# An Assessment of the Environmental Impact of Introducing Grass Carp into Montana

**Prepared for the**

**Montana Department of Fish, Wildlife and Parks**

**by**

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## EXECUTIVE SUMMARY

The objective of this report is to assess the environmental impacts and consequences of importing and releasing grass carp *Ctenopharyngodon idella* into Montana. Based on a review of the published literature and agency reports on the species, and on contacts with diverse experts on fish ecology, genetics, and diseases, the following conclusions were reached:

1. Because of the northerly latitude, high elevations, and short growing season, many Montana waters are too cold for *optimal* growth and survival of grass carp. However, many low elevation areas of Montana would provide conditions *suitable* for use of grass carp in vegetation control, in particular, locations where water temperatures are 18°C or higher for 65-70 days. These areas would include eastern portion of Region 5, most of Region 6, and all of Region 7 in the Yellowstone and Missouri river basins. Selected ponds, sloughs and lakes in western Montana also are sufficiently warm that vegetation control by grass carp would be expected.

2. Based on habitat requirements and available habitat in Montana rivers, *diploid* grass carp would have a moderate to high probability of reproducing in some Montana rivers if accidentally released into the state. In particular, portions of Regions 5 and 6, and all of Region 7 would be likely areas of potential reproduction, as well as other portions of the state (including thermal effluents) where sufficiently warm waters exist. Much of the lower

**Yellowstone River and portions of the Missouri River and their tributaries have thermal, hydraulic, hydrologic, and turbidity characteristics that render them potentially suitable as spawning areas. These areas also contain several fishes that are endangered, threatened, or of special concern, including the pallid sturgeon *Scaphirhynchus albus*, sturgeon chub *Macrhybopsis gelida*, sicklefin chub *Macrhybopsis meeki*, flathead chub *Platygobio gracilis,* blue sucker *Cycleptus elongatus,* and paddlefish *Polyodon spathula.* Several west-slope rivers such as the lower Clark Fork, Bitterroot, and Blackfoot rivers also reach temperatures in spring and summer suitable for grass carp spawning.**

**3. Once grass carp reproduction occurs, fish would have a moderate to high probability of survival in numerous locations throughout both eastern and western Montana, especially if they found suitable habitat associated with river sloughs and backwaters, or reservoirs.**

**4. *Triploid* grass carp have a very low but non-zero probability of reproducing. This is true even if established, commercially-viable methods of triploidy induction and certification are followed. The probability of enough individuals surviving to establish a population is much lower than for diploid fish.**

**5. Any grass carp stocked into Montana would have a moderate probability of escaping (with or without human assistance) from their confined area and dispersing to other waters.**

6. Without certification, grass carp introduced into Montana have a high probability of bringing in exotic diseases and pests, including Asian tapeworm, zebra mussel, and other known, monitored pathogens. Even with disease certification and 100% accuracy, grass carp are thought to harbor other diseases such as *Centrocestus formosanus* that are insufficiently known in the U. S. for their effects to be evaluated. Unlike the triploidy certification, which is rather uniformly conducted with procedures well documented in the scientific literature, disease certification procedures for many pathogens, including the Asian tapeworm, are non-uniform, not well established, and not adhered to by all states. The probability of disease entry into the state from grass carp is significant. Impacts of such an entry on native species would be significant and difficult to contain.

7. The Asian tapeworm has an established record of infecting and debilitating native minnows (Cyprinidae), suckers (Catostomidae) and killifishes (Cyprinodontidae) in western rivers, and, if introduced into Montana, would have a high probability of infecting native fishes in these families. These would include, but not be limited to, the sicklefin chub, sturgeon chub, flathead chub, and blue sucker, all of which are species of concern in the Missouri and Yellowstone river basins. In addition, other pathogens could be expected to have similar effects on native fish when their pathology is better known.

8. Grass carp have repeatedly proven difficult to contain and difficult to eradicate once they have entered large water bodies.

**9. North Dakota, which receives Montana waters from the Missouri and Yellowstone rivers, has no grass carp and no interest in releasing them. Grass carp moving down the large rivers could find their way not only into the Missouri and Yellowstone rivers but ultimately into Lake Sakakawea and other Missouri River mainstem reservoirs.**

**10. It is recommended that grass carp not be stocked in Montana. The benefits of limited application in the state in a few, primarily private, situations does not balance the potential costs to native species and public waters. If, despite this recommendation, grass carp are stocked into Montana, a detailed list of criteria has been prepared that should be met before any introduction occurs.**

# INTRODUCTION

The objective of this report is to assess the environmental impacts and consequences of importing and releasing grass carp *Ctenopharyngodon idella* into Montana waters. The grass carp, a large, herbivorous minnow (Family Cyprinidae) native to eastern Asia, was first introduced into the United States (Arkansas) in 1963 as an aquatic vegetation control agent (Fedorenko and Fraser 1978). Since that time, it has become widely distributed throughout the United States, and now inhabits more than 40 of the 50 states (Pflieger 1978, Bain 1993, Cassani 1996, Fuller et al. 1999). Grass carp have been used to control aquatic vegetation in numerous water bodies, including small ponds (Cassani et al. 1995, Eades and Steinkoenig 1995, Beck 1996), large lakes (Henson and Sliger 1993, Thomas 1994, Killgore et al. 1998), and irrigation systems (Beaty et al. 1985, Spencer 1994), with varying results, from highly successful to unsuccessful, and with a wide range of effects on aquatic ecosystems (Bain 1993, Cassani 1996).

Recently, grass carp have been proposed for introduction into Montana. As part of any consideration for introduction of an exotic species, an environmental assessment is warranted (Clugston 1986, United States Department of Agriculture Risk Assessment and Management Committee 1996). Numerous scientists have documented the risks of introducing exotic species into aquatic ecosystems (Magnuson et al. 1976, Kohler and Courtenay 1986, Crossman 1991, Courtenay 1995). To minimize these risks, the assessment should involve an evaluation prior to a decision on introduction and, in the event that the introduction is made, an evaluation following the introduction (Kohler and

**Courtenay 1986). Although several grass carp assessments have been conducted elsewhere (e.g., Beaty et al. 1985, Beck 1996), the assessments have often been conducted after, rather than before, an introduction. Accordingly, these assessments have often tacitly assumed that the introduction was certain or highly likely, and that the issue was primarily one of establishing boundaries and conditions for grass carp entry. Inasmuch as no grass carp are at present legally in Montana, this assessment was primarily designed to first consider the costs and benefits of allowing any grass carp in the state, and, if they were permitted into the state, what limitations and restrictions should be applied to their usage to avoid negative impacts on other aquatic resources (Cassani 1996, Figure 1)**

**As the grass carp has attained a wider distribution and increased abundance in the United States, the number of studies on it has increased rapidly. The literature on grass carp has been reviewed several times. Fedorenko and Fraser (1978) and Shireman and Smith (1983) reviewed biological and ecological studies up to the early 1980s. Chilton and Muoneke (1992), Bain (1993) and Cassani (1996) reviewed much of the more recent literature through the mid-1990s. Some comprehensive reviews have been associated with risk assessments for introduction of grass carp into specific waters (California, Pelzman 1971; British Columbia, Fedorenko and Fraser 1978; Louisiana, Louisiana Department of Wildlife and Fisheries, 1989; Alberta, Beck 1996). In Montana, Johnson (1989) reviewed much of the literature on grass carp introductions and followed it with a briefer evaluation (Johnson 1998) of the implications of introducing the species into the state.**

**The objective of this environmental assessment was to review and update relevant information useful in evaluating the advantages and disadvantages of introducing grass**

**carp into Montana. The review emphasizes primary research and management literature and, where recent developments have not yet been published, relies on personal communication with the experts active in grass carp research and management.**

**The environmental assessment has five sections. Section 1 is a review and update of the literature on grass carp. Topics discussed are biology and life history, including diseases and genetics, use as a biological control agent, and effects on the aquatic environment. Section 2 is an evaluation, specific to Montana waters, of how introduction of grass carp would relate to escape and dispersal of the species, reproduction and potential for establishment, effects on native species, ability to remove the fish should they become pests, and risk of disease transmission to other species. In Section 3, grass carp policies and procedures in selected other states and provinces are reviewed, with emphasis on entities bordering Montana and linked by river drainages. Section 4 contains a brief discussion and conclusions, and Section 5 provides recommendations derived from the assessment.**

# SECTION 1 -- LITERATURE REVIEW AND UPDATE

## BIOLOGY AND LIFE HISTORY

### Description

The grass carp *Ctenopharyngodon idella* is a large, herbivorous minnow (Family Cyprinidae) first described by Cuvier and Valenciennes in 1844. Grass carp are dark grey dorsally, lighter colored on the sides, and olivaceous to silvery-white ventrally (Beck 1996). Scales are cycloid. Grass carp grow to a length of more than 1m and a weight exceeding 50 kg ( Shireman and Smith 1983), although typical sizes are 200-250 mm (8-10 inches) at stocking. The head is broad and eyes located in or above the axis of the body. Although they are distinctive from all native North American fishes, it has been reported that grass carp look very similar to, and may be easily confused with, the black carp *Mylopharyngodon piceus*, an Asian molluscivore species that has escaped into the Osage River (Fuller et al. 1999; J. Bonneau, Missouri Department of Conservation, Personal Communication).

Grass carp have pharyngeal (throat) teeth specialized for tearing and grinding plant material. The alimentary tract is poorly defined and consists of an esophagus, pyloric sphincter, intestinal swelling, intestine, and rectum. There is no stomach. Edwards (1973) notes that the gut to body length ratio of grass carp is 2.25:1, greater than the typical 1:1 ratio for carnivorous fish but much less than the 12:1 ratio of the phytoplankton-eating silver carp *Hypophthalmichthys molitrix.* The lower ratio indicates that grass carp are imperfectly adapted to a vegetarian diet. Other details of the anatomy are provided by Opuszynski and Shireman (1995) and Beck (1996).

**Origin and taxonomy**

**The grass carp is the sole species in its genus. The genus name *Ctenopharyngodon* is from the Greek meaning "comb-like throat teeth" (pharyngeal teeth) and the species name *idella* (sometimes written *idellus* is Greek for "distinct". No subspecies have been identified and little variation in gross morphology has been reported. The most widely-used common names are grass carp and white amur, but it is known by numerous other common names worldwide where it has been introduced (listed in Shireman and Smith 1983, Beck 1996).**

**Distribution**

**According to Shireman and Smith (1983), "the original distribution [of grass carp] includes low-gradient rivers, lakes and ponds below 1,000 m on the Pacific coasts of USSR and China from latitude 50-23° N. ... A monsoon climate characterizes the area. Average annual humidity varies from 70% to 80% and average annual temperature varies from 24° C in southern China to 0° C in the north." The Yangtze River in China and the Amur River in Siberia are cited by Chilton and Muoneke (1992) as typical examples of native habitat. Beck (1996) notes that the northern limit of its native range would correspond to a line through Canada at the latitude of Lake Nipigon. (For comparison, Montana's latitude extends from about 45° N to 49° N.) The native distribution thus indicates a rather wide range of ecological and thermal tolerance.**

**Although grass carp have been shown to be capable of long migrations in large**

rivers (>1600 km; Guillory and Gasaway 1978), most of their range extension in this century has been a result of intentional distribution by humans. Grass carp have been introduced into more than 50 countries (Louisiana Department of Wildlife and Fisheries 1989), including most European countries and all of the former USSR, for protein production, aquatic vegetation control, and research (Beck 1996). Beginning in 1955, grass carp were stocked in the lower reaches of the Volga River and numerous other waters in the former USSR (Vinogradov and Zolotova (1974). During the 8-year period beginning in 1964, 50 million age-0 fish and more than a million age-1 and older fish were released (Martino 1974). As a result, grass carp established naturally reproducing populations in Europe and central Asia at latitudes of 38 to 46° N (Beck 1996). Negonovskaya (1980) reported that successful introductions were often associated with large lakes, inland seas, or reservoirs. Grass carp have also been introduced into Borneo, non-native areas of China, India, Indonesia, Israel, Japan, Malaysia, Philippines, Singapore, Thailand, New Zealand (Mitchell 1977), Vietnam (Chilton and Muoneke 1992) and areas of Africa (Zunguze 1996). They also undoubtedly exist in many other documented and undocumented locations worldwide. Many of these locations have both triploid fish and diploid fish.

The first grass carp (70 fingerlings) introduced into the United States arrived from Malaysia at the Fish Farming Experiment Station in Stuttgart, Arkansas on November 16, 1963 (Stevenson 1965). Soon afterward, Taiwan sent a second shipment of grass carp to Auburn University. Grass carp were first stocked into a North American lake (Texas) in 1966. From the 1960s through 1980s, a combination of intentional stockings and unintentional dispersal through river systems has greatly expanded their range in the United States. Grass carp are now found in several major rivers, including the upper and lower Mississippi rivers, Atchafalaya River, Missouri River, Ohio River, and Illinois River (Fuller et al. 1999). They have inhabited the Columbia River system (Willamette River) since the 1970s. Loch and Bonar (1999) recently reported that over the period August, 1996-September 1997, 49 adult grass carp of unknown origin were observed migrating past Lower Columbia and Snake River dams. Forty of the 49 sightings were at the two lowest dams, Bonneville and The Dalles, on the Washington-Oregon border.

As of 1995, 37 states allowed introductions of grass carp. Most states restrict the introductions to sterile (triploid) fish (Beck 1996). As of 1999, grass carp were evidently in all but 5 states -- Maine, Vermont, Rhode Island, Alaska, and Montana. They have established reproducing populations in only about 8 states, however (Fuller et al. 1999).

Wattendorf and Phillipy (1996) provided a distribution map of the species by regulatory status. Most states outside of the lower and middle Mississippi valley require that stocked fish be triploid (Figure 2). Diploid brood fish are present in Alberta and California, however (Beck 1996).

Grass carp were first introduced into Canada in southern Alberta (49-50° N latitude) in 1988 for vegetation control in irrigation canals, and later into farm ponds and golf course ponds (Beck 1996). They were evaluated for introduction into British Columbia (Fedorenko and Fraser 1978) but were not recommended for use there (Beck 1996).

Growth, longevity, and age at maturity

Under ideal conditions, grass carp are among the fastest growing temperate freshwater fishes, with growth up to 29 g/day (Leslie et al. 1996). Growth rate is dependent on a variety of factors, including climate and growing season (Shrestha 1999), fish density, and plant abundance and plant species composition. Growth rates in northern states are typically less than in southern states, assuming that high fish density and resultant low food supply is not a limiting factor. Caldwell (1980) reported that grass carp in Colorado ponds grew from 0.54 kg to 2.72 kg in 26 weeks. Fish stunted (i.e., stopped growing at a subnormal size) quickly in ponds with no vegetation, however, and did not switch to the fathead minnows *Pimephales promelas* and aquatic insects (Odonata, Ephemeroptera, Hemiptera) available to them. Vecht (1992) reported that age-5 (triploid) grass carp in Washington ponds commonly exceeded 700 mm total length (TL) and weighed 4-6 kg. In an Alabama lake, growth of fish (unknown ploidy) averaged 2.33 kg/year through age-4, but only 0.71 kg/year after age-4. Fish reached age-9, at which time they weighed 12.5 kg (Morrow and Kirk 1995). It was unknown if the slower growth of older fish was a natural physiological response or a response to a lack of food. Fish having appropriate habitat and food can grow very large; fish at the Rawhide plant in Colorado exceed 165 cm (65 inches) in length and 45 kg (100 lbs) in weight (Eric Bergersen, Colorado Cooperative Fish and Wildlife Research Unit, Personal Communication).

Grass carp stocked into impoundments as fingerlings (35-55 fish/kg; 15-25 fish/lb) have generally shown low mortality and the capacity to live many years. For example, Hill (1986) found very low mortality rates for grass carp stocked as fingerlings in two Iowa lakes. Of 138 age-0 grass carp (55 fish/kg) stocked in Cold Springs lake (6.4 Ha) in 1976, an estimated 128 (+/- 17) remained in 1983. Of 160 fish (33/kg) stocked in 1980, 148 (+/- 18) remained three years later. Annual mortality rates ranged from 2.0 to 7.7%. He attributed the low mortality rates to lack of predation and rapid growth to a size beyond vulnerability to predation. In many situations where food is adequate and overwinter conditions not too severe (i.e., no winterkill), once grass carp are large enough to escape predation, they may persist with low annual mortality for 10-15 years or longer.

Grass carp life expectancy was projected by Shireman and Smith (1983) as 21 years in warm climates and 11 years in cold climates. Grass carp commonly reach ages of 8-10 years, and 20-30 years in some locations. Fish stocked in a cement-lined pond in the mid-1970s were still alive 14-15 years later (Scott Bonar, Washington Department of Fish and Wildlife, Personal Communication). In Colorado, grass carp stocked in a pond at the Rawhide Power Plant near Ft. Collins are age-15 or older, (Eric Bergersen, Colorado Cooperative Fish and Wildlife Research Unit, Personal Communication). Fish stocked in North Dakota in 1971 and 1972 were known to be alive as recently as 1996 (Terry Steinwand, Chief of Fisheries, North Dakota Game and Fish Department, Personal Communication). Fish in Missouri ponds may live more than 20 years, during which time they suffer low annual mortality (J. Bonneau, Missouri Department of Conservation, Personal Communication). More information on longevity will be available in the next few years as fish from documented past stockings are recovered. Otoliths and scales are used to age the fish (Morrow and Kirk 1995), but recoveries of known age fish provide the most reliable information.

Age at maturity in grass carp varies widely with geographic location and rearing conditions. Under ideal conditions, males may mature at age 2 and females at age 3. In the Amur River, fish mature at 8-9 years at a length of 63-67.2 cm (Gorbach 1961, cited in Chilton and Muoneke 1992). Maturation occurs at a much younger age in areas of longer growing seasons, better feeding conditions, or thermal effluents (Beck 1996). In most stocks, males typically mature about a year younger than females (Shireman and Smith 1983).

Reproduction

Spawning of grass carp is typically associated with large rivers, and occurs in spring and summer (Figure 3) at times of high turbidity accompanying a sudden rise in water levels (Stanley et al. 1978, Shireman and Smith 1983). They are polygamous, broadcast spawners. Fecundity for a 14.6 kg fish was estimated to be about a million eggs (Shireman and Smith 1983); highest fecundity may approach 2 million eggs (Heft 1994). The annual period of potential reproduction is narrower in more temperate portions of their range and expands in duration toward the tropics. The eggs are semi-buoyant, non-adhesive, and may drift 50-180 km before hatching (Robison and Buchanan 1988). Eggs are about 2 mm in diameter when expelled and swell to 6 mm near hatching (Louisiana Department of Wildlife and Fisheries 1989). Hatching of eggs occurs in 16 to 60 hours at water temperatures of 17-30° C; at 25° C (77 F), hatching occurs in 24-36 hours (Shireman and Smith 1983). The young drift into side channels and backwaters where they rear. Early development is described in detail in Shireman and Smith (1983)

Several studies have been conducted on spawning requirements for grass carp.

Stanley et al. (1978) concluded that velocities of 0.6 m/sec are needed to keep grass carp eggs supported in the water column, but Leslie et al. (1982) reported that unfertilized eggs were transportable downriver in water of much lower velocity (0.23m/sec). Successful reproduction also requires a rearing area downstream safe from excessive predation (Stanley et al. 1978). According to Beck (1996), it is almost impossible for grass carp to reproduce in a pond or lake because of the limited mobility of the proto-larvae (during the first 3 days) and their tendency to suffocate in silt (Shireman and Smith 1983).

A review of numerous studies indicates that suitable spawning temperatures range widely depending on geographical area, from as low as 17° C to as high as 30° C. Stanley et al. (1978) reported that in their native habitat sexually mature fish move toward the spawning area as water temperatures reach 15-17° C, begin spawning when water temperatures reach 18-19° C, and peak in spawning between 20° C and 22° C. In the same review, Stanley et al. (1978) reported that Kuronuma (1958) found grass carp spawning at 17.6-22° C in Japan. Nezdoliy and Mitrofanov (1975) reported that spawning occurred as temperatures reached 18.7° C in May and a second spawning occurred at 23.5° C in June. Weber (1974) concluded that crass carp needed to be in hatchery water above 18° C for ripening, but this is evidently not required in natural waters. Martino (1974) found that grass carp were able to spawn in the Volga delta "where hydrometeorology...differs considerably from that in the [native] far eastern rivers where the monsoon is the dominant factor". Fish evidently spawned in mid-May in the Volga meadows, where waters warmed more rapidly than in the main channel yet had velocities of 0.2-0.5 m/sec.

Stanley et al. (1978) concluded, based on general ecological requirements, that grass carp spawning would occur on some American rivers. They also concluded, however, that the environmental impact would be minor except in local situations. The forecast of successful spawning was correct, but after the fact. Conner et al. (1980) had discovered grass carp larvae in the lower Mississippi River in 1975; by 1977 larvae had become abundant. Larvae were also found in the Atchafalaya River (Conner et al. 1980, Bryan 1982) In 1984, Pflieger and Grace (1987) reported the discovery of 78 dead, juvenile grass carp (79-133 mm standard length (SL)) in a desiccated Missouri River flood plain pool. Juvenile grass carp have also been found in the lower Missouri River and tributaries by Brown and Coon (1991) and in the Trinity and San Jacinto Rivers, Texas (Howells 1994, Elder and Murphy 1997). The fish from the Trinity River are suspected to be from natural reproduction; 85% of the fish tested were diploids (Elder and Murphy 1997). Raibley et al. (1995) reported the presence of juveniles (some less than 20 mm long) and diploid adults in the Illinois and Upper Mississippi rivers over the period 1990-1994. Their presence suggested to them that reproduction was occurring and larval fish were rearing in backwaters adjacent to the main river.

Grass carp have also reproduced naturally outside of their native range in portions of the former USSR (Nezdoliy and Mitrofanov 1975). In the Ili River, where acclimated grass carp spawned, the mean annual flow of the river was 460 $m^3$/sec, with a flood peak in May, shifting banks and resultant high turbidity, and ice cover from December to March. In their study, the peak downstream drift of eggs in two successive years occurred on May 19 (water temperature 19.5° C) one year and on May 24 (temperature 19.9° C) the next year. Larvae abundance peaked in these years on May 18-20 and May 27-30. They concluded that water temperature (19.5-19.9° C) was a critical factor in the onset of grass carp spawning.

Loch and Bonar (1999) concluded that portions of the Columbia and Snake Rivers would probably be suitable spawning and rearing habitat for grass carp. Diploid grass carp could be expected based on habitat requirements to be able to reproduce at other North American locations as well (Stanley et al. 1978).

One factor that might serve to reduce recruitment from natural reproduction and the establishment of grass carp is reduced genetic variability in hatchery stocks. Lizhao et al. (1993) documented that genetic variation of wild grass carp in the Yangtze River, China was much higher than for hatchery stocks. They attributed the difference to artificially-imposed factors during propagation, such as small effective population size, inbreeding, and directional selection.

Distributional, growth, and habitat constraints

Grass carp have long been known to tolerate a wide range of environmental conditions (Guillory and Gasaway 1978), including a wide range of temperatures, salinities (Pelzman 1971, Routray and Routray 1997), and dissolved oxygen concentrations.

According to Clugston and Shireman (1987), "Because the range of temperatures at which grass carp can live and function is wider than that of most other herbivorous fish, this species is potentially useful throughout the United States. Although grass carp eat irregularly at 3-6° C (37-43° F), feeding becomes steady at about 14° C (57° F) and peaks at 20-26° C (68-79° F). Feeding decreases when water temperature reaches about 33° C

(91 F)." Liangyin et al. (1998) reported that the upper lethal temperature for 5-day old fish was 36.5 C; for adults, it is 38-39° C (Opuszynski 1972). Swanson and Bergersen (1988) modeled crass carp stocking rates and concluded that the species would start to eat at 10-12 ° C (Opuszynski 1972) and begin to grow at 13° C. Growth rates increased exponentially up to 33° C. They considered lakes with less than 400 daily thermal units (DTU) per year as too cold for grass carp to function as a biological control agent. DTUs per year were calculated as the sum of ($T_1$ -55) + ($T_2$-55) +... + $T_n$-55) where $T_1$ through $T_n$ are sequential mean daily water surface temperatures for T> 55° F. Beck (1996; R. Beck, Northland Aquatic Sciences, Personal Communication) indicated that grass carp rear well and control aquatic vegetation in Alberta in farm ponds where water temperatures reach 18° C or higher for 65-70 days. Fish do not grow, survive, or control vegetation well in colder, spring-fed ponds.

Chilton and Muoneke (1992) reported that grass carp tolerate oxygen concentrations of less than 0.5 mg/l, and salinities up to 9 g/l (parts per thousand) for age-0 fish and 17 g/l for age-2 and older fish (Cross 1970). Kilambi (1980) raised grass carp at 3, 5, 7, and 9 % salinity and found no difference in growth rates among salinities. These tolerances make the fish resistant to death in oxygen-deficient conditions as well as a threat to emigrate through large river systems and estuaries from the tropics to the latitude of southern Canada. Grass carp are known to have emigrated from the Volga River delta through estuarine waters of the Caspian Sea and entered other rivers (Vinogradov and Zolotova 1974). In addition, the fish are capable of moving great distances in open water systems (Raibley et al. 1995). Whereas their spawning requirements are rather specific

**(much as with many other large river species), grass carp show great adaptability to rearing in a variety of freshwater habitats, including large rivers, ponds, lakes, and reservoirs (Beck 1996).**

**Diseases**

**Nie and Pan (1985) reviewed the historical records (1953-1983) of diseases of grass carp in China; essentially all of these studies have been associated with culture operations. They considered grass carp the most susceptible to diseases of the four main farmed fish species in China. Shireman and Smith (1983) listed a large number of diseases and parasites that have been isolated from grass carp, including 2 viruses, 7 bacteria, 2 fungi, 51 protozoa, 26 trematoda, 5 cestoda, 5 nematoda, 10 crustacea, and 1 pentastomida. Most of the pathogens have also been reported in culture operations where they cause considerable mortality (Wang 1963, Shireman et al. 1976, Zhang and Yang 1981, Ahne et al. 1987, Jianzhong et al. 1996).**

**Grass carp can be infected with the common, non-specific fungal diseases and non-specific parasites to the extent of other cyprinids (Beck 1996). Numerous parasites are associated with grass carp (Figure 4). Parasites specific to grass carp (from their native range) transferred with the introduction to Europe include *Entamoeba ctenopharyngodoni, Dactylogyrus lamellatus, Dactylogyrus ctenophryngodoni* and *Gyrodactylus ctenopharyngodoni.* The *Dactylogyrus* spp. occurs in the gills and the *Gyrodactylus* spp. in the scales and fins. Other European cyprinids have been parasitized by the cestode *Khawia sinensis,* which was also introduced into Europe by grass carp.**

**The Asian tapeworm, *Bothriocephalus acheilognathi (= gowkongensis)* has been a particularly important parasite introduced into Europe (were it has afflicted common carp *Cyprinus carpio*) and North America from Asia (Ahne et al. 1987) by grass carp. Dr. Richard Heckmann, Professor at Brigham Young University and an expert on the Asian tapeworm, indicates (Personal Communication) that the parasite was probably first introduced into Arkansas from Asia, then transported westward with bait minnows. In southern Utah, the tapeworm is thought to have been introduced into the Virgin River from Lake Mead. By 1997 it had inhabited portions of the San Juan River in Utah and New Mexico as well as the Upper Colorado River in Utah (Hauck 1997). This introduction has seriously infected several species of threatened, endangered, and declining native minnows, including the humpback chub *Gila cypha*, roundtail chub *Gila robusta,* woundfin *Plagopterus argentissimus*, the Virgin River spinedace *Lepidomeda albivallis*, and the Colorado River pikeminnow *Ptychocheilus lucius* . A woundfin 7.5 cm long has carried as many as 40 tapeworms. It has also infected more common native minnows such as the speckled dace *Rhinichthys osculus,* golden shiner *Notemigonis crysoleucas* and red shiner *Notropis lutrensis* (Heckmann et al. 1987, 1989).**

**Pathological effects of the Asian tapeworm on fish hosts are summarized by Clarkson et al. (1997). Effects include intestinal abrasion and disintegration, loss or separation of gut microvilli and enterocytes, and blockage or perforation of the gastrointestinal tract. Asian tapeworms are particularly damaging to the fish's intestinal walls as the parasites attempt to move out of the intestine. Chronic effects are not well studied but may include emaciation, anemia, reduced growth and reproductive capacity,**

and depressed swimming ability. Fish also become more susceptible to secondary infections. The effects on fish in natural environments are poorly known and need further study. More information is also needed on how well the organism would survive at the latitude of Montana.

Other potentially harmful parasites include *Lernea cyprini*, which is reported to be widespread on trout (Salmonidae) and catfish (Ictaluridae) in eastern Colorado. This parasite has been reported on grass carp in the Imperial Valley, California (Beck 1996). It reportedly damages gill filaments in channel catfish (Goodwin 1999).

Beck (1996) reported that grass carp brood fish from Colorado destined for Alberta were screened for a large variety of diseases at the U. S. Fish and Wildlife Disease Control Center in Fort Morgan, Colorado in 1992. Similar screening was conducted in 1995 for Imperial Valley, California brood fish. No parasites, bacteria, or viruses were detected in these fish.

Mussels can also be accidentally spread by grass carp introductions. Of particular concern is the zebra mussel *Dreissena polymorpha.* Since its introduction in 1985-86, it has become a widespread pest in the eastern United States (Nalepa and Schloesser 1993). In addition to causing damage to water intakes, it is colonizing native freshwater mussels (Unionidae), causing their death (Tucker and Mihuc 1998). Unlike the unionids, however, zebra mussels do not adhere to fish. The primary threat is the unintentional distribution of the glochidia in waters containing the grass carp.

Other mussels can also be transported on grass carp. Watters (1997) reported that the freshwater mussel *Anodonta woodiana,* native to eastern Asia, has been spread to fish hatcheries in several European countries and Indonesia by several exotic aquaculture species, one of which is grass carp. Although this species has not yet been found in North America, its entry could pose a threat to already depleted freshwater mussel populations.

## Genetics and Ploidy

Diploid grass carp have 48 chromosomes (i.e., 2N=48). Because of the potential for reproduction of escaped diploid fish, most states require that only sterile grass carp be stocked to avoid the possibility of escape, natural reproduction, and resultant effects on natural aquatic ecosystems (Van Eenennaam et al. 1990).

Research began in the 1970s to produce either monosex or sterile grass carp (Leslie et al. 1996) . Stanley (1976) studied hybridization of grass carp (with common carp), androgenesis, and gynogenesis as potential methods for producing non-reproductive populations of grass carp for stocking. His methods were not entirely successful; some fish were not sterile, some males were produced, and few gynogenetic fish were produced, which made the method expensive for production of large numbers of non-reproducing fish. Surgical sterilization by gonadectomy also proved unsuccessful because grass carp can regenerate viable sex organs (Clippinger and Osborne 1984). Sex reversal techniques were also developed to produce all female offspring by crossing a sex-reversed (male) grass carp with an untreated female (Boney et al. 1984).

Attempts were also made to cross female grass carp with bighead carp (*Hypophthalmichthys nobilis*), producing a triploid hybrid (Marian and Krasznai 1978) . These fish have been less desirable than triploids because a low percentage of actual triploid hybrids is actually produced, mortality rates are high, and feeding rates are much lower than for diploid fish (Harberg and Modde 1985, Wiley and Wike 1986). This hybrid is also reported to slow its consumption of vegetation after age-1 (Prentice 1993).

