler **satisfaction** and its attendant elements (how important is each

contributing element to the overall experience, and what can/should DOW do about it?); 3) the **objectives** for our program(s); and 4) fishery **management variables** (i.e., angler use, catch rate, stocking rates, and regulations). While we know quite a bit about angler use and catch rate (with confidence intervals of +/- 10-30%), as well as other fishery management variables and objectives for the program(s), it is the relationship among these variables that must be understood better and applied to our management programs.

Potential Economic Approaches

The DOW's Aquatic Resources program has traditionally undertaken some of our most diverse and costly activities--program administration, sportfish management, endangered species recovery, habitat enhancement, and hatchery production and distribution--all of which expend a significant portion of the agency's budget (43-50% for the period 1993-95). While the DOW is currently fiscally self-sufficient, some of our programs are not, including the Aquatic Resources program.

There are probably many ways to encourage the fiscal self-reliance mandated in our strategic documents--to have programs "pay their own way." This report raises several options that may be useful in that regard, including gaining more insight into what constitutes demand for, and satisfaction with, our fishing programs and using those data to guide our hatchery production; indexing subsequent years' hatchery production on angler use (catch, license/stamp sales) from a given year; or adopting strategies from private enterprise, such as catchout ponds. Many Aquatic Resources program activities require significant lead time to anticipate, plan, and budget. Indexing expenditures to some quantifiable variable would be better than arbitrarily to cap or fix program allocations as a percentage of the DOW's budget.

Currently, we cannot truly assess the public demand for hatchery-raised, catchable trout from an economic perspective. Experience in urban fishing waters has demonstrated that the public will "consume" all available supplies of catchable trout under the current pricing (license fee) structure and market distribution schedule (year-round; 8 fish/angler/trip). A similar scenario is evident from angler preferences for trout to be stocked seasonally in Front Range and eastern plains' waters (without decreasing stocking into mountain waters). Demand for catchable trout will always exceed supply under these conditions. To assess demand from an economic perspective, we would have to use catchable trout in more controlled situations, such as is done in Missouri (with the state park catchout ponds), to determine the willingness of the public to pay for this relatively expensive hatchery product. The state of Arizona also uses the catchout pond concept in urban areas where the trout product is provided totally by private sector trout farms, which produce the fish in surrounding states. The user buys a license or permit to fish in the catchout ponds. When the quota has been caught by an individual angler, that individual must either quit fishing or purchase another "license" to fish. These programs are *highly* successful in both Missouri and Arizona and may have applications in Colorado.

Another option for assessing the public demand for this type of fishing is also possible by examining commercial aquaculture sales of catchable trout in the private sector and the gross sales from private fishing ponds throughout the state. An alternative to the highly structured, pay-as-you-go, closed public-fishery program in Arizona and Missouri would require anglers fishing at waters managed with catchable trout to purchase either a trout stamp to be displayed on their Conservation Certificate, or "catchable trout tags" to fasten to any trout caught at these waters. The DOW could then index catchable trout production to the amount of "product" the angling public was willing to pay for in previous years' sales of stamps or tags. These latter options would better accommodate the present habitat conditions in Colorado, in which 41% of our waters are managed in the **Intensive Use** category. In summary, the DOW needs to assess demand for catchable trout, develop a new management strategy or tool that is responsive as an economic index of this demand, which provides a basis for the production and distribution of catchable trout, and a context in which environmental limitations can be considered.

Because we do not have pertinent information on demand to form the basis for recommending how hatchery production should be amended, the following discussion of alternatives will focus on initiating an appropriate information base. Results obtained from implementation of these alternatives will assist the DOW in making decisions regarding hatchery production, based on demand and angler satisfaction. However, they should be used with the other reliable key parameters (angler success and catch rates) to adjust hatchery production goals in the future.

1. Standardize key terminology and processes (e.g., cost of producing various sizes and species of fish; data about the existing aquatic habitat base; angler use, etc.) to minimize confusion about key data and how they were derived and used. The official data should then be published, and others should be encouraged to use it rather than re-creating slightly different perspectives with each attempt to use the information.

2. Initiate a study similar to Bergersen et al. (1982) to gain a more thorough understanding of "angler satisfaction" (and its components) and more relevant estimates of angler success (CPH) and demand by water category.

3. Initiate an economics-based study (Johnson et al. 1995) that examines the cost, benefits, and anglers' willingness-to-pay for hatchery-reared fish in Colorado. This should be done on a broad enough scale that the results can be applied to the entire hatchery system (based on what they call a discrepancy between the economic cost of producing catchables and their economic benefits, Johnson et al. [1995] suggest that Colorado's catchable trout program might be inefficient).

4. Assess demand for catchable trout through catchout pond programs, commercial sales of catchable trout to the private sector, and gross sales from private fishing ponds statewide.

5. Assess demand for catchable trout by implementing user fee mechanisms like trout stamps or catchable trout tags, and index catchable trout production to the amount of sales.

Public Education

The DOW should initiate and maintain a high-profile, aggressive public education program. Through the Information and Education Section, we should provide all of our publics with frequent updates on progress in all facets of the DOW plan for attacking, containing, and controlling the spread of the WD pathogen. We need to be realistic and honest about the existing and potential impacts of WD to our trout fisheries and refrain from false optimism about the problems and solutions. Anglers also need to **clearly** understand DOW's fish stocking and recreation projections, so that they can formulate accurate expectations when deciding to purchase a fishing license.

Everyone interested in trout fishing is going to be affected to some degree for the foreseeable future. If resource protection is of paramount importance (LRP 1994; Five-Year Plan 1996), then changes in our management approach and more realistic expectations with respect to fishing recreation goals must occur.

The credibility of the DOW requires that we be the first bearers of news, good or bad, concerning WD issues. We should strive to have the best and most up-to-date information and communicate this with the public accurately, honestly, and in a timely manner. This is necessary to minimize the use of distorted, inaccurate, or false information by our internal and external constituents. The DOW should launch internal and external efforts to enhance public understanding of the need to solve some of these difficult problems, and to create support for the potentially significant changes some of our angling publics may experience over the next 3-5 years.

Timely communication to the angling public should also be used to guide anglers to locations that provide abundant fishing opportunities for stocked fish with very low risk to wild trout or native fish resources. An education program also needs to educate anglers on preventive measures that they should follow to minimize transfer of the pathogen to negative waters--an effort noticeably lacking thus far.

VI. HATCHERY PRODUCTION

The state hatchery system operated with 89.4 permanent employees, and 167.5 months (14 FTE) of temporary time, and had an annual budget of $7.56 million, including capital construction projects. Presently, the system consists of 14 coldwater units, 2 warmwater facilities, 1 combination cold/warmwater hatchery, and a planting base. Support services include a fish health section and research hatchery. The 1995-96 budget totaled $776,000 for the fish health program

and research hatchery. Operations equaled $133,500 for the research hatchery ($12,000 of this figure was in the form of grant funds) and $198,000 for fish health activities. The rest of the cost was used for personnel services, both permanent and temporary. Warmwater production for 1995 totaled 44.7 million fish or 53,000 pounds (28.9 million inches). Coldwater production for 1995 catchables totaled 4.4 million fish (10.2 inches average per fish), or 1.9 million pounds. Coldwater production for 1995 subcatchables totaled 10.1 million fish (3.3 inches average per fish) or 149,000 pounds. Total coldwater production for 1995 equaled 78.0 million inches.

Individual Hatchery Information

Specific information on each hatchery concerning location, rearing facilities, water source, personnel, operating costs, disease history, etc., is included in Table 10 and Appendix E. Following is a brief synopsis of options for control of WD or changes in production at each unit.

Bellvue Hatchery

The Bellvue Hatchery became positive for WD in June 1996. The source of the infection was unknown and only found in the settling ponds below the facility. Due to the physical configuration of the unit (concrete raceways and covered wells), the life cycle of the pathogen can easily be broken. A present proposal is to immediately depopulate the outside rearing containers and dewater the settling ponds. The hatchery building has the potential to be operated as a separate unit, with the discharge water going to the Watson Lake settling ponds. Extensive WD testing on the fish in the hatchery would also have to be performed. The UV filter system will help alleviate some of the other fish health problems when the outside raceways are reactivated. The outside rearing basins are covered with birdnetting. The unit is best suited to continue producing subcatchables of various coldwater species based on the limited rearing space and water supply. An oxygenation system could be explored to increase production.

Watson Rearing Unit

The Poudre River, which is the water supply for the rearing unit, is positive for WD, but the vector of infection is unknown. At present, treating the water supply to try to regain a negative status would not be economically feasible. Personnel at the unit are in the process of covering the raceways with birdnetting; the project is 95% complete. Netting will protect the fish from piscivorous birds, a major source of fish mortality and mode of transportation of the WD parasite. The facility also supplies office space, equipment, and freezer space for the Bellvue Hatchery. Since Watson has historically supplied most of the fish for northeastern Colorado, the additional cost of transporting fish a farther distance might make it feasible to operate Watson in the summer months as a planting base. Watson could also be used as a DOW visitor center since it is close to a large population area and receives an exceptionally large number of visitors each year. Educational material could be provided on all aspects of DOW activities, which might qualify it for GOCO funding; the blueprints have already been drawn. The facility also has the potential to be used for WD research because it is located close to Colorado State University and the future Fish Health Lab (if it is moved to Fort Collins). Since the decision has been made to eliminate production at this facility, the preceding options, plus other options, are currently being evaluated.

Table 10. Colorado state hatchery system comparison, June 1996.

Hatchery	Location (County)	Rearing Containers	Water Source	Number of Permanent Personnel	Type of Fish Rearing	Operating Costs (3 year average)	Operating Cost per Inch Planted (3 year avg.)	Whirling Disease Status
Bellvue Hatchery	Larimer	Hatchery Bldg. Nurse basins Raceways	Springs	10.25*	Subcatchables	$208,200	0.069	+
Watson Rearing Unit	Larimer	Nurse Basins Raceways	Surface		Catchables	$326,491	0.080	+
Buena Vista	Chaffee	Raceways	Spring	1 & inmate labor	Subcatchables Catchables	$52,989	0.130	-
Chalk Cliffs Rearing Unit	Chaffee	Raceways Ponds	Surface	6	Catchables	$428,683	0.052	+
Crystal River Hatchery	Garfield	Hatchery Bldg. Raceways	Spring	3**	Eggs (brood unit) Catchables	$207,732	0.460	-
Durango	La Plata	Hatchery Nurse basins Raceways	Seep Surface with infiltration	4.75**	Subcatchable Catchable	$332,031	0.078	-
Finger Rock Rearing Unit	Routt	Raceways Ponds	Springs	2**	Subcatchable Catchable	$166,858	0.059	+
Glenwood Springs hatchery	Garfield	Hatchery Nurse basins Raceways	Surface Springs	4**	Eggs (brood unit) Subcatchables Catchables	$196,335	0.036	-
Mt. Ouray Hatchery	Chaffee	Hatchery Nurse basins	Spring	10.6*	Subcatchable	------	------	-
Mt. Shavano Hatchery	Chaffee	Hatchery Nurse basins Raceways Concrete ponds	Surface Springs Seep		Subcatchable Catchables	$607,719	0.057	+
Pitkin Hatchery	Gunnison	Hatchery Nurse basins Raceways Dirt ponds	Surface Springs Seep	6*	Subcatchables Catchables	$290,096	0.090	-
Poudre Rearing Unit	Larimer	Raceways Dirt ponds	Surface	2.75*	Subcatchables Catchables	$174,558	0.049	+
Rifle Falls Hatchery	Garfield	Hatchery Nurse basins Raceways	Springs Surface	11.75*	Subcatchables Catchables	$772,071	0.046	+
Roaring Judy Hatchery	Gunnison	Hatchery Nurse basins Raceways Dirt ponds	Springs Surface	9	Eggs (brood unit) Subcatchables Catchables	$500,346	0.059	+
Las Animas Warmwater Hatchery	Bent	Hatchery Raceways Dirt ponds	Surface	3*	Warmwater	$173,843	0.161	-
Wray Hatchery Combination	Yuma	Hatchery Raceways Dirt ponds	Spring Surface	4*	Warmwater Coldwater	$280,368	0.037	-
Pueblo Combination	Pueblo	Hatchery Raceways Dirt ponds	Reservoir Springs	7	Warmwater Coldwater	$453,539	0.033	Suspect

* Supervision and FTE's are shared with another facility
** Supervision is shared with another facility

Buena Vista Correctional Facility

This facility is currently negative for WD. The possibility exists to increase the spring water collection system, at an approximate cost of $200,000. Increased production by the addition of new water could equate to as much as 50,000 catchables and 300,000 subcatchables. The correctional facility has an unlimited supply of cheap labor, and the physical facility presently in place has additional production capacity. If additional water could be obtained, no additional raceways would be needed. The facility also has the potential to be used as a wild native cutthroat facility. Fish from wild parents generally are harder to rear and require more care than offspring from "domesticated" stock.

Chalk Cliffs Rearing Unit

With a surface water supply and most of the production in dirt bottom ponds, the chance of making Chalk Cliffs WD- is remote. However, the unit is centrally located, which facilitates economical fish hauling throughout the state. The water supply is also unique because it gets warmer in the winter, which translates into rapid fish growth. If management objectives dictate, the unit could be used to rear coolwater species rather than coldwater trout.

Crystal River Hatchery

This WD- hatchery is the main rainbow brood fish hatchery for the state, supplying all of the state's coldwater units with eggs. The water supply is fairly secure, but WD has been found in the Crystal River. Therefore, it is recommended that every step be taken to ensure that the river cannot connect with the springs, and at some point in the future, a UV filter system should be installed for the incoming water (cost of filter system is approximately $250,000).

Durango Hatchery

This WD- unit is fairly secure from WD, but the quality and quantity of water could become a problem in the future. The water supplies are very vulnerable to the rapid growth taking place in the Durango area. The unit could be converted to an egg-producing brood unit for coldwater native species found in the basin if another source for clean fish could be found in the area. A brood unit would not require as much water as a production facility and the facility, in the past, has been used as an egg-producing hatchery. The spawning house is still intact. Also, the Durango hatchery receives more visitors than any other hatchery, so GOCO funds could perhaps be used to build a visitor's center to promote DOW activities.

The State Auditor's report completed in February 1995 recommended four options for the facility: 1) close the unit; 2) close the unit and acquire a new hatchery; 3) keep the unit open, but change its mission to accommodate reduced water flows; or 4) pursue a combination of approaches.

Finger Rock Rearing Unit

The nature of this unit's water supply and dirt ponds would make it very difficult to rid the facility of WD. In the past, some work by our Engineering Section was conducted on exploring the use of a thermal aquifer in the area. The unit could possibly be cleaned up if another water source and/or disinfection of the present springs could be performed, along with using only concrete raceways. The location of the facility could lend itself to the possibility of using some of the ponds as an angler education area.

Glenwood Springs Hatchery

Continue to use unit in its present capacity--rood unit, egg station, and subcatchable production.

Mt. Ouray Hatchery

Refer to discussion below section on Mt. Shavano.

Mt. Shavano Hatchery

If river water were eliminated and Mt. Shavano and Mt. Ouray were operated only on spring water, the life cycle of WD could be broken and the units could potentially become negative (NOTE: Mt. Ouray is now considered negative with a third negative inspection in May 1996). The two units could then operate on 5-10 cfs of "clean" water and produce 400,000 catchables (approximately half of what they are presently producing). The subcatchable numbers would remain at the current level. With a change in water rights, dependent on the city/DOW land exchange, clean spring water could be enhanced by a factor of two. This would involve using the gravel pit above the hatchery to filter river water, which would eventually trickle back into the unit's spring line free of WD spores. The complex is centrally located for economical stocking throughout the state.

Pitkin Hatchery

The superintendent believes that with modifications to four raceways (work being completed this summer), along with an attempt to increase fish numbers in the present ponds, production at this WD- hatchery might be increased by another 100,000 catchables.

Poudre Rearing Unit

This unit is a unique facility because it is located on a "wild and scenic" river that receives a tremendous number of visitor uses each year. If this WD+ unit is not continued at full production, then some options or combination of options might be to 1) use it as a cost-effective planting base for the immediate area; 2) use some of the ponds for WD research; 3) because of the high use in the area, develop a self-guided visitor's center, based on the high use in the area, concentrating on DOW activities in the valley and WD research; or 4) develop some of the ponds for senior citizen and/or disability fishing (possibly with the aid of GOCO funds).

Rifle Falls Hatchery

Steps could be taken to isolate the springs from the creek and more collection lines could be added. This WD+ unit might be a good location to try a sand filter similar to a municipal water treatment plant to remove WD spores from the water.

Roaring Judy Hatchery

Several different scenarios are possible for this WD+ facility, including 1) if the spring lines were reworked in conjunction with the UV filter, they could potentially become spore-free, providing enough water to use the hatchery, nurse basins, and one set of raceways to provide WD- production; 2) two crops of kokanee could be reared per season (approximately 3 million) if trout production was discontinued; 3) with the various water sources, it would make an excellent location to conduct WD research (i.e., study various water disinfection methods on a pilot basis in the raceways); 4) the property, which includes an excellent wildlife area of 850 acres, 2 miles of stream fishing, and fishing ponds, would lend itself to several management schemes; or 5) the facility could be used to produce subcatchables to stock in Blue Mesa Reservoir in exchange for clean fish from the Hotchkiss National Fish Hatchery, which is WD- and normally stocks Blue Mesa. According to the DOW WD policy, Blue Mesa Reservoir can be stocked with lightly infected WD fish.

Las Animas

Mainly a warmwater unit based on location and water supply

Wray

If this WD- facility had a new hatchery building ($350,000) and the water supply conduit to the 10 acres of ponds on the unit was lined with concrete ($1 million), fish production could be increased by 50% (400% by weight). The facility in the past has also raised rainbow trout. *Lernaea* (anchor worm) has become established in the rearing water so the DOW fish pathologist has recommended against reintroducing trout at the Wray facility for fear of spreading the organism throughout the state by stocking.

Pueblo

This unit can produce both warm and coldwater fish, but the facility is presently considered WD suspect due to the presence of WD+ rainbow trout found in Pueblo Reservoir.

NOTE: The Chatfield Planting Base and the Fish Research Hatchery were not included in the preceding hatchery discussion. The Chatfield Planting Base does not have fish on a year-round basis and functions as an extension of the Rifle Falls Hatchery. Its main purpose is to serve as a central location to plant fish from along the Front Range. The Fish Research Hatchery is, as the name implies, a research facility. It serves as a brood fish station for the greenback cutthroat trout and the Rio Grand cutthroat trout. It is also used for developing culture techniques for various cool- and warmwater native species, including amphibians. Two members of the staff are assigned on a part-time or as-needed basis to the fish health and genetics programs.

Federal Hatcheries

The USFWS presently operates two coldwater fish hatcheries in the state: Leadville NFH and Hotchkiss NFH. Some warmwater fish (mainly catfish) are hauled into the state from federal hatcheries located in the southern part of the United States.

Leadville NFH

Located in Lake County the facility stocked 186,000 subcatchable and catchable cutthroat trout, 7,000 six-inch lake trout, and 118,000 catchable rainbow trout in state waters in 1995 (Appendix F). During an annual fish health inspection on March 13, 1996, the unit was found positive for WD and *Renibacterium salmoninarum*, the causative agent of bacterial kidney disease (BKD). The outside facility consists of concrete raceways and dirt ponds, with water supplied from surface sources.

Hotchkiss NFH

Located in Delta County, this WD- the facility stocked 1.3 million subcatchable and catchable rainbow trout in state waters in 1995. From this total, Blue Mesa Reservoir received 700,000 subcatchables that average between 4 and 5 inches (Appendix G).

Additional Information

As a general rule, most of the state hatcheries are operating at maximum production. The coldwater hatcheries can convert production from rainbow trout to any other coldwater species with very little disruption. A word of caution--the closer the fish are to the genetic makeup of their wild counterparts, the harder they are to culture. As a general rule of thumb, catchable production can be traded for subcatchable trout on a 2 or 3 subcatchable for 1 catchable basis. Negative state units could produce only fry and fingerlings. This figure is highly dependent on the individual hatchery. Due to fish health concerns, our warmwater hatcheries should not be relied on to produce coldwater fish; only the Chalk Cliffs Rearing Unit has the capability to produce some warm-coolwater fish. Before any hatchery is closed, the water rights issue should be addressed; Appendix H contains a letter on this issue. This report does not address the need for more or fewer employees based on the proposed modifications. As a final word of caution, most of the concepts presented here are based on an educated opinion. If any of the major recommendations are given further consideration, a cost:benefit analysis should be conducted on each project. Another important consideration is that significant changes in fish production such as changes in brood stock and species management can take up to 2 or 3 years to complete.

Modifying Fish Hatcheries to Eliminate Whirling Disease

Much has already been accomplished to eliminate WD from Colorado's fish hatcheries. Although more DOW fish culture facilities tested WD+ in 1996 than in 1988 or even in 1992, the level of infectivity and virulence in rainbow trout at the WD+ facilities has been dramatically reduced and in some cases controlled to the point that it is almost undetectable with standard techniques. However, controlling the spread of this fish pathogen within the state's hatchery system has proven to be a very intractable problem for two reasons. First, the parasite was widely distributed in the state's surface waters in 1987 and 1988. Once introduced into running water, this parasite is highly transmissible downstream and to a much lesser extent, upstream. Second, virtually all of the state's fish culture facilities rely on surface water supplies at some point of their fish culture operation and are, therefore, highly vulnerable to contamination.

Prophylaxis and disinfection of equipment and facilities have been very effective in minimizing the spread of this pathogen from one fish culture facility to another. Most of the spread of the pathogen into the state's fish culture facilities has occurred as a result of the movement of the parasite onto the facility from contaminated surface water supplies. Fish held and reared in ponds, concrete raceways, and nurse basins using surface water have suffered the greatest exposure and infection rates. Since 1992, three hatch houses have also tested positive for the parasite as well.

Clearly, more aggressive control and containment techniques are necessary. There are a number of measures shown by experience (in other states) to be highly effective in reducing or eliminating the pathogen. Some immediate solutions known to be effective are:

1. **Enclose and secure hatchery water supplies in concrete.** This eliminates a substrate for the tubificid worm, the obligate alternate host for the disease. Without the alternate host to produce the waterborne, fish-infective spore, the disease cannot be transmitted to the fish.

2. **Eliminate all earthen ponds from fish culture facilities.** According to the July 1995 Deloitte and Touche Hatchery System Analysis Final Report, five of eight WD+ facilities have earthen holding ponds used for rearing rainbow trout. Earthen ponds that become laden with organic nutrients are a prime breeding ground for the tubificid worm that transmits the disease to fish. Replacement of earthen ponds with concrete raceways that are properly maintained, cleaned, and disinfected annually should minimize the substrate for the worms.

3. **Hatch and rear fingerling trout inside hatch houses with secure water supplies known to be free of the WD pathogen.** This is *absolutely* imperative for fish destined for stocking in WD- environments. To every extent possible, this should also be done for fry/fingerlings known to be vulnerable to the parasite. Current knowledge dictates that these fish should not be moved into nurse basins or raceways on WD+ surface waters until they are at least 3-4 inches in size and more resistant to the parasite. Although this practice may prevent the fingerlings from exhibiting clinical signs, they are still potential carriers of the pathogen. If fish production must be reduced to accomplish this objective, it should be regarded as an acceptable tradeoff, at least in the short term.

4. **Use state-of-the-art technology to detect/monitor the pathogen.** The polymerase chain reaction (PCR) DNA "fingerprinting" of the WD pathogen has been completed and will soon be available commercially for testing and detection of the parasite in fish, worms, and water. Recent research tests at the University of California at Davis have shown that DNA from a single waterborne spore can be detected by the PCR test. This technology has far more utility than current standard testing procedures as it may be capable of detecting the pathogen in all its phases and forms with reliable accuracy and precision. When this technology is commercially available, the DOW should seriously consider acquisition of this testing capability.

5. **Implement technological solutions: filters, UV light, and ozone.** Whether installed independently or in combination, the chosen strategy(s) must be able to stop the infective stage of *M. cerebralis*. Various filtration materials (sand and membrane filters), of oxidizing agents (ozone), and ultraviolet light have shown promise against water-borne pathogens. These are not without drawbacks, however. UV light works best in clean water and obviously, to be effective, must be functional 100% of the time (i.e., is susceptible to power failures). Sand filters must be cleaned occasionally, and drum filters can leak or become damaged and may be restricted by water flow rates. Overall, the effectiveness of this solution can be improved with a combination of strategies. For example, in our Bellvue SFH, we are evaluating the effectiveness of using a small drum to pre-filter the water for UV light treatment before it enters the raceway system. Presently, most of this technology cannot be justified economically for rearing units with only surface water supplies.

NOTE: The DOW should proceed with caution in adopting any "quick fix" technology. We should avoid acquisition of any expensive control techniques if these methods are not tested and proven effective. Desires to achieve a "quick fix" for WD could leave the DOW burdened with an inventory of expensive capital investments that turn out to be ineffective solutions. For example, ultraviolet light systems cost $200,000 to $250,000 per unit, according to the July 1995 Deloitte and Touche Hatchery System Analysis Report. Installation of these units at all WD+ fish culture facilities would cost $2 million to $3 million. Before going any further with this technology, the unit that has been purchased and

installed at the Roaring Judy facility needs to be subjected to thorough testing for at least a year to determine its cost-effectiveness in disease prevention and control, particularly with regard to WD. This remains to be done. The cost and benefits of UV systems should be weighed against the benefits of investing a similar amount toward the four immediate solutions described above proven to be effective in protecting hatcheries from WD.

Likewise, before seriously considering spending millions of dollars to acquire additional fish culture facilities (that are currently WD-), the DOW needs to have a thorough assessment of the probabilities that those units will be secure, or can be made secure, from the WD parasite and if so, what would be the additional capital construction costs.

Options for Obtaining WD- Fish from Other Sources

1. Purchase fish from private hatcheries

The DOW initiated this option last summer (1995) but the money ($40,000) was not approved until August. By that time, the private sources that showed interest in selling fish to us had already contracted their fish out for the season. Our Hatchery Section sent out another letter in March/April 1996 to all aquaculture license holders asking if they would be interested in selling 9- to 10-inch catchable trout to us for $1.60/pound up to a maximum of $10,000 (anything more than $10,000 would have to go to out on bid and could not be handled by a contract). We also stated we would haul the fish. Four responses were received, but one was rejected due to other disease concerns. The DOW could purchase 45,000 trout 9-10 inches in length. As a result, the DOW has presently contracted with three operators for $30,000. If the price were increased above $1.60/pound, more people might be interested in selling fish. The DOW hatchery system produces 10-inch fish for $1.75/pound, including hauling costs.

Buying WD- fish from the private sector could immediately help the DOW in fulfilling its stocking programs, but there are some inherent problems associated with purchasing fish. First, the private sector is presently selling all the fish produced in Colorado, so more fish may need to be imported either for us or their other customers. Importing large fish increases the threat of introducing other pathogens (i.e., WD and redmouth were imported into the state and both are enzóótic now). Second, we do not have as thorough disease histories on private hatcheries as we have on DOW facilities. Third, if we haul the fish, we have to furnish the truck and driver. There may be some liability if we use our equipment on their property because of the threat of bringing in a pathogen.

2. Purchase or trade for fish from other states

Our Hatchery Section presently trades with other states for the eggs of coldwater "special species" and some warmwater fish. At this time, it is not known whether other states would be interested in selling or trading with us for WD- coldwater fish. Some of the same issues as discussed previously would need to be addressed (labor required to haul the fish and threat of bringing in another pathogen). As a side note, if eggs taken from WD+ fish are disinfected, the resulting fry are considered WD- if reared in a WD-free environment. Therefore, the DOW can still provide the eggs necessary for our management programs even if the source is or becomes positive.

3. Purchase or lease a private hatchery

If we could lease a private unit, WD- fish could be obtained immediately. Monitoring for the overall fish health status of the unit could be started, and the long-term solution of a WD-free water source identified.

4. Acquire federal fish

The Hotchkiss NFH is presently producing approximately 1.4 million WD- rainbow trout. The USFWS has indicated they are willing to work with the DOW on exchanging some of their fish for some of our lightly-infected fish. Unfortunately, the same option is not available for the Leadville NFH because the unit is presently positive for both WD and BKD.

Additional Information

In addition to our shortfall of WD- fish, there are a couple of other issues that must be factored into our future fish production system. First, fish stocking from the Leadville NFH in Colorado will be altered in the future. Second, if WD is destroying most of our wild rainbow trout reproduction, will hatchery-reared fish be required to supplement these populations so they do not become extirpated?

Another related issue concerning the hatchery system is the culture of nonsport native fishes. The DOW is presently exploring the possibility of obtaining a water source and building a facility in the San Luis Valley for culturing and studying these fish. This specialized unit would be built to hold a large number of different species as compared with a production hatchery, which is designed to produce a maximum number of one or two species. A native species facility will also require a large quantity of warmwater (80° F). Based on the aforementioned reasons, converting a present production hatchery into a native nonsport species facility would probably not be practical.

Summary of Recommendations

The following is a list of possible alternatives to overcome the immediate shortfall in WD negative fish:

1. Enter into an agreement with the USFWS to trade for WD- trout from the Hotchkiss NFH (i.e., allow Roaring Judy to stock approximately 700,000 lightly infected subcatchable fish into Blue Mesa Reservoir and take the same amount of production from Hotchkiss to stock into WD- habitat throughout the west slope).

2. Explore the possibility of leasing/purchasing a private hatchery.

3. Modify the water source at Mt. Shavano and eliminate production of 800,000 WD+ catchables, using only spring water to produce 400,000 WD- catchables.

4. Explore the possibility of expanding the use of spring water at the Buena Vista Correctional Facility. Additional raceways to accommodate the increased production are already in place.

5. Explore the possibility of converting some positive production unit(s) into a planting base, satellite research facility, a visitor center, and/or fishing ponds.

6. Expand production at the Pitkin Hatchery.

7. Purchase WD- trout from private hatcheries.

VII. SUMMARY OF ALTERNATIVES

The following is a list of alternatives identified in the preceding text.

Protection

1. Implement the WD Policy with respect to protection/stocking restrictions in native cutthroat and wild trout waters.

2. Implement recovery, conservation, and management plans to restore and expand the three native cutthroat species to a viable status.

3. Use native cutthroat in their respective drainages as the primary species for management in headwater drainages to provide catch-and-release and limited-harvest fisheries.

4. Initiate research to determine the density, periodicity, and seasonality of waterborne spore production in infested waters to reduce negative impacts to stocked trout, and evaluate other species and strains of salmonids for resistance to WD.

Recreation

5. Initiate a public information program to educate anglers on preventive measures to minimize transfer of the pathogen to negative waters.

6. Conduct a research project to answer the question of whether the continued stocking of trout from WD+ units into WD+ habitats increases or maintains WD spore levels above that produced by the alternative tubifex worm host.