The preferred method of prevention of unintentional grass carp reproduction has been the use of triploid fish (3N = 72) . Triploid grass carp were first produced in 1983. In 1984, J. M. Malone and Sons, Lonoke, Arkansas, announced the successful production of commercial quantities of a true triploid grass carp that is the preferred fish for nearly all applications today. The near 100% sterility of triploid grass carp has lessened concerns nationwide about the species becoming established where it would become a pest. According to Leslie et al. (1996), "On December 2, 1984, the U. S. Fish and Wildlife Service issued a biological opinion that female triploid grass carp are functionally sterile and that triploid sperm are probably non-functional (Sanders et al. 1991). The formal statement opened the door to wider use of triploid grass carp in the U. S."

The methods of inducing triploidy are thermal shock or hydrostatic pressure shock (Thompson et al. 1987). Today, pressure shock is used almost exclusively. Fish produced by these methods have been shown to be similar to diploid grass carp in hardiness, growth, and behavior (Wiley and Wike 1986, Bowers et al. 1987). Tetraploid induction has met with only moderate success (Cassani et al. 1990, Zhang et al. 1993) and even short-term survival of tetraploids has been poor (Cassani 1990).

## USE AS A BIOLOGICAL CONTROL AGENT

**Although grass carp have been used as a food fish in polyculture for centuries, their use as a biological control agent is fairly recent; early studies in England (Pentelow and Stott 1965) foreshadowed their use in the United States. Increasing rates of eutrophication of waters from development and intensive agriculture, combined with the accidental introduction and establishment of nuisance exotic plants has resulted in a greater need for control methods for nuisance aquatic vegetation (Mitchell 1974). Biological control of vegetation with grass carp has often been considered along with, or in place of, mechanical and chemical control methods.**

**Food habits, food preferences, and feeding behavior**

***Food habits*** **--Under ideal conditions, grass carp of 1.2 kg may eat several times their weight daily in vegetation; larger fish may eat their weight daily in vegetation (Shireman and Smith 1983). The food habits of grass carp vary with a variety of factors such as age and size of fish, temperature, species of food plants available, size of pond, stocking density, amount of disturbance, and previous feeding history (Buck et al. 1975). Newly-hatched larvae feed on phytoplankton and zooplankton, but become mainly herbivorous as they grow (Heft 1994). Clugston and Shireman (1987) indicated that they are almost strictly herbivores after a length of about 100 mm. Colle et al. (1978) reported that grass carp (63-220 mm TL) in a small Florida pond contained less than 0.1% animal matter in diets. Fish 105-150 mm fork length (FL) have been shown in aquaria studies, however, to consume a variety of invertebrates, as well as trout (Salmonidae) fry (Edwards 1973). Although vegetation is their preferred food in nearly all cases, grass carp are less well adapted**

**anatomically to planktivory than some other Asian carps ( Edwards 1973). They thus pass large quantities of undigested plant food through feces (Takamura et al. 1993), to enrich waters or to be used by other species (Iwata et al. 1992) in natural systems or polyculture operations (Shrestha 1999). The inefficient use of forage has relegated them to a lesser status than other pond culture carps in polyculture (Vinogradov and Zolotova 1974). Incomplete adaptation to herbivory may explain why under some conditions grass carp can grow faster on invertebrate diets than on vegetation (Cui et al. 1992).**

*Food preferences* **--Although grass carp will eat a large variety of aquatic vegetation (listed in Clugston and Shireman 1987), they exhibit strong selectivity for particular foods (Mitchell 1977, Bowers et al. 1987, Pauley et al. 1987, Bain 1996; Figure 5). Their general preference ranking is submerged, rooted macrophytes, followed by filamentous algae, then fibrous, rooted emergents (Avault 1965). In the absence of submerged aquatic vegetation, they will consume rooted terrestrial macrophytes that they are able to reach (Elder and Murphy 1997). Their preferences have been ranked in various regions to better indicate the likely pattern of vegetation removal (Sutton and Vandiver 1986). Colle et al. (1978) observed positive selection for *Sagittaria graminea,* slight positive selection for *Eleocharis* sp., and discrimination against *Najas flexilis*, *Ceratophyllum demersum*, and *Potamogeton illinoensis*. In their study, only the leaves, not the stems, of *Potamogeton* were ingested. Preferences also varied with fish size, fish age, and season. Catarino et al. (1997) found that grass carp selectivity decreased with age from age-0 to age-2. Age-0 fish preferred mostly young, tender plants whereas older fish ate a greater variety of species, native and non-native. Because of their selectivity, growth rates of fish can be influenced by the** amount and species composition of forage.

With this selectivity, grass carp tend to feed on preferred items until they are eliminated, then switch to less preferred items (Sills 1970, Edwards 1974, Fowler and Robson 1978, Bain 1993). As a result, in some waters grass carp may favor some highly undesirable species at the expense of desired ones (Catarino et al. 1997). Areas may be left to the unpalatable species after the grass carp have moved on (Mitchell 1980). Stocking rate and the grass carp feeding preference thus both exert an effect on the resulting plant community composition (Pauley et al. 1988). In California ponds, Pine and Anderson (1991) reported that because grass carp favored sago pondweed and *Chara* over watermilfoil, the latter had been stimulated to grow in the more heavily stocked pond as the other plant species were depleted. These authors indicated that the most important factor determining preference for grass carp was handling time, which was related to the accessibility of the plant and the ease with which the fish is able to chew the plant material. More research is needed, however, on the underlying factors affecting palatability.

*Feeding behavior* -- Grass carp feed in shoals (Mitchell 1980), often in the warmest, shallowest water where macrophytes are present. In cooler waters, they slow activity and tend to stay deeper (Nixon and Miller 1978). Feeding rates are strongly temperature dependent. Colle et al. (1978) reported that fish grew rapidly (0.59 g/day; 1.29 mm/day) until water temperatures fell to below 14° C. Below 14° C, the number of fish gut samples that was empty doubled, food consumption decreased to near maintenance, and growth slowed. Osborne and Riddle (1999) reported from cage trials that triploid grass carp feeding rates at 17° C were only 25% of that at 27° C. Above 25° C, small grass carp (0.2-

**0.4 kg) consumed their body weight per day in *Hydrilla*. They found that although relative feeding rates (gm *Hydrilla*/gm fish/day) declined with increase in fish size, absolute feeding rates (gm/*Hydrilla*/fish/day) did not; large triploid fish (7-10 kg) thus were as effective at removing vegetation as smaller ones (0-3 kg) on a per fish basis.**

**In Alberta, grass carp have optimal feeding temperatures of 18° C or higher, with moderate activity between 13° C and 18° C, and limited feeding below 13° C. Fish will feed on artificial diets (fish feed) at temperatures as low as 7° C, however. Water temperatures in southern Alberta farm ponds are within active feeding ranges for only four months of the year (77 days >18° C and 43 days at 13-18° C). Farther north, the season is even shorter, but the exact number of feeding days also depends on pond depth, wind exposure, and water source (Alberta Agriculture, Food and Rural Development 1998).**

**Stocking rates**

**Stocking rates of grass carp are influenced by the goals of the introduction, by geography and climate (growing season), as well as by a host of physical, chemical, and ecological aspects of the waters stocked. Optimal stocking rates depend on the degree of vegetation removal sought. If the retention of some macrophytes is desired for water quality, for cover and food substrate for juvenile fish, or for waterfowl, then optimal stocking rates may be lower than for total elimination of macrophytes (Blackwell and Murphy 1996). Complete vegetation elimination has sometimes been sought in golf course ponds and stock ponds not used for fishing. More often, it has been an accidental outcome of overstocking. Grass carp stocked in sufficiently high densities can denude a small pond,**

mid-sized lake, or a large reservoir of macrophytes (Vinogradov and Zolotova 1974). Scarnecchia and Wahl (1992) reported that grass carp completely eliminated macrophytes from a 104 Ha Iowa glacial lake. Maceina et al. (1992) reported grass carp completely eliminated macrophytes from an 8,100 Ha Texas reservoir.

The objective for most management agencies, however, has been maintenance control of vegetation (i.e., partial removal), not total removal (Cassani 1996). In detailed studies in Washington state, for example, the objective was to "learn if intermediate levels of aquatic plant biomass which are presumed to be beneficial to sport fish production can be maintained by grass carp grazing" (Pauley and Thomas 1988, Bonar et al. 1996). But according to Mitchell (1980), "Unfortunately, different values for standing crop, [plant] growth, [plant] regrowth following browsing, water temperatures, fish growth, and mortality in different water bodies make the prior calculation of theoretically optimal stocking densities extremely difficult." Where only partial removal of vegetation is desired, more precise and intensive management of the stock size will be necessary.

One reason for the difficulty in quantifying and comparing stocking rates is the lack of standardization in units of area and fish. Stocking rates are usually estimated from the surface area of macrophyte coverage, which fails to adequately quantify the biomass of macrophytes available (Cassani et al. 1995). Different sizes of fish stocked, as well as different consumption rates and growth rates of fish after stocking, also complicate comparisons among studies.

Beyond these difficulties, it has also proven difficult in many regions to find a simple stocking rate that would provide partial control (Flickinger and Satterfield 1995).

According to Cassani (1995), intermediate control is rarely achieved because of unique conditions in each lake such as climate, nutrient loading, levels of predation on grass carp, target plant phenology, and different target weed species that affect plant consumption by grass carp. Bonar et al. (1996) evaluated 98 Washington lakes where triploid grass carp had been introduced; in more than 80% of these lakes vegetation was either completely removed or not controlled; the desired partial control was thus rarely achieved. It generally took more than 24 months before an effect of grass carp grazing was observed. Stocking rates that achieved eradication of vegetation ranged from 5 to 174 fish per vegetated acre; median stocking rates which resulted in control were 24 fish per vegetated acre (Figure 6). Stocking rates which resulted in no control varied from 7 to 74 fish per vegetated acre. They found no relation between stocking rates for effective control and accumulated water temperature units. Their study provided no simple stocking rate that would apply statewide. Blackwell and Murphy (1996) were able to control vegetation in small impoundments in Texas with low densities of stocking (4.0 to 7.5 fish/Ha), but they noted that in low-density stocking, vegetation type and vegetation biomass must be considered to prevent selective browsing on preferred vegetation types and the favoring of less palatable types.

Swanson and Bergersen (1986, 1988) developed a stocking model for grass carp in coldwater lakes. Key variables that affected recommended stocking rates included water temperature, density, distribution, and species of plants present, and degree of human disturbance. A stocking rate model has also been developed by Blancher and Buglewicz (1982) for Lake Conway, Florida. The stocking rate model had only two state variables (biomass of target plants and biomass of grass carp); the ecological response model was considerably more complex, however, and had 15 state variables and 94 constants and parameters. Spencer (1994) modeled grass carp-pondweed interactions in a California canal and concluded that stocking rates (50 to 250 kg of fish per vegetated hectare) would have to be higher than reported in simulations in other U. S. localities. These models can be used as starting points for stocking programs elsewhere, but would need to be modified appropriately for a particular region.

A few generalizations and conclusions emerged from a review of stocking rates. First, stocking rates will need to be higher where food consumption by individual grass carp is lower. Hill (1986) recommended that stocking rates in Iowa ponds and lakes should not exceed 15 fish per acre. In contrast, in Alberta, where the cold climate and shorter growing season reduces vegetation consumption, the standard stocking rate is 400 25-cm sized grass carp per hectare (Alberta Agriculture, Food and Rural Development 1998). Second, moderate stocking rates may lead to the selective removal of more palatable species and an increase in the abundance of less palatable ones (Vinogradov and Zolotova 1974). Third, an integrated approach that may be preferable to stocking too many fish is to first treat the lake with herbicides and then stock a low number of fish for maintenance control (Clugston and Shireman 1987, Kirk 1992). This approach will allow lower stocking densities and cause fewer ecological impacts of the grass carp. In this situation, however, open waters may afford little protection for small grass carp. Fish smaller than 200-250 mm should not be stocked if piscivorous fish are present. Larger fish, which are less vulnerable to predation, should be stocked (Sutton and Vandiver 1976, 1986). Hill (1986) concluded that because of low natural mortality rates and long life spans, additional stockings of grass carp in waters should occur only when clear evidence of additional vegetation control is needed.

## EFFECT OF GRASS CARP ON THE AQUATIC ENVIRONMENT

According to Bain (1996), "triploid grass carp have potential for being a nuisance in open aquatic systems because the species is capable of consuming large volumes of aquatic vegetation..., inhabiting large rivers, tolerating a wide range of environmental conditions, and dispersing widely from target waters." He recommended that target areas be viewed as a system that includes upstream and downstream waters where grass carp are introduced.

As a large biomass of macrophytes is depleted by grass carp, major ecological changes in the aquatic system may be expected as the effects of plant removal cascades through trophic levels. For example, Maceina et al. (1992) found that once grass carp had removed the macrophytes from 8,100-Ha Lake Conroe, Texas, autotrophic production switched from macrophytes to phytoplankton, resulting in a nearly two-fold increase in algal biomass as measured by chlorophyll-a. Fish community structure was altered, and an expansion of planktivorous forage fish occurred. The introduction of grass carp can thus been viewed not only as a possible remedy for excessive vegetation but also as a biomanipulation process affecting trophic status of lakes. It is also a conversion into fish flesh of excessive eutrophication formerly tied up as plant biomass (van Zon 1980).

Aquatic ecology

**Documented effects on aquatic ecology associated with vegetation removal by grass carp include increased bank erosion, increased turbidity, increased chlorophyll-a concentrations, increases in nutrient concentrations, and increased likelihood of algal blooms. Lembi et al. (1978) evaluated the effects of vegetation removal by grass carp on water chemistry and phytoplankton in six Indiana ponds. The most strongly affected factors were water turbidity and potassium, both of which increased significantly after grass carp had consumed available vegetation. Increased turbidity was evidently a result of suspension of flocculent matter in the water. As much as 54% of the phosphorus and 42% of the nitrogen released by consumption of plants were incorporated into fish flesh. In contrast, little potassium was incorporated into fish flesh. No significant differences in total phytoplankton numbers were found in the 2-year study.**

**Bonar et al. (1996) found for Washington lakes that turbidity was significantly ($P<0.001$) higher in lakes where submersed macrophytes were eliminated than in lakes where control (i.e., partial elimination) or no control occurred. No differences in chlorophyll-a were found among the three treatments (eradication, control, no control).**

**Holdren and Porter (1986) found that introduction of grass carp into McNeely Lake, Kentucky resulted in no significant changes in nutrient concentrations or oxygen deficit conditions. Composition of macrophytes and algal communities did change, however, as nuisance growths of *Lemna minor* and other macrophytes were eliminated. Shifts in dominant taxa of diatoms and blue-green algae were also observed.**

Mitchell et al. (1984) stocked a small (1.92 Ha) New Zealand impoundment with grass carp and reported that although the macrophytes *Egeria densa* and *Eleocharis sphacelata* were eliminated after two years, it did not result in any significant change in dissolved oxygen, water temperature, or annual fluctuations in lake levels over the two-year period. Some reduction in water transparency occurred, although chlorophyll-a levels showed no increase. Zooplankton numbers and biomass increased.

Leslie et al. ( 1983) found that after grass carp were introduced into four Florida lakes for control of *Hydrilla* and other plants, turbidity increased in all four lakes and chlorophyll-a decreased significantly in three of the lakes. Three lakes showed long-term increases in nutrient-related variables (Kjeldahl nitrogen, orthophosphorus, or total phosphorus). They concluded that the degree to which enrichment occurs is probably related to the rate of external nutrient loading and the degree of plant reduction.

Rottman and Anderson (1976) reported that contrary to reports of grass carp introductions resulting in turbidity and algal blooms, they found no tendency toward increased turbidity or algal blooms in 14 Missouri ponds. They also found no discernable effect on benthic biomass.

Maceina et al. (1992) found that a reduction in the areal coverage of submerged macrophytes from 44% to 0% in 8,100-Ha Lake Conroe, Texas resulted in increased nutrient concentrations and increased abundance of all phytoplankton divisions (including Cyanophyta, Chrysophyta, Chlorophyta, and Chrytophyta). Over a 7-year period, chlorophyll-a levels increased and water clarity declined. The decline in water clarity was attributed to higher algal biomass and not to increases in abiotic turbidity.

Mitzner (1978a,b; 1980) evaluated the effects of grass carp on water quality and primary productivity in Red Haw Lake, Iowa. He found that any major effects of grass carp on the internal relationships among grass carp, macrophytes, and nutrients were masked by effects of external nutrient loading from agricultural lands. Other factors were more important to water quality than grass carp.

The consumption of vegetation by grass carp alters the relationships among aquatic plants, nutrients, turbidity, and algal growth. As macrophytes are reduced, turbidity may increase, especially in shallow lakes typically prone to excessive vegetation. Lake location may affect its tendency to be affected by wind and waves. As nutrients formerly utilized by aquatic macrophytes become available, and as grass carp feces are added to the water (Pauley et al. 1987), algal blooms may become more likely, resulting in even higher turbidity (Figure 7). In this regard, the effects of grass carp may in some cases mimic the effects of too many common carp in a system (as described by Bonneau 1999). In the latter case the uprooting of vegetation can reduce turbidity and increase likelihood of algal blooms (Petr 1993), showing similar symptoms as would be expected from grass carp.

In some instances, especially when plant food is scarce, grass carp have been shown to directly influence community structure through competition for food. Forester and Avault (1978) studied the effects of grass carp on red swamp crawfish *Procambarus clarki* in ponds in Louisiana. Grass carp of 190 g were stocked at 4 fish per 0.01 Ha pond. The significant reduction observed in yield of crawfish was attributed, based in analysis of stomach contents, to competition for food between the grass carp and crawfish.

Other fishes

The grass carp occupies a different niche than other native North American fishes, so its impact on other fishes is mostly indirect, i.e., through removal of vegetation. Aquatic macrophytes play an important role in the complex interrelationships among nutrients, plankton, periphyton, macroinvertebrates and fish (Wetzel 1983, Engel 1985, Janecek 1988). Aquatic vegetation is also used by many freshwater fish species during one or more of their life periods: as spawning substrates (Breder and Rosen 1966, Becker 1983, Janecek 1988), as protective cover from predators (Brown and Colgan 1982, Savino and Stein 1982, 1989, Werner and Hall 1988), and as feeding sites (Janecek 1988). Bryan and Scarnecchia (1992) reported that 18 of 20 species of juvenile fish in a large glacial Iowa lake were in greater abundance in naturally vegetated sites than in sites from which vegetation had been mechanically removed. Within all sites, juvenile fishes were most abundant where macrophyte abundance and species richness were greatest. A major concern has thus been that as grass carp eliminate vegetation, fish reproduction and recruitment will be adversely affected, standing crops of game fishes such as Centrarchids will decline, and poorer fishing will result.

Conversely, another concern has been that as the amount of vegetation becomes too great, often as a result of eutrophication related to agricultural practices, fishing and boating opportunities decline (Wyatt 1993), and in many cases the fish community itself is harmed (Beck 1996). Dense growth of submersed plants can limit plankton growth. It can also provide excessive cover for small fishes, which can result in over-reproduction of prey fish, too little predation by piscivores, and stunted growth of all fish. Excessive plant growth can also lower nutrient levels in the water, resulting in lower fish production (Bailey 1978).

Accordingly, fisheries agencies have generally sought partial removal on the assumption that fisheries would be enhanced with an intermediate amount of vegetation (Beck 1996, Figure 8). Because the emphasis has been on the fish and vegetation interaction, too little attention has been focused on the indirect effects of grass carp on other fish.

The studies of the effects of grass carp on other species have shown differing, sometimes contradictory results depending on the size and other physical and chemical characteristics of the water body, the degree of vegetation reduction, and the other fish species in question. When Bailey (1978) compared fish populations in 31 Arkansas lakes (areas 32 - 3,600 Ha) stocked with grass carp and having differing amounts of vegetative coverage, he found a wide range of changes in fish populations after grass carp stocking but " the introduction of grass carp into lakes in Arkansas resulted in neither consistent improvement nor a consistent decline in the quality of fish populations." The large number of variables through which indirect effects of grass carp on fish are produced results in better conditions for a species in one situation and worse conditions in another. Some examples are reported here.

Fowler (1985) found that grass carp stocked into a small English lake (0.145 Ha) coexisted with a varied community of rough fish. Maceina et al. (1992) reported extensive changes in the fish community in an 8,100 Ha reservoir following macrophyte removal by grass carp. Although they found it difficult to assign specific causes to the changes, they noted that the fish community changes were associated with major changes in the zooplankton community.

Killgore et al. (1998) evaluated the response of grass carp stocking on the *Hydrilla* density and resultant effects on other fishes in upper Lake Marion, South Carolina (area, 10,000 Ha). Despite large declines in *Hydrilla*, other forms of vegetative cover remained adequate to provide sufficient complexity for littoral fishes such as sunfishes (Centrarchidae). Grass carp thus controlled *Hydrilla* but did not create any detectable negative effects on the littoral fish assemblage during the duration of the study.

Rottman and Anderson (1976) reported that grass carp were not detrimental to fathead minnows *Pimephales promelas* or bluegills *Lepomis macrochirus* in small Missouri ponds; numbers of young bluegills significantly increased in ponds stocked with grass carp. They argued that the idea that grass carp compete with or feed on young fish has developed mainly from experiments in aquaria. In their view "the addition of grass carp may enhance the production of fathead minnows, bluegills, and other fishes with similar reproduction and food habits...". It was unclear from their paper the mechanism by which numbers of young bluegills were increased in the presence of grass carp.

Forester and Lawrence (1978) evaluated the effects of grass carp on populations of bluegills and largemouth bass *Micropterus salmoides* in ponds denuded of vegetation. After 2 growing seasons, bluegill standing crop had been reduced 52% from controls in ponds stocked with grass carp. Largemouth bass standing crops did not change. The authors did not attribute the decreased bluegill standing crop to water quality differences or to competition for food since there were no major differences in measured water quality parameters nor in numbers of benthic organisms between ponds with and without grass carp. They attributed the differences to disturbances of bluegills on spawning beds by grass carp, but indicated that their results may only be valid in situations where grass carp are stocked at high rates in small ponds.

Kilgen (1978) reported that grass carp stocked in 12 ponds at Auburn University reduced standing crop of water hyacinths *Eichornia crassipes* but did not reduce growth or production of channel catfish *Ictalurus punctatus* or striped bass *Morone saxatilis*. The author concluded that the water hyacinths were detrimental to the growth of both species, but that their growth was not adversely affected by the presence of grass carp.

Rowe (1984) reported that although grass carp had no direct effects on rainbow trout *Oncorhynchus mykiss* in a New Zealand lake, the removal of vegetation by the grass carp aggravated water quality problems, resulting in low dissolved oxygen that ultimately eliminated trout from the lake.

In ponds where vegetation has been depleted, grass carp may compete directly with other fishes. According to Lewis (1978), grass carp in vegetation-depleted ponds contained 95% fingernail clams *Sphaerium* sp. and 5% terrestrial plant material. The clams were thought to be an important food source for channel catfish *Ictalurus punctatus* and redear sunfish *Lepomis microlophus.*

From the above studies, it can be concluded that vegetation removal will in most (but not all) cases significantly alter the fish community. The exact response will vary greatly with site-specific conditions and species, and even in relatively simple ponds, will be difficult to accurately predict. Prediction of effects will be even more difficult should fish escape into more complex large river habitats.

Waterfowl

Grass carp introductions can adversely affect waterfowl through direct competition for food (Chilton and Mouneke 1992). McKnight and Hepp (1995) showed that grass carp in enclosures were able to reduce native species of vegetation preferred by many waterfowl. In contrast, the introduced Eurasian watermilfoil *Myriophyllum spicatum*, which was less palatable for both grass carp and waterfowl, was not affected.

## SECTION 2 -- ENVIRONMENTAL ASSESSMENT FOR MONTANA WATERS

The main issues addressed in this section are 1) the likelihood of escape and dispersal of grass carp from designated areas into the open waters of Montana, 2) the likelihood of escaped fish being able to reproduce and establish a breeding population, 3) the likelihood of escaped fish becoming sufficiently abundant to impact native species 4) the ease of removal of grass carp if they become a pest, and 5) the likelihood of grass carp spreading diseases to other Montana fishes.

Escape and dispersal

Accidental escape and dispersal of exotic fish has contributed to numerous unintentional introductions of fish in the United States (Nico and Fuller 1999). A common occurrence has been for raceways and pond spillways to overflow during times of floods (Cassani 1995). Aquaculture ponds are often built near main sources of water such as streams and rivers, which makes it easy for fish from an overflowing pond to find their way into watercourses. For this reason, considerable effort has been expended to locate facilities away from flood zones. For example, pond sites for grass carp in Alberta and most states adjoining Montana are required to be outside of the 100 year floodplain (See Section 4). Inlet and outlet streams and pipes are typically required to be screened (Wynne 1992). Cassani (1996) depicts various barrier screens. Despite these precautions for grass carp and other species, escape and dispersal of fish often occurs. According to Cassani (1995), " containment is generally practical and inexpensive in relatively small, isolated systems but difficult in lakes or impounded rivers." There is every reason to believe that escape of fish from designated areas in Montana would occur from some sites. The likelihood will depend on a variety of factors, including, but not limited to, site location, water level fluctuations, effectiveness of screening, and degree of on-site supervision.

Reproduction and establishment potential

*Ecological aspects*--Stanley et al. (1978) reviewed literature, interviewed experts, visited spawning sites, and concluded that successful spawning occurred "only in large rivers or canals where water velocity exceeds 0.8 m/s and volume is roughly 400 $m^3$/s. The eggs are carried downstream 50 to 180 km..." . They concluded that there was a likelihood of successful spawning of diploid fish in North American rivers, a prediction borne out. Since then, grass carp have shown that they are an adaptable species that can find suitable spawning and rearing habitat in many locations in the United States (See Section 1 under "Reproduction").

**In evaluating the potential for spawning and rearing success, it is assumed in this report that grass carp can begin spawning at 18-19°C, peak in spawning at 20-22 C, and also spawn in water as warm as 30 C (Stanley et al. 1978). It is also assumed that grass carp can rear successfully at temperatures between 14 and 33 C, with optimal temperatures of 20-26 C (Clugston and Shireman 1987).**

**Based on temperature considerations, several large river habitats in Montana would be suitable for grass carp spawning and rearing. The 18-30° C temperature range commonly used by grass carp for spawning, and later rearing, occurs in the Yellowstone, Missouri, Clark Fork, Bitterroot, Blackfoot, and other Montana rivers in late spring and summer.**

**One potential spawning and rearing area would be the lower Yellowstone River, where discharge, turbidity, and temperature in spring and early summer are well within the range of suitable conditions for grass carp spawning. For example, Yellowstone River temperatures 1 km below the Intake Diversion Dam in 1991, a high runoff year, ranged between 14.4° C and 23.3° C for the period May 17 to July 11 (D. Scarnecchia, Unpublished data from thermograph at River Kilometer 112.6). Nearly all water temperatures during this period, and later into the summer, were within the acceptable (18°C and higher) range of temperatures for grass carp spawning and rearing. Similar thermal regimes occurred in other high-water years such as 1995-1997. In lower water years such as 1992, 1994, and 1998, waters would warm earlier in spring and an even longer period of suitable temperatures would exist.**

**In portions of the Missouri River, temperatures are also within the range of suitable**

grass carp spawning and rearing for much of the summer, even though temperature are cooled upriver by hypolimnetic discharges from Fort Peck Dam. For example, in 1998 temperatures at Nohly Bridge near the Yellowstone River confluence exceeded 18°C on June 24 and remained from 18-22°C for all of July and August (Figure 9). In the Milk River at Bjornburg, temperatures ranged from 17-26°C over the period June 21-September 21, with temperatures in exceeding 22°C in June and 26°C in August (Figure 10).

West of the Continental Divide, suitable spawning and rearing habitat is also present. The Clark Fork River (both below and above Noxon Reservoir) warmed to 18-22°C for all of July and August in 1989 and 1991 (Beak Consultants 1997). Water temperatures in the Bitterroot River may reach 20°C and beyond for much of July and August (Figure 11). The Blackfoot River had 25 days over 20°C in 1999 (Chris Clancy, Montana Department of Fish, Wildlife and Parks, Unpublished data). All of these rivers are candidates for successful reproduction and rearing by grass carp.

Many suitable lake and reservoir rearing habitats for the species exist in Montana. Although the lower Yellowstone is not rich in backwaters and side channels, such areas exist (e.g., Joe's Island near the Intake fishing site and Erickson Island on the Missouri River below the confluence with the Yellowstone). In addition, the headwaters of Lake Sakakawea, North Dakota would provide an abundance of rearing habitat for young fish; these fish could later migrate back into Montana. Other reservoirs such as Tongue River reservoir are thermally suited to grass carp. In the west, Noxon Reservoir and Hungry horse reservoirs also warm to temperatures above 17°C in the epilimnion in summer (Beak Consultants 1997). Because of their warm temperatures compared to rivers, numerous reservoirs in both eastern and western Montana may thus provide suitable rearing conditions for grass carp.

If spawning were successful, grass carp would have a fair chance of survival during rearing, for several reasons. First, their period of embryological development is short. At temperatures of 21-25° C, hatching results from 22 to 33 hours after fertilization; at 28-31° C, hatching takes only 19-23 hours. Rapid early larval development (13-20 days) thus requires that favorable incubation and rearing conditions exist for only a short period of time to assure survival (Shireman and Smith 1983).

Second, under favorable temperatures and feeding conditions, grass carp can grow up to 1 kg/year in their first year (Mitzner 1978a) and 2-3 kg/year thereafter (Shireman and Smith 1983). They will thus outgrow most native fishes and, much like the common carp, grow sufficiently large, and past a size of being preyed upon, in as brief a period as one year.

Because the grass carp are near, but not at, the northern limit of their potential range in Montana, the likelihood of establishment, all else equal, would probably be greatest in the region of the state with the longest growing season, i.e., eastern portions of Regions 5, most or all of Region 6, and all of Region 7. This area includes portions of the Missouri River and lower Yellowstone River. Establishment in other areas on both sides of the Continental Divide areas statewide should also be considered possible, particularly where growing seasons are longer and sufficiently warm water temperatures exist. In some cases, water temperatures may be adequate for grass carp to become established, while not reaching the threshold recommended by Beck (1996) as necessary for successful vegetation control (at least 18°C for 65-70 days).

Once grass carp were able to spawn,rear and become established in the lower Yellowstone or upper Missouri rivers, as well as western rivers, there would in most cases be few dams to impede migration. To avoid possible reproduction, it is therefore advisable to insure that diploid grass carp do not reach Montana's large rivers or reservoirs on either side of the Continental Divide.

*Genetic aspects* --The triploid grass carp offered for sale by dealers is often touted as completely incapable of reproduction and thus a solution to the possibility of unintentional reproduction and establishment of grass carp. A close inspection, however, of the processes by which triploid fish are created and certified indicates that lack of reproduction of a dealer's triploid fish, although nearly assured, cannot be 100% guaranteed. This applies even to fish *certified* to be sterile with the available inspection and certification program. There are several steps in the process at which triploid grass carp reproduction could occur, although reproductive success is highly unlikely at each step.