7. Balance the use of WD+/- trout (use all WD- catchables on the west slope, use WD+ trout stocking in the Front Range and warmwater seasonal fisheries) to protect resources while creating and directing fishing recreation.

8. Increase warmwater fishing opportunities to shift angler pressure and stocking away from protected habitats.

9. Emphasize wild trout management and restrictive harvest regulations to reduce the level of coldwater fish stocking.

10. Increase coldwater habitat protection and enhancement programs (instream flow, water quality, and habitat manipulation) to maximize the biological potential of streams and lakes.

11. Shift aquatic management from **Intensive Use** (catchable stocking) to **Optimum Use** (fry or fingerling, or no stocking).

Demand

12. Standardize key terminology and processes (e.g., cost of producing various sizes and species of fish, data about the existing aquatic habitat base, angler use, etc.) to minimize confusion about key data and how they were derived and used.

13. Undertake an economics-based study that examines the cost, benefits, and anglers' willingness to pay for hatchery-reared fish in Colorado. This should also incorporate results to enable an understanding of "angler satisfaction" and the estimation of angler success and demand by category. The study should be done on a broad scale so that the results can be applied to the entire hatchery system.

14. Implement user pay mechanisms to determine the demand for catchable trout and to enable DOW to index hatchery production.

Hatcheries

15. Initiate research to determine if UV light, sand filtration, or other screening materials provide a viable methodology for eliminating WD spores from hatchery supply waters.

16. Eliminate all production of WD+ trout from state hatcheries and accept the associated loss of stocking and recreation days.

17. Reduce or eliminate the WD pathogen from existing state production facilities.

18. Buy or lease WD- trout hatcheries.

19. Buy WD- trout from the private sector.

20. Modify existing WD- state hatcheries to produce more fish.

21. Trade for WD- trout from federal hatcheries.

22. Produce only fry and fingerling trout at WD- state hatcheries.

VIII. ALTERNATIVES

Assumed Alternatives

Several alternatives from the preceding list were thought to be "givens," i.e., either already very likely to occur or so obvious that little more than a reference would be needed to underscore their importance. They are:

Alternative 1: **Implement the WD Policy with respect to protection/stocking restrictions in native cutthroat trout and wild trout waters.**

Alternative 2: **Implement recovery, conservation and management plans to expand the range of three native cutthroat trout, and restore them to a viable biological status.**

Alternative 3: **Use native cutthroat in their respective drainages as the primary species for management in headwater drainages to provide catch-and-release and limited-harvest fishing opportunities.**

Alternative 4: **Initiate research to determine the density, periodicity, and seasonality of waterborne spore production in infested waters to reduce the negative impacts to stocked fish, and evaluate other species and strains of salmonids for resistance to WD.**

Alternative 6: **Conduct a research project to answer the question of whether the continued stocking of trout from WD+ units into WD+ habitats increases or maintains WD spore levels above that produced by the alternative tubifex worm host.**

Alternative 19: **Buy WD- trout from the private sector.**

Because of the time that may be involved to research appropriate methodology and the actual elimination of WD from infected units, a more immediate solution for the lack of WD- fish would be to purchase WD- trout from private units. The cost of this option, as well as the untested mechanics of meeting a specific and demanding stocking regime by private vendors, this alternative should only be considered for the most urgent "damage control" situations. The most rigorous testing should be given to the purchased fish (equal to that at state units) to assure high quality and disease-free status.

Alternative 21: **Trade for WD- trout from federal hatcheries.**

Another potential strategy for increasing the supply of WD- trout may be trading lightly infected WD+ trout from state units for WD- trout from the Hotchkiss National Fish Hatchery. For example, a swap might involve the stocking of lightly infected WD+ trout into Blue Mesa Reservoir (a positive habitat) and diverting the Hotchkiss WD- fish scheduled for Blue Mesa to waters limited to WD- stocking.

Preferred Alternatives

The criteria we used to identify **preferred alternatives** included the relative importance and urgency of the alternative, and the likelihood of success in accomplishing the task. These alternatives include:

Alternative 7: Balance the use of WD+ and WD- trout to protect resources while creating and directing fishing recreation.

Historically, catchable trout stocking has been dictated by supply and an ever-evolving and poorly understood stocking strategy that, nonetheless, resulted in a reasonably equitable allocation and distribution of hatchery products. With the onset and spread of WD in production units and natural resources, however, stocking management and recreation days have been radically altered. Demand and supply of hatchery fish are likely not balanced, particularly as one views the state in smaller geographical units. A need now exists to reevaluate the DOW stocking program, with the goal of assessing the demand for hatchery fish while protecting aquatic resources.

Stocking schedules for fry, fingerling, and subcatchable trout have been produced through a biological (productivity) assessment of receiving waters and an evaluation of targeted catch rate objectives by the biologist responsible. On the other hand, catchable stocking schedules have used an "allocation system" that is based on the 1992 Categorization System. Historical stocking rates, angler pressure, return to creel, and the specific category of water are all parts of the formula. Until the past couple of years, the WD factor has not been a determining variable in the stocking equation. However, since the DOW has now modified its stocking policy to protect habitats from WD exposure, the assumptions and relevant factors in the allocation system for catchable trout are likely no longer valid. As a result, there have been some inequalities and inefficiencies in the catchable stocking program, as explained in the **Recreation Section** of this report. This is most notable on the west slope, where it is projected that in 1997, the decrease in catchable trout stocking will result in a deficit of 500,000 recreation days as compared with the 1992 levels. Problems also may occur in waters of the west slope stocked with fry, fingerling, or subcatchables, as well as in some protected habitats on the east slope.

The allocation system for catchable trout needs to be reformulated to distribute the state's supply of catchable trout in an equitable manner, i.e., adhering to the Commission's WD Stocking Policy while allowing recreation day targets to be met. This should be broad-based, unbiased, and open to the alternatives, consistent with DOW's mission. For instance, the impact of diverting **all** WD- catchables to the west slope should be evaluated. Likewise, the strategy of stocking (or "overstocking") of Front Range and seasonal warmwater reservoirs to "divert" recreation days from protected habitats should be evaluated. This same kind of analysis should be completed for both WD+ and WD- fry, fingerling and

subcatchable stocking, however, with the understanding that success of stocking of those sizes of fish is largely dependent upon the productivity of the waters.

Alternative 13: **Undertake an economics-based study (Johnson et al. 1995) that examines the cost, benefits, and anglers' willingness to pay for hatchery-reared fish in Colorado. This should also incorporate results to enable an understanding of "angler satisfaction" and the estimation of angler success and demand by category. The study should be done on a broad scale so that the results can be applied to the entire hatchery system.**

This option calls for studies to be done to help us define and understand the role of fishery management and the hatchery system in Colorado. We need better information about angler use of our fishery resource, and their expectations for and satisfaction with angling experience. We could also gain an economic perspective of the efficiency of our hatchery programs through an assessment of the costs, benefits, and anglers' willingness to pay for their recreational use of hatchery-reared fish.

(1) One study could very well be patterned after a project completed for the DOW by the Cooperative Fisheries Research Unit at CSU (Bergersen et al. 1982). Because their work included large sample sizes, some important and powerful statistical inferences were possible. They addressed angler success (catch-per-hour), demand, and angler satisfaction with their fishing experience in Colorado. This information should be updated and expanded to provide DOW fishery managers with a fundamental understanding of the factors that make up angler satisfaction. Knowing the relative contribution of each independent variable to overall "satisfaction" would allow the DOW to manipulate stocking rates, regulations, or the availability of local amenities, etc., to achieve a desired level of angler satisfaction. Conversely, we would know that there are some (perhaps important) variables affecting satisfaction over which we have absolutely no control, e.g., we cannot be held responsible for the weather, and we cannot force people to go fishing.

(2) Another recommended study would use production cost information from our hatchery system and basic data on angler use to provide insight into the cost-benefits of our hatchery production system, answering the question, "Do the benefits realized on a local and statewide basis as a result of our fish stocking programs warrant the cost of producing the fish stocked?" A willingness-to-pay exercise would probably be a part of this assessment. Using these techniques, Johnson et al. (1995) drew some interesting and far-reaching conclusions about the efficiency of our hatchery system. Though none of the authors of this document profess to be an economist, it appears that these techniques should provide the DOW with additional decision-making criteria.

Alternative 14: Implement user pay mechanisms to determine the demand for catchable trout and to enable DOW to index hatchery production.

The DOW should implement a process for determining the link between demand for hatchery production of catchable trout and willingness to pay for that product. This process should be incorporated as formal agency procedure. The user-pay mechanism would be guided by the results obtained under Alternative 13. The specific approach or program implemented cannot be predicted at this point, since new methods may need to be added to those discussed in the **Demand Section**. Implementation of an index to establish hatchery production targets would inevitably result in some fluctuation and uncertainty from year-to-year. However, indexing hatchery production to real measures of demand for those products should greatly improve the efficiency of the system, make it more responsive to aquatic resource management needs, and provide a better method of cost containment.

Alternative 15: Initiate research to determine if UV light, sand filtration, or other screening materials provide a viable methodology for eliminating WD spores from hatchery supply waters.

The DOW has already committed to installing a UV light system at the Roaring Judy unit that should be fully evaluated for its efficiency and reliability in routine hatchery operations. Research results elsewhere have demonstrated promising results using sand filtration and high-technology screening materials for filtering water to remove WD waterborne spores completely. The application of sand filtration and other screening materials should also be evaluated for their applicability to the range of hatchery operations and water sources existing in the state system. If successful, one or more of these technologies could be employed at DOW's WD+ hatcheries at much greater cost-effectiveness than purchasing new facilities. Renovation of existing state units would also entail less disruption to existing personnel onsite.

Alternative 17: Reduce or eliminate the WD pathogen from existing state production facilities.

Because of the capital investment in property, structures, personnel, water rights and other local considerations, the maintenance and retention of the efficient components of our current hatchery system seems to be a prudent strategy. Over the years, there has been an enormous amount of evaluation, trial and error, and superintendent intuition in developing our production units into efficient operations. Nonetheless, if attempts to adapt technology to clean up a particular production unit are unsuccessful and there is no demonstrated need for the products from that unit, then closure should be considered. That decision should be carefully considered in light of 1) long-term management direction; and 2) current research activities that might discover a new method(s) to eliminate the pathogen (e.g., resistant strain(s), vaccination, etc.). There has been a great deal of technological, economic, and political evaluation completed regarding WD control in DOW hatcheries (see text and

references). Please refer to **Section** VI for more information on the hatchery production system.

Alternative 18. Buy or lease new WD- hatcheries.

The acquisition of new propagation facilities is currently an uncertain approach. Efforts to purchase WD- facilities in Colorado are already underway, but no purchases are certain at this point. It is important to remember that, in acquiring any facility, a risk of infestation of WD is always possible. For that reason, consideration of the costs of renovating the new facility with appropriate WD parasite control technology must be included in any evaluation of a potential purchase or purchase price. The capacity of the new unit to provide the most critical hatchery products (e.g., catchables, subcatchables, etc.) must be considered within the context of the long-term production needs from the hatchery system.

The decision to buy new WD- trout production facilities must be firmly grounded in relevant and well-understood factors, some of which will come from WD research efforts that may take several years to complete. Although there is some desire to acquire new WD- hatcheries, we believe it would be shortsighted and economically unwise to commit to a purchase agreement without determining other DOW needs for WD- or WD+ trout. As an example, research might indicate that stocking lightly infected trout into positive streams does not increase infection levels of the disease in those habitats, thus decreasing our needs for WD- stocking in those streams.

In the short-term (1-5 years), the DOW would be far more prudent to explore purchase options while leasing WD- hatcheries. This would require that the DOW incur costs for the "insurance policy" for several years until research results provide direction for a long-term commitment.

Alternative 20: Modify existing negative hatcheries to produce more fish.

Modifications are presently taking place at the Pitkin Hatchery that may allow it to produce another 100,000 catchables. The possibility also exists to increase the spring water collection system at the Buena Vista Correctional Facility, which would allow for the production of more negative fish. Labor to raise the fish would be supplied by inmates and the additional physical structures (raceways) are already in place.

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DOW ACTION PLAN: 1996 and beyond

Strategy	Tasks (Alternatives)	96-97	97-98	98-99+
MINIMIZE SPREAD OF WD	Implement Whirling Disease Policy (1/97)	Existing Resources		
	Implement Native Trout Recovery (1/97)	Existing Resources		
	Use native cutthroat as primary mgt. spp. ✓	Existing Resources		
	Research Whirling Disease spore production (7/96)	Existing Resources		
	Research effects of stocking WD+ into WD+ waters (7/96)	Existing Resources		
ASCERTAIN DEMAND FOR HATCHERY FISH	Economics-based study of willingness-to-pay, and benefit: cost study (7/96)	$ 35,000		
	Pilot "user pay" alternatives to test demand for catchables (follows above study)		Existing Resources	
INCREASE SUPPLY OF WD- FISH	Trade for WD- from federal hatchery (9/96) ✓		$ 58,000	$58,000/yr
	Lease/option of a WD- hatchery ✓	To Be Determined	To Be Determined	To Be Determined
	Exercise option if warranted by results of demand study			To Be Determined
	Buy WD- fish from private producer @$1/catchable fish ✓	$100,000	$200,000	$200,000/yr
	Increase production at existing DOW WD- hatcheries (9/96) ✓		$750,000 Cap.Cons	$61,500/yr
CLEANSE WD+ HATCHERIES TO WD-	Feasibility study of hatchery modifications (UV, filters, etc.) (9/96) ~	$30,000		
	Modifications to eliminate WD pathogen (following above study)		To Be Determined	
MEET FISHERIES DEMAND OVER LONG TERM	Balance WD+ and WD- stocking			Existing Resources
ESTIMATED COST		$165,000	$1,008,000	$319,500

IX. ACTION PLAN

DOW ACTION: 1984 to present

Strategy	Tasks	1984 To Present
	Hired first full-time certified fish pathologist	**APRIL 1984;** 1 FTE; $20,000 operations contract with U.S.Fish and Wildlife Service (USFWS)
	Myxobolus cerebralis found in Colorado	**NOVEMBER 1987;**
	Leased building for whirling disease (WD) lab in Fort Morgan	**JANUARY 1988;** 24 months temporary time; USFWS loaned us a fish pathologist for 18 months at no cost to help with the project
	Effort expended to determine the extent of WD in Colorado	**NOVEMBER 1987 through JULY 1988;** 7600 hours of labor; $172,000
	Operation and personnel assigned to the Fish Health Lab; costs do not include labor provided by biologists and law enforcement personnel to collect samples and insure compliance	**1989 through 1990;** 1 FTE; 24 months temporary; Total appropriation approximately $84,000 per year
	Senate bill 90-67 passed which provided increased funding and personnel for the fish health program. Moved into new larger laboratory in Brush	**1990;** Increased staff by 1.5 permanent FTEs; also allowed for compliance officer; Total appropriation $151,000 plus $24,000 for capital equipment
	WD suspected in loss of year classes in Colorado River	**1993-94**
	Research efforts: 1. Study Colorado River 2. Study affect of WD on other WD-positive rivers 3. Study effect of stocking fish from WD-positive hatcheries in positive streams and not stocking fish from positive hatcheries in positive streams. 4. Determine the susceptibility of different species of trout to WD. 5. Determine distribution and abundance of tubifex worms in relation to Colorado River native cutthroat habitat. 6. Gas saturation study Fish Health Laboratory Activities: 1. Hired new pathologist (DVM) 2. Determined infectivity rate at individual state hatcheries 3. Laboratory studies on interrelationship between WD and other stressors 4. Increased sampling capabilities at laboratory UV Installation at Fish Hatchery	**1994-96;** 2 FTEs/year;3 temporary FTEs/year; total appropriation minus administrative overhead, approximately $284,000/year 1 FTE funded by the CSU Fish. Coop unit; $33,700/year 4 FTEs; 5 Temporary FTEs; Total appropriation minus administrative overhead $400,000/year; capital equipment $34,000 5 Temporary FTEs $350,000

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APPENDICES

Appendix A

Locations in Colorado where *Myxobolus cerebralis*, causative agent of salmonid whirling disease, has been identified as of June 1, 1989.

No	Date Sampled	Site Name/Location	Site Type[1]	Drainage	Date of Diagnosis
01	112487	Bovee Trout Ranch/Salida	FC	Arkansas	1124 DF[2]
02	112487	Mt. Shavano SFH/Salida	FC	Arkansas	1124 DF
03	120187	Rainbow Falls Park/Woodland Park	FC	S. Platte	1207 F
04	120187	H&H Hatchery/Creede	FC	Rio Grande	1204
05	121587	Hagen Western Fisheries/Wellington	FC	S. Platte	0201 D
06	012988	Walton Ranch/Las Animas Co.	FR	Cimarron	NM F&G[3]
07	020188	Chalk Cliffs RU/Nathrop	FC	Arkansas	0306 D
08	030988	Hagen Western Fisheries/Nathrop	FC	Arkansas	0326 D
09	030988	USAF Academy/El Paso Co.	FR	Arkansas	0316 F
10	040488	Great Sand Dunes Oasis/Alamosa Co.	FR	Rio Grande	0502 D
11	041588	Domingo Baitlon property/Salida	FC	Arkansas	0426 D
12	050388	Rito Alto Wilderness Area/Custer Co.	FR	Arkansas	0504 D
13	050488	Catamount Lake/Routt Co.	FR	Yampa	0531 D
14	050588	Always Unlimited Trout/Rollinsville	FR	S. Platte	0531 D
15	051088	Correctional Facility/Buena Vista	FC	Arkansas	0517 DF
16	051188	Rye Trout Farm/Rye	FC	Arkansas	0516 D
17	061088	Rainbow Lake Resort/Buena Vista	FR	Arkansas	0629 D
18	061288	Bauer Lake/Mancos	FR	Mancos	0614 D
19	061688	Dowdy Lake/Red Feather	FR	S. Platte	0727 D
20	062088	Baca Grande Homeowners/Crestone	FR	Rio Grande	0629 D
21	062188	North Fork Reservoir/Chaffee Co.	FR	Arkansas	0629 D
22	062488	Poudre Canyon RU/Larimer Co.	FC	S. Platte	0715 D
23	062988	Lake Fork Ranch/Lake City	FR	Gunnison	0726 D
24	062988	Meridan Lake-Lacey's/Crested Butte	FR	Gunnison	0802 D
25	073088	Hoaglin Pond/Salida	FR	Arkansas	0817 D
26	092488	Trauman Stephen/Grand Lake	FR	Colorado	1006 D
27	092688	Country Club of the Rockies/Edwards	FR	Colorado	1005 D
28	092888	Marty Stouffer/Aspen	FR	Colorado	1011 D
29	092888	Wolf Creek Guest Ranch/South Fork	FR	Rio Grande	1013 D
30	092988	Floyd Watkins/Woody Creek	FR	Colorado	1013 D
31	100488	Wilds of the Rockies/Kremmling	FR	Colorado	1013 D
32	100488	Ginger Quill Ranch (N. Platte R./Jackson Co.	FR	N. Platte	WY F&G[4]
33	100688	Single Tree Golf Course/Edwards	FR	Colorado	1013 D
34	100688	Trap Lake/Larimer Co.	FR	S. Platte	1117 D
35	101188	S. Platte R. (Waterton Canyon)/Jefferson Co.	FR	S. Platte	1102 D
36	102688	Vallecito Reservoir/La Platta Co.	FR	San Juan	1215 D
37	100588	Skyline Guest Ranch/Telluride	FR	San Miguel	0104 D
38	100688	Oliver Ranch/Powderhorn	FR	Gunnison	0106 D
39	100688	Cebolla River Ranches/ Powderhorn	FR	Gunnison	0106 D
40	101688	Bricklin Ranch/Meeker	FR	White	0109 D
41	100688	Powderhorn Guest Ranch/Powderhorn	FR	Gunnison	0109 D
42	092888	J.R. Ford/Pagosa Springs	FR	San Juan	0111 D
43	100888	C Lazy U Ranch/Granby	FR	Colorado	0113 D
44	101888	Horseshoe Reservoir/Huerfano Co.	FR	Arkansas	0113 D
45	101888	Trout Creek (upper station)/Teller Co.	FR	S. Platte	0118 D
46	110288	Clear Creek Ranch/Chaffee Co.	FR	Arkansas	0130 D
47	102688	Antero Reservoir/Park Co.	FR	S. Platte	0202 D
48	110388	S. Boulder Creek (Jumbo Mtn. P. G.)/Gilpin Co.	FR	S. Platte	0214 D
49	111088	Goose Creek (.5m above Cheeseman L.)/Jeff.	FR	S. Platte	0215 D
50	111088	Goose Creek (1.2m above Cheeseman L)/Jeff.	FR	S. Platte	0215 D
51	102588	Indian Head Ranch/Larimer Co.	FR	S. Platte	0322 D

[1]FC is fish culture site; FR is free-ranging population

[2]Laboratory testing conducted by Colorado DOW (D) or USFWS (F)

[3]Sampling and testing conducted by New Mexico Fish and Game Department

[4]Sampling and testing conducted by Wyoming Fish and Game Department

Appendix B

Major River Drainages[a] in Colorado

A. Positive drainages
   1. Rio Grande
   2. Arkansas
   3. South Platte
   4. Yampa
   5. Colorado River
   6. Gunnison
   7. Mancos
   8. North Platte
   9. White
   10. Dolores - San Miguel
   11. La Plata
   12. San Juan
   13. Little Snake

B. Negative drainages
   1. Republican
   2. Animas

[a]Contiguous water in the same basin which normally supports salmonid fish.

Appendix C

Whirling Disease+ Fish Production Hatcheries* and the Date They Became Positive

Date	Name	Location County	Ownership
11/87	Bovee Trout Ranch (Mt. Ouray)	Chaffee	Private/State
11/87	Mt. Shavano	Chaffee	State
12/87	Rainbow Falls Park	Teller	Private
12/87	H&H Hatchery (closed)	Mineral	Private
12/87	Hagen Western Fisheries	Larimer	Private
2/88	Chalk Cliffs	Chaffee	State
3/88	Hagen Western Fisheries	Chaffee	Private
4/88	Domingo Baitlon	Chaffee	Private
5/88	Buena Vista Correctional Facility	Chaffee	State
5/88	Rye Trout Farm (now considered negative)	Pueblo	Private
6/88	Poudre River Rearing Unit	Larimer	State
1/92	Roaring Judy	Gunnison	State
5/94	Rifle Falls	Garfield	State
5/94	Finger Rock	Routt	State
10/94	Watson Lake	Larimer	State
3/96	Korinek Trout Farm	Crowley	Private
3/96	Boulder Fish & Game	Boulder	Non-profit club
3/96	Leadville NFH	Lake	Federal

* Fish hatchery as defined by Senate Bill 90-67

Appendix D

STATE OF COLORADO
DIVISION OF WILDLIFE
DEPARTMENT OF NATURAL RESOURCES

DATE: 9 June 1995

TO: Bruce McCloskey

FROM: Eddie Kochman

SUBJECT: Whirling Disease Research Projects

At the May 31st Whirling Disease Committee meeting the following research projects were selected and will be initiated as soon as sufficient resources are acquired. Significant redirection of resources has been accomplished. Additional resources are also required. One project requires a contract with CSU and and sufficient money is not available in the current fiscal year to complete the work. If awarded, the contractor should be able to provide a quick test using DNA analysis to determine if whirling disease organisms are present in water samples, tubifex worms, and small fish under five months of age after refining a new technique. The contractor will be required to assist in the analysis of samples as dictated by research and management objectives using the new technique. Southwest Region Fisheries has agreed to supply $14,000 this year and I recommend we use $6,000 from the Coldwater Fisheries Donation fund to begin the contract. An additional $10,000 will be needed in 1995-96.

Following are the research projects that will be accomplished if sufficient resources can be acquired. The activities believed to be top priority are listed below followed by tables showing the resources that have been redirected in an attempt to accomplish these projects and the additional resources needed.

(1) A research project has been designed to answer the question of whether the continued stocking of trout from WD+ units increases or maintains WD spore levels in WD+ flowing waters above levels produced by the alternate tubifex worm host. Barry Nehring has been given resources taken from other research projects to conduct the field portion of this project and Pete Walker will perform the pathology analysis. It is expected that this project will take at least 4 years as WD spore levels will be monitored in trout populations where: (A) wild rainbow trout populations are known to be WD positive, year classes are missing and stocking of WD+ rainbow trout is continued. (B) Wild rainbow trout populations are known to be WD positive and there are no missing year classes and WD positive rainbow trout will continue to be stocked, followed by no stocking. (C) Wild rainbow trout populations known to be WD+, year classes are missing and no continued stocking of WD+ fish followed by stocking WD+ fish. Susceptible size rainbow trout will be placed in cages to be sentinels for pathology analysis in selected streams. These fish along with sampling the feral population of trout in each stream will provide the information that will answer the question. An additional $11,500 or

6 temporary FTE months will be needed by Pete to perform the pathology analysis.

(2) A research project that will determine the susceptibility of the three native cutthroat trout subspecies along with brook trout, other wild rainbow trout strains, grayling and whitefish will be conducted. If less susceptible (resistant) species or subspecies are identified, genetic analysis will be performed in an attempt to distinguish these strains for future management consideration. Barry will be responsible for the field investigations and Pete will conduct similar controlled experiments and perform the pathology analysis for both the field and laboratory experiments. An additional $10,000 or 5 months of temporary FTE months will be needed by Pete to provide the disease analysis.

(3) A research project that will survey known Colorado River native cutthroat trout populations to determine the distribution and abundance of tubifex worm habitat and density of the worms if such habitat is found. It is assumed if tubifex exists in cutthroat trout habitat the risk of those populations becoming infected is greater than if such habitat is not present or is very limited in abundance and distribution. While sampling these habitats, the trout populations will also be sampled for disease analysis and to see if there are any missing age groups. In addition this project will provide CSU geneticists with samples to test their DNA techniques on the worms. This portion of the project will also help answer the question of whether there are other alternate Oligochete hosts besides tubifex worms. If such techniques can be perfected then habitats could be tested for the presence of WD spores without having to test the fish which requires at least four months exposure to the spores and is the most time and resource consuming. Mary McAfee has been reassigned to conduct the field portion of this project along with 6 temporary FTE months, Anita Martinez will coordinate the genetic analysis and Pete will perform the disease analysis. An additional $6,000 or 4 temporary months will be needed by Pete for this project.

(4) Hatchery infectivity study will also be conducted to identify spore levels at each WD+ unit. Pete will be responsible for the disease analysis and the Research hatchery will be responsible for collecting the fish for analysis. An additional $13,000 dollars or 7 temporary months are needed for this project.

(5) A research project to investigate the dissolved gas effect in the Colorado River has been initiated through the Colorado Cooperative Research Unit at CSU. This project is costing $33,700 this year. Pete will lead a graduate student project investigating the relationship between gas bubble disease and WD in controlled experiments using a part of Pat Davies Toxicology Laboratory (a redirection of resources). In addition Barry will be monitoring gas saturation at each of the rivers listed under the first project. An additional $36,500 and 9 temporary months are needed to fund the graduate study and do the pathology analysis.

(6) Distribution and identification of specific sights positive for WD will be conducted by assaying spore levels in specimens collected by regional biologists. Pete will be responsible for this on-going disease analysis. On-going additional costs experienced for the past year have been $57,500 and 27 months of temporary time and hiring a qualified pathologist through a contract with CSU at a cost of $11,000.

Resources redirected to accomplish WD research and hatchery clean-up priorities

ACTIVITIES	DOLLARS	FTE MONTHS	SOURCE
DNA Analysis for WD/CSU Contr.	$20,000	0	SWR & Donation fund
R. Judy UV System	250,000	0	Hatchery Cap. Const.
Pathology Lab Equip.	23,000	0	Hatchery Cap. Equip.
Species Susceptibility	6,000	4	Aquatic Research
CRN Habitat/tubifex (field)	23,600	8	Aquatic Research
Gas Saturation (field)	33,700	1994-95	Aquatic Administration
GBD/WD (lab)	10,000	2	Aquatic Research
Genetic Analysis	14,000	6	Research Hatchery
Hatchery Sample Collection	19,000	6	Research Hatchery
Temporary Pathologist Salary	11,000	0	Pathology lab
Spore Loading/Gas Satu.(field)	121,000	18	Aquatic Research
U. N. Carolina Sample Analysis	13,000	1994-95	Aquatic Administration
Pathologist salary/CSU	11,000	0	Research Hatchery
Total	$555,300	44	

Additional Resources needed in 1995-96 to accomplish WD research priorities.

ACTIVITIES	DOLLARS	TEMP. FTE MONTHS	
DNA Analysis/CSU Contr.	$10,000	12	
On-going Path. Lab duties	57,500	27	
Species Susceptibility (lab)	10,000	5	$1,000 histopathology
CSU Contract for Pathologist	11,000	0	
CRN Habitat/tubifex (lab)	6,000	4	
GBD/WD Lab Experiment	36,500	9	$20,000 Grad Study
Spore Loading (lab)	11,500	6	$1,500 histopathology
Hatchery Infectivity	13,000	7	
Total	$155,500	70	5.8 FTE

Total cost of redirected and needed money without counting all the administrative time that will be spent by you, myself, Don Horak, Larry Harris, Tom Powell, and others is $710,800 of which Aquatic Resources has redirected enough resources to cover 78% and are requesting 22% be provided through additional allocations. In Summary we need an additional $155,500 and 70 temporary months.

Appendix E

Bellvue Hatchery

Location: Bellvue, Larimer County

Physical Structure: Built in 1924 and upgraded to present level of 68 hatchery troughs, 16 nurse basins, and 16 raceways.

Water Source: Hatchery and nurse basins operate on 500-1000 gpm at 54°F. Upper raceways operate on 700 gpm of recycled water pumped from settling ponds and this combines with nurse basin water to operate lower raceways.

Number of Personnel: 10.25 permanent FTEs and 15 months temporary (NOTE: numbers are total for both Bellvue and Watson)

Species Reared: Colorado River Rainbow, McConaughy Rainbow, Steelhead, brook, brown, kokanee, Snake River cutthroat, Pikes Peak cutthroat, Colorado River Cutthroat, golden and splake

Three-Year Production Average: 1.1 million subcatchables; average size 2.7 inches

Operating Costs: $208,200

Operating Cost per Inch Planted: $0.069

Fish Health History: 1970 - IPNV; 1972 - IHNV; 1991 - furunculosis; 1993 - BKD

Current Health Status: specific pathogen free

Watson Rearing Unit

Location: Bellvue, Larimer County

Physical Structure: twenty-four nurse basins and 14 raceways

Water Source: Watson Lake (Poudre River) 7,000 to 14,000 gpm at temperature of 36 to 68°F. Limited water in the winter results in recycling 2,500 to 5,000 gpm from November through March.