First, *nearly all* (but not *all*) true triploid grass carp are incapable of reproduction. Triploid grass carp are, with high probability, functionally infertile (Allen and Wattendorf 1987), as a result of aneuploid gametes (Beck et al. 1980). Gonads of females are abnormal and functional oocytes evidently are not developed (Stevens, Undated.) Allen et al. (1986) reported that because of abnormalities in the spermatids of triploid grass carp, only 60 of every 1 billion spermatids would be expected to be haploids, and that the probability of successful reproduction was very low. They also noted that the presence of triploids may actually disrupt spawning by diploids, thus reducing overall reproductive potential even further.

However, Van Eenennaam et al. (1990) noted that "while somatic triploidy greatly affects sexual maturation, it does not exclude potential fertility of some individuals ." Mature testes, spermatogenesis, and normal endocrine cycles may be expected in triploid males. Van Eenennaam et al. (1990) evaluated Allen et al's (1986) conclusion of low reproductive potential with breeding experiments on grass carp and found that survival rates of diploid female x triploid male crosses from hatching to 5 months were 0.21% and 0.125% compared to 95% and 84% for diploid x diploid crosses. Goudie et al. (1989) hormonally induced 3 of 7 triploid female and 3 of 11 triploid male grass carp to spawn. Hatching success of offspring from all-triploid matings was less than 0.5%. Only 4 of 19 triploid males produced enough milt to inseminate eggs of diploid females. For both sexes, triploid nearly always implies no reproduction, but this is not true 100% of the time (N. Heil, U. S. Fish and Wildlife Service Triploid Grass Carp Inspection Program, Personal Communication).

Second, not *all* eggs induced to triploidy with best available scientific methods are actually triploids. Success sometimes approaches 100% using hydrostatic pressure, the dominant technique now in use (Cassani and Caton 1985, 1986). Thompson et al. (1987) used various cold and heat shocks to eggs and were able to obtain up to 87% triploids. McCarter (1988) achieved 95% triploidy with hydrostatic pressure shocks. Cassani and Caton (1985) used high hydrostatic pressure 6,000-8,000 PSI /2 and 5 min intervals to obtain 91.7-99.4% conversion to triploidy. Although these authors believed they had achieved 100% efficiency immediately after the pressure treatment of eggs, subsequent analysis by Coulter Counter confirmed less than 100% efficiency. Considerable effort has gone into development and refinement of methods and timing associated with inducing polyploidy in grass carp with maximal efficiency (Shelton and Rothbard 1993). Despite these efforts, the status of triploid production techniques is well summarized by Harrell et al. (1998): "Methods for mechanical induction of polyploidy are not 100% effective." For this reason, grass carp suppliers will often test their fish when the fish are small with the flow cytometry method (see below) to insure that the percentage of triploids is high. If the percentage is found to be too low, producers will often sacrifice the entire lot rather than incur the expense of raising fish that have a high frequency of diploids.

Third, although all triploids can be positively identified as such with best scientific methods available, it is not economically feasible to do so. Bonar et al. (1988) found no single morphometric and meristic method that was 100% reliable for separating diploid and triploid fish, so more technical methods must be used. Harrell et al. (1998) reviewed several methods for assessing ploidy of grass carp and other fish, including cytological karyotyping (Thorgaard and Disney 1990), staining nucleolar organizing regions (NORs; Phillips et al. 1986), use of a Coulter Counter to measure erythrocyte volume, and flow cytometry (which measures relative DNA content of blood cells). They discussed advantages and disadvantages related to reliability, time required, chemical hazards, necessary expertise, sampling invasiveness and expense. Results are summarized here.

Chromosome enumeration by karyotyping is the only absolutely reliable method of assessing triploidy, but it requires sufficient time and effort as to be unsuitable for mass screening of fish. It also involves toxic chemicals and a lab setting. It is not practical for assessing ploidy of each fish in a shipment lot of grass carp.

Silver staining NORs requires that the investigator must analyze large numbers of individual cells per fish (>100) for accuracy and results vary with fish age. The method is also invasive (may need to kill or greatly stress fish on removal of gill tissue). It is not practical for assessing ploidy of a shipment lot of grass carp, and is not 100% reliable.

Flow cytometry requires expensive equipment and expertise, but has applicability to mass screening. It is preferred if tissue samples (batch or larvae) rather than individuals are to be analyzed. It is not cost-effective for analysis of ploidy in grass carp.

Particle size analysis of erythrocytes with a Coulter Counter provides a rapid, convenient, reliable and cost-effective method of determining ploidy state independent of fish age and nutritional status (Wattendorf 1986), and is the preferred method for ploidy determination in situations where large numbers of individuals must be tested and diploids separated from triploids (Harrell et al. 1998). Although analytical costs are not high ($2-3/fish), initial costs for equipment are high enough that analysis would typically be done at universities or analytical laboratories.

The Coulter Counter "estimates particle size by measuring the increase in resistance experienced by a continuous current passing through a small orifice (70 u) whenever a particle passes through displacing the electrolyte... . The measurements of resistance are processed by a channelizer and displayed as a probability distribution which provides an indication of particle size. Size differences of diploid and triploid erythrocytes make this method practical." (Bonar et al. 1985). The method is highly accurate, but not 100% reliable. Wattendorf (1986) showed a very slight overlap in nuclear volume distributions for diploid and triploid fish; assuming random sampling and a normal distribution, "...99.5% of all diploids should have nuclear volumes with a mode between 8.32 and 11.75 $um^3$ and a similar proportion of the triploids should have a modal nuclear volume between 12.12 and 17.52 $um^3$... (Figures 12,13). Van Eenennaam et al. (1990) reported that Coulter Counter measurements incorrectly assigned 9 diploid x triploid grass carp crosses as diploids. In practice, producers will typically be especially cautious and sacrifice any fish having a nuclear volume in or near the overlap zone, to absolutely insure triploidy.

The conclusion is that no economically viable method exists for 100% reliable assessment of ploidy of individual grass carp from batches to be considered for stocking.

Fourth, even if a"lot" of fish induced to be triploids is *certified* as a 100% triploid lot with the best certification program available, not all fish in the lot are tested under the standard certification guidelines. The U. S. Fish and Wildlife Service (USFWS) offers a triploid grass carp inspection and certification service. The purpose of the program is to provide assurance to natural resource agencies that shipments of putative triploid fish are indeed all triploids and do not, "within the confidence limits of the inspection program, contain diploids". This program is voluntary, i.e., for producers who want to cooperate. Even for voluntary submission of a shipment lot, the program, although professionally conducted and valid in its approach, is not 100% reliable. Before outlining the reasons for the unreliability, the certification program is reviewed here (See Appendix 1 for guidelines).

Under the program guidelines, the USFWS inspection consists of a "re-testing by the Producer, in the presence of the Inspector, of 120 individuals randomly selected by the

**Inspector from the identified lot of alleged 100% triploid grass carp." This lot will typically consist of a minimum of 1500 fish to be shipped *within 4 working days* from a containment unit. (Smaller lots need special arrangements.)**

**The inspector will view the group of fish to be certified, verifying that it is isolated from production ponds. The inspector will channelize (test) at a minimum, every tenth fish during the inspection of the 120-fish sample of alleged triploid fish. Any non-triploid fish will immediately cause the entire lot to fail the inspection, and no certification can be provided until another inspection is scheduled.**

**In FY99, USFWS Region 3 had 10% failed inspections (1 of 10), USFWS Region 4 had 6.8% failed inspections ( 17 of 252), Stuttgart (Arkansas) had 7.5% failed inspections (17 of 226), and Warm Springs (Georgia) had 0% failed inspections (0 of 26; Appendix 1) . These fish were assumed *a priori* to be 100% triploid.**

**In a January 18, 2000 letter to D. L. Scarnecchia (Appendix 1 ), G. Conover, USFWS, stated that "In regards to your question about the [Certification] program's ability to prevent the unintentional certification of diploids, please be aware that the [U. S. Fish and Wildlife] Service's TGCICP [Triploid Grass Carp Inspection and Certification Program] does not guarantee 100% triploids in a certified lot of fish. The testing, or re-testing, of any number less than the total number of fish in the lot, only gives the probability that the lot contains less than a certain percent of diploids. The 120 fish subsample used by the Service provides at a 95% confidence level that when 2.5% or more of the fish in the lot are diploid, at least one will be detected in the inspection (Ossiander and Wedemeyer 1973; Griffin and Mitchell 1992)... . Stated another way, "the inspection**

**gives assurance at a 95% confidence level that the producer's error in testing is no greater than 2.5% for a lot of 1 million fish, no greater than 2.4% for a lot of 5,000 fish, no greater then 2.3% for a lot of 1,000 fish, and no greater than 2.1% for a lot of 500 fish (Griffin and Mitchell 1992). Once a lot of fish is certified as triploid, the Service has no further involvement with the fish or their shipment. The Service and TGCICP Standards have no provision for following certified fish from the inspection to their final destination."**

**One main reason for some unreliability is thus a result of sampling procedures necessary to certify a "lot" of fish based on a sample of fish from that lot. Simply stated, not every fish is tested in their standard certification process. Some states have required that each *fish*, not just every lot of fish, be tested, in which case the cost of triploidy certification increases from 0.24 cents per fish shipped to $1.00 per fish shipped.**

**In conclusion, available evidence suggests that there is no way to assure that diploid grass carp may not be present in supposedly all-triploid lots of fish even if the procedures were strictly followed for supplying only triploid fish. Although the probabilities for reproduction of diploids when only triploids were intended to be introduced are very low at each step in the process (i.e., few triploids will be able to reproduce, few triploid-induced eggs will actually remain diploids, few diploids will be mis-identified as triploids, and few diploids will pass through the inspection/certification process), a few diploid fish are bound to enter the state eventually even if careful procedures to exclude them are followed. Although the likelihood of an introduction of reproductively-capable fish is remote (probably less than 1%) for a given event, the likelihood will increase as the number of lots entering the state increases.**

**A more likely source of introduction of diploid fish would be accidental mixing of tested and untested fish, either through accidental mixing of lots or by fish jumping from one tank to the other. There are no provisions for assuring that the certified fish may not be accidentally or intentionally mixed with other fish prior to shipment. This may provide a greater probability of diploid fish entering the state than the comparatively minor weaknesses in the triploidy inducement and certification process.**

**All of these probabilities would in turn be less likely than an unauthorized introduction of diploid fish by some member of the public. Diploid fish are available from many states, including nearby (eastern) Colorado. The issue is well-stated by Beck (1996): There appears to be a history of diploid grass carp appearing in natural waters of states within the United States even when a "triploids only" policy exists. Such introductions are likely the product of unauthorized introductions or escapees from research or propagation facilities. ... The publicity given the triploid grass carp project [in Alberta] will in all probability generate a demand... for the use of grass carp.... Many habitats will not be eligible for stocking grass carp because of proximity/connectedness to natural surface waters. In such cases, some landowners/stakeholders may be inclined to conduct unauthorized releases of diploid grass carp as the current regulatory regime to prevent the importation of live fish is fraught with loop-holes. These problems could be exacerbated by the widespread promotion and use of triploid grass carp which could provide cover for such activities".**

**<u>Impact on native species</u>**

**Other than disease issues, which are discussed in a separate section below, the effects on native fishes would be most pronounced through the indirect effect of vegetation removal on the trophic ecology of the invaded waters, as described in detail in Section 2 under "aquatic ecology", "other fishes" and "waterfowl". The exact character of interactions is difficult to predict; it would depend on a variety of factors such as the physical and chemical characteristics of the water body where the grass carp were introduced, how many fish became established, and the composition of the existing aquatic community, including fish and waterfowl. Inasmuch as the vegetation is a key component of the aquatic community, however, (Janecek 1988, Bryan and Scarnecchia 1992), major alteration of the vegetation in lakes, as well as in river sloughs and backwaters would be expected to substantially change the ecology of these sites. Fishes relying on vegetation for reproduction, food substrates, or protection from predators would be expected to suffer reduced habitat quality.**

**The lower Yellowstone River is home to an endangered species, the pallid sturgeon *Scaphirhynchus albus* as well as threatened species and species of special concern. These species include the sturgeon chub *Macrhybopsis gelida*, the sicklefin chub *Macrhybopsis meeki*, the flathead chub *Platygobio gracilis,* the blue sucker *Cycleptus elongatus,* and the paddlefish *Polyodon spathula.* Minnows, suckers and other native fishes that occur west of the Continental Divide may also be affected by interactions with introduced grass carp.**

<u>Removal of grass carp (population control)</u>

**Once grass carp are in large bodies of water, they can be difficult to remove, especially in larger waters. Hestand (1996) reviewed results of several studies and those and other studies are reviewed here. Techniques used for the removal of grass carp have included gillnets, trammel nets, hoop nets, fyke nets, pound nets, wire catfish nets, trotlines, electrofishing, commercial haul seining, water flows (attractant) and primacord, baited lift nets, hook and line angling, archery, herding, rotenone, and rotenone baits. Hestand (1996) reported that only electrofishing, angling, haul seining, and rotenone had reasonably high success rates.**

**Mitzner (1978a) found that large grass carp easily avoided open water gill nets and could jump over them. Mitchell (1980) removed some portion of grass carp from a small lake with seining. Wilson and Cottrell (1979) tried angling for grass carp in small ponds with 4 kinds of baits (artificial minnows, spinners, live earthworms, and aquatic vegetation) and were able to land only two fish in 427 hours of angling. Greater angling success was reported by Mallison et al. (1994) with doughballs and worms. Bonar (1993) was able to herd fish in ponds with splashing and other noise-making until he could seine and gillnet fish. Morrow and Kirk (1995) were able to remove grass carp by use of bow and arrow; they concluded that it was a useful technique when most other methods failed. Hestand (1996) reported that bow-hunted grass carp quickly became wary in Florida lakes, and catch-per-effort dropped as the season progressed.**

**Grass carp have been reported to be about as susceptible to fish toxicants as the common carp (Marking 1972). Mallison et al. (1994; 1995) found that rotenone-laced baits were successful in reducing the number of triploid grass carp from Florida lakes, with**

**minimal loss of other fish species. Their trials indicated that removal was much more effective for small ponds (e.g. hatchery-sized ponds) than in large lakes (38-152 Ha). Colle et el. (1978) used 0.1 mg/l rotenone to selectively remove grass carp (with minimal loss of sport fish) from an 80-Ha Florida lake.**

**Overall, grass carp have proven difficult to remove from all but small bodies of water. For that reason, some states have restricted their use to small ponds. Furthermore, in many cases natural mortality is low, and fish may persist for years after the vegetation problem has been solved (e.g., Scarnecchia and Wahl 1992).**

**Risk of disease introduction and transmission**

**If grass carp are introduced into Montana, the possibility exists for several diseases and other pests to be introduced with them.**

**The Asian tapeworm parasite, which has a simple fish-copepod-fish life cycle, was introduced into the United States by grass carp and is now known to infect many native North American species of minnows, suckers, and livebearers. According to Dr. Richard Heckmann, an expert from Brigham Young University, if the tapeworm was introduced by grass carp into Montana, it would have a moderate to high probability of infecting numerous species of Montana minnows and suckers. Vulnerable species would include, but not be limited to, the sicklefin chub, sturgeon chub, flathead chub, blue sucker, and plains killifish *Fundulus zebrinus*), all of which are threatened or species of concern in the Missouri River basin. Native minnows and suckers west of the Continental divide would also be susceptible. It is not yet known if the tapeworm infects salmonids.**

There is currently no coordinated national program or clearing house for testing or treating for Asian tapeworm. Treatment is on a state-by state basis. In Arkansas, testing is usually done at the University of Arkansas, Pine Bluff; no testing is done at the Stuttgart Aquaculture Research Center. There is also no standard procedure or protocol for inspection for Asian tapeworm (Drew Mitchell, Stuttgart National Aquaculture Research Center, Personal Communication). The life cycle is well known, but the environmental tolerances (e.g., temperature) are less well known, and there is insufficient knowledge of the effects of large numbers of tapeworms on host growth and mortality (Dr. Richard Heckmann, Brigham Young University, Personal Communication).

The treatment for Asian tapeworms consists of Praziquantal, an injectable anti-helminthic that is very effective for eliminating the parasite. The typical approach is not to use costly injections, however, but to run fish through a treated water bath for 1-1.5 hours. The drug is not approved by the United States Food and Drug Administration, however, so it is to be used only for fish not destined for human consumption. According to Dr. Heckmann, effectiveness with a water bath will be greater than 95%, and with a second bath it should be 100%. A statistical sample of 20-30 fish should indicate presence or absence in the entire batch, because if the parasite is present in the pond, nearly all fish will also have it. Once the tapeworm is established in a pond or river, it is difficult to eradicate.

There is considerable variation in how seriously different states view the threat of Asian tapeworm, and consequently how stringent their requirements are for testing and certification. For example, Colorado has testing requirements for it, but no longer tests

**for it in practice. Washington requires testing and certification. The lack of standard, widely applied protocols for testing, and the laxity of some states in testing for it makes it likely that problems with Asian tapeworm will increase in the future (Appendix 2).**

**The introduction of zebra mussels and the quagga mussel (a deeper water relative) at all life stages is also a significant concern in grass carp introductions. The state of Washington requires that any fish shipped from east of the Rocky Mountains be certified as free of zebra mussels. Often this requirement is met by receipt of a statement from a knowledgeable source that there are no known infestations in the area where the fish farm is located (A. Appleby, Washington Department of Fish and Wildlife, Personal Communication). North Dakota also requires that grass carp not be taken from a source where zebra mussels are known to exist. Colorado requires that any importer sign a statement indicating no knowledge of the presence of zebra mussels. Transmission of various life stages, especially veligers, with water is a possibility, especially when fish are shipped from areas such as the Mississippi River valley, portions of which are rife with zebra mussels.**

**In discussion with Peter Walker, Colorado Division of Natural Resources, Wildlife Division, there are other potentially serious problems with disease introduction from grass carp and other warm water fishes. Several viruses may present treatment problems. In addition, there is a recently documented threat in *Centrocestus formosanus*, a trematode from India (Alcaraz et al. 1999). Centrocestia is the disease caused by the metacercarial stage of *C. formosanus*. The cercariae penetrate into the branchial epithelium, resulting in gill tissue lesions and affecting fish respiration (Alcaraz et al. 1999). This parasite has a**

**snail-fish-bird life cycle that presents no problem unless the red-rim melania snail, *Melaniodes tuberculatus*, is introduced. The snail, also native to India, has been found in Florida, Louisiana, Texas, Oregon, and Arizona and appears to be spreading. The trematode is very pathogenic to a range of fishes. The threat of introduction of snail and trematode exists, and its likely effects are poorly understood.**

**Inasmuch as grass carp (particularly hatchery-reared fish) harbor many other diseases (Shireman and Smith 1983), a well-enforced policy on disease testing and certification would be necessary to prevent introduction of diseases into Montana by grass carp.**

## SECTION 3 -- MANAGEMENT AND ENFORCEMENT ISSUES IN MONTANA AND NEIGHBORING STATES

**Montana's actions on grass carp will affect, and be affected by, actions in other states and provinces, especially those states and provinces sharing common drainage basins with Montana. A review of programs on other states was provided by Johnson (1998), and emphasis here is on updating his results and reporting on a few additional neighboring states and provinces. Some of the information is published and is referenced as such, but most information is from interviews with fisheries experts in each state or province. Additional documentation for each state is provided in Appendix 3.**

**Idaho -- Stocking of triploid grass carp was legalized in Idaho in 1988 (Loch and Bonar**

1999). Permits for grass carp transport and stocking have been issued for more than 10 years. Idaho's grass carp program is supervised by Keith Johnson (208:939-2413) from the Idaho Department of Fish and Game's (IDFG) Eagle Laboratory. IDFG issues import and transport permits, which are required for each action with grass carp. They receive 25-30 stocking requests per year, mostly for 25 fish or less. Fish entering Idaho come from only one supplier, Keo Fish Farms, of Arkansas. All fish entering the state must be certified triploid and free of Asian tapeworm (tested in Arkansas). The importer is Opaline Aquafarms, Melba, and some of their imported fish are sold to Sweetwater Aquaculture in Lapwai, near Lewiston. The receiver is required to have a private pond permit, and the pond is always inspected for the water source and outflow, typically by an IDFG Conservation officer, for a subjective evaluation of escape risk. Fish cost about $1 per inch, or $8/fish for a typical fish stocked. Grass carp 71 cm (28 inches) TL long are in Idaho, so they are clearly able to grow in the state in some situations. According to Johnson, they have been effective in golf course ponds but less effective in irrigation canals, for reasons unknown. More information is needed on their requirements for success in Idaho.

Johnson reported that he thinks the IDFG's grass carp program has been successful. He suggested that a tightly controlled and monitored entry program is an alternative to an outright ban, where diploid or uninspected, potentially diseased fish may find their way into a state by freelance fish stockers.

Oregon -- Oregon's grass carp program is very small. Last year (1999) was the first year that permits could be sought for grass carp introduction. Before that, Oregon had not

**allowed grass carp stocking except for one research site, Devils Lake near Lincoln City (Pauley et al. 1987, 1988).**

**According to Ray Temple, Warmwater Biologist at the Oregon Department of Fish and Wildlife (ODFW) Portland Office (503:872-5310), in about 1973, Oregon, Washington, and Idaho signed a compact indicating that except for institutions such as universities and zoos, grass carp were undesirable and were not to be introduced. In the 15-20 year period after this agreement, ODFW located (with Oregon State Police help) and eradicated (with rotenone) about 12 ponds with illegally-introduced grass carp. The fish were of course banned for use but private citizens brought them in illegally. Fish were typically diploids.**

**Legal activities in Oregon with grass carp began in 1985, when the Devils Lake Water Improvement District requested their use for vegetation control. Excessive vegetation was interfering with boating and swimming. There was local opposition to herbicide use, so the group won authorization from the Oregon Fish and Wildlife Commission (against ODFW opposition) to stock the lake. The stocking was to be followed by 4 years of monitoring of impacts on aquatic vegetation, water quality, fish, and waterfowl. That work was completed. The grass carp partially controlled vegetation but did not eliminate it, and warmwater fisheries for bass continued. About 1992, supplemental stocking was authorized and this additional stocking was associated with a decline in the warmwater fishery. It has been speculated that juvenile coho salmon *Oncorhynchus kisutch* habitat improved in the lake as their rearing habitat was reclaimed from warmwater fish, but a detailed study was not done after the vegetation had disappeared. The perception in Oregon from the Devils Lake study is that grass carp will**

**harm bass and bluegill fisheries in Oregon if they eliminate the vegetation.**

**Between 1992 and 1998, at least two other proposals for introduction were rejected. In late 1998, ODFW approved rules that allowed entry of the fish into the state. Key requirements (Appendix 3) are:**

1. **Fish must be batch-certified as triploid.**
2. **No stocking in ponds larger than 10 acres (This requirement keeps stocking small in number and more controllable).**
3. **Ponds must be screened to prevent escape.**
4. **Ponds cannot *effectively* be in 100 year floodplain.**
5. **All fish must be PIT-tagged.**
6. **Fish must be certified free of Asian tapeworm.**
7. **Fish must be from an out-of-state supplier (i.e., no in-state brokers allowed).**

**These restrictions are thought to have constrained interest in stocking the fish among many members of the public. Most requests are coming from western Oregon.**

**Overall, ODFW has historically been reluctant to support or engage in grass carp stocking because it has been viewed as not yielding many public benefits (most benefits are private), but costing considerable public funds for permitting, evaluation, site inspection, etc. Additional public costs might accrue if fish escaped into public waterways. Wildlife biologists have also expressed concerns about the potential effects of vegetation removal on wetlands and waterfowl. ODFW has thus reluctantly entered into a permitting process. Funds for their work to date have come from license revenues.**

**There are some grass carp in the wild in Oregon today. In addition to recent reports from the Columbia River (perhaps triploids from Washington; Loch and Bonar 1999), some fish (probably diploids from past illegal stockings) are taken by archery in the Willamette River, a large tributary entering the Columbia River at Portland.**

**Washington -- Washington has a much more extensive grass carp program than Oregon. There was considerable unauthorized introduction of grass carp into the state in the 1970s, and in the 1980s, about 20 lakes were treated with rotenone to remove illegally-stocked fish. Research was also conducted in the 1980s on the efficacy of triploid grass carp as vegetation control agents (Pauley et al. 1987, 1988; Bonar et al. 1996). Stocking of triploid grass carp was legalized in Washington in 1990 (Loch and Bonar 1999). Over the period 1990-1995, the Washington Department of Fish and Wildlife (WDFW) approved applications to stock triploid fish in 184 lakes and ponds (Bonar et al. 1996). Numbers of permits were highest immediately after legalization (>40). Most stocking have occurred in small ponds and lakes in the Puget Sound region, with scattered stocking statewide (Figures 14,15).**

**Scott Bonar, WDFW biologist (360:902-8415) indicated that Washington has had little success in achieving partial control; it has been mostly complete eradication or no effect. Initially, they had assumed that because Washington was near the northern end of the range of grass carp, that more fish would be required for vegetation control than farther south. Stocking rates of 50-200 fish per vegetated acre proved to be far too high. Overall, 20-22 200 mm (8-inch) fish per acre is typical as the appropriate stocking rate, but**

that rate varies greatly. Some variation results from highly variable annual mortality. In early stocking efforts in Washington, poor handling methods may have resulted in much higher transport mortality than exists today. They have thus had difficulty assessing how many grass carp were in the lake or pond at any time.

In a study of permit-holder satisfaction, Bonar et al. (1996) found that stocking grass carp has been a popular method for controlling vegetation with permit holders. All property owners achieving partial control or eradication were highly or moderately satisfied. Grass carp had little effect on the *perceived* angling quality in lakes. Few changes in angling quality were reported in the lakes. Most landowners were pleased with aesthetic changes in the lakes.

According to Jim Uehara, WDFW biologist (360:902-2200), the agency has three main policies on grass carp.

1. Grass carp should not be stocked in situations where one does not want complete eradication of vegetation. (It has proven too difficult to achieve partial removal of vegetation.)
2. All outlets from stocked waters must be screened.
3. Stocked fish must be triploid.

WDFW also requires that if grass carp are planted into waters that have never contained them, they must have a risk assessment under the State Environmental Assessment Act (SEPA). Depending on the perceived risk, this requirements under SEPA may be met by as little as a declaration of non-significance, or may require a more detailed risk assessment (A. Appleby, WDFW, Personal Communication).

WDFW requires testing for the Asian Tapeworm before any triploid fish enter the state. The test is not conducted by them, but proof is in the form of a letter from a laboratory judged to be reputable (A. Appleby, WDFW, Personal Communication). According to A. Appleby, Washington is particularly concerned about the Asian tapeworm and zebra mussel.

WDFW biologists contacted indicated that diploid grass carp could be expected to spawn somewhere in the Columbia River if they were introduced there.

Wyoming -- According to Bob Wiley (307:777-4559), Wyoming Game and Fish Department, only triploid grass carp are allowed in Wyoming, subject to approval by regional fisheries personnel. Triploid fish must be batch-certified by the USFWS. Wyoming requires that fish be certified free of Asian tapeworm (Tests are conducted by USFWS, not the state). Grass carp are not stocked in the Clark Fork (of the Yellowstone) Drainage in northern Wyoming. There are some grass carp in the Bighorn drainage although the outflows are dry and fish have nowhere to go. Renner Reservoir, which has had vegetation problems, has been stocked with grass carp. All stocked ponds must be away from the floodplain. One private broker (Nye) handles the trade. Many requests are for 1-5 fish, and these are generally not approved. According to B. Wiley, there has been little or no interest in stocking grass carp in the Tongue and Powder river basins. Much of Wyoming is too high in elevation and has too short of growing seasons for good growth and survival of grass carp. One stocking on the Laramie plains (elevation >2130 m (7000 feet)) has been successful, however. A likely area for good growth would be the northeastern portion of the state. No grass carp reproduction has been noted and the program has not had any significant problems. He knew of no problems with illegal introductions in Wyoming.

Colorado -- Colorado has a long history of grass carp introductions, especially in the eastern drainages. Grass carp are permitted for use in accordance with the Colorado Wildlife Commission Policy (Appendix 3) and the Colorado River Wildlife Council. The requirements have not changed since reviewed by Johnson (1998). The main requirements are:

1. Diploid grass carp are permitted in standing water east of the Continental Divide except in the San Luis Valley. Certified triploid grass carp may be used in standing waters west of the Continental Divide and in the San Luis Valley when authorized in writing in accordance with the policy for grass carp as approved by the Colorado River Wildlife Council.

2. All shipments of grass carp into the state must comply with state regulations on importing live fish and viable fish eggs.

3. All triploid fish must be certified triploid at their point of origin and a notarized certificate of triploidy must accompany each shipment

**4. All persons wishing to import grass carp must apply for a grass carp permit. Imported fish must meet established health criteria (This rule is evidently not strongly enforced).**

**5. Persons may apply in writing to the Department of Natural Resources (CDNR), Wildlife Division for a grass carp use permit. Each application for a grass carp use permit must be accompanied by a description of the body of water to be stocked, a site location map, and the source of fish. Stocking in the Colorado River basin can occur only in waters "where escape from that habitat is unlikely."**

**Requirements for Asian tapeworm are not stringent. According to Peter Walker (CDNR; 970:842-6312), the state of Colorado initially had regulations for testing designed to prevent its entry, but much resistance was encountered by the industry. By the 1980s, there was a brisk trade in diploid fish in eastern Colorado, and introduction of the tapeworm was not seen as preventable. Ironically, in eastern Colorado (North Platte, South Platte, and Arkansas Rivers) where grass carp exchange is much less regulated and diploids are legal, the tapeworm has not been seen. In western Colorado, where only triploids are legal, it has been found in the Colorado River. The exact source of the tapeworm is unknown, but it is thought to have been introduced by the USFWS from fathead minnows *Pimephales promelas* held at their hatchery on the Pecos River as a food supply for Colorado River pikeminnow *Ptychocheilus lucius* recovery efforts. With the large number of fishes of special concern in the Colorado River (especially Cyprinidae, Catostomidae, and Cyprinodontidae known to be susceptible to infection), the tapeworm has thus become established where the CDNR was most concerned about its introduction.**

**The actual requirement that testing for the tapeworm occur was thus dropped about 1989-1990. No visible impacts on native minnows, suckers, or killifishes have been identified in Colorado, although serious effects have been documented in other states (Heckmann 1987, 1993)**

**<u>North Dakota</u> -- North Dakota's grass carp issues are administered by Terry Steinwand, Chief of Fisheries of the North Dakota Game and Fish Department (701:221-6313). NDGF has had two stockings: 4,000 fingerlings into Spiritwood Lake near Jamestown in 1971 and 300 larger fingerlings into Spiritwood in 1972. Although the fish have not been closely monitored, the last of these fish evidently died about 1996. They are difficult to catch in nets so their exact status is unknown. There is no evidence of natural reproduction. One unauthorized stocking of grass carp also occurred in a Fargo pond, but NDGF required that the fish be killed (rotenone).**

**North Dakota has a policy that states "it shall be illegal to take, possess, or transport any grass carp in North Dakota". The state can nevertheless allow stocking with the appropriate permits (Appendix 3).**

**The Garrison Conservancy District requested permission in 1995 to plant grass carp in a canal for vegetation control. NDGF requirements included that the fish be from a disease-free hatchery, not from east of Alexandria, Minnesota (to avoid zebra mussel infestations), 100% contained, and that each fish be tested for triploidy. The request was not pursued.**

**There are no present or future plans to introduce grass carp into North Dakota.**

**South Dakota -- Requirements in South Dakota were summarized by Johnson (1998) and have not changed as of 2000 (Appendix 3). According to Dennis Unkenholz, Fisheries Administrator for the South Dakota Department of Game, Fish and Parks (605:773-4508), there are no known populations of grass carp in South Dakota at this time other than fish in the Missouri River below Gavins Point Dam. According to him, stock dams in South Dakota sometimes have emergent vegetation problems, but less often have problems with submerged vegetation, so requests for grass carp stocking are few. Initial experiments with grass carp in South Dakota did not produce very good results. Overwinter survival (winterkill) is often a problem in many ponds and lakes.**

**Grass carp are not allowed in the state without a license issued by the Department. Key provisions in South Dakota's grass carp policy (Appendix 3) are that inlets and outlets must be controlled or screened and only batch-certified triploid grass carp should be used. The Department has discussed the use of grass carp with golf course operators and others in the past. He believes that interest in the use of this fish has declined because of the strict importation regulation established by the Department.**

**D. Unkenholz indicated the Department is concerned about the increasing populations of bighead carp *Hypophthalmichthys nobilis* in the river belowGavins Point Dam.**

**Alberta -- In 1987, an inter-agency committee consisting of representatives of the federal government, provincial government, and irrigation districts was formed to evaluate the feasibility of using grass carp to control aquatic plants in Alberta's irrigation canals.**

Grass carp were first introduced into southern Alberta (49-50° N) that year on a research basis. They conducted initial (Phase 1) tests over the period 1987-1992 in a program under the control of a Provincial committee (the Committee on Biological Control of Aquatic Vegetation, CBCAV), which included representatives from Alberta Agriculture, Food and Rural Development, Environmental Protection (Fish and Wildlife Division), other agricultural entities, and the Eastern Irrigation District. In 1993, Phase 2 studies were implemented to study weed control in small ponds, evaluate brood fish management, larval rearing, fish growth, and overwinter survival.

Weed control has proven successful in ponds and irrigation canals in the southern grassland region (Beck 1996). According to Ron Beck, Northland Aquatic Sciences (403:758-6227), there are now about 15,000 grass carp stocked in 700-750 ponds, a tiny fraction of the estimated 60,000 ponds in the province. The ponds, called "dugouts" are typically small (125 feet x 50 feet), into which 18-20 fish are typically stocked. About 8 golf course ponds have also been stocked. No canals are stocked at present. There is no limit on the size of pond or lake that may be stocked. All stocking is private. Each pond must have a license for recreational fish culture, and is inspected by Alberta Aquaculture, Food, and Rural Development for screening. Because of thick ice and snowpack, winterkill is common, so ponds must usually be aerated to keep a portion of it ice-free. The higher oxygen level also helps survival of trout, which are also often stocked. Bird predation (as well as northern pike *Esox lucius* predation in ponds fed by irrigation water) on smaller fish can be a problem, so only grass carp 254 mm ( 10 inches) or longer are stocked. Nine of ten pond owners are estimated to be satisfied with the program. The fish are slow to eat one plant, the white water buttercup *Ranunculus aquatilis*, especially old plants, which are high in alkaloids. The fish consume vegetation and grow well in areas where water temperatures are 18° C or higher for 65-70 days. They do not do well in cold, spring-fed ponds or high elevation ponds and lakes. Each released fish is tagged with a coded-wire tag. Beck suggests that their controlled program may have obviated the temptation to illegally introduce fish in the province.

Grass carp are in ponds in the Milk River basin, which flows into Montana, even though they are theoretically prevented from entering the river. Although each pond must be inspected and licensed, there is a possibility of escape of fish into the river or tributaries.

According to Eric Hutchings (403:381-5573; 317-3531), Alberta now has their own brood fish in Lethbridge. These fish were obtained from Colorado and California (Imperial Valley). The first big production cycle was last spring. About 80 brood fish are held, 60 females and 20 males. Another 120 fish from the 1995 year class are just becoming mature. Original imported brood fish are now about 12 years old. The brood fish are kept indoors in winter but are held in outside ponds in summer; ponds are covered by netting and surrounded by a fence. Fish are spawned from February to April.

Alberta also produces its own triploid fish (using the pressure shock method) and conduct its own tests for triploidy. Triploidy is assured with the Coulter Counter method of Wattendorf (1986). Every fish is tested. When fish are 4 inches long, the gills are pricked with a needle and blood drawn for the test with a pipette. Their triploid fish have done well; they have grown from 0.90 kg (2 lb) to more than 2.3 kg (5 lb) in two years . Grass carp evaluations have been conducted in about 20 ponds. Triploid fish are now

**being sold privately in Alberta by the Eastern Irrigation District, a private consortium.**

**Disease inspections were done at the Bozeman Fish Health Center 3 or 4 times in the past (Crystal Hudson, Bozeman, Montana Fish Health Center, Personal Communication), but are now done in the Department of Fisheries and Oceans lab in Winnipeg, Manitoba (Ron Beck, Northland Aquatic Sciences, Personal Communication). There is a standard suite of tests for salmonid diseases. There have been some occurrences of the parasite *Dactylogyra.***

**Saskatchewan -- Saskatchewan has no grass carp program, even though it has many waters similar to those in Alberta where grass carp have been successful. Fish have been stocked only in Loch Leven in the Cypress Hills (Ron Beck, Northland Aquatic Sciences, Personal communication).**

## SECTION 4 -- DISCUSSION AND CONCLUSIONS

### Discussion

**The grass carp has been used widely throughout the world, and often successfully, as a biological control agent for excessive growths of aquatic vegetation (Cassani 1996). Although caution has been recommended on its distribution and use since its early days in the U. S. (Pelzman 1971), its range expansion has been inexorable until it now occupies (or has recently occupied) at least 45 of the 50 states (Fuller et al. 1999). What is nearly always overlooked is that its use has in many cases *treated symptoms* of poor or ill-advised land use practices ( e.g., over-fertilization of lands adjacent to waters, improper**

introduction of other exotics, improper conversion of wetlands to fishing lakes) and obviated the need to improve land use practices and stewardship. Grass carp are generally a short term palliative to some long-term environmental problem. Although Montana has documented problems with nuisance aquatic vegetation at specific sites such as golf course lakes, some public lakes, and sewage ponds, the problems are much less acute than in most other states.

Successful control of aquatic vegetation with grass carp in one location, no matter what the possible risks outlined above, will probably further increase interest by the public in stocking more fish in suitable and unsuitable areas elsewhere. It will also increase the probability of members of the public illegally introducing or transporting diploid or triploid fish in areas deemed too risky for introduction. In this regard, the dilemma for fisheries managers is that even if grass carp were shown to enter and disrupt natural river and lake ecosystems, to harm native species, and to spread diseases, any member of the public with the single-minded, short-term objective of removing vegetation from a pond might ignore all of these costs and illegally stock fish. As local and regional vegetation control "success stories" become known, and knowledge of local and regional sources of fish becomes better known, the likelihood of illegal introductions increases. The likelihood of intentional, illegal stocking resulting in reproduction and establishment may be greater than any of the other risks associated with low probability events such as failure to detect a putative triploid fish as diploid or failure to accurately detect all diseases of fish legally entering the state. Some states (e.g., Idaho and Oregon) have rationalized that a restrictive plan for controlled use is safer than an outright ban on use.

**<u>Conclusions</u>**

**1. Because of the northerly latitude, high elevations, and short growing season, many Montana waters are too cold for *optimal* growth and survival of grass carp. However, many low elevation areas of Montana would provide conditions *suitable* for use of grass carp in vegetation control, in particular, locations where water temperatures are 18°C or higher for 65-70 days. These areas would be mainly in eastern portions of Region 5, most of Region 6, and all of Region 7 in the Yellowstone and Missouri river basins. Some of the warmer ponds, lakes and reservoirs in western Montana would also be suitable for vegetation control by grass carp.**

**2. Based on habitat requirements and available habitat in Montana rivers, *diploid* grass carp would have a moderate to high probability of reproducing in some Montana Rivers if accidentally released into the state. In particular, portions of Regions 5 and 6, and all of Region 7 would be likely areas of potential reproduction, as well as other portions of the state (including thermal effluents) where sufficiently warm waters exist. Much of the lower Yellowstone River and portions of the Missouri river and their tributaries have thermal, hydraulic, hydrologic, and turbidity characteristics that render them potentially suitable as spawning areas. These areas also contain several fishes that are endangered, threatened, or of special concern, including the pallid sturgeon, sturgeon chub, sicklefin chub, flathead chub, blue sucker, and paddlefish. The possibility of successful reproduction also exists in drainages west of the Continental Divide such as the Clark Fork, Bitterroot River, and Blackfoot River, which all have thermal conditions in spring and early summer within**

**acceptable limits (<18°C) for grass carp reproduction.**

**3. If grass carp reproduction occured in Montana, young fish would have a moderate to high probability of survival, especially if they found suitable reservoir or backwater habitat associated with river sloughs and backwaters, or reservoirs. Numerous reservoirs and lakes on both sides of the divide are within thermal tolerance limits for grass carp.**

**4. *Triploid* grass carp have a very low but non-zero probability of reproducing. This is true even if established, commercially-viable methods of triploidy induction and certification are followed. The probability of enough individuals surviving to establish a population is much lower than for diploid fish.**

**5. Any grass carp stocked into Montana would have a moderate probability of escaping (with or without human assistance) from their confined area and dispersing to other waters.**

**6. Without certification, grass carp introduced into Montana have a high probability of bringing in exotic diseases and pests, including Asian tapeworm, zebra mussel, and other known, monitored pathogens. Even with disease certification and 100% accuracy, grass carp are thought to harbor other diseases such as *Centrocestus formosanus* that are insufficiently known in the U. S. for their effects to be evaluated. Unlike the triploidy certification, which is rather uniformly conducted with procedures well documented in the**

**scientific literature, disease certification procedures for many pathogens, including the Asian tapeworm, are non-uniform, not well established, and not adhered to by all states. The probability of disease entry into the state from grass carp is moderate, even with certification procedures.**

**7. The Asian tapeworm has an established record of infecting and debilitating native minnows (Cyprinidae), suckers (Catostomidae) and killifishes (Cyprinodontidae) in western rivers, and, if introduced into Montana, would have a high probability of infecting native fishes in these families. These would include, but would not be limited to, the sicklefin chub, sturgeon chub, flathead chub, blue sucker, and plains killifish, all of which are species of concern in the Missouri and Yellowstone river basins. In addition, other pathogens could be expected to have similar effects on native fish when their pathology is better known.**

**8. Grass carp have repeatedly proven difficult to contain and difficult to eradicate once they have entered large water bodies.**

**9. North Dakota, which receives Montana waters from the Missouri and Yellowstone rivers has no grass carp and no interest in releasing them. Their requirements for entry are stringent. Grass carp moving down the large rivers could find their way not only into the Missouri and Yellowstone rivers but ultimately into Lake Sakakawea and other Missouri River mainstem reservoirs.**

**SECTION 5 -- RECOMMENDATIONS**

**It is recommended that grass carp not be stocked in Montana. The benefits of their limited application in the state in a few, primarily private, situations does not balance the potential costs to native species and public waters.**

**If, despite this recommendation, grass carp are stocked into Montana, the following criteria should be met:**

**1. Grass carp should be eligible for importation only as an aquatic vegetation control agent for a designated water body. Permits should be required for introducing the fish into the state, transporting the fish, and stocking into the designated water body. These permits should be required in advance of any importation. The introduction and transport permit(s) should be required to accompany the shipment.**

**2. All fish should be required to be imported into the state; no breeding facilities should be established in Montana.**

**3. Only fish 10 inches (250 mm) or longer should be imported.**

**4. *Every grass carp* entering the state should be certified as a triploid with the Coulter Counter method (Wattendorf 1986) by the USFWS Triploid Grass Carp Inspection and Certification Program.**

**5. Every fish entering the state should be certified as disease-free for known pathogens, diseases and parasites by one state-designated lab.**

**6. No fish should be purchased from hatchery/rearing sites or drainages known to contain zebra mussels. All triploids should be certified free of all life stages of the zebra mussel by one state-designated lab.**

**7. Before fish entering the state are released into licensed, designated waters, every fish should have a batch coded wire or PIT tag identifying the fish origin, date stocked, and the person or group stocking the fish.**

**8. Grass carp should not be stocked in ponds larger than 10 acres (4.04 Ha). Larger ponds and lakes are difficult to screen and, once fish are established, they are difficult to eradicate. No canals should be stocked.**

**9. The pond should in all cases be outside the 100 year floodplain.**

**10. No ponds having any direct return flows to natural surface waters should be stocked.**

**11. Stocking should occur only in ponds with screens approved by the Montana Department of Fish, Wildlife and Parks (MTFWP). Screens should have mesh sizes of 3/4 inch or less for grass carp 10-19 inches TL and two inches or less for grass carp 19 or more**

**inches TL. Screens should be removable for cleaning and installed in tandem pairs for double screening, and so that one screen is in place while the other is being cleaned. A third replacement screen should be available.**

**12. Ponds for grass carp should be initially inspected by a MTFWP biologist prior to permit approval to ascertain that there is an aquatic vegetation problem, that there is no surface outflow, that all inflows and outflows (no matter what their origin or destination) are screened, and that floodplain requirements are met.**

**13. Periodic, unscheduled inspections of the pond by MTFWP should be allowed to be conducted during reasonable business hours.**

**14. Revocation of the permit should be possible if violation of statutes or rules under the permit are detected. Upon revocation, if it became necessary to kill or remove fish, the expense should lie with the pond owner.**

**15. The permitting process should require fees adequate to cover the cost of the inspection, fish tagging, and any longer-term monitoring to be conducted by the state.**

**16. A non-trivial portion of costs associated with the removal of escaped grass carp from public waters should be borne by the permittee(s) responsible for the escaped (marked) fish.**

**17. Stocking rates should be based on successful rates in Wyoming, but should be lower than those recommended in Alberta.**

**18. A brief management plan outline should be required as part of the permit process. The plan should include:**

- **a. Applicant name, address, daytime telephone number.**
- **b. Water body description.**
- **c. Site location, including Township, Range, Section, and 1/4 Section.**
- **d. Stocking rate, size and origin of fish.**
- **e. Emergency procedures to be followed during flood events.**
- **f. Description of how fish will be removed at the end of the project.**
- **g. Documentation that the site is outside the 100-year floodplain.**
- **h. Documentation that the lake does not exceed 10 acres.**
- **I. A written description of how public access will be controlled.**
- **j. A detailed description of any screening structures.**
- **k. A description of the stocking rate and how it was determined.**

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## FIGURES

Ruggles, Montana Department of Fish, Wildlife and Parks, Unpublished data).

Figure 10. Water temperatures at Bjornburg, Milk River, 1998 (M. Ruggles, Montana Department of fish, Wildlife and Parks, Unpublished data).

Figure 11. Water temperatures at selected locations, Bitterroot River, 1998 (C. Clancy, Montana Department of Fish, Wildlife and Parks, Personal Communication).

Figure 12. Plot made by an X-Y recorder showing typical nuclear size distributions of diploid and triploid erythrocytes. Vertical lines correspond to the colored overly on the oscilloscope. The diploid nuclei have a modal size of 9.72 $\mu m^3$ shown in channel 23, while the triploid mode occurred in channel 40 (14.92 $\mu m^3$).

Figure 13. Histogram showing channel modes and corresponding nuclear volume distributions ( $\mu m^3$ for 500 diploid and 500 triploid erythrocytes). Vertical dashed lines delineate the channels considered as diploid and triploid. Stars over the distributions represent the means of 10.06 for diploids and 14.82 for triploids. Each horizontal line represents the mean ± 2.81 x SD, which is expected to include 99.5% of the diploid or

**triploid population.**

**Figure 14.** **Locations of lakes in Washington where confirmed grass carp stockings took place, April 1990-June 1995. (Bonar et al. 1996)**

**Figure 15.** **Size of distribution of Washington lakes stocked with grass carp. (Bonar et al. 1996)**

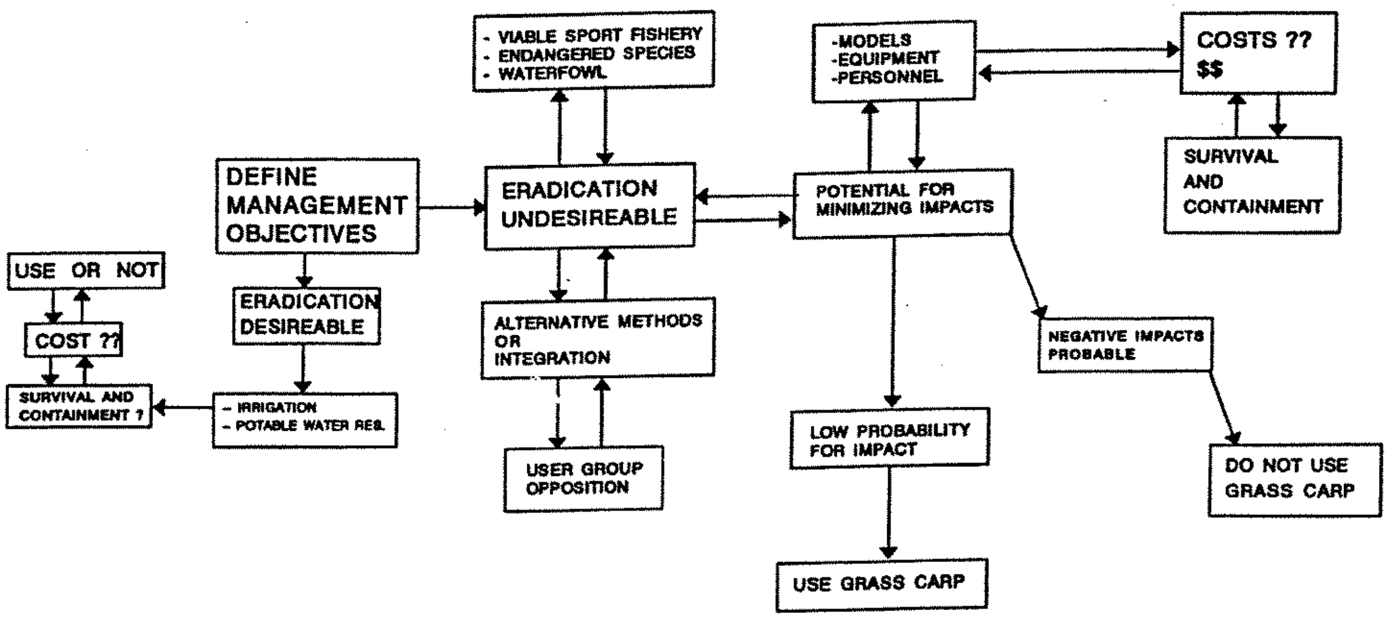



**Figure 1. Interactive variables associated with grass carp use determination. (Cassani 1996)**

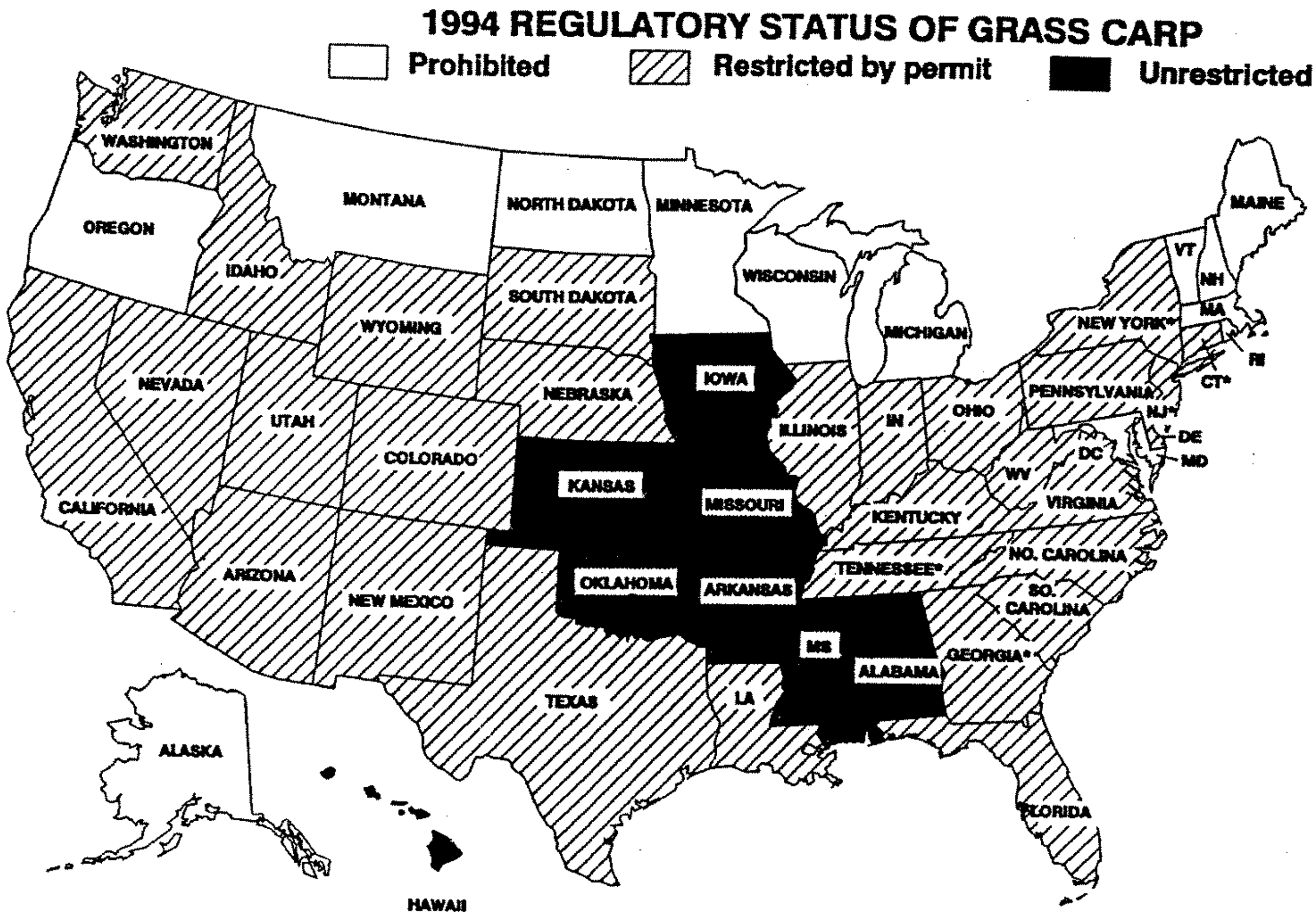



Figure 2. 1994 regulatory status of grass carp. Prohibited means that both diploid and triploid grass carp are illegal, the only exception being for research at enclosed locations. Restricted means that triploid grass carp are by the state to manage some public waters (Note: New Jersey and Connecticut do not use the fish in public waters) and private citizens may also use the fish by permit. (Note: Georgia and Tennessee do not issue permits, but do allow triploids; New York does not allow private use). Unrestricted means that both diploid and triploid grass carp can be used without permit. (Wattendorf and Phillipy 1996)

Figure 3. Seasonality of maturation in naturalized and cultured grass carp (Shireman and Smith 1983)

| Location | Maturation season | Authority |
|---|---|---|
| Austria | June | Brown (1977) |
| India (Cuttack) | May-July<br>June-August | Alikunhi, Sukumaran, and Parameswaran (1963a) |
| (Tamilnadu) | May-August | Chaudhuri, Singh, and Sukumaran (1966) |
| Japan (Tone River*) | June-July | Kuronuma (1955) |
| | June-early August | Inaba, Nomura and Nakamura (1957) |
| | June-August (peaks late June--mid-July) | Tsuchiya (1979) |
| (Shiga Prefecture) | April-July | Kawamoto (1950) |
| Korea | July-August | Kim (1970) |
| Malaysia (Malacca) | May-August[a/] | Slack (1962) |
| | all months | Hickling (1967a) |
| | all months | Chen, Chow and Sim (1969) |
| Nepal | mid-May--June | Shrestha (1973) |
| Netherlands | July | Huisman (1978) |
| Taiwan, Prov. of China | May-early July<br>March-July | Lin (1965)<br>Chen (1976) |
| USA (Arkansas) | May-July | Bailey and Boyd (1970, 1973) |
| | May-June | Addor and Theriot (1977) |
| USSR | | |
| Astrakhan | latter June | Anon. (1970c) |
| Ili River* | peaks mid/late May | Nezdoliy and Mitrofanov (1975) |
| Kara Kum Canal* | May-June | Aliyev (1976) |
| Krasnodar | latter May | Anon. (1970c) |
| Moldavia | early June | Anon. (1970c) |
| Syrdar'ya River* | latter May | Verigin, Makeeva and Zaki Mokhamed (1978) |
| Turkmen | early May | Anon. (1970c) |
| Ukraine, southern | late May-late June | Hao (1973) |
| Uzbek | early May | Anon. (1970c) |
| Volga R. (lower) | May--mid-August | Martino (1974) |
| Volgograd | latter June | Anon. (1970c) |

* Indicate self-reproducing populations. All other localities relate to induced spawning

a/ Imported as fingerlings

**Figure 4. Parasites of grass carp. (Shireman and Smith 1983)**

| | |
|---|---|
| **VIRUSES** | |
| *Rhabdovirus* spp. | 3,8 |
| *R. carpio* | 8 |
| **BACTERIA** | |
| *Achromabacter* spp. | 24 |
| *Aeromonas* spp. | 24 |
| *A. punctata* | 25 |
| *A. salmonicida* var. *achromogenes* | 8 |
| *Flexibacter columnaris* | 5 |
| *Myxococcus piscicola* | 18 |
| *Pseudomonas* spp. | 24 |
| **FUNGI** | |
| *Branchiomyces sanguinis* | 8 |
| *Saproglenia* spp. | 11,12,15,20 |
| **PROTOZOA** | |
| *Apiosoma cylindriformis* | 16,21(a,b,e) |
| *A. magna* | 21(f) |
| *A. minimicro nucleata* | 21(f) |
| *A. piscicola* | 16,21(f) |
| *Balantidium ctenopharynogodontis* | 5,7,20,21(a,b,e) |
| *Chilodonella* spp. | 8 |
| *C. cyprini* | 10,16,17,19,20,21(d,e) |
| *Chloromyxum* spp. | 17 |
| *C. cyprini* | 21(a,e) |
| *C. nanum* | 21(a,e) |
| *Costia necatrix* | 10,21(b) |
| *Cryptobia* spp. | 8 |
| *C. brancialis* | 10,16,21(a,b,e) |
| *C. cyprini* | 1 |
| *Eimeria carpelli* | 21(f) |
| *Eimeria mylopharyngodonis* | 16 |
| *E. sinensis* | 16 |
| *Entamoeba ctenopharyngodontis* | 21(a,b) |
| *Epistylis* spp. | 21(f) |
| *E. lwoffi* | 21(d) |
| *Euglenosoma caudata* | 21(b) |
| *Glaucoma pyriformis* | 21(b) |
| *Hemiophrys macrostoma* | 21(a,b) |
| *Hexamita* spp. | 21(b,g) |
| *Icthyophthyrius* spp. | 8 |
| *I. multifiliis* | 9,10,12,16, 17,18,21(b,d,e),22 |
| *Myxidium* spp. | 21(e) |
| *M. ctenopharyngodonis* | 21(a) |
| *Myxobolus dispar* | 21(e) |
| *M. ellipsoides* | 21(a) |
| *Sphaerospora carassii* | 21(e,f) |
| *Spironucleus* spp. | 21(e) |
| *Tetrahymena pyriformis* | 21(a) |
| *Thelohanellus oculi-leucisci* | 26 |
| *Trichodina* spp. | 10,19,21(g) |
| *T. bulbosa* | 21(b,d) |
| *T. carasii* | 21(d) |
| *T. domerguei* | 21(c,d) |
| *T. meridionalis* | 21(d) |
| *T. nigra* | 21(d,f) |
| *T. nobilis* | 21(d),25 |
| *T. ovaliformis* | 21(a,b) |
| *T. pediculus* | 21(a,b,c,f) |
| *T. reticulata* | 16,21(f) |
| *Trichodinella epizootica* | 21(c,e) |
| *Trichophrya* spp. | 21(g) |
| *T. sinensis* | 10,16,21(a,b,e) |
| *Tripartiella* spp. | 12,21(e) |
| *T. bulbosa* | 21(a,c) |
| *T. lata* | 16 |
| *Zschokkella nova* | 21(a) |
| **TREMATODA** | |
| *Amurotrema dombrowskajae* | 5,21(a) |
| *Ancyrocephalus subaequalis* | 21(a) |
| *Apharyngostrigea curnu* | 8 |
| *Aspidogaster amurensis* | 21(a) |
| *Cotylurus communis* | 21(g) |
| *C. pileatus* | 21(f) |
| *Dactylogyrus* spp. | 10 |
| *D. ctenopharyngodontis* | 12,16,19,21(a,g) |
| *D. lamellatus* | 5,16,17,19,21(a,d) |
| *D. magnihamatus* | 21(a) |
| *Diplostomum* spp. | 21(d) |
| *D. indistinctum* | 21(d) |
| *D. macrostomum* | 21(f) |
| *D. mergi* | 21(f) |
| *D. paraspathaceum* | 21(d) |
| *D. spathaceum* | 8,16,19,21(a,d) |
| *Diplozoon paradoxum* | 21(a,f) |
| *Gyrodactylus* spp. | 10 |
| *G. ctenopharyngodontis* | 12,19,21(a) |
| *G. kathariner* | 21(f) |
| *Metagonimus yokogawai* | 19,21(a) |
| *Opisthorchis* (=*Chlonorchis*) *sinensis* | 13 |
| *Posthodiplostomum cuticola* | 19 |
| *Tetracotyle* spp. | 19 |
| *T. percae fluviatilis* | 8 |
| *T. variegata* | 16 |
| **CESTODA** | |
| *Biacetabulum appendiculatum* | 16 |

Figure 4. Parasites of grass carp continued. (Shireman and Smith 1983)

| | |
|---|---|
| *Bothriocephalus acheilognathi* (=*gowkongensis*) | 2,6,7, 8,10,12,16,19, 21(a,d,g),23 |
| *Khawia sinensis* | 8,16,19,21(d) |
| *Ligula intestinalis* | 16 |
| *Triaenophorus nodulosus* | 21(a) |
| NEMATODA | |
| *Capillaria* spp. | 16,21(g) |
| *Philometra* spp. | 21(g) |
| *P. lusiana* | 8 |
| *Rhabdochona denudata* | 21(a) |
| *Spiroxys* spp. | 21(g) |
| CRUSTACEA | |
| *Argulus* spp. | 10,16,20 |
| *Lernaea* spp. | 4,6,10,16 |
| *L. ctenopharynogodontis* | 19,21(a) |
| *L. cyprinacea* | 12,19,22 |
| *L. elegans* | 14,23 |
| *L. quadrincuifera* | 21(a) |
| *Neoergasilus longispinosus* | 21(a) |
| *Paraergasilus medius* | 21(a) |
| *Sinergasilus lieni* | 23 |
| *S. major* | 5,10,19,21(a),23 |
| PENTASTOMIDA | |
| *Sebekia oxycephala* | 21 |

Key to reference numbers:

1) Anon. 1972b
2) Anon. 1976a
3) Ahne 1975
4) Alikunhi and Sukumaran 1964
5) Astakhova and Stepanova 1972
6) Bardach, Ryther and McLarney 1972
7) Bauer 1968
8) Bohl 1979
9) Cross 1969
10) Dah-Shu 1957
11) Doroshev 1963
12) Edwards and Hine 1974
13) Faust and Khaw 1927
14) Gidumal 1958
15) Huisman 1978
16) Ivasik, Kulakovskaya, and Vorona 1969
17) Konradt and Faktorovich 1970
18) Laboratory of Fish Disease (date unknown)
19) Musselius and Strelkov 1968
20) Prabhavathy and Sreenivasan 1977
21) Riley 1978 citing;
    (a) Bykovskaya-Pavlovskaya *et al.* 1964
    (b) Chen 1955 (c) Ivanova 1966
    (d) Kashkovskii 1974
    (e) Molnar 1971 (f) Stepanova 1971
    (g) Sullivan and Rogers, pers.comm.
22) Stevenson 1965
23) Sutton, Miley, and Stanley 1977
24) Szakolczai and Molnar 1966
25) Wu 1971
26) Yukhimenko 1972

**Figure 5. Grass carp feeding preference on aquatic plants from various locations. (Leslie et al. 1996)**

| Pacific Northwest U.S. (a) | New Zealand (b) | Florida (c) | Florida (d) |
|---|---|---|---|
| HIGHLY PREFERRED | *Nitella, Chara* | *Hydrilla verticillata* | PREFERRED |
| *Potamogenton crispus* | *Callitriche, Stagnalis* | *Chara* spp. | *Hydrilla verticillata* |
| *Pectinatus* | *Largarosiphon* major (Lake Rotoiti) "young" | *Najas guadalupensis* | duckweeds |
| *Pectinatus Zosteriformes* | *Potamogeton crispus* | *Egeria densa* | Filamentous algae |
| *Elodea canadensis* | *Pectinatus ochreatus* | *Wolffia* | *Brasenia screberi* |
| *Vallisneria americana* | *Largarosiphon* major (Lake Karapiro) "young" | duckweeds | *Ceratophyllum demersum* |
| VARIABLY PREFERRED | *Lemna, Spirodela* | *Azolla* spp. | *Myriophyllum laxum* |
| *Myriophyllum spicatum* | *Egeria densa* (Waikato River) | *Potamogenton* spp. | *Potamogenton illinoensis* |
| *Cratophyllum demersum* | *Elodea canadensis* (Lake Rotoiti) | *Ceratophyllum demersum* | *Utricularia* spp. |
| *Utricularia vulgaris* | *Potamogeton cheesemanii* | *Panicum repens* | INTERMEDIATE |
| *Polygonum amphibium* | *Largarosiphon* major "old" | *Typha* spp. | *Salvinia minima* |
| NON-PREFERRED | *Vallisneria gigantea* | *Stratiotes aloides* | *Typha* spp. |
| *Potamogeton natans* | *Ceratophyllum demersum* | *Nasturtium* spp. | *Sagittaria lancifolia* |
| *Brasneia schreberi* | *Salvinia herzgii* | *Myriophyllum spicatum* | *Eichhornia crassipes* |
| *Egeria densa* | *Limnosella lineata / Triglochin striata / Lilaeopsis lacustris / Isoetes Kirkii* | *Vallisneria americans* | *Panicym hemitomon* |
| | *Elodea canadensis* (Western Springs) | *Mytiphyllum aquaticum* | *Pontederia cordata* |
| | *Myriophyllum propinquum* | *Eichhornia crassipes* | *Eleocharis* spp. |
| | *Myriophyllum elatinoides* | *Pistia stratiotes* | *Panicum repens* |
| | *Egeria densa* (Western Springs) | *Nymphaea* spp. | NON-PREFERRED |
| | Rejected: *Largarosiphon* stems "tough"; *Vallisneria* rootstocks; *Typha angustifolia' Myriphyllum brasiliense* | *Nuphar luteum* | *Myriophyllum spicatum* |
| | | | *Alternanthera philoxeroides* |
| | | | *Vallisneria americana* |
| | | | *Nymphaea odorata* |
| | | | *Ludwigia octovalis* |
| | | | *Hydrocotyle* spp. |
| | | | *Cladium jamaicense* |

(a) Overall preference ranking for 12 species of aquatic plants by triploid grass carp in the Pacific Northwest U.S. (Bowers et al. 1987).