Number of Personnel: 10.25 permanent FTEs and 15 months temporary (NOTE: numbers are total for both Bellvue and Watson)

Species Reared: rainbow trout

Three-Year Production Average: 397,000 catchables average size 10.35 inches

Operating Costs: $326,491

Operating Cost per Inch Planted: $0.080

Fish Health History: 1975 - ERM & IPNV; 1977 - Bloodfluke; 1985 - "Ich" and Columnaris; 1986 - Gyrodactylus; 1993 - BKD; 1994 - BKD; 1995 - Whirling disease

Current Health Status: whirling-disease positive

Buena Vista Correctional Facility

Location: two miles south of the town of Buena Vista in Chaffee County

Physical Structure: The unit is on Colorado Department of Corrections property and is inside the perimeter fence. The unit has 20 raceways.

Water Source: springs 418 to 668 gpm

Operating Costs: $52,989

Operating Cost per Inch Planted: $0.130

Number of Personnel: one permanent FTE and inmate labor

Species Reared: rainbow trout and Snake River cutthroat

Three-Year Production Average: 22,000 catchables average size 9.52 inches and 38,000 subcatchables average size 5.14 inches

Fish Health History: 1988 - whirling disease; 1990 - ERM

Current Health Status: Specific pathogen free

Chalk Cliffs Rearing Unit

Location: on Chalk Creek in Chaffee County near the town of Nathrop

Physical Structure: Seven earthen rearing ponds and four main raceways adjacent to the ponds

Water Source: Chalk Creek. The creek flow fluctuates seasonally from about 25 cfs to well over 1,200 cfs. A good portion of the creek flow originates from warm springs upstream of the unit. Therefore, the water temperature is slightly higher than would be expected for the climate with a range of 40°F to 70°F.

Number of Personnel: six permanent FTE's, 10 months of temporary FTE's. Supervision is shared with Buena Vista.

Species reared: rainbow, brown, and Pike's Peak cutthroat

Three-Year Production Average: 820,000 catchables, average size 10.11 inches

Operating Costs: $428,683

Operating Costs per Inch Planted: $0.052

Fish Health History: 1975 - IPNV & ERM; 1984 - "Ich"; 1985 - ERM; 1988 - whirling disease

Current Health Status: whirling-disease positive

Crystal River Hatchery

Location: The brood unit is located on the Crystal River in Garfield County near the town of Carbondale.

Physical Structure: Hatchery building containing various egg containers and 10 hatchery troughs. The total number of outdoor raceway sections is fifty-four.

Water Source: Springs with an average flow of 1,000 gpm in the winter and 6,000 gpm in the summer. In addition, the unit has three wells but only one is used as the primary water supply and it has an average flow of approximately 1,100 gpm.

Number of Personnel: Three permanent FTE's, with supervision provided from the Glenwood Spring's hatchery. Sixteen months of temporary time shared with the Glenwood Springs hatchery.

Species Reared: Mainly rainbow trout brood fish.

Three-Year Production Average: 35,000 catchables (surplus brood fish and local catchable plants) average size 12.76 inches. In addition, the unit produces 16 million+ rainbow trout eggs.

Operating Cost: $207,732

Operating Cost per Inch Planted: $0.460 (NOTE: this figure does not take into account the main function of the unit - egg production)

Fish Health History: 1992 - bacterial coldwater disease

Current Health Status: specific pathogen free

Durango Hatchery

Location: The hatchery is situated in the town of Durango located on the Animas River in La Plata County.

Physical Structure: The hatchery building has 20 incubators and 40 troughs. The outside facility contains 20 nurse basins, 26 raceway sections, one concrete planting basin, and a show pond.

Water Source: Junction Creek through a filtration system produces an estimated average flow of 20 cfs. The temperature ranges from 42° to 58°F. The unit also has a seep collection pipe line which has a total capacity of 3.2 cfs in a temperature range of 49°F to 51°F.

Number of Personnel: 4.75 permanent FTE's, in addition, the supervisor is responsible for both Durango and Pitkin. The unit has 20 months FTE time.

Species Reared: rainbow trout, kokanee, Snake River cutthroat, Colorado River cutthroat, brook trout, and brown trout

Three-Year Production Average: 168,000 catchables with an average size of 10.35 inches and 998,000 subcatchables with an average size of 2.51 inches.

Operating Costs: $332,031

Operating Cost per Inch Produced: $0.078

Fish Health History: 1979 - BKD; 1981 - ERM

Current Health Status: Specific pathogen free

Finger Rock Rearing Unit

Location: The unit is located 3 miles south of the town of Yampa in Routt County.

Physical Structure: Five earthen ponds with a total surface are of 4.66 acres and two long raceways.

Water Supply: Two springs greatly influenced by irrigation, summer flows 6.3 cfs and winter flows 2.8 cfs. Water temperature varies from 42°F to 50°F. A second source of water is Pony Creek, but this source is seldom used.

Number of Personnel: Two permanent FTE's with supervision provided from the Rifle Falls hatchery. The unit also has 10 months of temporary time.

Species Reared: rainbow trout, Snake River cutthroat, and Emerald Lake cutthroat

Three-year production average: 273,000 catchable with an average size of 9.95 inches and 41,600 subcatchables with an average size of 2.32 inches.

Operating Costs: $166,858

Operating Costs per Inch Planted: $0.059

Fish Health History: 1978 - ERM; 1994 - whirling disease

Current Health Status: whirling-disease positive

Glenwood Springs Hatchery

Location: The hatchery is located on Mitchell Creek near the town of Glenwood in Garfield County.

Physical Structure: One hatchery building capable of holding 21 million eggs and hatching 5 million eggs, 12 nurse basins, and one series of raceways containing eight connecting units.

Water Source: Springs adjudicated for 3.75 cfs and a diversion on Mitchell Creek that is adjusted for 4.52 cfs. Water temperature from both sources varies from 34°F to 50°F.

Number of Personnel: Four permanent FTE's. The supervisor is responsible for both Glenwood and Crystal River. Sixteen months of temporary time are also split with Crystal River.

Species Reared: rainbow trout, kokanee, mackinaw, Colorado River cutthroat (A-strain), brook trout, and splake

Three-Year Production Average: 549 catchables at an average size of 20.37 inches (surplus brood fish) and 3 million subcatchables at an average size of 1.85 inches.

Operating Costs: $196,335

Operating Cost per Inch Planted: $0.036

Fish Health History: 1975 - BKD; 1987 - ERM

Current Health Status: Specific pathogen free

Mt. Ouray Hatchery

Location: Two miles northwest of Salida in Chaffee County.

Physical Structure: Small hatchery, 12 troughs and six nurse basins; plans are already approved to double the size of the hatchery and put in a UV filter system.

Water Source: one spring, 600 to 700 gpm, and one spring on the Hux lease that supplies 400 gpm of piped water to the unit

Number of Personnel: run in conjunction with Mt. Shavano hatchery

Species Reared: rainbow trout

One-Year Production: 348,000 subcatchables

Operating Cost: No figures available.

Operating Cost per Inch Planted: No figures available.

Fish Health History: 1989 - whirling disease

Current Health Status: whirling-disease positive but could become negative this month (May) with the completion of one more negative inspection.

Mt. Shavano Hatchery

Location: The hatchery is located on the Arkansas River ½ mile northwest of Salida in Chaffee County.

Physical Structure: Hatchery building containing 22 hatchery troughs/basins and 5 incubators. Six nurse basins (covered), along with 3,500 ft of outside raceways and 18 concrete rearing ponds.

Water Source: Surface water, Arkansas River amounting to 17 cfs; springs, seepage and Mt. Ouray hatchery recycled water can total approximately 10-26 cfs.

Number of Personnel: 10.6 permanent FTE's and 12 months of temporary time (NOTE: this unit is operated in conjugation with the Mt. Ouray hatchery)

Species Reared: rainbow trout, Snake River cutthroat, Pikes Peak Cutthroat, kokanee, brook trout, brown trout, mackinaw, and splake

Three-Year Production Average: 764,000 catchables with an average size of 9.95 inches and 932,000 subcatchable with an average size of 3.21 inches

Operating Costs: $607,719

Operating Cost per Inch Planted: $0.057

Fish Health History: 1975 - ERM and IPNV; 1982 - Gyrodactylus and Epistylis; 1983 - IHNV; 1985 - "Ich"; 1987 - whirling disease; 1990 - Nodular gill disease and 1992 - BKD

Current Health Status: whirling-disease positive

Pitkin Hatchery

Location: The hatchery is located adjacent to Quartz Creek approximately 3/4 mile southwest of the town of Pitkin in Gunnison County.

Physical Structure: Hatchery building contains 48 hatchery troughs and three incubators. Twenty-five nurse basins are located outside, along with 3,500 feet of raceways and six earthen ponds.

Water Source: Surface water (Quartz Creek) approximately 10 cfs, water temperature varies from 34°F to 70°F; ground water is also collected by 240 feet of perforated pipe with a capacity of 12.6 cfs. Springs can account for up to 3.87 cfs.

Number of Personnel: six permanent FTE's (NOTE: supervision is shared with the Durango hatchery) and 20 months of temporary labor

Species Reared: rainbow trout, brook trout, Snake River cutthroat, Pikes Peak cutthroat, and brown trout

Three-Year Production Average: 278,000 catchables with an average size of 9.24 inches and 236,000 subcatchable with an average size of 2.70 inches

Operating Costs: $290,096

Operating Cost per Inch Planted: $0.090

Fish Health History: 1975 - IPNV; 1984 - ERM; 1989 - Strawberry disease

Current Health Status: Specific pathogen free

Poudre Rearing Unit

Location: The unit is located on the Poudre River, 47 miles west of Fort Collins in Larimer County.

Physical Structure: 12 raceways and eight earthen ponds totaling 7.65 acres

Water Source: surface water (Poudre River) with the DOW owning a total of 36 cfs

Number of Personnel: 2.75 permanent FTE's, with shared supervision coming from the Watson Unit, and 3.5 months of temporary time

Species Reared: rainbow trout and Snake River cutthroat

Three-Year Production Average: 308,000 catchable with an average size of 9.92 inches and 75,500 subcatchables with an average size of 7.13 inches

Operating Costs: $174,558

Operating Cost per Inch Planted: $0.049

Fish Health History: 1978 - IPNV & ERM; 1988 - whirling disease; 1993 - tapeworms; 1994 - Costia, nodular gill disease and gill lice

Current Health Status: whirling-disease positive

Rifle Falls Hatchery

Location: The hatchery is situated 18 miles northeast of Rifle on Rifle Creek in Garfield County.

Physical Structure: Hatchery contains 36 basins and 11 incubators. Thirty-two nurse basins are located outside along with 40 raceway sections. A set of lower raceways along with 11 earthen ponds are no longer used because of a unique disease problem (Type C botulism).

Water Source: Surface water (east Rifle Creek) average flow of 38.4 cfs; spring collection line 10.8 cfs

Number of Personnel: 11.75 permanent FTE's. The supervisor is also responsible for both Rifle Falls and Finger Rock.

Species Reared: Rainbow trout, Snake River cutthroat, Colorado River cutthroat, brown trout, kokanee, and Mackinaw

Three Year Production Average: 677,000 catchables with an average size of 10.14 inches and 1.3 million subcatchables with an average of size 4.04 inches

Operating Costs: $772,071

Operating Cost per Inch Planted: $0.046

Fish Health History: 1975 - ERM; 1978 - IPNV; 1984 - Bacterial coldwater disease and Costia; 1985 - Columnaris; 1986 - Type C botulism and Gyrodactylus; 1990 - Gill amoeba; 1994 - whirling disease

Current Health Status: Whirling disease positive

Roaring Judy Hatchery

Location: The hatchery is located 4 miles north of Almont adjacent to the East River in Gunnison County.

Physical Structure: hatchery building contains 26 hatchery troughs, 22 basins, and 22 incubators. The outside facility is composed of 36 nurse basin (some are covered with bird netting); 10,800 feet of raceway space, and 6 earthen rearing ponds.

Water Source: surface water (East River) 46 cfs adjudicated. Springs, seep and wells total 53 cfs adjudicated.

Number of Personnel: Nine permanent FTE's and 6 months of temporary time

Species Reared: rainbow trout, brook trout, Emerald Lake cutthroat, Pike's Peak cutthroat, Snake River cutthroat, kokanee (spawn taking and rearing); and Mackinaw

Three Year Production Average: 405,000 catchables with an average size of 10.61 inches and 1.9 million subcatchables with an average size of 2.19 inches (NOTE: the unit also spawns wild kokanee running up the East River)

Operating Costs: $500,346

Operating Cost per Inch Planted: $0.059

Fish Health History: 1979 - ERM; 1981 - Furunculosis; 1985 - Columnaris, "Ich", and Costia; 1986 - Epistylis, Gyrodactylus, Trichodina and Bacterial coldwater disease; 1987 - Strawberry disease; 1988 - Whirling disease; 1990 - Nodular gill disease

Current Health Status: Whirling disease positive

Las Animas

Location: Near the town of Las Animas in Bent County.

Physical Structure: 13 ponds and 250 feet of raceways. Indoors: 6 nurse basin tanks and 6 troughs

Water Source: Adobe Creek 3-4 cfs

Number of Personnel: 3 permanent FTE's (with some supervision provided by the Wray Hatchery) and 10 months of temporary time

Species Reared: catfish, crappie, hybrid grass carp, northern pike, Sacramento perch, walleye, white bass, yellow perch, and rainbow trout

Three Year Production Average: 559,000 warmwater fish at an average size of 1.93 inches

Operating Costs: $173,843

Operating Cost per Inch Planted: $0.161

Fish Health History: 1985 - "Ich"; 1986 - Costia and Bass tapeworm; 1987 - white grub

Current Health Status: Channel catfish virus disease (CCVD)

Wray

Location: Three miles east of the town of Wray in Yuma County.

Physical Structure: Hatchery building has 18 hatchery basins 17 circular tanks and 3 incubation batteries for walleye eggs. The outside facility contains 27 rearing ponds and 13 raceways.

Water Source: hatchery spring averages 600 gpm and surface water (Chief Creek) which averages 3-5 cfs

Number of Personnel: 4 permanent FTE's (supervisor is also responsible for overall supervision of Las Animas Hatchery) and 12 months of temporary time

Species Reared: channel catfish, crappie, fathead minnows, hybrid grass carp, northern pike, sunfish, tiger muskie, walleye, rainbow trout

Three Year Production Average: 26.8 million warmwater species averaging 0.29 inches (NOTE: Wray is a major walleye hatching hatchery which is reflected in the small size of the average fish planted)

Operating Costs: $280,368

Operating Cost per Inch Planted: $0.037

Fish Health History: 1982 - White grub; 1983 - Trichodina and Gyrodactylus; 1985 - Copepoda, "Ich", Anchor worm, and bass tapeworm; 1986 - Chllodonella; 1987 - Costia; 1995 - Henneguya

Current Health Status: Specific pathogen free

Pueblo

Location: Directly east of Pueblo Reservoir in the county of Pueblo.

Physical Structure: Hatchery building includes 5 rearing basins, 32 circular tanks, and 15 troughs. The outside facility contains 32 concrete raceways and 32 dirt ponds encompassing 25 surface acres of water.

Water Source: Pueblo Reservoir can supply up to 30 cfs of water and three wells produce up to 450 gpms. Water conditioning systems are connected to the water sources

Number of personnel: 7 permanent FTE's and 15 months of temporary time

Species Reared: largemouth bass, bluegill, blue and channel catfish, sauger, saugeye, walleye, wiper, Snake River cutthroat, and rainbow trout

Three Year Production Average: 87,000 catchable rainbow trout with an average size of 9.86 inches; 537,000 subcatchable trout with an average size of 3.77 inches, and 18 million warmwater fish with an average size of 0.61 inches (NOTE: Pueblo is a major walleye hatching hatchery which is reflected in the small size of the average subcatchable planted).

Operating Costs: $453,539

Operating Cost per Inch Planted: $0.033

Fish Health History: 1993 - Costia

Current Health Status: Specific pathogen free but suspect for whirling disease. WD+, free-ranging rainbow trout have been found near the hatchery water intake.

Appendix F

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05/16/96

LEADVILLE NFH FISH DISTRIBUTION
FY 1995 (10/01/94-09/30/95)

SPECIES	NUMBER STOCKED	SIZE INCHES	DATE STOCKED	WATER	MANAGEMENT AREA
CUT	1408	2.0	10/14/94	DECKERS LAKE	COLORADO
CUT	3179	2.4	09/12/95	ELEVEN-MILE RES.	COLORADO
CUT	323	2.9	10/19/94	SMALL BIRD	FORT CARSON
CUT	2617	2.9	10/19/94	TOWNSEND	FORT CARSON
CUT	1117	2.9	10/19/94	WOMACK	FORT CARSON
CUT	12165	4.7	09/11/95	ELEVEN-MILE RES.	COLORADO
CUT	5777	7.2	10/20/94	TELLER RESERVOIR	TELLER RESERVOIR
CUT	1700	8.1	07/13/95	DEADMANS	AIR FORCE ACADEMY
CUT	201	8.1	07/13/95	WOMACK	FORT CARSON
CUT	1094	8.1	07/13/95	KETTLE #3	AIR FORCE ACADEMY
CUT	2574	8.4	04/27/95	GENERALS POND	FITZSIMONS H
CUT	1055	8.4	03/14/95	GENERALS POND	FITZSIMONS H
CUT	1002	8.4	03/08/95	WOMACK	FORT CARSON
CUT	900	8.4	03/09/95	ICE LAKE	AIR FORCE ACADEMY
CUT	3014	8.4	03/09/95	GOLF COURSE PONDS	PETERSON AFB
CUT	1300	8.4	03/08/95	HAYNES	FORT CARSON
CUT	1300	8.4	03/08/95	TOWNSEND	FORT CARSON
CUT	2000	8.4	03/14/95	WILLIAMS LAKE	BUCKLEY ANG
CUT	4009	8.4	04/27/95	BUCKLEY LAKE	BUCKLEY AFB
CUT	414	8.4	03/08/95	SMALL BIRD	FORT CARSON
CUT	900	8.4	03/09/95	KETTLE #1	AIR FORCE ACADEMY
CUT	1118	8.4	03/09/95	KETTLE #3	AIR FORCE ACADEMY
CUT	1100	8.4	03/09/95	KETTLE #2	AIR FORCE ACADEMY
CUT	2631	8.5	05/11/95	WOMACK	FORT CARSON
CUT	2012	8.5	05/11/95	TOWNSEND	FORT CARSON
CUT	3970	8.5	05/23/95	PLATTE CANYON RES.	COLORADO
CUT	1005	8.5	05/11/95	HAYNES	FORT CARSON
CUT	505	8.5	05/11/95	SMALL BIRD	FORT CARSON
CUT	4040	8.5	05/02/95	GOLF COURSE PONDS	PETERSON AFB
CUT	1206	8.6	05/18/95	KETTLE #1	AIR FORCE ACADEMY
CUT	1000	8.6	08/08/95	WOMACK	FORT CARSON
CUT	2003	8.6	05/18/95	DEADMANS	AIR FORCE ACADEMY
CUT	1000	8.6	08/23/95	DEADMANS	AIR FORCE ACADEMY
CUT	2010	8.6	07/27/95	WOMACK	FORT CARSON
CUT	2304	8.6	06/01/95	WOMACK	FORT CARSON
CUT	1037	8.6	08/08/95	TOWNSEND	FORT CARSON
CUT	2004	8.6	06/01/95	HAYNES	FORT CARSON
CUT	5650	8.6	07/27/95	TOWNSEND	FORT CARSON
CUT	3004	8.6	06/01/95	TOWNSEND	FORT CARSON
CUT	701	8.6	06/01/95	SMALL BIRD	FORT CARSON
CUT	2801	8.6	05/18/95	KETTLE #3	AIR FORCE ACADEMY
CUT	1799	8.6	08/23/95	KETTLE #3	AIR FORCE ACADEMY
CUT	1400	8.6	08/08/95	KETTLE #3	AIR FORCE ACADEMY
CUT	2003	8.6	05/18/95	KETTLE #2	AIR FORCE ACADEMY
CUT	493	8.6	08/08/95	KETTLE #2	AIR FORCE ACADEMY
CUT	5008	8.7	06/08/95	BUCKLEY LAKE	BUCKLEY AFB
CUT	3005	8.7	06/08/95	GENERALS POND	FITZSIMONS H
CUT	938	8.7	07/27/95	LEO EFFLUENT POND	USFWS
CUT	1000	8.9	08/30/95	WOMACK	FORT CARSON
CUT	1000	8.9	08/08/95	DEADMANS	AIR FORCE ACADEMY
CUT	15052	8.9	08/29/95	CLEAR CREEK RES.	COLORADO
CUT	3001	8.9	08/30/95	TOWNSEND	FORT CARSON

LEADVILLE NFH FISH DISTRIBUTION
FY 1995 (10/01/94-09/30/95)

SPECIES	NUMBER STOCKED	SIZE INCHES	DATE STOCKED	WATER	MANAGEMENT AREA
CUT	21273	9.0	09/11/95	ELEVEN-MILE RES.	COLORADO
CUT	600	9.0	08/08/95	KETTLE #1	AIR FORCE ACADEMY
CUT	2067	9.1	08/22/95	GRACE	FARISH MEMOR
CUT	1857	9.1	08/22/95	LEO	FARISH MEMOR
CUT	1357	9.1	08/22/95	SAPPHIRE	FARISH MEMOR
CUT	1322	9.1	08/23/95	KETTLE #2	AIR FORCE ACADEMY
CUT	900	9.1	08/23/95	KETTLE #1	AIR FORCE ACADEMY
CUT	2250	9.2	05/24/95	LEO	FARISH MEMOR
CUT	3150	9.2	05/24/95	GRACE	FARISH MEMOR
CUT	1804	9.2	05/24/95	SAPPHIRE	FARISH MEMOR
CUT	1700	9.3	06/21/95	TOWNSEND	FORT CARSON
CUT	500	9.3	06/21/95	SMALL BIRD	FORT CARSON
CUT	1007	9.3	10/13/94	BUCKLEY LAKE	BUCKLEY AFB
CUT	1200	9.3	06/21/95	WOMACK	FORT CARSON
CUT	842	9.3	06/21/95	HAYNES	FORT CARSON
CUT	2000	9.3	06/21/95	GOLF COURSE PONDS	PETERSON AFB
CUT	1157	9.3	05/24/95	LED EFFLUENT POND	USFWS
CUT	999	9.4	07/12/95	GRACE	FARISH MEMOR
CUT	2502	9.4	07/12/95	SAPPHIRE	FARISH MEMOR
CUT	515	9.4	10/19/94	GOLF COURSE PONDS	PETERSON AFB
CUT	2499	9.4	07/12/95	LEO	FARISH MEMOR
CUT	999	9.4	07/13/95	KETTLE #1	AIR FORCE ACADEMY
CUT	507	9.4	08/08/95	KETTLE #2	AIR FORCE ACADEMY
CUT	1221	9.4	07/13/95	KETTLE #3	AIR FORCE ACADEMY
CUT	1800	9.4	07/13/95	KETTLE #2	AIR FORCE ACADEMY
CUT	617	9.4	10/20/94	LED EFFLUENT POND	USFWS
CUT	735	9.7	06/27/95	SAPPHIRE	FARISH MEMOR
CUT	849	9.7	06/27/95	LEO	FARISH MEMOR
CUT	1307	9.7	06/27/95	GRACE	FARISH MEMOR
CUT	438	9.7	06/27/95	DEADMANS	AIR FORCE ACADEMY
CUT	438	9.7	06/27/95	KETTLE #1	AIR FORCE ACADEMY
CUT	735	9.7	06/27/95	KETTLE #2	AIR FORCE ACADEMY
CUT	1307	9.7	06/27/95	KETTLE #3	AIR FORCE ACADEMY
SPECIES TOTAL	186303				
LAT	7105	6.6	07/07/95	RAMPART RES.	COLORADO
SPECIES TOTAL	7105				
RBT	1027	8.9	11/17/94	GRACE LAKE	FARISH O.R.A.
RBT	3040	9.4	05/23/95	PLATTE CANYON RES.	COLORADO
RBT	5856	9.8	08/03/95	TWIN LAKES	COLORADO
RBT	63100	9.8	06/22/95	SPINNEY MT. RES.	COLORADO
RBT	10089	9.8	05/19/95	CLEAR CREEK RES.	COLORADO
RBT	5025	10.0	06/22/95	LED EFFLUENT POND	USFWS
RBT	30020	10.2	08/10/95	ELEVEN-MILE RES.	COLORADO
SPECIES TOTAL	118157				
	311565	HATCHERY TOTAL			

Appendix G

ge No. 1 HOTCHKISS NFH FISH DISTRIBUTION
/16/96 FY 1995 (10/01/94-09/30/95)

ECIES	NUMBER STOCKED	SIZE INCHES	DATE STOCKED	WATER	MANAGEMENT AREA
3T	157859	4.4	07/25/95	BLUE MESA RESERVOIR	CRSP
3T	39105	4.7	08/22/95	BLUE MESA RESERVOIR	CRSP
3T	8000	4.7	10/20/94	GUNNISON RIVER	COLORADO
3T	5000	4.7	10/19/94	UNCOMPAHGRE RIVER	COLORADO
3T	380631	4.8	05/05/95	BLUE MESA RESERVOIR	CRSP
3T	135841	5.0	07/05/95	BLUE MESA RESERVOIR	CRSP
3T	273521	5.3	09/19/95	MCPHEE RESERVOIR	CRSP
3T	193705	5.7	03/16/95	NAVAJO RESERVOIR	CRSP
3T	3734	5.7	09/28/95	NORTH FORK GUN. RIVR	COLORADO
3T	6620	6.6	12/21/94	RIDGEWAY RESERVOIR	COLORADO
3T	3049	6.6	12/21/94	UNCOMPAHGRE RIVER	COLORADO
3T	32362	7.1	05/01/95	HERON RESERVOIR	NEW MEXICO
3T	13267	8.2	06/01/95	LEMON RESERVOIR	CRSP
3T	32320	8.2	08/09/95	LEADVILLE NFH	USFWS
3T	22722	8.3	09/11/95	HERON RESERVOIR	NEW MEXICO
3T	10476	8.9	03/29/95	CRAWFORD RESERVOIR	CRSP
3T	40061	9.0	04/19/95	RIDGEWAY RESERVOIR	CRSP
3T	1047	9.4	06/27/95	MESA LAKE	COLORADO/GRAND MESA
3T	500	9.4	06/27/95	SUNSET LAKE	COLORADO/GRAND MESA
3T	600	9.4	06/27/95	JUMBO LAKE	COLORADO/GRAND MESA
3T	7416	9.4	09/11/95	HERON RESERVOIR	NEW MEXICO
3T	1419	9.4	05/23/95	MONTE VISTA NWR POND	MONTE VISTA NWR
3T	7996	9.5	04/28/95	HERON RESERVOIR	CRSP
3T	500	9.7	06/28/95	ENOCH RES.	COLORADO/GRAND MESA
3T	500	9.7	06/28/95	FRUITLAND RES. #1	COLORADO/GRAND MESA
3T	1500	9.7	06/19/95	COLLBRAN(RESERVOIRS)	COLLBRAN JC
3T	1000	9.7	06/28/95	FRUITLAND RES. #4	COLORADO/GRAND MESA
3T	3000	12.0	07/07/95	STAGECOACH RESERVOIR	COLORADO
3T	1124	12.1	08/02/95	NEVERSWEAT RES.	COLORADO/GRAND MESA
3T	893	12.1	08/02/95	COTTONWOOD RES. #4	COLORADO/GRAND MESA
3T	2000	12.5	07/26/95	COTTONWOOD RES. #1	COLORADO/GRAND MESA
3T	990	12.8	08/10/95	LOST LAKE SLOUGH	COLORADO/GRAND MESA
3T	308	12.8	08/29/95	BAILEY RESERVOIR	COLORADO/GRAND MESA
3T	630	12.8	08/08/95	COTTONWOOD RES. #4	COLORADO/GRAND MESA
3T	1170	12.8	08/08/95	COTTONWOOD RES. #1	COLORADO/GRAND MESA
3T	1045	12.8	07/29/95	HOT. FISHING DERBY	HOTCHKISS NFH PONDS
PECIES	-------				
OTAL	1391911				

1391911 HATCHERY TOTAL

STATE OF COLORADO
DIVISION OF WILDLIFE
DEPARTMENT OF NATURAL RESOURCES

TO: Walt Graul

FROM: Grady McNeill

DATE: May 16, 1996

SUBJECT: Hatchery Water Rights Proposed for Closure

You had asked for an assessment of the water right situation of several hatcheries being considered for closure. Specifically you had asked for "red flags". There are some site specific issues associated with each of the hatcheries being considered for closure which I will discuss below. First some general red flag issues the leadership team needs to be aware. For any unit being considered for closure the first 'red flag' issue is whether the DOW intends to abandon the unit as a fish production facility and the water rights used in the production of fish. In other words do we intend to abandon a portion of the assets as part of the closing decision. If not, we need to be very clear that the closure is not an act of abandoning the asset.

Briefly, the abandonment of a water right requires two actions. First, there needs to be an intent to abandon, which a closure could be construed to be. The second action is non use of the water right. It typically takes 10 years of nonuse to raise the issue of abandonment. The intent to abandon can be formed simply from non use but it would take 40 years to form the intent in this manner. However, as a practical matter, each year of non use has the effect of reducing the entitlement of a water right to divert its full amount particularly. This will be a significant issue in reopening unit in the future.

The second 'red flag' is if we establish that we don't intend to abandon the water right, how do we protect it from diminution by the exercise or changes of other water rights. We have actively pursued court action to protect our hatchery water rights from diminution resulting from changes in water rights and water management in the streams on which our rights are located. We will need to develop a strategy for continuing to protect the water rights absent actual use of the water right.

We might want to consider leasing the hatchery water rights to the Colorado Water Conservation Board as part of the instream flow program. However, there is a red flag issue with this scenario that you should be aware. The CWCB could lease our water rights for instream flow purposes, however they could not accept water rights in excess of the amount necessary to protect the

natural environment to a reasonable as established by their rules and regulations. For example, the instream flow amount deemed necessary to protect the natural environment to a reasonable degree on Chalk Creek is 20 cfs, the DOW hatchery water rights on Chalk Creek amount to 36.7 cfs. In this case, the CWCB might be willing to accept 20 cfs but we would need to have a strategy to protect the remaining 16.7 cfs.

Chalk Cliffs Hatchery

As mentioned above the DOW has a right to use 36.7 cfs of water out of Chalk Creek when the water is physically available in the stream. These water rights are fairly secure because of the relative seniority. The right to use this water is from a combination of DOW owned decrees and perpetual right of use easements. At least one of the perpetual use easements reverts the water rights in the event the DOW abandons the fish production activities at the hatchery.