(b) Grass carp feeding preference in New Zealand, North Island fish size 3-10 kg. (Chapman and Coffey 1971).

(c) Approximate order of preference for selected aquatic plants in Florida. Preference ranges from highly preferred at the top to non-preferred at the bottom. (Sutton and Vandiver 1986).

(d) Apparent food preferences of grass carp in Florida lakes over a 10-year period. (Van Dyke et al. 1984).

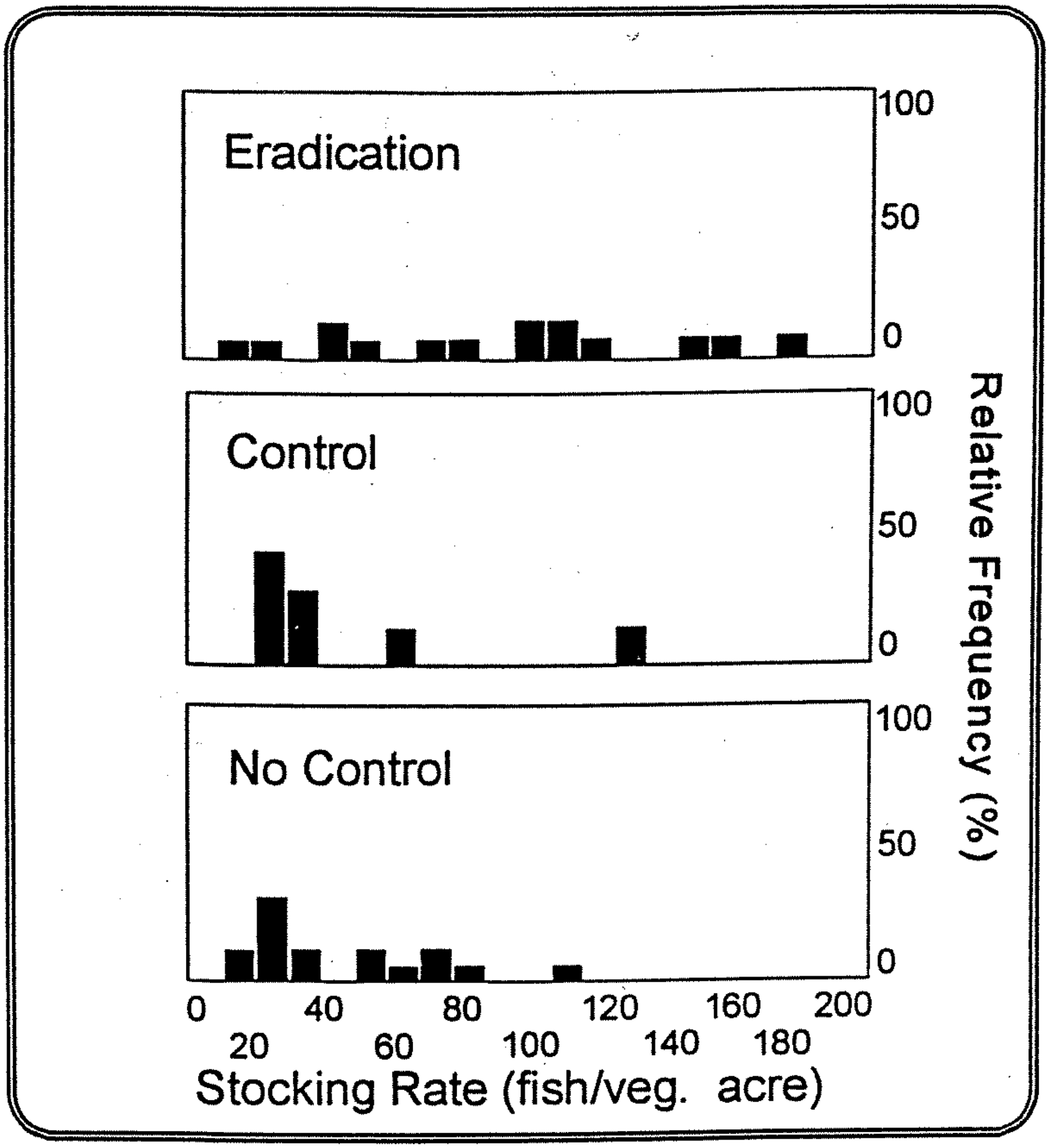



**Figure 6. Relative frequency of stocking rates by level of aquatic macrophyte control. (Bonar et al. 1996)**

Figure 7. Potential effects of stocking grass carp in an ecosystem. (Shireman and Smith 1983)

GRASS CARP

| MODERATE STOCKING | | INTENSIVE STOCKING | |
|---|---|---|---|
| LOW MACROPHYTE DENSITY | HIGH MACROPHYTE DENSITY | LOW MACROPHYTE DENSITY | HIGH MACROPHYTE DENSITY |
| Macrophyte control and moderate nutrient increase in sediments, increase in emergent plants, possible reduction in recruitment of phytophilous spawners, potential plankton and benthos increases, exposure of plant-inhabiting animals to predation, possible production increases of predators (gamefish, etc.). | Partial and/or temporary control and moderate nutrient increase in sediments, increase in emergent plants, changes the same, but not as extreme as with complete macrophyte control. | Macrophyte elimination (overcontrol), initial nutrient increase in water and sediments.<br><br>Phytoplankton bloom, reduction in recruitment of phytophilous spawners, possible changes in benthos population, exposure of plant-inhabiting animals to predation and elimination, shift from littoral to pelagic species.<br><br>Possible increase in detritivores, decreased oxygen levels and pulses, slight reduction in pH. | Macrophyte control, nutrient release to water and sediments and temporary increase in emergent plants.<br><br>Possible reduction in recruitment of phytophilous spawners, probable increased predation on plant inhabiting animals, probable production increases of predators (gamefish, etc.)<br><br>Possible increase in detritivores.<br><br>Decreased oxygen levels and pulses and a reduction in pH.<br><br>Increased alkalinity. |

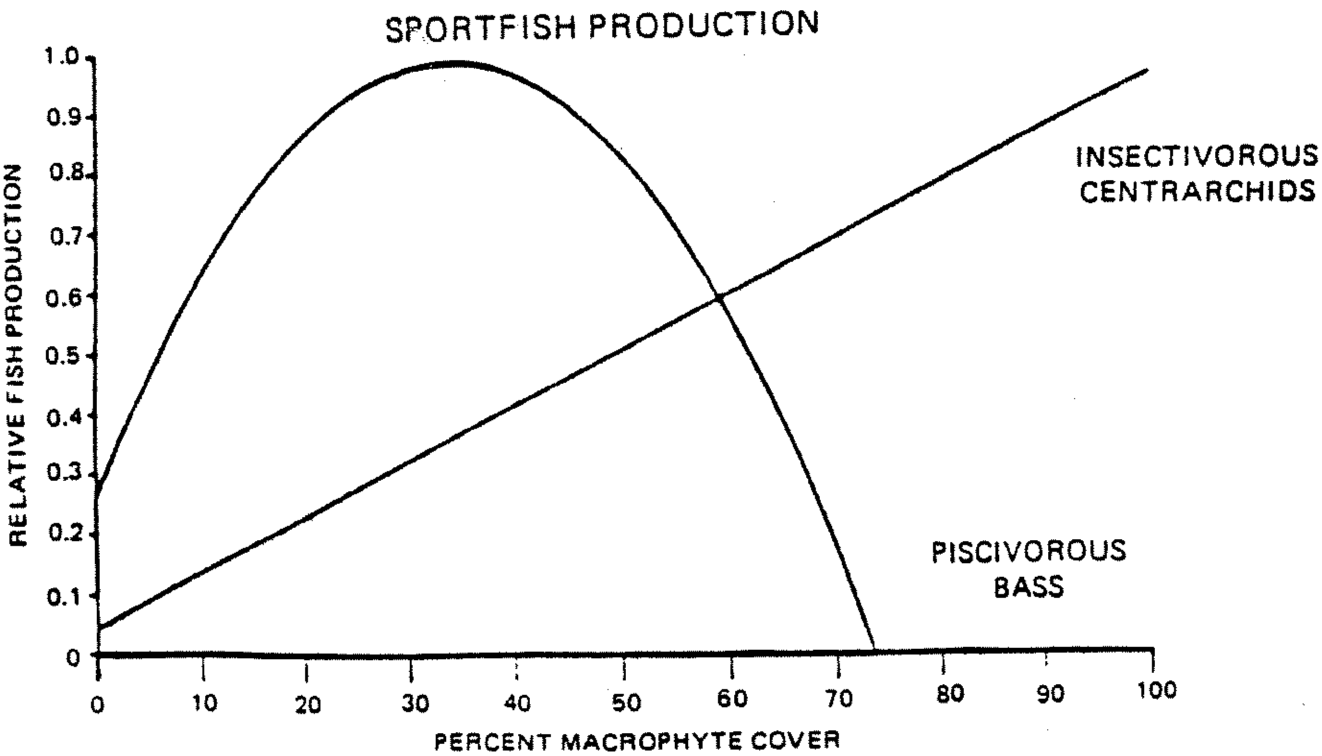



**Figure 8. Relative production of piscivorous largemouth bass and insectivorous centrarchids as a function of macrophyte cover. Optimal macrophyte cover for bass production is 30 to 40 percent. (Modified from a trophic dynamic model and field data by Pauley et al. (1987).**

**Figure 9** Water temperatures at Nohly Bridge, Missouri River, 1998 (M. Ruggles, Montana Department of Fish, Wildlife and Parks, Unpublished data).

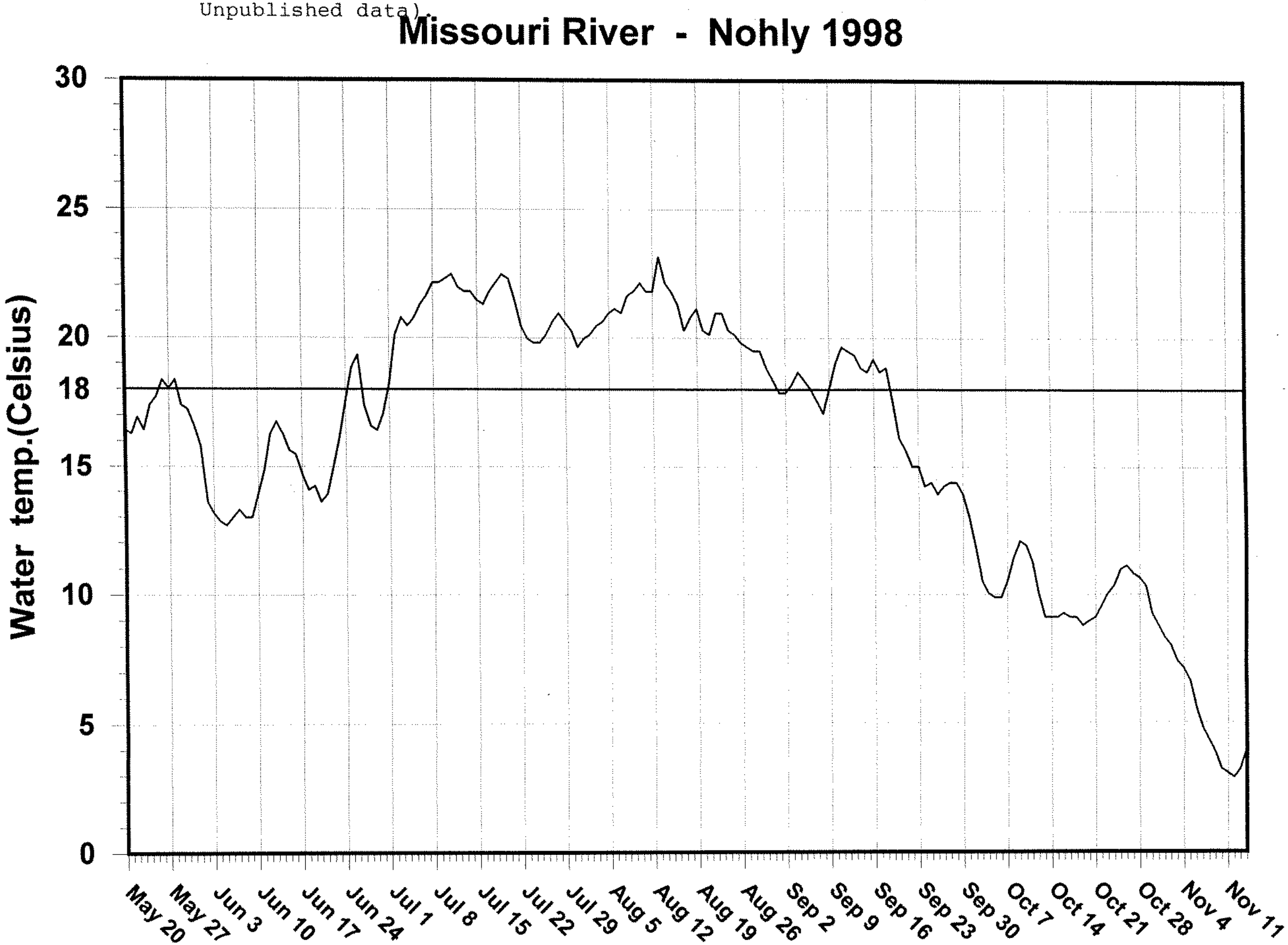


**Figure 10** Water temperatures at Bjornburg, Milk River, 1998 (M. Ruggles, Montana Department of Fish, Wildlife and Parks, Unpublished data).

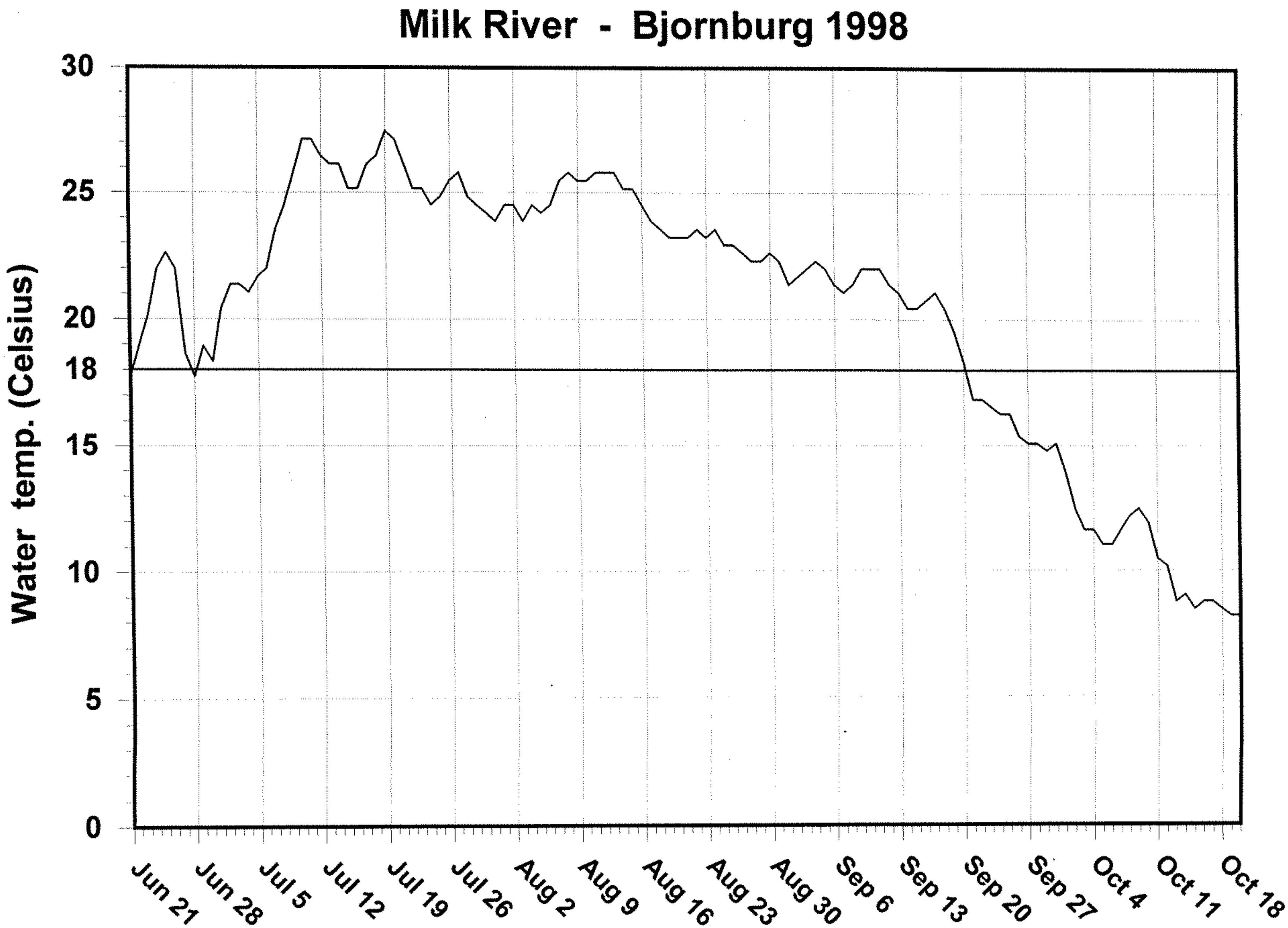
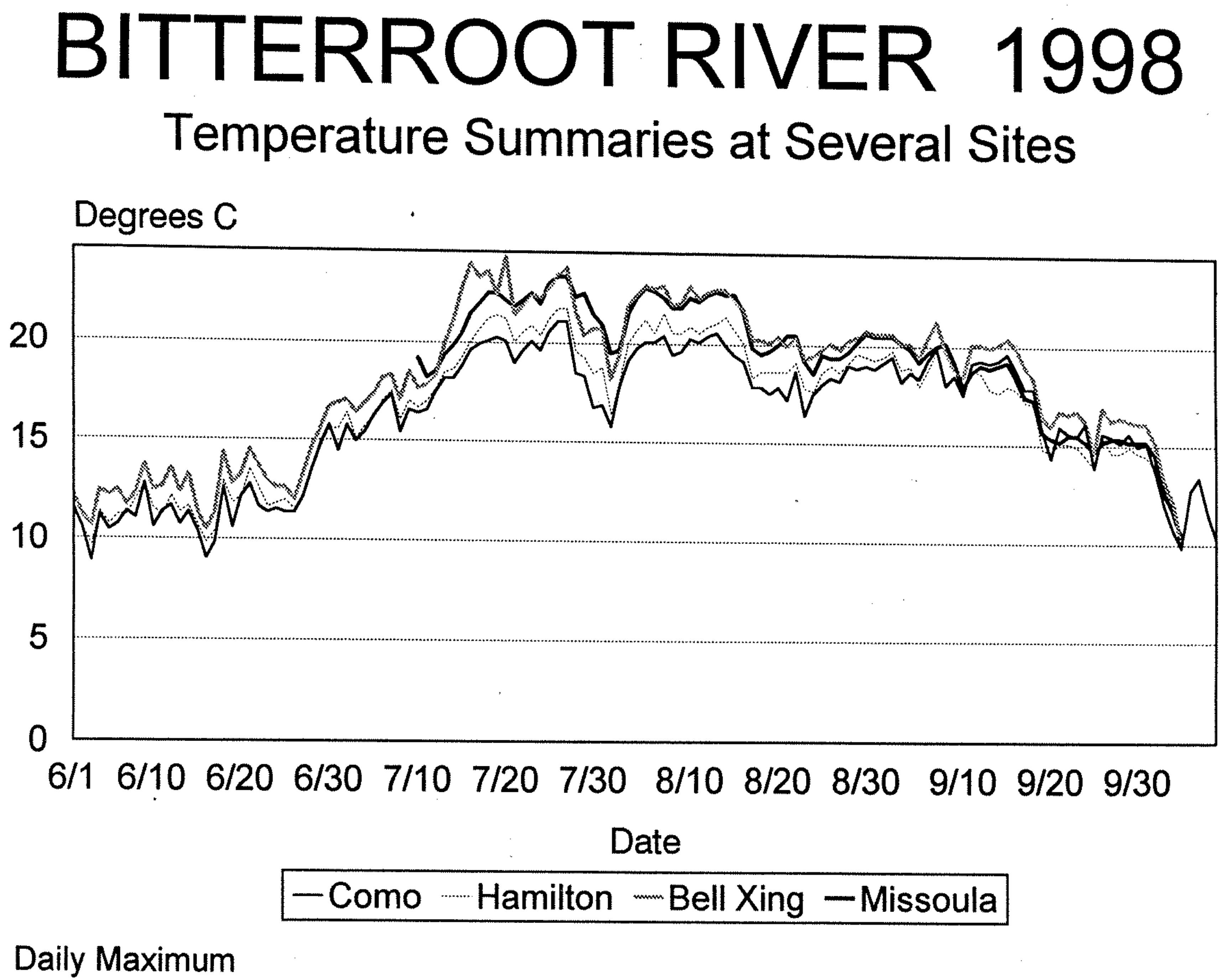


Figure 11 Water temperatures at selected locations, Bitterroot River, 1998 (C. Clancy, Montana Department of Fish, Wildlife and Parks, Personal Communication).



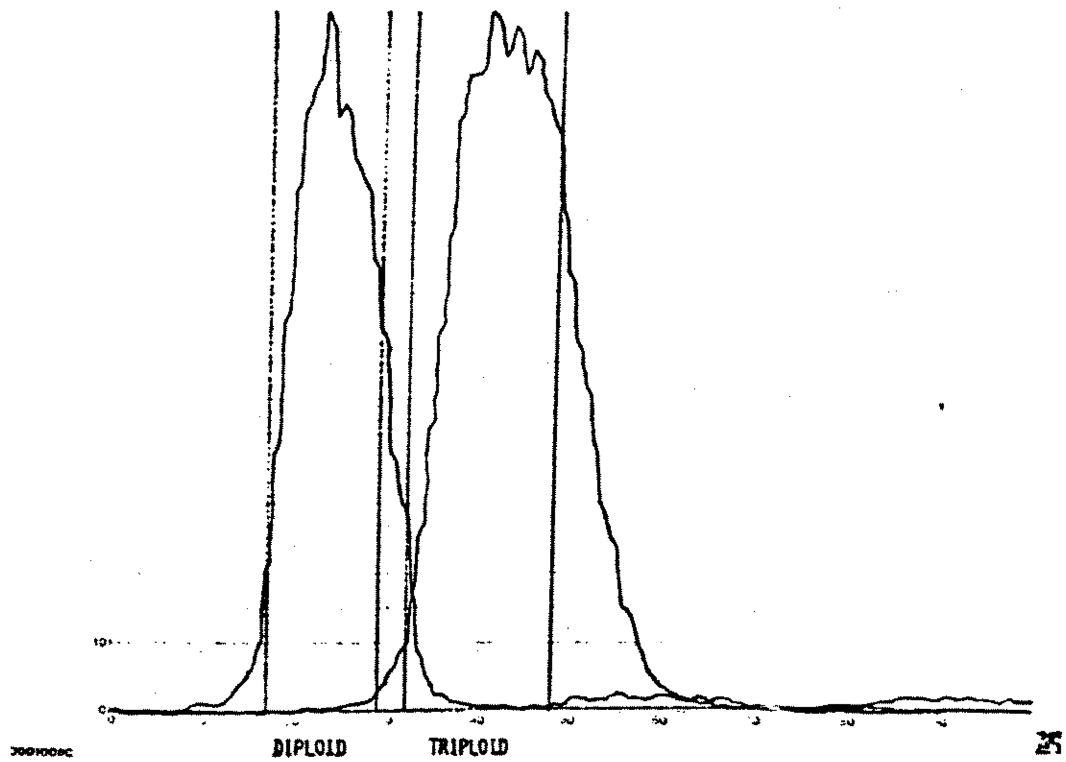



Figure 12 Plot made by an X-Y recorder showing typical nuclear size distibutions of diploid and triploid erythrocytes. Vertical lines correspond to the colored overly on the oscilloscope. The diploid nuclei have a modal size of 9.72 $\mu m^3$ shown in channel 23, while the triploid mode occurred in channel 40 (14.92 $\mu m^3$). (Wattendorf 1986)

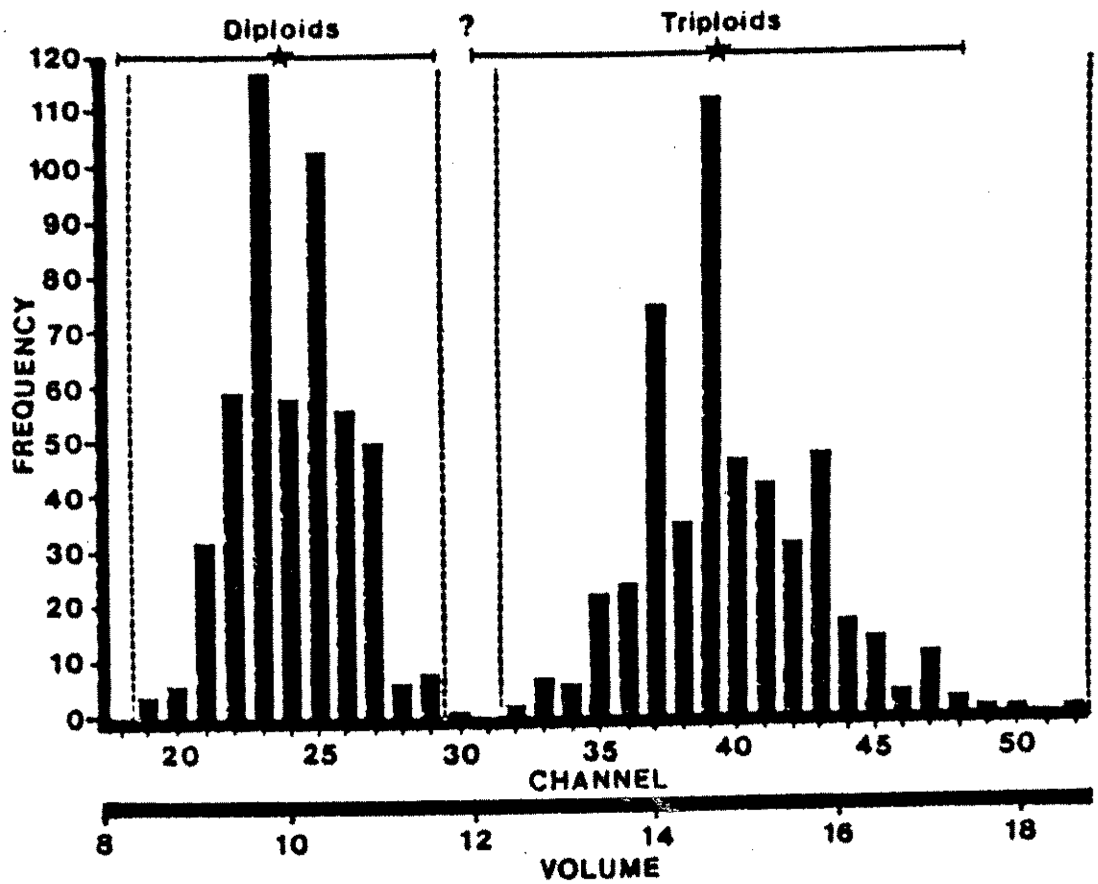



Figure 13 Histogram showing channel modes and corresponding nuclear volume distributions ( $\mu m^3$for 500 diploid and 500 triploid erythrocytes. Vertical dashed lines delineate the channels considered as diploid and triploid. Stars over the distributions represent the means of 10.06 for diploids and 14.82 for triploids. Each horizontal line represents the mean ± 2.81 x SD, which is expected to include 99.5% of the diploid or triploid population. (Wattendorf 1986)

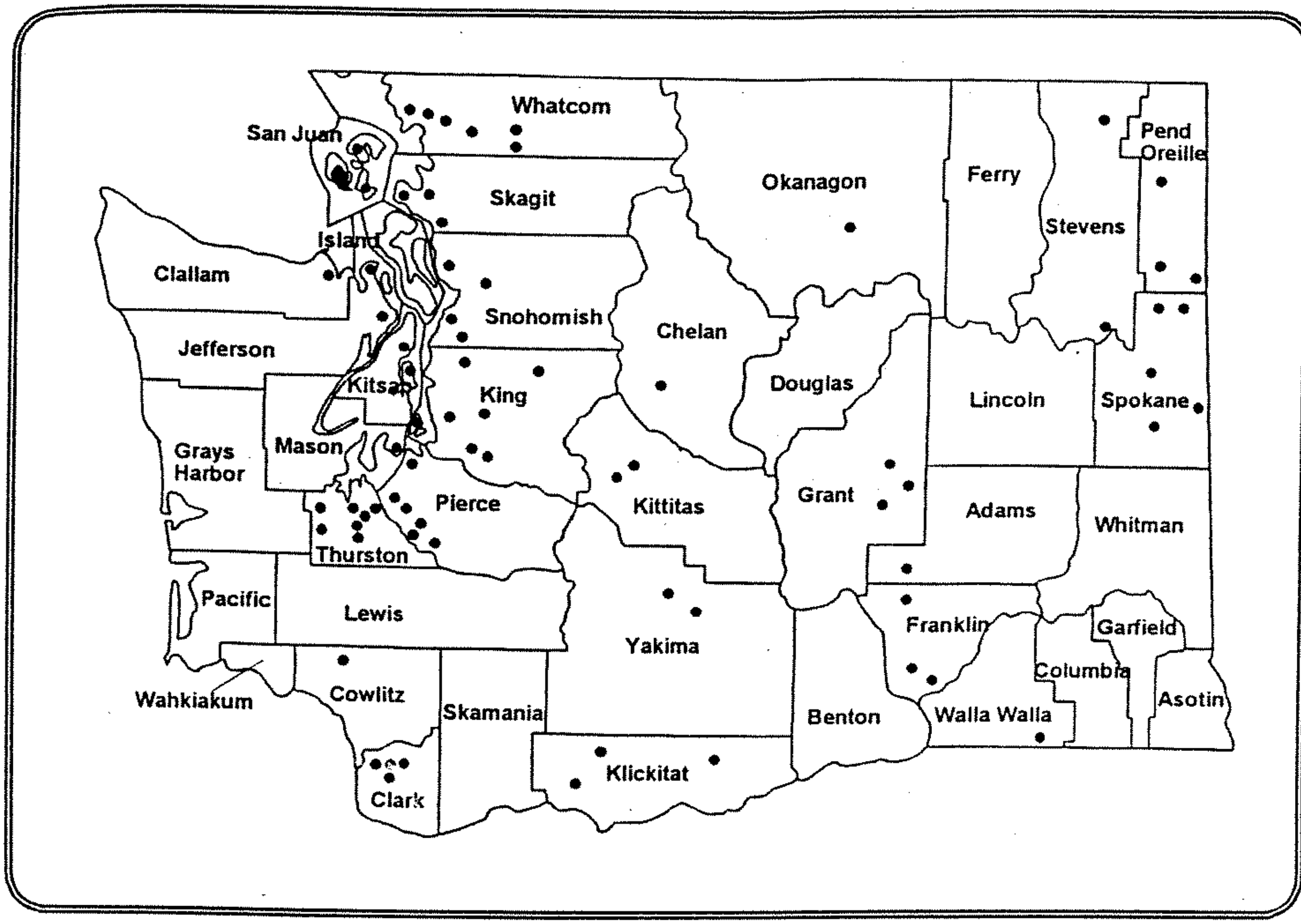



**Figure 14** **Locations of lakes in Washington where confirmed grass carp stockings took place, April 1990-June 1995. (Bonar et al. 1996)**

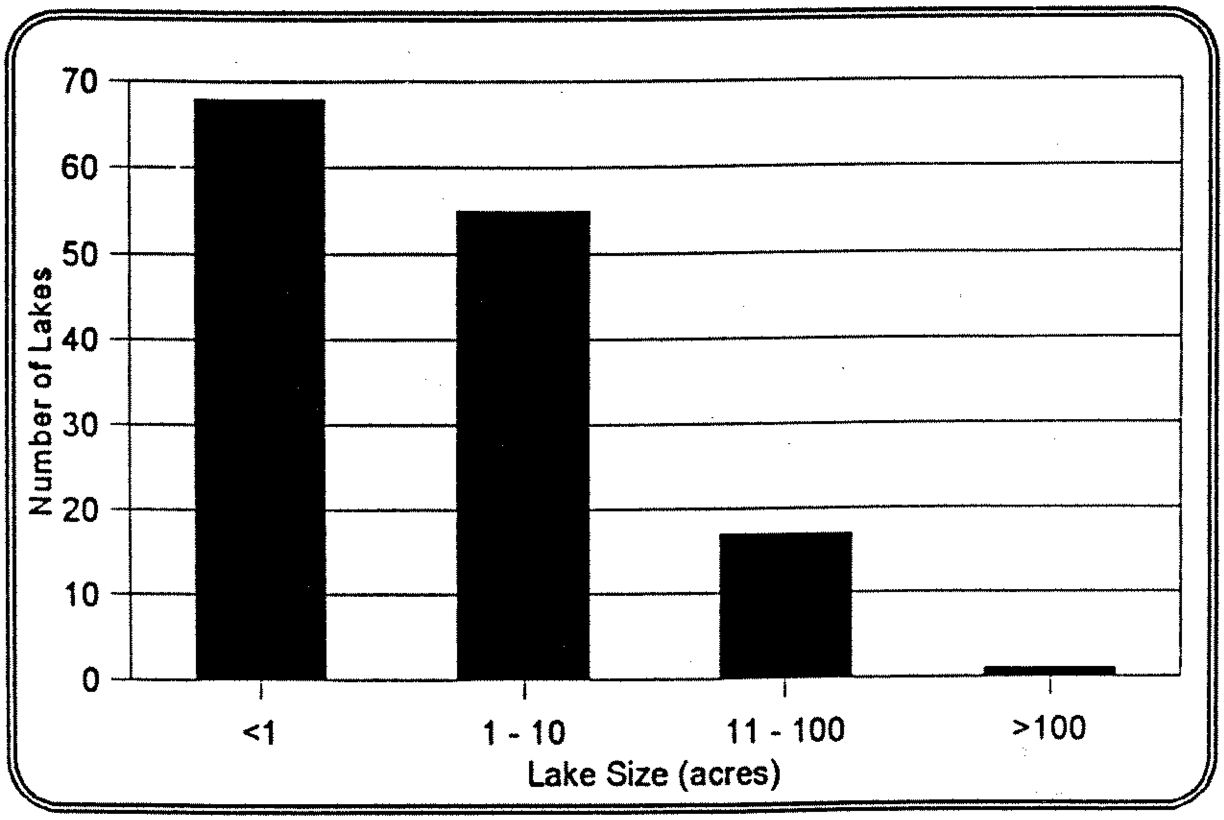



Figure 15 Size of distribution of Washington lakes stocked with grass carp. (Bonar et al. 1996)

# Appendices

# Appendix 1

# Triploid Testing and Certification

App. 1 — TRIPLOID TESTING FOR CERTIFICATION

United States Department of the Interior

FISH AND WILDLIFE SERVICE
**CARTERVILLE FISHERY RESOURCES OFFICE**
**9053 ROUTE 148, SUITE A**
**MARION, IL 62959**
**(618) 997-6869**

January 18, 2000

Dennis Scarnecchia
Department of Fish & Wildlife Resources
College of Forestry, Wildlife, & Range Science
University of Idaho
Moscow, ID 83844

Dennis,

This letter is a follow-up to our telephone conversation on Friday, January 14th, at which time you were inquiring about the U.S. Fish & Wildlife Service's Triploid Grass Carp Inspection and Certification Program (TGCICP). Enclosed are a few articles regarding the TGCICP and handouts from the TGCICP meeting this past August in Nashville, TN. The meeting handouts include a draft copy of the most recent version of the TGCICP standards, summary reports from both Regions 3 and 4 for FY 1999, and Region 4's Annual Report.

In regards to your question about the Program's ability to prevent the unintentional certification of diploids, please be aware that the Service's TGCICP does not guarantee 100% triploids in a certified lot of fish. The Standards require the Service inspector to observe the retesting of a 120 fish subsample from a lot of alleged 100% triploid fish. The testing, or retesting, of any number less than the total number of fish in a lot, only gives the probability that the lot contains less than a certain percent of diploids. The 120 fish subsample used by the Service provides at a 95% confidence level that when 2.5% or more of the fish in a lot are diploid at least one will be detected in the inspection (Griffin and Mitchell 1992). I have enclosed a copy of the Ossiander and Wedemeyer (1973) paper discussed by Griffin and Mitchell (1992) in determining the sample size required to detect diploid fish.

Once a lot of fish is certified as triploid, the Service has no further involvement with the fish or their shipment. The Service and TGCICP Standards have no provision for following certified fish from the inspection to their final destination. All enforcement regarding the shipment of grass carp is the responsibility of the States. It is the States responsibility for making sure that shipments of grass carp into their state contain only certified triploid fish.

I hope this information is useful. If you have any further questions don't hesitate to contact either myself or Vince Mudrak at the Fish Health Center in Warm Springs, GA.

Sincerely,

Greg Conover

# STANDARDS FOR
# THE U.S. FISH & WILDLIFE SERVICE
# TRIPLOID GRASS CARP INSPECTION AND CERTIFICATION PROGRAM

## PURPOSE

The US Fish and Wildlife Service (USFWS) offers a triploid grass carp inspection service for natural resource agencies in the United States and in other countries, to help states and others protect their aquatic habitats. The inspection program is to provide assurance to these agencies, and others concerned about protecting aquatic resources, that shipments of grass carp alleged to be all triploid, do not, within the confidence limits of the inspection program, contain diploids.

## AUTHORIZATION

The inspection service was addressed by the Senate and House of Representatives of the United States of America, in the first session of the 104th Congress, assembled in Washington, DC, 04 January, 1995. Through Congressional Action (S.268): "The Secretary of the Interior, acting through the Director of the U.S. Fish and Wildlife Service, may charge reasonable fees for expenses to the federal Government for triploid grass carp certification inspections requested by a person who owns or operates an aquaculture facility."

## INSPECTION PROGRAM

The USFWS Triploid Grass Carp Inspection and Certification Program evolved (B.R.Griffin and A.J. Mitchell, 1992, Aquaculture Magazine, 18:73-74) from years of work experience. Inputs from private grass carp producers and state resource agency needs were examined . The information which follows is a rendering of these ideas into standards, which the USFWS will use to provide consistency and fairness in dealing with different circumstances encountered in the implementation of a national triploid grass carp Inspection & Certification Program. The critical elements of the Program are described in four categories: (1) Standards for USFWS Inspectors; (2) Standards for Grass Carp Producers; (3) Checklist for Inspectors and Producers; and (4) Standards for Collection of Fees .

******Changes are noted in Bold*****(8-2-99 proposed)**

# Standards for Triploid Fish Inspectors

1. The USFWS Inspector, before confirmation of an Inspection date, will ask the Producer whether the conditions, as specified in the Checklist for Inspection (i.e., available diploid controls, working Coulter Counter, etc.) will be met.

******(See checklist for Inspectors and Triploid Grass Carp Producers-- Inspector will verify checklist with signature and date)*******

2. The USFWS Inspector will provide Inspection services for a minimum of 1500 fish to be shipped, within four working days, from isolated groups of fish being maintained within a containment unit, or units (tank/vat/etc). Inspection requests by the Producer for groups of fish of less than 1500 will only be performed when agreed upon by the USFWS Inspector, prior to the inspection trip (See: "Collection of Fees" page 7, #4).

3. The Inspector will require that the sample size, for fish to be taken from the isolated group of grass carp to be certified, will be 120 randomly-selected fish. If fish to be Certified are from sufficiently different size lots, care must be exercised to ensure that diploid controls represent the lots to be Certified.

4. The Inspector will view the group of fish that is to be Certified, verify that the group is isolated in a containment unit at least 100-ft away from the production ponds (thus reducing the chance of inadvertent mixing of triploids & diploids) and that numbers of fish are approximately equal to the orders for Certification.

5. The Inspector will channelize (at a minimum) every tenth fish during the Inspection of the 120-fish sample of alleged triploid grass carp. Any sample with a questionable monitor reading will also be channelized, and any questionable data resulting from channelization will be considered non-triploid.

6. The observance by the USFWS Inspector of any non-triploid fish will immediately FAIL the Inspection. No Certification can be done until another inspection is rescheduled.

7. For states requiring an Asian tapeworm examination, Inspectors will report their on-site findings based on one initial exam of the numbers of fish as specified by the state.

8. The Inspector will contact the receiving state's representative within 24-hours and notify the prospective receiving state that the Inspection/Certification was completed. The USFWS Inspector will retain the original Certification report. Copies of the signed Inspection/Certification will be made and distributed as follows:
   (1) Triploid fish Producer (day of inspection)
   (2) State Agencies requiring official written notification (copy by USFWS)
   (3) USFWS Regional Accounting Office for grass carp work (optional)

9. Each USFWS Triploid Grass Carp Inspection Office will reserve one-day each week (generally Tuesday or Wednesday) for administrative duties, vehicle maintenance, and other required activities.

10. The USFWS Inspector will collect the appropriate fee-for-service, via one check, from the Producer prior to departure from the Inspection site. As of 01 January 1999, the fee structure requires the Inspector to collect twenty-two cents per Certified triploid grass carp that is shipped as a result of the Certification Inspection.

11. The USFWS will provide quality control assurances (QA/QC)for the Grass Carp Inspection and Certification Program.

   (1) Employee Training.

   (2)Retain records and maintain a Triploid Grass Carp database.

   (3)Maintain a file on State grass carp regulations.

# Standards for Grass Carp Producers

1. The USFWS only provides the Inspection and Certification service to Producers that want to cooperate, and participation is completely voluntary.

2. The Grass Carp Producer, prior to the Inspection date, will examine the checklist of requirements for Triploid Grass Carp Producers, and ensure that the conditions of the Protocol will be met (i.e., available diploid controls, a working Coulter Counter, etc.) .

*****(Producers signature removed from checklist)*****

3. All grass carp, in an identified lot, offered for sale, will have been individually tested by Coulter Counter techniques before a USFWS Triploid Grass Carp Inspection will be performed. The USFWS Inspection consists of a retesting by the Producer, in the presence of the Inspector, of 120 individuals randomly selected by the Inspector from the identified lot of alleged 100% triploid grass carp.

4. Producers must have a fully operational particle sizer (such as the Coulter Counter) with channelizer, and trained personnel available to gather and process fish for the Inspection.

5. The Grass Carp Producer will ensure that the diploid grass carp control fish come from the same site, and be the same relative age/size as the group of fish that are to be Certified for triploidy.

6. The Grass Carp Producer will maintain the isolated group(s) of allegedly 100% triploid grass carp in containment units at least 100-ft away from production ponds (thus reducing the chance of inadvertent mixing of triploids & diploids). Fish must be maintained in the containment units away from production ponds until sold or delivered to purchaser within four working days.

7. The containment units will be provisioned with water that is clear enough to allow the isolated fish population to be viewed by the USFWS Inspector .

8. If a diploid is found in the course of testing the 120 fish sample, the lot fails Certification. All fish in that lot of fish must to be retested, individually, by the Producer, before another inspection of that lot of fish is rescheduled for Certification Inspection.

9. Producers who receive a Certification from a USFWS Inspector must sell or ship the certified fish maintained in the defined holding area(s), within four working days. If fish are not sold or shipped within the four day working period of the certificate, the fish must be re-certified in order to retain USFWS certification for sale or shipment.

10. Once Inspected and Certified, no additional fish can be added to an identified lot of triploid grass carp.

11. Officials, in states where fish are scheduled for delivery, will be notified by phone within 24 hours. Information to be communicated will be the number of fish involved in a shipment, the source of the fish, the final destination of the fish, estimated date/time of arrival, and the name of the dealer or hauler of the fish. Written documentation will then be sent by mail.

12. No diagnostic services will be required of the USFWS Inspector. Nevertheless, a fully trained Inspector could assist the Producer in the finding and identification of Asian tapeworms.

13. If visual examination by the Inspector identifies some phenotypic anomaly, further scrutiny and investigation would not be the responsibility of the Inspector under the Grass Carp Program. If such work is desired by the Grass Carp Producer, it should be directed to a fish veterinarian, a certified fish health specialist, or a fish pathologist.

14. Grass Carp Producers will retain records of their Certification transactions and provide copies of the Certification to truck drivers, and others, delivering the fish to the place of destination.

15. The USFWS provides triploidy Certification; it is the obligation of the Producer to comply with laws, regulations, and guidelines of the states.

16. Fees for service will be handled by check, issued to the Inspector at the time of the Inspection, and made payable to the US Fish and Wildlife Service for the number of fish Certified to be shipped.

17. For additional information about the USFWS Triploid Grass Carp Inspection and Certification Program, Producers should direct questions to their closest regional representative:

| | | |
|---|---|---|
| Vince Mudrak | Chuck Surprenant | David Hendrix |
| Warm Springs, GA 31830 | Marion, IL 62959 | Neosho, MO 64850 |
| Tele # (706-655-3382) | Tel. # (618) 997-6869 | Tele # (417) 451-0554 |

# Checklist for Inspectors and Triploid Grass Carp Producers

Before the Grass Carp Producer contacts the USFWS Inspector he/she will review their on-site conditions to ensure that the Certification process will be efficient and effective. The Grass Carp Producer will conform to the checklist requirements:

- ☐ [1]The Grass Carp Producer will contact the USFWS Inspector and schedule an Inspection. [2]The Grass Carp Producer will identify the number of fish expected to be shipped and provide this number to the Inspector.
  Number ___________

- ☐ A minimum of two diploid grass carp control fish from the Producer's site (and preferably taken from the lot of fish being Certified) will be used to calibrate the Inspection equipment for each and every Inspection.

- ☐ [3]The Producer will individually check the group of grass carp for ploidy, and segregate the triploid grass carp within isolated containment units (vat/ tank) prior to the Inspection visit by the USFWS Inspector.

- ☐ The Channelizer and Coulter Counter will be in acceptable working order prior to on-site arrival of the USFWS Inspector.

Notes:

[1]Producers will recognize that each Inspection Office will keep one day "free" for other USFWS activites, and accordingly, the Producers will request Certification Inspections for an alternate weekday. The Producer will give the USFWS Inspector sufficient notice that a triploidy inspection is needed -- a minimum of two-working-days should give the USFWS Inspector sufficient time to adjust his/her schedule.

[2]Inspection requests by the Producer for groups of fish of less than 1500 will only be performed when agreed upon, in advance, by the USFWS Inspector (See: "Collection of Fees" page 7, #4).

[3] If fish are not sold or shipped within the four day working period of the certificate, the fish must be re-certified in order to retain USFWS certification for sale or shipment after the expiration date of the original certificate.

******(Producer signature to be deleted from checklist, Inspector will verify requirements with signature and date for clarification.)********

~~Producer~~ ______________________ Inspection Date ________________
~~Signed~~

Inspector ______________________ Inspection Time ________________
Signed

## Standards for Collection of Fees

1. The established standard fee for inspection services will be twenty two cents (~~$.22~~) per fish shipped as a result of the inspection ( ~~effective January 1, 1999~~).

******(New fee of $.24 per fish shipped effective January 1, 2000)******

2. A check for the appropriate amount will be written, and made payable to the U.S. Fish & Wildlife Service. Check information will include the following: the Producer or Company's name, address, & phone number; the Producer representative's signature; the date; reference to transaction rece~~ipt~~ for a specified number of fish.

3. If no Certificate can be issued by the Inspector ( Examples: failed inspection, no diploid controls , Coulter Counter malfunction, etc) a fee of $50.00 will be collected by the USFWS Inspector, from the Triploid Grass Carp Producer, to defray the trip cost.

4. If the USFWS Inspector makes an Inspection/Certification trip, and for some unusual reason the work results in the Certification of less than 1500-fish, then the fee to be collected by the USFWS Inspector will be $50, or the number of fish shipped X ~~$.22,~~ (whichever is the greater amount). ******($.24 @ January 1, 2000)******

5. Fees collected for Certifications will <u>be</u> held for seven days and then be deposited into separate Regional accounts as established by USFWS Washington Office and the Denver Finance Center.

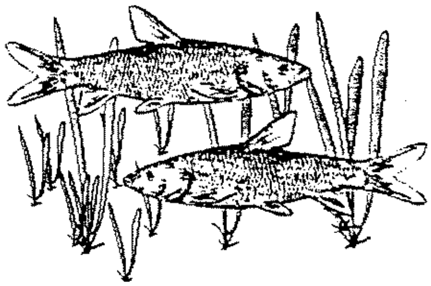
6. The USFWS Inspector will retain the Producer's check for seven-days to allow for adjustments of any purchase order cancellation. A cancelled order qualifies that same number of Certified triploid grass carp, to be available for another sale and shipment within the original "four working day period."

7. The USFWS Inspector will not credit accounts for Dead-on-Arrival fish. The Grass Carp Producer must assume the burden for safe shipping of the triploid grass carp.

8. The USFWS desires to retain a standardized statistically valid 120-fish sampling protocol. However, should a state or fishery program absolutely require that the number of fish to be sampled be increased (above the standard 120-fish sample), the fee for Inspection services will increase from ~~22-~~cents, to one dollar, ($1.00) per fish shipped.

*******($.24 @ January 1, 2000)******

Triploid Grass Carp
Certification Program

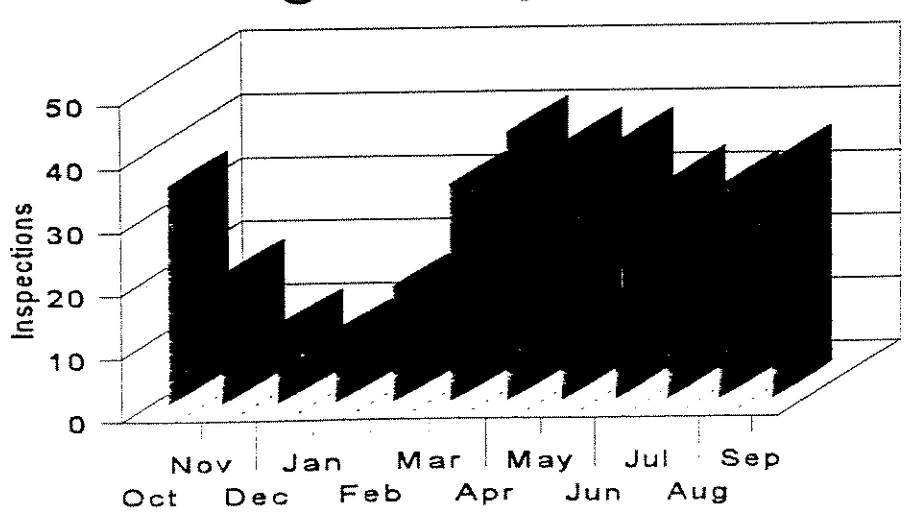


The Region 4 triploid grass carp inspection program is administered by the Warm Springs Fish Health Laboratory.

**Certified Triploid Grass Carp Inspections Performed - Region 4**

| Fiscal Year | Inspections Performed | Certificates Issued | Fish Shipped | | Fee's Collected |
|---|---|---|---|---|---|
| **FY-98** | 298 | 896 | 392,932 | $ | *77,437.63* |
| **FY-97** | 359 | 1,012 | 441,512 | $ | *75,057.04* |
| **FY-96** | 373 | 932 | 486,962 | $ | *47,746.53* |
| **FY-95** | 382 | 983 | 392,563 | $ | *0.00* |
| **FY-94** | 394 | 1,014 | 411,934 | $ | *0.00* |
| **FY-93** | 381 | 1,072 | 555,856 | $ | *0.00* |
| **FY-92** | 372 | 851 | 559,690 | $ | *0.00* |
| **FY-91** | 300 | 605 | 468,706 | $ | *0.00* |
| **Total** | 2,561 | 6,469 | 3,317,223 | $ | *200,241.20* |

## Average Inspections



## Summary of species composition of triploid groups

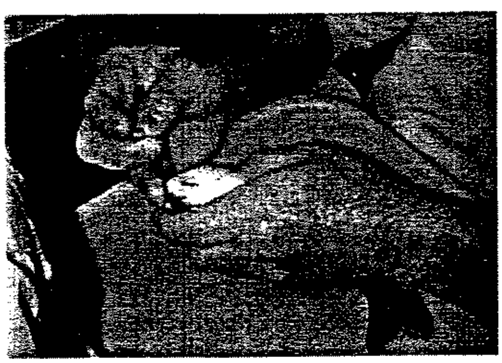
| Common Name | Species | Number |
|---|---|---|
| Grass Carp | *Ctenopharyngodon idella* | 390,417 |
| Black Carp | *Mylopharyngodon piceus* | 2500 |
| Silver Carp | *Hypophthalmichthys molitrix* | 15 |

## Triploid Grass Carp Destination Summary FY 1998
## Region 4 Inspections

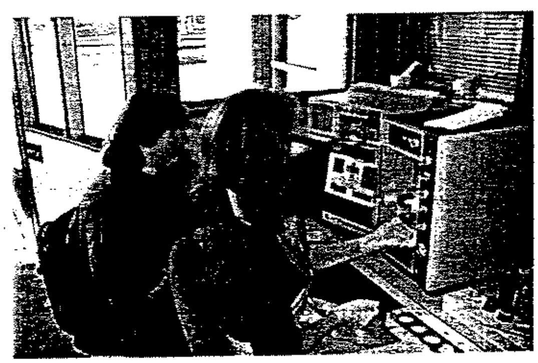
| State | Warm Springs | Stuttgart | Summary | State | Warm Springs | Stuttgart | Summar |
|---|---|---|---|---|---|---|---|
| Alabama | 0 | 0 | 0 | Mississippi | 0 | 17 | 17 |
| Arizona | 1,000 | 53,605 | 54,605 | Missouri | 0 | 0 | 0 |
| Arkansas | 0 | | 0 | Nebraska | 0 | 1,000 | 1,000 |
| California | 0 | | 0 | Nevada | 0 | 1,318 | 1,318 |
| Colorado | 0 | 8,510 | 8,510 | New Jersey | 0 | 1,455 | 1,455 |
| Connecticu | 0 | 2,250 | 2,250 | New Mexico | 0 | 1,675 | 1,675 |
| Delaware | 0 | 11 | 11 | New York | 0 | 13,891 | 13,891 |
| Florida | 37,067 | 66,913 | 103,980 | North | 920 | 27,203 | 28,123 |
| Georgia | 0 | 13,050 | 13,050 | Ohio | 5,400 | 44,895 | 50,295 |
| Hawaii | 0 | | 0 | Oklahoma | 0 | 0 | 0 |
| Idaho | 0 | 1,012 | 1,012 | Oregon | 0 | 0 | 0 |
| Illinois | 0 | 7,788 | 7,788 | Pennsylvania | 0 | 4,967 | 4,967 |
| Indiana | 0 | 17,245 | 17,245 | South | 0 | 0 | 0 |
| Iowa | 0 | 0 | 0 | South Dakota | 0 | 0 | 0 |
| Kansas | 0 | 0 | 0 | Tennessee | 0 | 0 | 0 |
| Kentucky | 0 | 13,434 | 13,434 | Texas | 0 | 25,938 | 25,938 |
| Louisiana | 1,965 | 17,931 | 19,896 | Virginia | 400 | 7,821 | 8,221 |
| Mississippi | 0 | 17 | 17 | Washington | 0 | 1,480 | 1,480 |
| Missouri | 0 | 0 | 0 | West | 10 | 1,522 | 1,532 |
| Nebraska | 0 | 1,000 | 1,000 | Wyoming | 0 | 2,400 | 2,400 |
| Nevada | 0 | 1,318 | 1,318 | Mexico | 0 | 150 | 150 |
| | | | | Spain | 0 | 300 | 300 |

# Producers for Whom Triploid Carp Certification Inspections Were Provided in FY-98

| | | | |
|---|---|---|---|
| American Sport Fish Hatchery<br>P.O. Box 20050<br>Montgomery, AL 36120 | 334-281-7703 | Larry Farley<br>17771 HWY 18<br>Cash, AR 72421 | 870-477-5530 |
| Jack Dunn<br>P.O. Box 157<br>Monroe, AR 72108 | 870-734-1304 | Hopper-Stephens Hatcheries<br>5205 HWY 31 South<br>Lonoke, AR 72086 | 501-676-2435 |
| Bill Easterling<br>674 Easterling Mill Road<br>Clio, AL 36017 | 334-397-4437 | Keo Fish Farm<br>P.O. Box 123<br>Keo, AR 72083 | 501-842-2872 |
| J.M. Malone and Son Enterprises<br>P.O. Box 158<br>Lonoke, AR 72086 | 501-676-2800 | Owens and Williams Fish Farm<br>Route 1, Box 2000<br>Hawkinsville, GA 31036 | 912-892-3144 |



Blood Sampling



Susan Persons conducting Inspection

## U.S. Fish and Wildlife Service Ploidy Inspectors

**Stuttgart, AR** 870-673-4483
Susan "Nikki" Persons

**Warm Springs, GA** 706-655-3382
Norman Heil
Howard Jackson
Brian Hickson
Kurt Ulrich
Robert Reeve

Beginning on January 1, 1998 a fee of $0.20 for each certified triploid fish shipped was assessed against each triploid fish producer. During the course of FY-98 the Triploid Grass Carp program standards were revised and amended to reflect needed changes to the program. Producers and inspectors as well as management staff were provided the opportunity to comment and review the changes. The standards were then rewritten to reflect those changes agreed upon and thus will go into effect January 1, 1999. Included in those changes is an increase of $.02 to $.22 per fish shipped to cover the costs of the program. The Triploid Grass Carp Standards are also available on the internet at web site address http://www.fws.gov/r4eao/wildlife/frgrscrp.html

Annual Summary For Triploid Grass Carp Program
Region 3

| Month | Number of Inspections | Failures | Certificates Issued | Number of Fish | Fee's Collected |
|---|---|---|---|---|---|
| October | 2 | 0 | 4 | 4520 | $904.00 |
| November | 0 | 0 | 0 | 0 | $0.00 |
| December | 0 | 0 | 0 | 0 | $0.00 |
| January | 0 | 0 | 0 | 0 | $0.00 |
| February | 0 | 0 | 0 | 0 | $0.00 |
| March | 4 | 1 | 8 | 4970 | $1,143.40 |
| April | 2 | 0 | 5 | 2062 | $453.64 |
| May | 0 | 0 | 0 | 0 | $0.00 |
| June | 1 | 0 | 2 | 550 | $121.00 |
| July | 0 | 0 | 0 | 0 | $0.00 |
| August | 1 | 0 | 2 | 290 | $63.80 |
| September | 0 | 0 | 0 | 0 | $0.00 |
| Total | 10 | 1 | 21 | 12392 | $2,685.84 |