Over the years, we have been vigilant in protect the DOW water rights from water right changes within the basin that would deplete the flow of Chalk Creek. In particular, we were concerned about the winter months. The DOW's hatchery water rights are the only winter time use water on Chalk Creek. This has prevented dry up of the Chalk Creek. We recently entered into a stipulation with the Upper Arkansas Water Conservancy District that effectively limits the amount of water use (and development) above the hatchery. If we shut the unit down, the district may move to change the terms of the agreement or simply ignore it. We also have other stipulations with other water users on Chalk Creek that have been entered into to protect the hatchery water right which could be negated by the closure of the unit.

You might recognize that a spinoff of the hatchery water operation is a significant amount of aquatic and terrestrial habitat protection.

Finger Rock

There are no legal water right problems at the Finger Rock Unit that I am aware. The only problem that has historically existed at the unit is a limited physical water supply, combined with fluctuations of flow between winter and summer.

Mt. Shavano

Because of expansion at the Mt. Shavano/ Mt Ouray Units in the past decade, combined with the Arkansas River Compact Litigation, we are currently working on a water augmentation plan for the unit. Unless we intend to shut the unit down permanently, we need to get the augmentation plan decreed before the unit production is cutback.

Roaring Judy

We are currently addressing some minor water right issues at Roaring Judy related to three wells on the unit. Other than cleaning up these issues there are no legal water rights issues related to our water use at this facility.

However, the East River drainage above the hatchery is rapidly being developed. Again we have been vigilant in protecting our water rights at the unit. If it were to be closed, enforcement of those stipulations would be difficult. There are currently several plans for water development in the East River drainage that would significantly dewater the drainage resulting in both Aquatic and Terrestrial habitat impacts. Further, if the Roaring Judy unit were closed, we would likely have a significant fight to reestablish our water use on the East River.

Watson

We developed a water augmentation plan for the Bellvue and Watson units in 1987 and all water uses at these units are fully protected. However the augmentation plan does not guarantee a full physical water supply in the Poudre River. There are times when the Poudre River stream flows drop to very low levels because of senior irrigation and municipal water diversions upstream from the unit. We have had some informal discussion with the City of Fort Collins to help us solve the low flow conditions.

Again, we have been vigilant in protecting the water rights of the unit. There are plans by the City of Thornton that would effectively dry up the Poudre River at the mouth of the Poudre Canon. If the Watson Unit were taken off line, it would be difficult to enforce these stipulations and reopening the unit would be extremely difficult and costly.

GM/
cc: Towry
Kochman

We have been in negotiations with the City of Salida to exchange some irrigation water that currently doesn't benefit the fish production for augmentation water. If we intend to shut the unit down, the City will be unlikely to complete the exchange.

We have been vigilant in protecting the water rights for the Mt. Shavano Unit and we have secured a number of stipulations with water users to prevent injury to the hatchery water rights. If the unit is shut down those stipulations may become unenforceable.

Poudre River Unit

There are water right problems at the Poudre Unit which needs to be addressed. Most of the water used on the unit is currently decreed for irrigation and not for fish production. Unless we intend to close the unit permanently, we need to file to have the water rights changed to fish propagation. We would probably have the benefit of some grand fathering in of the change of water rights because of the water laws that were in effect at the time we purchased and built the Poudre Unit. However, even if the change of water right is approved, there will likely be a need to have a water augmentation plan, because the water rights on the unit are relatively junior.

If the changes are not taken care of in advance of closing the unit, the cost of reopening the unit in the future will likely be prohibitive. Water cost in the Poudre have risen sharply because of demand and growth.

Rifle Falls

We have been working on a change of water right and water augmentation plan for the Rifle unit for several years. Currently, we are within a few weeks of getting the augmentation plan approved. Once it is approved, Rifle will have the most secure water supply of any unit in the state. Because of the trouble we have had with other water users on Rifle Creek in decreeing our augmentation plan, if we shut the unit down we are likely to be in for a fight to reopen it. The water users are attempting to pose terms in our augmentation plan that would reduce our future augmentation claim to only that amount we actually use. In other words, if we shut the unit down for a period of time and in the future try to reopen it, they could force us to operate as a much smaller size unit than we currently operate. We have been resisting these terms in our negotiation with the users.

As an aside, based on my knowledge of the spring supply, it would be relatively cheap to reduce and/or eliminate the source of WD contamination at this unit. By simply extending the collection pipelines into the springs, we could take advantage of the hundreds of feet of aquifer thickness between the recharge zones on the Flat Tops and our collection system. I have serious question as to whether further contamination treatment (such as UV) would be necessary if the extension of the spring collection lines were constructed.

Divisional Correspondence

STATE OF COLORADO
DIVISION OF WILDLIFE
DEPARTMENT OF NATURAL RESOURCES

TO: Walt Graul

FROM: Patty Mercer/Grady McNeill

DATE: May 16, 1996

SUBJECT: Hatchery Water Rights

Grady asked me to review his memo regarding hatchery water rights. Unfortunately my timing didn't correspond with Grady's and he has already sent his memo to you. Therefore, my comments are follow up and are with regard to the value of the water rights.

Grady's memo refers to abandoning of the water rights due to the hatchery closure and the result being the loss of an "asset". Colorado law recognizes water rights as property rights and as such, Division owned water rights need to be viewed as assets, just as land is viewed as an asset. In addition to the potential loss of the water rights due to non use, the market value of the rights decrease with every year of non use. Every year that a "0" is recorded by the Division of Water Resources for non use, that "0" is calculated into the determination of the historic consumptive use. Consumptive use is the actual amount of water consumed, i.e. crops consume a specific amount of water, some of the water evaporates or flows off the fields. The consumptive use amount is the amount of water that is available for sale, not the entire water right as decreed. In the case of the fish hatcheries, the consumptive use is relatively low because the operation of the hatcheries does not result in high consumptive use figures.

If the hatcheries are closed for a period of time and then reopened, the Division will face the issues of receiving less water due to lack of use. If the hatcheries are not reopened and are sold the Division will receive far less value of the water, as compared to other water sales in the area.

PUBLIC INPUT

Responses to Public Comments:

By August 23, 1996, we received comments, suggestions and questions from the following people or organizations:

1. Jerry Hart--United Sportsmen's Council
2. Larry Strohl
3. Michael D. Stone--Wyoming Game and Fish Department
4. Greg Policky
5. Robert J. Behnke--CSU
6. Ken Cline--Cline Trout Farms
7. Lynn M. Ensley--Colorado Sportsmen Wildlife Fund, Inc.
8. David Nickum--Trout Unlimited
9. Fisheries Program Manager--National Park Service
10. Richard Domingue
11. Brenda Mitchell--Bureau of Land Management
12. Mike Miller--Colorado Fishing Federation
13. Keith A. Johnson--Idaho Fish & Game, Fish Health Lab
14. Mary McAfee
15. Duane L. Shroufe--Arizona Game and Fish Department

It would have been impractical to address each comment or question separately, but we tried to address all of the input we received. The following is a summary of that input, grouped by topic. Hopefully, our responses aimed at the general topic covered the points raised by the majority of those who contributed.

User Surveys and Economic Studies:

Comment: A few comments focused on "user surveys", questioning the recommendation for a "willingness-to-pay" component to the study, suggesting that users already pay their share, that the data in Table 9 were misleading, and noted that evidence from other states suggested that the stocking of catchable trout is not the governing factor controlling license sales. We were also urged to consider the potentially significant effects of our recommendations on local and state economies.

Response: Confusion about "demand" involves distinguishing between what anglers do and what they want. The authors acknowledged the uncertainty of making comparisons across time with the preference questionnaire results, but it is clear that there are distinct differences between what anglers prefer in fishing opportunities (wild trout-70%/catchable trout-12%) and what they actually participate in (78% of people fished in put-and-take waters/41% of people fished in wild trout waters). All data are

open to interpretation. Certainly there may be other factors (e.g.,changing angling regulations; stocking patterns) that affect the percentage of anglers that claim they fish in put-and-take fisheries (Table 9). Our point here (and with similar issues in the Assessment) was not that exactly 78% of the anglers in Colorado fish in put-and-take waters, but that the proportion of anglers using put-and-take waters was significant, and that when compared with data from 1982 and 1986, the trend was upward.

The cause/effect in this trend was attributed by a reviewer to actions by CDOW, that expanded the number of put-and-take waters, making more available to the public. No factual basis is provided to support this statement, but even if true, it does not take away from the indication that a large segment of the angling public in Colorado did fish at put-and-take waters in 1994. This cannot necessarily be tied to the availability of these waters, nor does it suggest these people fished only in put-and-take waters. The trend in Table 9 to suggest fishing at put-and-take waters has increased is certainly possible given the increase in Front Range urban population.

We know that there are other factors affecting fishing participation (anglers' satisfaction and willingness-to-pay); we know that people who fish in Colorado are already paying for the opportunity to catch fish, but anglers are not a homogenous group in the types of angling opportunities they engage in. One of the alternatives recommended was targeted at better defining this dichotomy between preference and use through the willingness to pay study. This would also suggest how the angling community desires to see their license revenues spent on alternative management options such as wild trout and catchable trout. We know that economists have said that the costs of producing catchable-sized trout that are stocked into some waters in Colorado outweigh the economic benefits derived from fishing for those trout. We propose economic-based studies and angler surveys to gain the reliable information needed by the DOW to be able to determine the "need" for hatchery-reared fish, and effectively manage our wild and native fisheries as well as our catchable trout fisheries.

Willingness to pay studies are one economic tool to assess the public value of commodities. Understanding that economic approaches cannot capture all the values associated with wildlife or an angling experience, they can still be used in concert with other economic, philosophical, ecological and biologic criteria to guide management decisions regarding recreational opportunities and fisheries possible in a range of habitat types. The DOW should not avoid access to this type of information.

A user pay mechanism (Alternative #14) would not be implemented until the results of the study(ies) generated in Alternative #13 are available for review. These studies will differentiate among different users, what they prefer, what they would be willing to pay to sustain what they prefer, and the relative economic benefits associated with each type of fishery option. As indicated in Alternative #14, the desire is to establish a procedure for indexing public demand for hatchery products like catchable trout to guide a more efficient production of these products within the hatchery system. As

indicated before, implementation of a user pay mechanism that employed added fees, however targeted, would be subject to discussion and approval through the Wildlife Commission and State legislature.

The authors are aware that some of the recommendations touted in this Assessment could have effects on local and regional economies. None of us want to cause any economic hardship, and neither do we want to risk damaging Colorado's natural resources--we are clearly asking for "expert" help in this area. The long-term consequences of making a mistake now are so severe, that we advocate a conservative approach. It would be irresponsible for us to risk the future of our healthy aquatic habitats in the name of short-term gain. Sure, the temporary loss of 500,000 recreation-days on the westslope is significant! But part of our mandate is to consider that loss along with the protection of our native and wild fisheries, and the long-term productivity of our waters.

Demand Studies:

Comment: Almost everyone had an opinion about what contributes to the "demand" for hatchery fish: angler satisfaction is a primary factor; the 78% participation rate for put-and-take fisheries shows that hatchery product is important, yet in California, the stocking of catchable trout didn't affect license sales; and there appears to be a philosophical bias against stocking in Colorado, and a management bias toward stocked trout.

Response: One of our conclusions was that the DOW should generate more conclusive information to justify the kinds, numbers and sizes of fish needed to meet management goals and guide the production of hatchery fish. The ability of various waters to sustain fish populations and the need for stocking fish was recognized and discussed in detail in the Recreation section of the report. This could be interpreted as a "stocking bias" by some. Aside from the contradictory inputs like, "the DOW has a bias both for and against stocking", we believe most reviewers made some good points. Satisfaction is important to angler participation and the ultimate sale of licenses; but what are the factors that make up that satisfaction? From the scientific literature we know that studies of "demand" and angler satisfaction have identified the important variables that contribute to angler satisfaction. Some studies, for example, showed that scenery, solitude, lack of traffic and other factors were considered more important by anglers than any factor relating to the fish they caught. Having up-to-date information would allow the DOW to better address satisfaction by concentrating on the factors that contribute to it.

Education:

Comment: It was evident that many readers believed that education and communication will be an important way to curb the spread of whirling disease, and deal with other issues (e.g., advise public of all potential problems and solutions; curb the spread of WD by piscivorous birds, equipment, anglers; public education about "under-utilized" fishery resources in Colorado; educate anglers about how to handle fish more carefully, and to catch/handle fewer fish, and don't advertise the schedule of the fish stocking truck).

Response: Until there is an effective way to control or eliminate WD from the wild in Colorado, the DOW should promote every means possible to keep waters from becoming WD-positive, and slow the progression of the parasite within habitats where it already exists. This will involve communication and education among DOW employees and peers in other agencies who use equipment in the field, and among others who frequent the state's aquatic habitats to alert them about the importance of protecting the state's WD-negative waters. We should also be more forthcoming about the status of the work we (and others) have already done, or plan to combat WD in Colorado. These efforts will rely heavily on our Education and Information specialists, and our rapport with experts in other agencies.

Budget Issues:

Comment: There were a few questions aimed at the Aquatic Program's budget, asking for a reconciliation of the amounts allocated and spent (for hatchery production), and suggesting that the Aquatic Section seeks to maximize its budget.

Response: In this Assessment we tried to provide ideas about what could be done to make the hatchery system more efficient and responsive to DOW's management "needs", and deal with pathogens (like whirling disease). Our assignment didn't include an evaluation of the DOW's budget, so the only real reference to dollars will be in the Action Plan now appended to the Assessment. It deals with timelines, human resources and dollars for the work that DOW plans to do. Changes to the license fee structure alluded to via user pay mechanisms cannot be implemented without going through the 3-step process of the Wildlife Commission and legislative approval of the budget. The Aquatic Section budget analysis requested would be part of the justification necessary.

Native/Wild Trout Issues:

Comment: Suggestions for management options include adding total bans or restricted seasons to protect these populations as well as restoration activities. Several reviewers reiterated the need to put protection/conservation of native trout resources above recreational considerations. Support for native and wild trout opportunities should not be confused with actual participation or even preference. With respect to native cutthroat and wild trout resources, several reviewers questioned the logic of an

enhancement strategy given limited potential habitat, increased susceptibility to WD, and the inadequacy of wild trout to meet fishery management objectives. To the contrary, it was suggested DOW was not doing enough to enhance wild trout fisheries based on growth of this fishing opportunity in the private sector.

Response: Fishery management options such as restricted seasons or closures are always available, and implied in the report statement that says protection of these resources should not be compromised to sustain recreational use levels. The use of catch-and-release regulations to protect native, Gold Medal, and wild trout populations have proven satisfactory in limiting harvest mortality to very low levels and maintaining abundant population levels in the target waters. No data was available to us that suggested any trout populations currently impacted by whirling disease mortality was threatened to a greater degree by angling mortality as a result. Replacement stocking with appropriate clean fish to replace year class losses has been employed to date. Restoration of native cutthroat populations is a priority activity as well as protection of existing populations. All options are open. As stated in the assessment, expansion of native cutthroat populations into new habitat will only be conducted were biologically feasible. This implies that the habitat must be suitable. Presence of WD in a given water would discourage any management objective of establishing a self-sustaining population of native cutthroat.

Protection and expansion of native cutthroat populations is clearly emphasized in the report. The effect of this conservation management approach and its sportfishery implications (net decrease in present recreation days) is addressed. The report indicates management of native cutthroat species encompasses both conservation and recreation elements, and conservation objectives must take precedence over recreation opportunities or related demand.