Annual Summary For Triploid Grass Carp Program
Region 4

Total

| Month | Number of Inspections | Failures | Certificates Issued | Number of Fish | Fee's Collected | Check | Difference |
|---|---|---|---|---|---|---|---|
| October | 25 | 2 | 80 | 33,536 | $6,847.20 | $6,707.20 | $140.00 |
| November | 22 | 0 | 46 | 22,325 | $4,623.80 | $4,465.00 | $158.80 |
| December | 16 | 1 | 40 | 23,822 | $4,842.40 | $4,764.40 | $78.00 |
| January | 10 | 1 | 24 | 38,000 | $8,435.80 | $8,360.00 | $75.80 |
| February | 17 | 1 | 45 | 24,627 | $5,508.54 | $5,417.94 | $90.60 |
| March | 30 | 2 | 84 | 51,487 | $11,462.58 | $11,327.14 | $135.44 |
| April | 31 | 0 | 130 | 73,674 | $16,208.28 | $16,208.28 | $0.00 |
| May | 35 | 2 | 131 | 57,287 | $12,633.13 | $12,603.14 | $29.99 |
| June | 36 | 4 | 134 | 62,483 | $13,951.40 | $13,746.26 | $205.14 |
| July | 30 | 4 | 105 | 33,667 | $7,643.60 | $7,406.74 | $236.86 |
| August | 0 | 0 | 0 | 0 | $0.00 | $0.00 | $0.00 |
| September | 0 | 0 | 0 | 0 | $0.00 | $0.00 | $0.00 |
| Total | 252 | 17 | 819 | 420,908 | $92,156.73 | $91,006.10 | $1,150.63 |

Stuttgart Summary for FY99

| Month | Number of Inspections | Failures | Certificates Issued | Number of Fish | Fee's Collected | Check | Difference |
|---|---|---|---|---|---|---|---|
| October | 23 | 2 | 77 | 31,397 | $6,419.40 | $6,279.40 | $140.00 |
| November | 18 | 0 | 37 | 17,960 | $3,703.20 | $3,592.00 | $111.20 |
| December | 12 | 1 | 34 | 18,143 | $3,686.60 | $3,628.60 | $58.00 |
| January | 9 | 1 | 21 | 35,504 | $7,886.68 | $7,810.88 | $75.80 |
| February | 15 | 1 | 43 | 23,326 | $5,198.72 | $5,131.72 | $67.00 |
| March | 28 | 2 | 81 | 49,307 | $10,977.54 | $10,847.54 | $130.00 |
| April | 29 | 0 | 125 | 69,125 | $15,207.50 | $15,207.50 | $0.00 |
| May | 31 | 2 | 117 | 51,189 | $11,291.58 | $11,261.58 | $30.00 |
| June | 34 | 4 | 128 | 61,063 | $13,639.00 | $13,433.86 | $205.14 |
| July | 27 | 4 | 99 | 25,490 | $5,824.80 | $5,607.80 | $217.00 |
| August | | | | | | $0.00 | $0.00 |
| September | | | | | | $0.00 | $0.00 |
| Total | 226 | 17 | 762 | 382,504 | $83,835.02 | $82,800.88 | $1,034.14 |

Black Carp Data integrated into totals Above

Black Carp Inspections

| | | | | | |
|---|---|---|---|---|---|
| May | 1 | 0 | 1 | 200 | $44.00 |

Warm Springs Annual Summary FY99

| Month | Number of Inspections | Failures | Certificates Issued | Number of Fish | Fee's Collected | Check | Difference |
|---|---|---|---|---|---|---|---|
| October | 2 | 0 | 3 | 2,139 | $427.80 | $427.80 | $0.00 |
| November | 4 | 0 | 9 | 4,365 | $920.60 | $873.00 | $47.60 |
| December | 4 | 0 | 6 | 5,679 | $1,155.80 | $1,135.80 | $20.00 |
| January | 1 | 0 | 3 | 2,496 | $549.12 | $549.12 | $0.00 |
| February | 2 | 0 | 2 | 1,301 | $309.82 | $286.22 | $23.60 |
| March | 2 | 0 | 3 | 2,180 | $485.04 | $479.60 | $5.44 |
| April | 2 | 0 | 5 | 4,549 | $1,000.78 | $1,000.78 | $0.00 |
| May | 4 | 0 | 14 | 6,098 | $1,341.55 | $1,341.56 | ($0.01) |
| June | 2 | 0 | 6 | 1,420 | $312.40 | $312.40 | $0.00 |
| July | 3 | 0 | 6 | 8,177 | $1,818.80 | $1,798.94 | $19.86 |
| August | | | | | | $0.00 | $0.00 |
| September | | | | | | $0.00 | $0.00 |
| Total | 26 | 0 | 57 | 38,404 | $8,321.71 | $8,205.22 | $116.49 |

United States Department of the Interior
FISH AND WILDLIFE SERVICE

TAKE PRIDE IN AMERICA

Fish Farming Experimental Laboratory
P.O. Box 860
Stuttgart, Arkansas 72160-0360
(501)673-4483


## Grass Carp Ploidy Release Authorization

Authority is hereby given to the Fish Farming Experimental Laboratory, USFWS, Stuttgart, Arkansas, to release the results of the ploidy determination of grass carp to Jerry Landye of the Arizona Game and Fish Department. This concerns a shipment of ____________ triploid grass carp on or about ____________________. One hundred and twenty randomly selected fish from an alleged 100% triploid lot were inspected for ploidy on the farm site Model ZM Coulter Counter. Diploid and triploid controls along with the use of a C-1000 Channelyzer were used to insure proper readings from the equipment. Observations showed __________ triploids and __________ diploids.

Sample

Dealer: ____________________________

General health:

____________________________

____________________________

____________________________

____________________________

____________________________
(Business Owner or Representative)

____________________________
(Business Name)

____________________________
(Inspector)

____________________________
(Date)

AZ
CARP1

# Appendix 2

# Asian Tapeworm

App 2 — TAPEWORM

ASIAN FISH TAPEWORM, BOTHRIOCEPHALUS OPSARICHTHYDIS*, PREVENTION AND CONTROL

Peter
Please return
my only copy
Dick

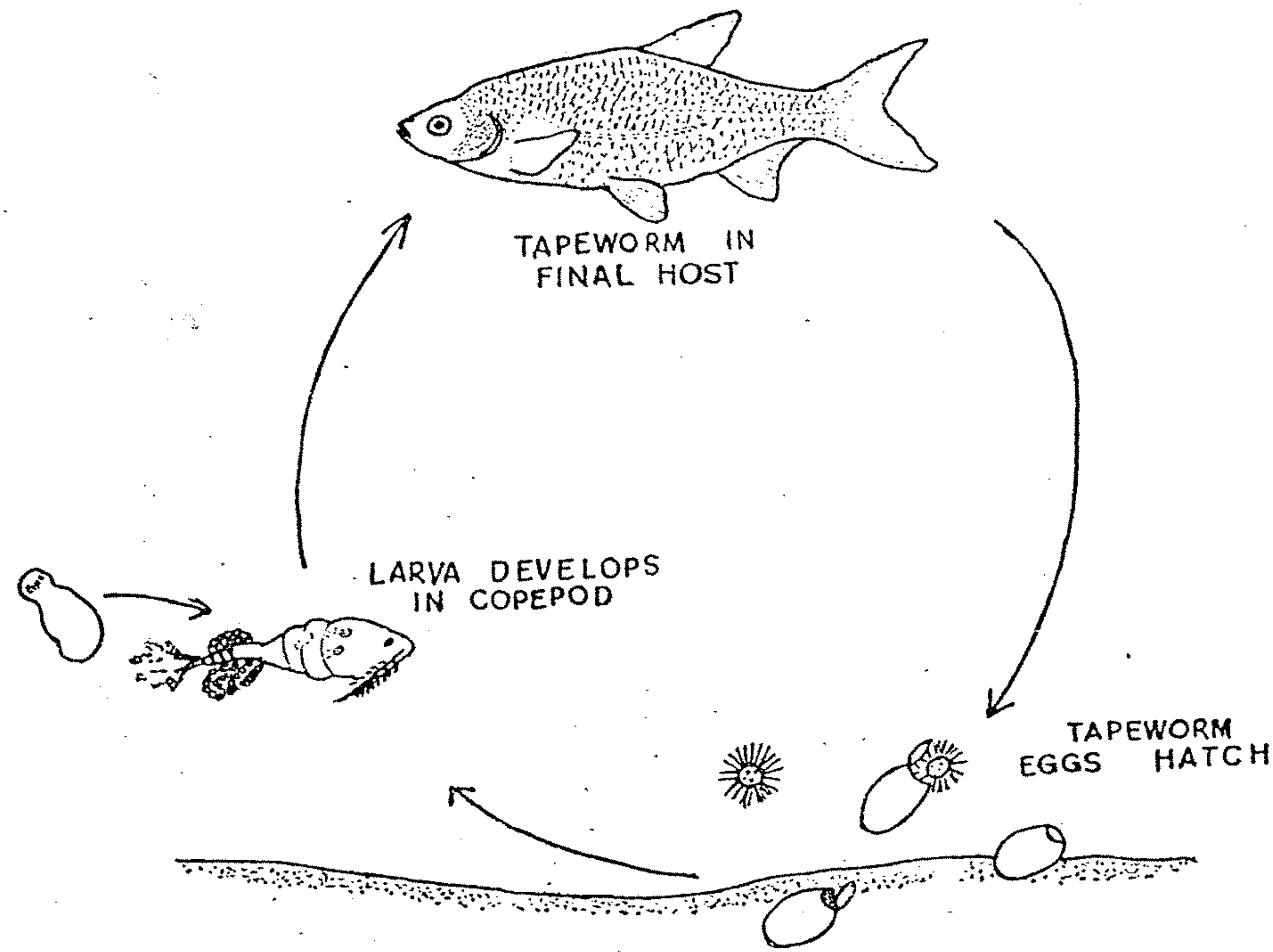
Revised June 7, 1983

Glenn L. Hoffman
U.S. Fish and Wildlife Service
Fish Farming Experimental Station
P.O. Box 860
Stuttgart, Arkansas 72160

This tapeworm*, characterized by its pit-viper-shaped head has been a dangerous parasite for cultured grass carp and German carp fingerlings in Europe. In the United States it has been found in golden shiners, fathead minnows, grass carp, mosquito fish In Europe it has also been found in European catfish and mosquito fish and others.

European fish farmers control it by drying the ponds annually or treating drained wet ponds with calcium chloride or calcium hydroxide to kill the copepod intermediate hosts, and treating the fish with anthelmintics. Valuable fish can be fed anthelmintic drugs such as di-n-butyl tin oxide, dibutyltin dilaurate, and Yomesan (Phenasal).

* According to Prof. M.N. Dubinina 1982 (Parazitologiya 16(1):41-45), Bothriocephalus gowkongensis and B. phoxini are synonyms of BOTHRIOCEPHALUS OPSARICHTHYDIS Yamaguti, 1934




ASIAN FISH TAPEWORM, BOTHRIOCEPHALUS OPSARICHTHYDIS

Attachment C

# Montana Fish, Wildlife & Parks

TO: Howard Johnson

FROM: Jim Peterson

DATE: Dec. 4, 1998

SUBJECT: Grass Carp

Grass carp have never been legally introduced into Montana, although an illegal introduction into a private pond in the Kalispell area was discovered earlier this year. Since grass carp have not been legally imported in the past, an environmental assessment (at a minimum) will have to be conducted prior to any introduction.

We have had several requests over the years to import grass carp. These requests have been denied for several reasons. The two primary concerns have been (1) the possible introduction of an exotic species that could negatively impact existing fisheries, and (2) disease concerns, primarily introduction of the Asian tapeworm. Advocates of importing grass carp will argue that the fish are sterile triploids that can not reproduce and will not result in a competing viable population if they escape into the wild. Advocates will also argue that grass carp can be treated to remove the Asian tapeworm and that stocks can be certified disease-free before shipping into Montana. These are valid arguments, and in fact, there are sources of grass carp available that advertise guaranteed sterile and disease-free grass carp. I know you have been investigating potential grass carp sources. I believe there is a high degree of certainty that triploid grass carp can be obtained. I will not attempt to evaluate the sterility of grass carp. However, I will offer the following information concerning the disease issue.

Grass carp are known to carry viruses. Even certified disease-free fish can be carriers of virus. So the possibility exists that a virus or other pathogen may be imported with grass carp, even if they have been tested and obtained a clean bill of health. The water these fish will be transported in may also harbor pathogens or other unwanted aquatic pests, including zebra mussel. These possibilities exist with any importation of live fish, not just grass carp. This is why we attempt to import fish eggs instead of live fish whenever possible. Eggs can be disinfected, and so can the water they are shipped in. The point is that we take a chance anytime we import fish from out-of-state. Movement of live fish into Montana should be avoided whenever possible. In a conversation I had several years ago with Drew Mitchell of the USFWS Fish Farm Experiment Station in Stutgart, Arkansas, Drew said, "You will import some parasites if you import these fish (grass carp). You may import golden shiner virus." I think Drew's statements just state a fact, and they get to the heart of the issue; if we import grass carp, we will import pathogens along with them. Then the question is, so what? I have always said that if we import fish (any fish) we have to assume that some fish will escape into the wild and we have to assume that any parasites or pathogens on those fish will also escape into the wild and our fish will be exposed to them. Again, so what?

The potential impact of exotic fish pathogens is unknown. We can not say for sure what impact a new pathogen or parasite will have on <u>our</u> fish in <u>our</u> waters. We only have to go back to December of 1994 to look at what we now know to be very serious impact to wild fish by an exotic parasite, *Myxobolus cerebralis* (whirling disease). The impact of the whirling disease parasite will vary from location to location for various reasons, but in some waters at least, the impact is very severe.

The Asian tapeworm, *Bothriocephalus acheilognathi*, is a parasite commonly found in grass carp. As a matter of fact, this tapeworm was first introduced into the United States with grass carp. It can have very servere impact in fish. Infected fish can die when large numbers of these tapeworms accumulate in the anterior intestine. Mortality can reach as high as 90%. This parasite is known to infect carp, grass carp, channel catfish and a variety of minnows, including fathead minnows and golden shiners. The Asian tapeworm has caused severe problems for the bait fish industry in the south. A variety of susceptible species occur in Montana. Potential impacts in Montana include the possible infection of important forage fish.

Grass carp are now widely distributed in the U.S. I am not aware of any negative impact from escaped fish. The Asian tapeworm is also very likely widely distributed, although I suspect the distribution in the wild is not known. In Wyoming, for example, grass carp are allowed to be imported and have been imported for many years, yet the Asian tapeworm has never been reported in Wyoming. Grass carp were first legally introduced into Utah in 1993. The Asian tapeworm is now established in the San Jaun and upper Colorado Rivers.

I suspect that both grass carp and the Asian tapeworm would have a difficult time becoming established in Montana, because the habitat and water temperatures are generally not suitable to them. The Asian tapeworm prefers temperatures higher than 25C. We have few waters that attain that temperature for extended periods of time. Glenn Hoffman, generally regarded at the nation's foremost fish parasitologist, reported that the Asian tapeworm is widespread in the mid South and Southeastern United States. but "has not been found farther north, and perhaps never will be, because it is a thermophile with an optimum temperature higher than 25C."

From a fish health standpoint, I am concerned about allowing grass carp into Montana. My primary concern is that they will bring Asian tapeworm with them and that this parasite may impact existing fisheries. Any request to import grass carp will have to jump through several hoops before an introduction could take place. If we decide to consider any request, we must do so carefully. Each request must include a specific proposal with a specific water identified. The fish can not be imported unless a pond license has been issued for a specific water. A pond license can not be issued for grass carp until an environmental assessment has been completed. The environmental assessment is required by law and will allow us time to research and consider the proposal. Then, before any fish may be imported, we have the final say in the matter because no fish may be imported until we issue an import permit. The fish would have to come from a *certified disease-free source* and be *certified triploid*. They would have to come from a source that is *free of the zebra mussel*. They should be treated to remove any tapeworms and shipped in clean well water. These are just a few of the concerns I have.

A variety of sources are available for grass carp. A private hatchery in Cody, Wyoming imports grass carp for Wyoming customers. Bill Nye, owner of the Wyoming Trout Ranch, told me that he takes orders for grass carp, then picks up a load of grass carp from a broker in Nebraska. The broker obtains the fish from Arkansas. Mr. Nye then brings the grass carp back to Wyoming and delivers them directly to buyers in Wyoming. Mr. Nye told me he would work with us to provide grass carp to Montana customers. Alberta, Canada is also in the grass carp sales business. They have only had grass carp available for about one year, but feel they have a disease-free source of fish. Their broodstock originated from Colorado and California. They originally imported the fish for research, but have since turned the fish over to private industry. They allow only triploid fish to be stocked. However, after heat treating the fish to produce triploidy, they have had varied success (20%-98%). They check every fish before stocking to insure that no diploid fish are stocked. I am waiting for a call from the Alberta biologist to inquire about the health status of the Alberta fish.

I would like to contact several other people about grass carp and the Asian tapeworm. I'll let you know as I get more information. I am providing this information and my thoughts concerning importation of grass carp in order to contribute to the discussion and decision-making process and help evaluate the threat. In some respects the disease threat associated with grass carp introduction is low. However, from my perspective there is a considerable amount of risk. The risk comes from the unknown and is difficult to quantify. But this risk must be considered along with the potential positive factors of importing grass carp. I see no positive factors to our existing fishery resources, and that is my biggest concern.

Cc: Jim Satterfield

Good luck with your report.

# Appendix 3

## State Reports

IDAHO

App-3 State reports

State of Idaho
Department of Fish and Game
Boise, Idaho

June 23, 1992

**MEMORANDUM**

TO: Regional Supervisors

FROM: Jerry Mallet, Assistant Director Operations

SUBJECT: Grass Carp

Evidently there is some confusion on issuing grass carp permits. Many regions do not handle enough permits to become familiar with the procedure, so here it is again:

I. The Commission adopted a policy of allowing the importation of triploid grass carp for release in closed systems or ones that are adequately screened to prevent the escape of fish.

II. Fish must be certified as triploid by the U.S. Fish and Wildlife Service.

III. A copy of the certification must be provided to the Department prior to importation and release.

IV. Private waters must have a current private pond permit.

V. The initial step in the process is for the region to: a) confirm that the permittee has a valid private pond permit, b) inspect the pond to ensure it is either a closed system or adequately screened, and c) forward that information to the Fisheries Bureau along with 1) the permittee's name and address, 2) the location of the pond, 3) the maximum number or numeric range of fish requested, and 4) time period for importation and release.

While we are still in the new stages of this, I would like to have all permits come to the Bureau of Fisheries and they will be issued by the Director. Attached is an example of a permit.

It also came to my attention there have been two recent incidents of persons inquiring about grass carp at a regional office and being told either that we discourage their use or even that we would not allow them. Please remind your personnel the Commission has established the policy on grass carp and it is inappropriate for individuals, even though they may not personally agree with the policy, to make up their own.

Attachment

F0AV328B

AGENDA ITEM NO. 7.C

**PROPOSAL:**

## STERILE TRIPLOID GRASS CARP

Over the last year, the Fisheries Bureau has received several requests for permission to import sterile triploid grass carp for use in controlling aquatic vegetation in sewage ponds and other closed systems. Department Policy FW-5.00 (attached) expressly prohibits the importation of grass carp except for research purposes.

Increasing use of grass carp around the country as a biological vegetation control (both legally and illegally) and concern for potential adverse impacts has resulted in development of a private market supplying sterile triploid grass carp. The USFWS provides an inspection and certification of sterility for individual shipments from suppliers. Sixteen states allow importation of grass carp, only with certification of sterility. Fifteen additional states allow importation of non-sterile diploid fish.

Costs for chemical treatment to control vegetation may range up to $400 per acre per year in severe cases; a sterile grass carp program may cost $3 to $5 per acre per year. These costs, and the development of the supply of certified sterile fish, has prompted the recent inquiries.

The Fisheries Bureau has been requested to ask the Commission to reconsider Policy FW-5.00 and either modify to allow sterile grass carp or reconfirm the prohibition.

Sterile grass carp pose the same potential impacts as regular grass carp plus increased longevity. If present in sufficient numbers, grass carp may impact waterfowl habitat and food and eliminate vegetation entirely.

Excessive stockings of grass carp have taken place in some small, mid-western impoundments where survival rates were underestimated. In some of those waters, a reduction of game fish populations occurred following complete elimination of vegetation. Where extensive aquatic vegetation was present, the conversion to basic nutrients by grass carp has resulted in algal blooms and water quality impacts.

The major advantage of sterile grass carp over diploids is absolute control of numbers. Though natural reproduction of diploid grass carp is rare, genetic adaptation is a potential threat. Sterile grass carp eliminate the potential for natural recruitment.

Allowing certified sterile grass carp for use in closed systems may reduce illegal importation of diploids which is going on in Idaho and the Northwest. It would result in reduced herbicide use and cost savings to pond owners. It would be opening the door for increased introductions, however.

*May 23, 1988*

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## MISCELLANEOUS

### Sterile Tripoid Grass Carp (Policy Change)

W. G. Nelson, Mayor, City of Kuna, and Leo Ray, Fish Breeders of Idaho, made presentations requesting that the Commission allow importation of sterile triploid grass carp for use in controlling aquatic vegetation in sewage lagoons to eliminate the need for use of herbicides.

Al Van Vooren, Resident Fishery Manager, reported survival rates of grass carp were underestimated in a number of small

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mid-western impoundments; elimination of vegetation and algal blooms resulted in a reduction in fish populations and water quality impacts. He said the triploids would be restricted to closed water systems in Idaho and not used in any public fishing waters. He added a consideration would be that the policy change would open the door for increased introductions.

88-60 Commissioner Christensen moved and Commissioner Guth seconded a motion TO ALLOW THE IMPORTATION OF TRIPLOID GRASS CARP WHICH HAVE BEEN CERTIFIED STERILE BY THE U.S. FISH AND WILDLIFE SERVICE AND THEIR RELEASE IN WATERS HAVING NO OUTLET OR OUTLETS WHICH ARE SCREENED TO PREVENT ESCAPE OF FISH. SUCH IMPORTATION AND RELEASE WOULD BE ALLOWED ONLY WITH WRITTEN PERMISSION OF THE DEPARTMENT DIRECTOR PURSUANT TO HIS AUTHORITY UNDER IDAHO CODE SECTION 36-105(e)5(A). The motion carried in a unanimous vote.

COPY

# STATE OF IDAHO
## DEPARTMENT OF FISH AND GAME

### Live Fish Transportation Permit

Permission to hereby grant to: Transportation Permit Number: HQ-00-026

Name: Chris Yehle

Issued Date: 4/18/00

Company:

Expired: 5/31/00

Address: 5487 S. Caper Place
Boise, ID 83716

Phone: (208) 368-5232

Fax: (208) 383-1168

For:

☐ Import into the State of Idaho. Permit approved by the Fisheries Bureau (*see #5).

☑ Transport fish within the State of Idaho. Permit issued by the Regional office (**see #5)

| NUMBER OF FISH/EGGS | SPECIES | SOURCE, PHONE # | DESTINATION |
|---|---|---|---|
| 2 | Grass carp | Opaline Aqua Farms, (208) 495-2654 | address above |

ADDITIONAL STIPULATIONS:

*Grass Carp must be certified triploid and tested free of Asian tapeworm by the U.S. Fish and Wildlife Service (Eagle Fish Health Laboratory has been provided these test results.)*
**Pond is backyard pond, filled by garden hose, with no outlet, Mr. Yehle has goldfish now.*

This transportation permit is issued in conjuction with the Permittee's Private Pond No. N/A and is not transferable.

Provisions of Permit Accepted: Please read reverse side of Permit.

Signature of Permitee Date

IDAHO DEPARTMENT OF FISH AND GAME
Rod Sando, Director

by Willian D. Horton

Chief, Fisheries Bureau or Reg. Supervisor Date

c: Region: 3 Southwest
William D. Horton

Eagle Fish Health Laboratory
1800 Trout Rd OFF(208) 939-2413
Eagle, ID 83616 FAX(208) 939-2415

WASHINGTON

# RECOMMENDATIONS FOR UPDATING CURRENT WDFW GRASS CARP MANAGEMENT

There are several areas in which we recommend current management be updated to reflect recently obtained information about grass carp in the Pacific Northwest.

1. Currently the policy sets 25% vegetated surface coverage as a minimum goal when using grass carp. The variability associated with the effects of various stocking rates suggest that controlled removal of submersed plants to a predetermined level is not currently feasible using grass carp. No control or complete eradication is much more common, even when the objective is control. Therefore we suggest grass carp should not be used in lakes where complete submersed plant eradication cannot be tolerated unless a complete rotenone treatment can be conducted on the lake if overstocked. We further suggest that all landowners and lake users considering using grass carp be informed that eradication of all submersed plants is a very real possibilty.

2. A stocking rate of 25 fish per vegetated acre should be set as the maximum with the potential of considering higher stocking rates on a case-by-case basis where rapid submersed macrophyte eradication may be desirable, such as in irrigation canals, fire control ponds, and aquaculture ponds. Although recommendation of incremental stocking of grass carp is popular, we could find no empirical evidence where this technique resulted in control in any more sites than a single stocking. However, in theory it seems reasonable and it is an approach which should be investigated.

3. Most stocking rates predicted by the University of Washington *area coverage* stocking rate model (COVER) are currently too high for the Pacific Northwest. Therefore stocking rates recommended in this report should be substituted for stocking rates recommended by the area coverage model. The *biomass* model (BIOMASS) developed by the University of Washington should be refined to reflect possible reductions in grass carp mortality. Until that time the model can be fine-tuned, it should be regarded with caution.

4. We found that almost all landowners, consultants and biologists freely shared information with us about the number of grass carp they had stocked and the results of their treatments. However, one consulting group who had stocked approximately 20 percnet of the lakes in Washington would not share basic information such as if fish were actually stocked in the lake after the permit was approved, date of stocking, number of grass carp stocked, and addresses of landowners. WDFW is charged with monitoring grass carp stockings in Washington and suggesting future improvements regarding their use. Therefore we feel that future permit approval should be contingent on providing basic post-stocking information such as if stocking actually occurred, the number of fish stocked, and landowner addresses.

5. The variability in the effects of a particular stocking rate was high partly because different non-standard methods were used to measure aquatic plant abundance to determine the

stocking rate. Measurement of vegetated area and submergent plant biomass should be standardized to remove variability in stocking rates. Since stocking rates based on plant biomass were developed using SCUBA methods outlined in Bonar (1990) these techniques should be required when stocking rate based on biomass is being calculated. Fish per vegetated area stocking rates should be based on surface area covered by submersed macrophytes. Research should be conducted to develop stocking rates based on macrophyte volume occupied. Measuring macrophyte volume is much less labor-intensive than biomass assessment, but considerably more accurate than surface coverage estimation.

6. The map of initial surface coverage of aquatic plants that landowners were required to submit with the permit was valuable for this study. We should continue to require that these maps be submitted for permit approval.

7. Currently, grass carp are illegal to capture in Washington. Provisions should be made to enable legal capture and removal of grass carp in lakes that are overstocked after contacting the WDFW. The policy should also reflect what is to be done with the captured fish.

8. Grass carp should not be stocked into lakes where increased turbidity, either algal or abiotic, cannot be tolerated unless a provision is made to allow a total lake rotenone treatment if turbidity reaches unacceptable levels. Removal of thick plant canopies which cover a majority of the lake's surface area may increase subsurface dissolved oxygen. Tradeoffs between increased subsurface dissolved oxygen and the potential for increased turbidity should be considered in these sites.

9. Because of the unpredictability of the effects of a grass carp treatment, lakes where *submersed* plant communities provide important habitat for fish and wildlife should not be stocked with grass carp.

10. Because of their difficulty in removal, submersed macrophyte eradication possibilities, and potential for damage if large numbers escape, grass carp should rarely, if ever, be used in large lakes and never in rivers.

11. To aid with quality control of grass carp shipments, the state of Washington should investigate supporting an in-state commercial vendor.

12. To improve stocking rate predictions and grass carp management, a follow-up study, similar to this, should be conducted on a regular basis.

OREGON

Oregon

DEPARTMENT O
FISH AND
WILDLIFE

FISH DIVISION

February 25 1999

Dear Applicant:

The following documents are included in this packet to aid you in your application to import grass carp:

- Department of Fish and Wildlife Application form and Management Plan outline.
- Application form for a Permit to Transport Live Fish or Eggs.
- Name and Address List of Department District Biologists to contact for pond inspections.
- Copy of Oregon Administrative Rules (635-056-0075) for Grass Carp Purchase and Importation.
- Copy of Oregon Administrative Rules (635-007-0555 through 635-007-0585) for Control of Fish Disease.
- Copy of Memo from Dr. Rich Holt to Bob Hooton describing Fish Health Requirements for Importation of Grass Carp in Oregon.

Please complete and fill out the Application Form, Management Plan and Fish Transport Permit Application and submit to Department of Fish and Wildlife, PO Box 59, Portland, Oregon 97207, ATTENTION: Lance Thomson. Lance will distribute your application and attachments to the appropriate staff within Fish Division.

As described in the application, you will also need to schedule an inspection of your proposed site with our nearest District Fish Biologist to you area. You should contact them early in the application process so they can schedule a site visit in a timely manner.

For sources of triploid grass carp we suggest you contact Susan Persons with the US Fish and Wildlife Service in Stuttgart, Arkansas. She can be contacted by phone at (870) 673-4483.

Grass carp application forms and attached information are also available in electronic format. For additional information on this matter please contact lance.thomson@state.or.us. We encourage applicants to apply via e-mail.

Sincerely,

Bob

Bob Hooton
Natural Production
Program Manager

John A. Kitzhaber
Governor

2501 SW First Avenue
PO Box 59
Portland, OR 97207
(503) 872-5252
FAX (503) 872-5632
TDD (503) 872-5259
Internet WWW:http://www.dfw.state.or.us/

State of Oregon

# DEPARTMENT OF FISH AND WILDLIFE

Mailing Address: P.O. Box 59, Portland, OR 97207
Main Office Location: 2501 SW First Ave., Portland, OR 97201

Grass carp may be purchased and imported from outside Oregon for release into lakes, ponds, reservoirs or irrigation ditches in Oregon only pursuant to the terms of a permit issued by the Department. Permit applications are available from any ODFW office, but must be submitted to the Oregon Department of Fish and Wildlife, 2501 SW First Avenue, P.O. Box 59, Portland, OR 97207. Complete applications shall be submitted a minimum of 60 days prior to the proposed stocking date. Approval of permits is dependent on meeting the following evaluation criteria:

1. Only sterile triploid grass carp will be authorized for importation into Oregon. Documentation from the U.S. Fish and Wildlife Service verifying each fish as triploid must be provided to ODFW prior to importation. Applicants will receive this from the vendor distributing the fish.

2. Grass carp must be certified free of Asian tapeworms prior to importation. This certification must be from a pathologist acceptable to ODFW. Health and disease inspections of triploid grass carp shall be conducted according to procedures outlined in Oregon Administrative Rules 635-007-0555 through 635-007-0585.

3. A Fish Transport permit must be received from ODFW prior to transporting grass carp within Oregon and must accompany the shipment.