The report also suggests that if an increased emphasis on wild trout management is desirable, then approximately 7,300 additional stream miles could be specifically managed as such. It is acknowledged that this approach would only provide a minimal redirection in the use of stocked fish. It is also anticipated in the report that this change is likely to cause a net decrease in recreation days, but the resultant quality of the fisheries based on these populations and the public's use of these restricted fisheries are unknown. The authors had no way of accessing data on the amount of private waters dedicated to wild trout fishing versus those private waters that are maintained by stocking via commercial aquaculture. Within the realm of waters on public lands suitable for wild trout management, the report does identify a 365% potential increase in stream miles that could be shifted to wild trout management. The use of the term "limited" is relative, and refers in part to the potential of these waters to substitute recreation days associated with stocked stream fisheries. The use of wild trout management in lakes, most without associated stream spawning habitat, appears limited. Potential or real recreational opportunity for wild trout fisheries in private waters is acknowledged, but these waters are access limited and not open to the public.

DOW management criteria for maintaining fishing recreation include expectations of what constitutes adequate natural reproduction and an adequate fishery (in terms of No. fish/trip). Clearly, these expectations would have to be changed with a shift in emphasis toward wild trout as described in the report. The expectation of the fishery provided by a self-sustaining wild trout population, regardless of what that level of abundance in the population may be, in terms of catch rate and size of fish would become the accepted norm or criterion rather than catch rate of fish size criteria that can only be sustained with stocked fish. This would represent a philosophical change in our agency expectations of fishery management products and services. As indicated in the report, expectations under Goal 12 would have to change with this change in emphasis, and thus remove the shackles perceived by our field biologists. Enhancement of wild trout fishery quality would rely on management tools to enhance physical habitat and water quality in order to improve productivity.

Hatchery Production Issues:

Comment: Reviewers suggested use of hatchery production must be reviewed, and indicated return-to-the-creel, seasonal use, and fishery uses should replace the DOW system of "equitable" allocation. They also questioned the statement in the report indicating that catchable trout production has been driven by a desire to maximize productivity and efficiency of the remaining hatchery potential.

Response: The use of hatchery production has, and will continue to be, one of the most reviewed aspects of aquatic wildlife management tools in DOW. This report was one more approach in that regard. Given that hatchery products are produced by a statewide hatchery system and these products may be stocked anywhere within the state, and a DOW goal is to enhance fishing recreation opportunity throughout the state, an equitable allocation of these hatchery products among the fish management biologists was considered appropriate. Otherwise, most catchable trout would be stocked in the Denver metro area based on the return-to-the-creel and pressure/acre criteria. Clearly, seasonal and return rate considerations are necessary to make adjustments to the allocation of hatchery products across the diverse management options in each geographic portion of the state.

As indicated in the Demand Section regarding catchable trout, the angling public has shown the capacity to "consume" all catchable trout produced under the current license fee/season structure and bag/possession limits. Given our goal of sustaining catch rates as a measurable means of providing angler satisfaction, it was logical to emphasize full and efficient production within the hatchery system to provide as many fish for stocking as possible. This paradigm is changing with increased popularity of catch-and-release and wild trout fisheries, as well as increased needs for hatchery space for the production of native trout and other fish species. The impact of WD on fisheries management and hatchery production have also affected this paradigm.

Stocking of WD+ Trout:

Comment: Reviewers wondered why some waters that were stocked with WD+ fish did not show signs of whirling disease; some waters should not be stocked with catchables regardless of the water's WD status; once a water has reached a WD-"equilibrium", we should be able to stock lightly infected WD+ fish; stocking of WD+ fish should be phased out as quickly as possible; putting WD+ fish into WD+ waters is contestable; should continue to protect waters that are currently WD-; what proportion of Gold Medal/Wild Trout waters is impacted by WD; protecting native cutthroat trout may be their eventual downfall; the lightly-infected fish that build up an immunity may eventually be healthier than the other fish in WD+ waters.

Response: We are committing significant resources to all facet of WD research, including studies to determine why some WD+ waters are not experiencing significant losses among their fish populations; however, this sort of research will not provide quick answers, nor is it likely to furnish us with a "magic bullet" cure-all solution.

High use streams may well need some supplemental stocking. Waters like the South Platte will be very mediocre fisheries without special regulations, or some stocking to take the pressure off the wild brown trout.

No one yet knows when, where or under what conditions (if ever) Myxobolus cerebralis reaches an equilibrium with its environment, with its hosts, etc.

The DOW is taking every precaution in protecting headwater habitats from the spread of this parasite. However, the DOW has no way of totally controlling or containing the spread of WD by avian or mammalian predators, or other vectors.

The stocking of WD- trout only into westslope waters is one option being considered by the DOW.

From 180-200 stream miles of designated Wild Trout/Gold Medal waters are suffering trout population declines due to whirling disease. The testing of wild cutthroat trout habitats is on-going. Much of the westslope will be tested by the end of 1996. Cooperative efforts among the Bureau of Land Management, the US Forest Service, US Fish and Wildlife Service, and the DOW in the field collection process would greatly assist this process.

While the protection afforded at present to our native cutthroats may eventually lead to their demise (by increasing the range and total exposure of the susceptible cutthroat trout) we think it would be irresponsible to not enact short-term protection measures against the devastating effects of WD, while we have the opportunities.

As to whether lightly (WD) infected fish building up some sort of immunity, and actually being healthier than other resident fish in WD+ waters--we think that would be wonderful, but presently is an unproven theory.

Stocking vs. Recreation-days:

Comment: Several reviewers of the Assessment suggested that the assumption of a direct and equal relationship between the number of catchable-size fish stocked and the number of fishing recreation days was too simple or erroneous (e.g., needs more analysis; DOW data indicate otherwise; other factors influence use).

Response: This assumption was acknowledged in the Assessment as an oversimplification of a rather complex relationship. An in-depth analysis was just not possible, there wasn't enough time. The assumption was used with the Categorization System to provide a baseline on which to assess the impacts of major changes in fish production or stocking on fishing recreation. Although this assumption was not validated through extensive research the authors believe it is an adequate and appropriate index on which to make the comparisons necessary for this Assessment. If future analysis is required, the assumption should be further tested.

The assumption has some validity because most coldwater lakes in Colorado (where the majority of trout are stocked) are limited by little or no natural reproduction. Therefore, stocking provides the primary mechanism by which fish populations, and the resulting catch rates (fishing recreation) are established. Some DOW studies suggest that over time, changes in stocking rates for some waters do not result in a corresponding change in the level of fishing recreation. However, if stocking in a specific water is substantially reduced (i.e., 50-100%) over a period of years, it is reasonable to assume that anglers would respond to the lower catch rates by fishing somewhere else or not fishing at all. Such a significant reduction in stocking is likely in westslope waters, where recreational losses are predicted. The assumption of a direct correlation between the stocking of catchable trout and recreation days is admittedly less valid for waters that would have natural reproduction (streams with wild trout or warmwater seasonal fisheries), but which are stocked with fewer catchable trout.

Angling Regulations:

Comment: There are suggestions that the DOW drastically change fishing regulations to protect wild trout resources (e.g., increase wild trout management; reduce bag limits; enact size restrictions).

Response: As stated in the Assessment, there are some opportunities to increase wild trout management and the associated recreation. However, the potential to greatly increase fishing recreation through this option appears to be limited. Nonetheless, the authors have suggested in the Assessment that any

proposed changes in regulations be biologically appropriate and discussed with full public participation through the Wildlife Commission process.

Issues Related to the Action Plan:

Comment: Many reviewers provided their recommendations on what the DOW should, and should not do, to alleviate the problems addressed in the Assessment. Most suggestions were reactions to the proposed alternatives (e.g., review how DOW uses hatchery products; acquire more WD- fish or hatcheries; private aquaculture is able to supply WD- trout; conduct extensive research on WD in both hatcheries and the wild; protect native species).

Response: Attached to the final version of the Assessment is an action plan that commits the DOW to a number of strategies and funding proposals. This Plan was developed by the DOW Leadership Team in cooperation with the authors, and other appropriate employees to provide the most appropriate, timely and cost-effective solutions to the problems discussed in the Assessment. The suggestions and comments from the public were useful in guiding the process and the resulting decisions.

Specific Questions/Issues:

Comment: Several reviewers recognized that fishing recreation has a substantial influence on the state's economy and suggested that fishing opportunities should be continued through the use of stocking. A particular concern was that fish stocking would be greatly curtailed or eliminated.

Response: The authors definitely have not proposed that stocking in Colorado be eliminated. Rather, the Assessment provides information on how fish stocking is currently utilized in the state and the emphasizes the biological need for fish stocking in many habitats. Because of restrictions on stocking WD+ trout, some areas of the state are not being stocked at adequate levels to maintain even minimum fishing opportunities. The DOW is committed to providing fish and fishing, as long as it does not jeopardize our coldwater resources. The next step is to actively pursue solutions.

Comment: A couple of readers questioned the estimate that 85% of Intensive Use recreation days were attributed to the stocking of catchable trout.

Response: The primary management objective for waters within the Intensive Use category is to maximize the number of fish that anglers catch and keep. The waters have been managed using catchable trout to meet angling expectations that could not be met using any other strategy. A requirement for the inclusion of any water into this category is that the primary stocking strategy *and the primary species sought and caught by anglers* is catchable

trout. This is true regardless if there are other wild fish species (both cold- or warmwater) in the particular water.

The 85% figure is based on many years of creel information and familiarity with the waters in this category by fishery biologists who have decades of experience. In many of the waters the only available fish are those catchables stocked by the DOW. In most streams and warmwater reservoirs in this category the catch composition is overwhelmingly catchable trout. If we had the time to tabulate all of our data, we believe that the estimate of 85% would be upheld.

Comment: We received some criticism regarding the estimate that hatchery-reared fish support approximately 80% of *coldwater* angling recreation days in Colorado.

Response: This estimate was computed for a study that was conducted by Deloitte and Touche, a management consultant in 1995, and used significant information that the DOW had available in the statewide Categorization System and DOW database files. Information included fish stocking records (water, species of fish, size of fish, number stocked) and extensive creel data.

A majority of coldwater recreation days occur in lakes where virtually all fishing is supported by stocking. Some anglers do not realize, as an example, that most cutthroats caught in pristine high lakes are the result of aerial plants of small trout. In addition, fishing recreation on streams is concentrated on a number of our larger rivers where the DOW stocks fingerling or catchable trout to maintain adequate catch rates or a diversity of fishing opportunities.

Comment: Several reviewers questioned the specific details of purchasing WD-negative fish from the private sector and the mechanism for trading fish with the U.S. Fish and Wildlife Service (i.e., acquisitions of private fish should have time- frame guidelines written into the contract(s) and fish health concerns regarding purchasing trout and trading fish with the USFWS).

Response: The DOW is working on a draft contract to purchase WD-negative fish. The draft contract has been forwarded to the Aquaculture Advisory Board for their input. The final contract will have input from the private sector to help assure that it is not unfairly restrictive. The final contract will also contain strong fish health testing criteria to ensure that the state is receiving a quality, healthy product.

The DOW and the USFWS are working on an agreement for obtaining WD-negative fish from the Hotchkiss National Fish Hatchery. The stocking of any salmonid fish in Colorado (state, federal or private) must adhere to DOW fish health regulations. Therefore, fish health criteria for receiving fish from the Hotchkiss National Fish Hatchery already have been established and should not be an issue except for some discussions on stocking protocol. No fish from WD-positive hatcheries will be transferred into Hotchkiss and any stocking from the DOW's WD-positive hatcheries

in locations previously stocked by Hotchkiss will only be conducted in accordance with the DOW's policy on stocking fish from WD-positive hatcheries.

Comment: All hatcheries should be reviewed for production efficiency. It should be determined if federal funds were utilized for acquisition or construction, and the implications from closure and/or disposal.

Response: Prior to the downsizing of the hatchery system, several cost/benefit comparisons were conducted on the WD-positive hatcheries. Before any state hatchery is permanently closed, all legal ramifications will be examined (i.e., were any federal funds used; will the DOW's water rights be affected; are there any qualifiers on the property if it is no longer used to raise fish?).

Comment: Consider building a new "state of the art" hatchery.

Response: Most of the high quality/quantity water sources in Colorado that could be used for rearing fish are already being used for that purpose; therefore, it would be very difficult to build a totally new "state of the art" coldwater hatchery. However, the DOW is looking at ways to improve our present hatchery system. Through a private consulting firm specializing in fish culture, the DOW is assessing efficient and cost-effective ways to disinfect all or part of the water supplies for our WD-positive hatcheries. The DOW is also exploring the possibility of leasing or purchasing a private facility with an adequate water supply.

Comment: Why is the state perilously close to losing the WD-negative status for the majority of its hatcheries?

Response: Most of the DOW's hatcheries are operated from surface or exposed water supplies which makes it very difficult to keep them pathogen-free. The DOW is studying the technology to prevent the introduction of pathogens into our hatcheries through the water supply.

Comment: A couple of reviewers mentioned that the Assessment devoted excessive space to the "well known" history of whirling disease, and some said that the document had an excellent historic perspective, while some called for a more comprehensive review by a panel of internal-external experts.

Response: We must be close to the "right place" on this issue, as evidenced by the criticism from both ends of the spectrum!

Comment: Fish health in the state's hatchery system must be improved; the effectiveness of WD clean-up strategies should be evaluated; and we should not focus only on whirling disease.

Response: We concur, as we hope the recommendations carried into the Action Plan will demonstrate.

Comment: If federal funds were used in the acquisition or construction of any of our hatcheries, we should assess the implications of closing or disposing of any unit.

Response: Good point.

Comment: There were several comments and suggestions that related to "factual" issues, e.g., the proper way to refer to "whirling disease" or Myxobolus cerebralis, the number of stream miles in some of the tables, etc.

Response: We made changes that affected understanding of the issues being developed in the Assessment, or our recommendations.

Comment: The S932M economic benefits should be considered before making fish management decisions.

Response: While economic impacts of wildlife decisions are a necessary component in the decision-making process, priority should be given to the health and integrity of the wildlife resources being managed in the public trust. This is consistent with the legal mandate and spirit of the DOW mission. Economics cannot capture all the benefits of wildlife resources and therefore should not be the primary determinant in guiding resource use decisions.

Comment: Table 2 figures not accurate for greenback cutthroat.

Response: These estimates are an interpretation of status of greenback populations by water, as provided in the recovery plan, to include only those waters with established, self-sustaining populations that are isolated from other salmonids. The assessment leaves the options open to expand GBC habitat to all feasible waters, perhaps beyond the estimated potential in Table 2.

Comment: Define "wild", then identify protection required and possibilities for habitat expansion.

Response: "Wild" refers to populations that rely on natural reproduction to sustain population abundance. This also implies a certain level of quality spawning habitat. The protection of wild trout and "wild" native cutthroat trout is already discussed in the Protection section. Habitat expansion for these trout populations is also provided.

Comment: Gold Medal and Wild Trout opportunities are already "maxed out"; expansion is irrelevant.

Response: Opportunities for expansion of Gold Medal fisheries is likely limited, as indicated, but opportunities for expansion of wild trout waters is significant (see response above).

Comment: Define "willingness to pay" and "by water category".

Response: Willingness to pay can be defined and determined by several criteria. These will be further explored in the implementation of Alternative #13. In a free market setting, willingness to pay describes the pricing process in which the demand for a given product is defined in terms of the amount a consumer is willing to pay (in dollars) to acquire that product given a choice of available products to spend on. "By water category" refers to the categorization system in which all waters are described within three general categories and 33 definitive subcategories.

Comment: Catch-out ponds don't provide an "angling experience.

Response: An angling experience is different for everyone and catch-out ponds have their place or the private sector industry would not exist. DOW criteria for maximizing return-to-the-creel of catchable trout in small pond or lake settings is a close management approximation (put-and-take) of a catch-out pond scenario. The report does not advocate catch-out ponds other than as an option to be explored.