4. Stocking will be allowed in water bodies within 100 year floodplains (as delineated on county or city land use maps, Federal Emergency Management Agency maps or U.S. Army Corp of Engineers maps) only if the applicant submits, and the Department approves, escape precaution measures and includes them in the applicant's management plan. Stocking will never be allowed in water bodies within 100 year floodplains during times of potential flood (as described by the Federal Emergency Management Agency and depicted on federal Flood Insurance Rate Maps).

5. Approval will not be granted where stocking will be detrimental to any population of a state or federal threatened or endangered species, or their habitat.

6. All grass carp releases will be specific to the site as identified in the Management Plan (see next section).

7. All sites may be inspected and must be approved by ODFW staff prior to importation and release of any grass carp.

8. Only grass carp 12 inches in length and greater may be imported.

9. Grass carp may be stocked only in water bodies on private land or land owned or controlled by an irrigation company or drainage district.

10. Stocking will occur only in water bodies with fish screens approved by ODFW. Such screens must be self-cleaning in a manner approved by the Department. Fixed panel screens must be installed in tandem to allow one screen at a time to be removed for

8. Documentation that the site to be treated is outside the 100 year flood plain, or documentation of the precautionary measures to prevent escape;

9. Documentation that the lake, pond or reservoir to be treated does not exceed 10 acres (not required for canals and ditches);

10. A written description of how public access will be controlled;

11. A detailed description of any necessary screening structures; and

12. A description of how the proposed stocking rate was determined.

## APPLICATION PROCEDURE TO STOCK TRIPLOID GRASS CARP:

1. Complete and submit the attached permit application and Management Plan for stocking triploid grass carp.

2. Contact the local District Fish Biologist to arrange for a site inspection (see attached list).

3. Locate a source of triploid grass carp and have them contact the ODFW Pathologist for disease certification requirements. The ODFW Pathology Section is located at the Department of Microbiology, Nash Hall 220, Oregon State University, Corvallis, Oregon 97331-3804, Ph: (541) 737-1863, FAX: (541) 737-0496. A list of certified sources for grass carp will be developed and made available to applicants as the program develops.

4. Complete and submit an application for an ODFW Fish Transport permit (form attached).

# OREGON DEPARTMENT OF FISH AND WILDLIFE
## Permit Application and Management Plan for Stocking Triploid Grass Carp

1. Name of Applicant Or Organization: ____________________

   Name of Principal Contact Person (if different than above): ____________________

2. Address: ____________________
   ____________________
   ____________________

3. Day Phone: ____________
   Fax: ____________
   E-mail: ____________

4. Name (if any) of lake or pond to be stocked: ____________________

5. Location of water body: ____________________

   County: ____________ Township: ____________ Range: ____________

   Section: ____________ ¼ Section: ____________

<u>Note</u>: **A photocopy of a county map showing rivers and streams and delineation of the 100 year flood plain at the proposed stocking site <u>MUST</u> be provided with this application.**

6. Size (acres) of lake or pond (1 acre = 208 ft x 208 ft) ___ Max. Depth (ft) ___ **(If the pond or lake is larger than 10 surface acres, a permit to stock grass carp cannot be issued.)**

   Describe how pond acreage was determined (survey, measurements, aerial photo, etc):

   ____________________
   ____________________
   ____________________
   ____________________

7. Origin of triploid grass carp to be stocked:

   Name of company/business: ____________________

   Address: ____________________ Day Phone: ____________
   ____________________ Fax: ____________
   ____________________ E-mail: ____________

8. Description of triploid grass carp to be stocked:

   Number: ________ Size (inches) - minimum: ________ Maximum: ________

   Number to be stocked per acre: ________

   <u>Note</u>: **Documentation from the U.S. Fish and Wildlife Service verifying each fish as triploid must be provided with this application.**

9. What emergency procedures will be followed during events (e.g. floods) to prevent fish from escaping from the site? (Attach additional pages as needed.)

______________________________________________

______________________________________________

______________________________________________

10. How will fish be removed and disposed of at the end of the project? (Attach additional pages as needed.)

______________________________________________

______________________________________________

______________________________________________

11 Is the site to be treated within the 100 year flood plain? Yes ☐ No ☐

12. If you answered "YES" to number 11, what precautionary measures will be taken to prevent grass carp from escaping? (Attach additional pages as needed.)

______________________________________________

______________________________________________

______________________________________________

13. Does this pond, lake or canal have public access? Yes ☐ No ☐

(Answer "NO" for golf course, sewage treatment or fish culture ponds and power or irrigation canals).

14. If you answered "YES" to number 13, how will public access be controlled? (Attach additional pages as needed.)

______________________________________________

______________________________________________

______________________________________________

15. Have all outlets and/or inlets been screened? Yes ☐ No ☐

If you answered "YES", describe the structures: (Attach additional pages as needed.)

______________________________________________

______________________________________________

______________________________________________

If you answered "NO", <u>The Department of Fish and Wildlife will not issue a permit to plant triploid grass carp into waters with unscreened outlets</u>.

# MAP OF LAKE OR POND

Please include distribution of each vegetation type. Irrigation and power canal applicants need only provide estimated acres of each plant type.

Name of Applicant: ______________________________

Name of Lake or Pond: ______________________________

# OREGON DEPARTMENT OF FISH AND WILDLIFE

## FISH REGIONAL / DISTRICT PERSONNEL

* *Assistant District Biologist*
** *STEP Biologist*
*** *Technician or Biologist who assists Fish or Wildlife District or Research*
**** *Fish Habitat Biologist*
***** *Fish Research Biologist*

| Region | Fish District | Region / Dist. | Research or Habitat Biologist | Telephone | Address |
|---|---|---|---|---|---|
| *NW REGION, CLACKAMAS* | Regional Office | Al Smith (Asst. Regional Supervisor) | | (503) 657-2000 | 17330 S.E. Evelyn St., Clackamas 97015 |
| | | *** | Rick Rowland | (503) 657-2000 x23 | 17330 S.E. Evelyn St., Clackamas 97015 |
| | Astoria Field Office | * | Joe Sheahan | (503) 338-0106 | Rt. 1, Box 764, House No. 2, Astoria 97104 |
| | Lower Willamette | Don Bennett | | 657-2000 x 231 | 17330 S.E. Evelyn St., Clackamas 97015 |
| | | * | David Liscia | 657-2000 x 232 | 17331 S.E. Evelyn St., Clackamas 97015 |
| | | ** | Dick Caldwell | 657-2000 x 235 | 17330 S.E. Evelyn St., Clackamas 97015 |
| | | **** | Art Martin | 657-2000 x 250 | 17330 S.E. Evelyn St., Clackamas 97015 |
| | | *** | Craig Foster | 657-2000 x 248 | 17330 S.E. Evelyn St., Clackamas 97015 |
| | | *** | Bill Day | 657-2000 x 234 | 17330 S.E. Evelyn St., Clackamas 97015 |
| | | **** | Jim Grimes | 621-3488 | 18330 NW Sauvie Island Rd., Portland 97231 |
| | Tillamook | Rick Klumph | | (503) 842-2741 | 4909 3rd St., Tillamook 97141 |
| | | * | Keith Braun | (503) 842-2741 | 4909 3rd St., Tillamook 97141 |
| | | ** | John Casteel | (503) 842-2741 | 4909 3rd St., Tillamook 97141 |
| *NW REGION, CORVALLIS* | Regional Office | Dave Anderson (Asst. Regional Supervisor) | | (541) 757-4186 | 7118 NE Vandenberg Ave., Corvallis 97330-9446 |
| | Coastal Salmon - Inventory | ***** | Steve Jacobs | (541) 737-4263 x26 | 28655 Hwy. 34, Corvallis 97333 |
| | | *** | Gary Susac | (541) 737-4263 x24 | 28655 Hwy. 34, Corvallis 97333 |
| | | *** | Julie Firman | (541) 737-4263 x24 | 28655 Hwy. 34, Corvallis 97333 |
| | Mid-Coast | Bob Buckman | | (541) 867-4741 | 2040 SE Marine Science Drive., Newport 97365-5 |
| | | * | George Westfall | (541) 867-4741 | 2040 SE Marine Science Drive., Newport 97365-5 |
| | | * | Kevin Goodson | (541) 867-4741 | 2040 SE Marine Science Drive., Newport 97365-5 |
| | | ** | William (Tony) Stein | (541) 867-4741 | 2040 SE Marine Science Drive., Newport 97365-5 |
| | | *** | Tami Wagner | (541) 867-4741 | 2040 SE Marine Science Drive., Newport 97365-5 |
| | Scale Studies | ***** | Lisa Borgerson | (541) 737-4263 x23 | 28655 Hwy. 34, Corvallis 97333 |
| | Upper Willamette | Jeff Ziller | | (541) 726-3515 | 3150 E. Main St., Springfield 97478 |
| | | * | Mark Wade | (541) 726-3515 | 3150 E. Main St., Springfield 97478 |
| | | ** | Dawn Kori Nearing | (541) 726-3515 | 3150 E. Main St., Springfield 97478 |
| | | *** | Dick Irish | (541) 726-3515 | 3150 E. Main St., Springfield 97478 |
| | Mid-Willamette | Steve Mamoyac | | (541) 757-4186 | 7118 NE Vandenberg Ave., Corvallis 97330-9446 |
| | | ** | Gary Galovich | (541) 757-4186 | 7118 NE Vandenberg Ave., Corvallis 97330-9446 |
| | | *** | Mark Nusom | (541) 757-4186 | 7118 NE Vandenberg Ave., Corvallis 97330-9446 |
| | | * | Wayne Hunt | (503) 378-6925 | 4412 Silverton Rd. NE, Salem 97305-2060 |
| | | *** | Tom Murtagh | (503) 378-6925 | 4412 Silverton Rd. NE, Salem 97305-2060 |
| | Wild Salmonid - Prod. Monitoring | ***** | Mario Solazzi | (541) 737-4263 x24 | 28655 Hwy. 34, Corvallis 97333 |
| | | *** | Steve Johnson | (541) 867-0300 x23 | 2040 SE Marine Science Dr., Newport 97365-529 |
| | | *** | Jeff Rodgers | (541) 737-4263 x23 | 28655 Hwy. 34, Corvallis 97333 |
| | | *** | Tim Dalton | (503) 842-2741 | 4909 3rd St., Tillamook, OR 97141 |
| | | *** | Bruce Miller | (541) 888-5515 | PO Box 5430, Charelston, OR 97420 |
| | Willamette CHS | ***** | Robert Lindsay | (541) 737-4263 x25 | 28655 Hwy. 34, Corvallis 97333 |
| | | *** | Ken Kenaston | (541) 737-4263 x25 | 28655 Hwy. 34, Corvallis 97333 |
| | | *** | Kirk Schroeder | (541) 737-4263 x25 | 28655 Hwy. 34, Corvallis 97333 |
| *SOUTHWEST* | Regional Office | Steve Denney (Asst. Regional Supervisor) | | (541) 440-3353 | 4192 N. Umpqua Hwy., Roseburg 97470 |
| | Coos-Coquille | Paul Reimers | | (541) 888-5515 | P.O. Box 5430, Charleston 97420 |
| | | * | Reese Bender | (541) 888-5515 | P.O. Box 5430, Charleston 97420 |
| | | * | Jim Muck | (541) 888-5515 | P.O. Box 5430, Charleston 97420 |
| | | ** | Tom Rumreich | (541) 888-5515 | P.O. Box 5430, Charleston 97420 |
| | Lower Rogue and South Coast | Russell Stauff | | (541) 247-7605 | P.O. Box 642, Gold Beach 97444 |
| | | * | Todd Confer | (541) 247-7605 | P.O. Box 642, Gold Beach 97444 |
| | | ** | Clayton Barber | (541) 247-7605 | P.O. Box 642, Gold Beach 97444 |
| | Rogue River and Elk Creek Research | ***** | Tom Satterthwaite | (541) 474-3145 | 5375 Monument Dr., Grants Pass 97526; 1600 Elk Creek Rd., Trail 97541 |
| | Umpqua | Dave Loomis | | (541) 440-3353 | 4192 N. Umpqua Hwy., Roseburg 97470 |
| | | ** | Laura Jackson | (541) 440-3353 | 4192 N. Umpqua Hwy., Roseburg 97470 |

**635-056-0075**
**Controlled Fish Species**

(1) Grass carp (*Ctenopharyngodon idella*): Grass carp may be purchased and imported from outside Oregon for release into lakes, ponds, reservoirs or irrigation ditches in Oregon only pursuant to the terms of a permit issued by the department.. Complete permit applications must be submitted to department headquarters (P.O. Box 59, Portland, OR 97207) at least 60 days before proposed stocking.

(a) Decisions concerning the issuance of grass carp permits are governed by the following standards:

(A) stocking will not detrimentally affect any population of a threatened or endangered species;

(B) stocking will occur only in water bodies on private land or on land owned or controlled by irrigation districts or drainage districts;

(C) stocking will occur only in water bodies with fish screens approved by the department. Such screens must have screen openings 1 inch or less for fish 12-19 inches total length and screen openings 2 inches or less for fish over 19 inches total length;

(D) appropriate stocking rate, size and origin of fish;

(E) stocking will be allowed in water bodies within 100 year floodplains (as delineated on county or city land use maps, Federal Emergency Management Agency maps or U.S. Army Corp of Engineers maps) only if the applicant submits, and the department approves, escape precaution measures and includes them in the applicant's management plan. Stocking will never be allowed in water bodies within 100 year floodplains during times of potential flood (as described by the Federal Emergency Management Agency and depicted on federal Flood Insurance Rate Maps);

(F) only sterile triploid grass carp at least 12 inches long may be imported.

(G) All grass carp imported in Oregon must be tagged with a Passive Induced Transponder (PIT) tag of frequency 134.2-kilohertz. Each tag must be programmed with a unique identification number. A list of unique tag numbers must be submitted to the Department prior to release.

(b) Each permit application shall include:

(A) applicant's name, address and daytime telephone number;

(B) description and size of the water body into which release is proposed;

(C) location of the water body, including township, range, section and quarter section, with map including written directions for access;

(D) proposed stocking rate (with explanation of how developed), size and origin (company, business or facility including complete address) of fish;

(E) stocking will not be allowed in lakes, ponds or reservoirs larger than 10 acres;

(F) documentation that the water body is outside the 100 year floodplain, unless the application includes a description of how fish will be removed and held or disposed of no later than 30 days before times of potential flood;

(G) documentation from the U.S. Fish and Wildlife Service that each fish is triploid;

(H) certification (by a pathologist approved by the department) that the fish are free of Asian tapeworms. Health and disease inspections shall be conducted according to OAR 635-007-0555 through 635-007-0585; and

(I) a management plan meeting the requirements contained in section (1)(c) below.

(c) The required management plan shall:

(A) rely on the use of grass carp for the total elimination of vegetation, not simply partial vegetation control;

(B) describe how public access to the water body will be restricted to prevent removal of grass carp (by angling or otherwise) by unauthorized persons. At a minimum, the water body must be posted as closed to angling and other access by the general public;

(C) describe emergency procedures for responding to fish escapes from approved sites;

(D) describe how fish will be removed and disposed of at the end of the proposed project;

(E) if stocking is proposed within a 100 year flood plain, describe how fish will be removed and held or disposed of no later than 30 days before times of potential flood; and

(F) describe in detail all proposed screening structures.

## DIVISION 007
## FISH MANAGEMENT AND HATCHERY OPERATION

### Control of Fish Disease

**Transport of Diseased Fish**

635-007-0555 (1) Live fish suspected by the Department to have a disease infection may not be transported from one watershed to another within this state or exported from this state without the written consent of the Department.

(2) The Department may restrict or prohibit transport of infected fish, or fish which may be infected, to or from certain watersheds or areas within watersheds.

Stat. Auth.: ORS 496.138, 496.146, 506.119 and 506.124
Stats. Implemented:
Hist.: FWC 25-1984, f. 6-21-84, ef. 7-1-84

**Grounds for Revocation of Licenses and Permits**

635-007-0560 Failure to comply with the requirements of OAR 635-007-0550 or 635-007-0555 shall be grounds for the revocation of any Fish Propagation License, Cooperative Salmon Hatchery Agreement, Fish Transport, or STEP Permit.

Stat. Auth.: ORS 496.138 and 506.119
Stats. Implemented: ORS 496.146 and 506.124
Hist.: Adopted 2-21-97, ef. upon filing

**Fish Disease Control Policy**

635-007-0565 It shall be the policy of the Oregon Department of Fish and Wildlife to protect the fish resources of the state by preventing the importation or introduction, to new waters or areas, those fish disease agents known to adversely affect hatchery or natural production of fish.

Stat. Auth.: ORS 496.138, 496.146, 506.119 and 506.124
Stats. Implemented:
Hist.: FWC 5-1984, f. 6-21-84, ef. 7-1-84

**Disease Control**

635-007-0570 Fish diseases shall be classified by category of concern:

(1) Category I. 'Emergency' fish diseases are those for which there is no known treatment and which have never been diagnosed as occurring in Oregon.

(2) Category II. 'Certifiable' diseases are highly contagious, may cause catastrophic losses, do not have a known cure and may or may not have been found in Oregon.

(3) Category III. 'Reportable' diseases are those infections which may be enzootic in populations and/or watersheds but are not necessarily of such concern as to prevent all transfer or release of fish. This category includes drug resistant strains of fish disease agents otherwise falling in Category IV.

(4) Category IV. 'Historical' diseases are related primarily to the area, waters, or facility either here or in another state or country in which fish are raised or those for which an intermediate host is found in other than the fish themselves. This category also includes Category I through III diseases if previously found at a particular facility but which do not now occur at that location. The record of agents in this category seldom prevent transfer or release of fish if the disease agent has not occurred within the past three years of fish rearing, or fish are appropriately treated for disease prior to transfer, or the agent also occurs in the receiving waters.

Stat. Auth.: ORS 496.138, 496.146, 506.119 and 506.124
Stats. Implemented:
Hist.: Adopted 1-15-92, ef. 2-1-92

**Disease Agents by Category**

635-007-0575 Fish diseases identified by category are set out as follows.

(1) Category I, Emergency:
(a) Viral Hemorrhagic Septicemia (VHS);
(b) channel catfish virus (CCV).
(2) Category II, Certifiable:
(a) Viral Hemorrhagic Septicemia (VHS);
(b) *Myxobolus cerebralis;*
(c) channel catfish virus (CCV);
(d) Infectious Hematopoietic Necrosis Virus (IHN);
(e) Infectious Pancreatic Necrosis Virus (IPN).
(3) Category III, Reportable:
(a) Viral Hemorrhagic Septicemia (VHS);
(b) *Myxobolus cerebralis*;
(c) channel catfish virus (CCV);
(d) Infectious Hematopoietic Necrosis Virus (IHN);
(e) Infectious Pancreatic Necrosis Virus (IPN);
(f) Proliferative kidney disease (PKD);
(g) Viral Erythrocytic Necrosis (VEN);
(h) *Yersinia ruckeri*;
(i) *Renibacterium salmoninarum*;
(j) *Aeromonas salmonicida*;
(k) Drug resistant strains of disease agents;
(l) *Ceratomyxa shasta.*
(4) Category IV, Historical:
(a) Viral Hemorrhagic Septicemia (VHS);
(b) *Myxobolus cerebralis*;
(c) channel catfish virus (CCV);
(d) Infectious Hematopoietic Necrosis Virus (IHN);
(e) Infectious Pancreatic Necrosis Virus (IPN);
(f) Proliferative kidney disease (PKD);
(g) Viral Erythrocytic Necrosis (VEN);
(h) *Yersinia ruckeri*;
(i) *Renibacterium salmoninarum*;
(j) *Aeromonas salmonicida*;
(k) Drug resistant strains of disease agents;
(l) *Ceratomyxa shasta*;

transferred to waters of the Columbia River and its tributaries except after acceptable disease examination results and consultation with Department pathologists.

(11) The Department may authorize transfer of salmonids from the Columbia River or its tributaries to an accepted isolation facility for scientific study pursuant to the objectives of projects acceptable to the Department.

Stat. Auth.: ORS 496.138, 496.146, and 506.119
Stats. Implemented: ORS 506.124
Hist.: Adopted 11-25-96, ef. 12-1-96

# ODFW MEMORANDUM

Date: February 9, 1999

To: Bob Hooton

From: Rich Holt

Subject: Fish health requirements for importation of grass carp into Oregon

The following is a list of fish health information and testing requirements requested before grass carp are imported:

1. Provide an up-to-date disease history of the facility of origin and the grass carp stock(s).

2. List of other species of fish currently reared at the facility and disease history for those stocks.

3. Description of water supply for the facility of origin.

4. Certified that they are asian tapeworm-free.

5. Certify that they come from a location that is free of zebra mussels.

6. If a recent fish health examination has not been conducted, we may request a fish health examination for bacteria, parasites and viruses be conducted on the stock to be imported. This exam may be sufficient to allow import from this location for one year, unless a change in status such as appearance of a new pathogen at the facility occurs during that year. The fish health inspector conducting the examination must be acceptable to ODFW.

The fish health information should be provided to:

Rich Holt, Senior Fish Pathologist, Dept. of Microbiology, 220 Nash Hall,
Oregon State University, Corvallis, Oregon 97331-3804
Tel. (541) 737-1863
Fax (541) 737-0496
e-mail holtr@ucs.orst.edu

c. Stickell, Daily, Amandi, Kaufman, Banner, Groberg, Kreps, Engelking

WYOMING

WYOMING GAME AND FISH DEPARTMENT

FISH DIVISION

ADMINISTRATIVE REPORT

TITLE: Using Grass Carp for Control of Nuisance Plants in Wyoming Lakes, Ponds, and Reservoirs

AUTHOR: Donald F. Pedlar

PROJECT: HE 7093-07-9002

DATE: July 1994

Grass carp (Ctenopharyngodon idella), first introduced to the USA in 1963, are useful in the control of aquatic weeds in lakes and ponds. An aquatic weed is any nuisance plant that is not perceived useful to man.

Grass carp (Figure 1) are long lived (10 or more years), tolerate cold water, cannot reproduce in lakes or ponds, prefer to feed on aquatic plants, and they can eat large quantities of vegetation. Like Rollaids[tm] and stomach acid, grass carp consume many times their weight in aquatic weeds.

The Wyoming Game and Fish Department (WGFD) requires that only sterile (genetically triploid) grass carp be used in Wyoming. A WGFD permit is required before grass carp can be purchased and planted in Wyoming. Please contact your local fisheries biologist (listed on page 8) for more information about grass carp and permits required to plant them.

## Controlling Aquatic Weeds with Grass Carp

If your lake or pond contains sport fish, its a good idea to maintain some aquatic plants. About 10-25% of the bottom should have plants in sparse to moderate densities. It is best to have very little or no emergent vegetation. Some plants are beneficial because sport fish hide and feed there. Grass carp can be used to help keep aquatic plant life at the desired level.

## Stocking Grass Carp

After permits are in hand, you need to figure how many grass carp to plant. Stocking rates (fish per surface acre) should be set to achieve 10-25% distribution of vegetation, four years after planting. Stocking too few grass carp won't give the desired result. Stocking too many may completely eliminate plants. Be careful, especially if you have a fish pond. If you are stocking a pond on a golf course or housing development, nearly complete removal of vegetation may be desirable.

EXAMPLE LAKE

# GRASCARP Stocking Model Worksheet

## I. STOCKING INDEX VALUES

Use attribute #1 and #2 VALUES (DTU and VEGETATION) to determine the STOCKING INDEX VALUE from the following table.

DTU VALUE from page 3 , MLO

VEGETATION VALUE from page 4 MHI

DAILY TEMPERATURE UNIT (DTU) VALUE

| VEGETATION VALUE | LOW | MLO | MED | MHI | HI |
|---|---|---|---|---|---|
| LOW | MLO | LOW | LOW | LOW | LOW |
| MLO | MED | MLO | MLO | LOW | LOW |
| MHI | HI | MED | MED | MLO | MLO |
| HI | HI | HI | HI | MED | MOD |

STOCKING INDEX VALUES and Descriptions:

LOW = low stocking density

MLO = moderate-low stocking density

MED = moderate stocking density

HI = high stocking density

Record the STOCKING INDEX VALUE (LOW, MLO, MED, or HI) here

## II. FEEDING BEHAVIOR INDEX

Use attribute #3 and #4 VALUES (PREFERENCE and DISTURBANCE) to determine the FEEDING BEHAVIOR INDEX VALUE from the following table.

PREFERENCE VALUE from page 5 ____

DISTURBANCE VALUE from page 6 ____

PREFERENCE VALUE

| DISTURBANCE VALUE | LOW | MED | HIGH |
|---|---|---|---|
| LOW | MED | MED | HI |
| MED | LOW | LOW | HI |
| HI | LOW | LOW | MED |

FEEDING BEHAVIOR INDEX VALUES and Descriptions:

LOW = low aquatic vegetation consumption activity

MED = medium aquatic vegetation consumption activity

HI = high aquatic vegetation consumption activity

Record the FEEDING BEHAVIOR INDEX VALUE (LOW, MED, or HI) here

## III. Non-adjusted STOCKING RATES

Use the STOCKING INDEX and FEEDING BEHAVIOR INDEX VALUES to determine the non-adjusted STOCKING RATES from the following table. The non-adjusted STOCKING RATES are presented as ranges representing numbers of grass carp to stock per lake surface acre.

STOCKING INDEX VALUE: MOD

FEEDING BEHAVIOR INDEX VALUE: HI

STOCKING INDEX VALUE

| FEEDING BEHAVIOR INDEX VALUE | LOW | MLO | MED | HI |
|---|---|---|---|---|
| LOW | 10-14 | 20-24 | 32-36 | 44-4 |
| MED | 9-13 | 18-22 | 29-31 | 40-4 |
| HI | 8-12 | 16-20 | 26-30 | 36-4 |

Record the non-adjusted STOCKING RATE from above here: 26-30

STOCKING RANGE ADJUSTMENT from page 7: use the LOW rate from the STOCKING RATE range above

26 Adjusted STOCKING RATE (no. per acre) A

FISH SIZE MODIFYING VALUE from page 8 1.0 B ——— B

GENETIC MODIFYING VALUE from page 8 1.1 C ——— C

Now, multiply values A, B, and C together, and enter result here: 29 This is your final STOCKING RATE (number of grass carp to stock per acre)

Multiply this final STOCKING RATE by the lake or pond surface acreage to determine the total number of grass carp to stock.

29 final STOCKING RATE x 14 SURFACE ACRES = 406 NUMBER OF GRASS CARP TO STOCK IN LAKE (A POND)

6. In water storage, decorative, or fish hatchery ponds stocked at high rates, the rapid consumption of a lot of vegetation and subsequent release of wastes may result in plankton blooms and poor water clarity in the first year or two after planting grass carp.

7. Where high and low preference plant species occur in the same lake, grass carp may cause spread of low preference plants as the preferred species decreases. Alternate (chemical or mechanical) means of plant reduction may be necessary to control the less desirable plants.

8. Please contact your local WGFD FISHERIES BIOLOGIST for assistance and further information about control of aquatic plants.

Regional Fisheries Supervisor
P. O. Box 67
Jackson, WY 83001
1-800-423-4113

Regional Fisheries Supervisor
2820 State HWY 120
Cody, WY 82414
1-800-654-1178

Regional Fisheries Supervisor
P. O. Box 850
Pinedale, WY 82941
1-307-367-4353

Regional Fisheries Supervisor
528 South Adams
Laramie, WY 82070
1-800-843-2352

Regional Fisheries Supervisor
260 Buena Vista
Lander, WY 82520
1-800-654-7862

Regional Fisheries Supervisor
P. O. Box 6249
Sheridan, WY 82801
1-800-331-9834

Regional Fisheries Supervisor
351 Astle Avenue
Green River, WY 82935
1-800-843-8096

Regional Fisheries Supervisor
3030 Energy Lane, Suite 100
Casper, WY 82604
1-800-233-8544

These guidelines are based on a report by E. D. Swanson and E. P. Bergersen (1986), GRASCARP: A crass carp stocking model for Colorado Lakes and ponds, Colorado Cooperative Fish and Wildlife Research Unit, Colorado State University, Fort Collins, CO 80523

| | Target Level Vegetation Distribution | Years | STOCKING RANGE ADJUSTMENT |
|---|---|---|---|
| LAKE MANAGEMENT OBJECTIVE | | | |
| Trout | | | |
| 1. Put-grow-and-take | 20-25% | 3-4 | LOW |
| 2. Trout and Wildlife | 20-25% | 3-4 | LOW |
| 3. Put and Take | 15-20% | 3-4 | MEDIAN |
| 4. Multiple use, fishing, boating, swimming, water supply. | 10-15% | 3-4 | HIGH |
| Pike, walleye, smallmouth bass | | | |
| 1. Sport fish only | 20-25% | 3-4 | LOW |
| 2. Multiple use | 15-20% | 3-4 | MEDIAN |
| Largemouth bass, bluegill, crappie, catfish | | | |
| 1. Sport fish only | 20-25% | 3-4 | LOW |
| 2. Multiple use | 15-20% | 3-4 | MEDIAN |
| Water storage and distribution, decorative, aesthetics, real estate value. | | | |
| 1. | 0-10% | 2 | HIGH +10 more/acre |
| 2. | 0-10% | 1 | HIGH +25 more/acre |
| Fish hatchery ponds | 0% | 1 | HIGH +45 more/acre |

Put on the worksheet (Page 9), the STOCKING RANGE ADJUSTMENT that applies to your LAKE MANAGEMENT OBJECTIVE.

ADDITIONAL MODIFYING FACTORS. Number of grass carp to stock also depends on the size stocked and whether the fish can reproduce. Because only sterile grass carp are allowed in Wyoming, the value is 1.1; record it on the Page 9 worksheet.

**STEP 6. SIZE OF GRASS CARP WHEN STOCKED.** The number of grass carp needed for desired control of aquatic plants varies with size of fish stocked. Generally, more smaller fish are needed to control the same amount of plants as fewer larger fish.

## VEGETATIVE VALUE

Determine the VEGETATIVE VALUE by finding the DENSITY VALUE and the DISTRIBUTION VALUE in the following table, then on worksheet (Page 9). From the table, a LOW DISTRIBUTION VALUE and a HI DENSITY VALUE give a MLO VEGETATION VALUE.

| | | DENSITY VALUE | | | |
|---|---|---|---|---|---|
| | | LOW | MED | HI | |
| DISTRIBUTION VALUE | LOW | LOW | LOW | MLO | VEGETATION VALUE |
| | MED | LOW | MLO | MHI | |
| | HI | LOW | MHI | HI | |

**STEP 3. Determine Grass Carp Feeding Preferences for Aquatic Plants**

Determine only one FEEDING PREFERENCE VALUE for the lake. Base this on which single plant is most abundant or causes the most problems when the plant is most numerous. If you don't know the plant species, record MOD on the worksheet (Page 9).

| FEEDING PREFERENCE VALUE | Common Name |
|---|---|
| LOW | Filamentous algae |
| | Northern water milfoil |
| | Curly-leaf pondweed |
| | Buttercup |
| | Yellow pond-lily |
| | Smartweed |
| | White-stemmed pondweed |
| | Bladderwort |
| MODERATE | Narrow-leaved pondweeds |
| | Sago pondweed |
| | Spikerush |
| | Clasping-leaf pondweed |
| | Widgeon grass |
| | Horned pondweed |
| HIGH | Canadian waterweed or elodea |
| | Coontail |
| | Muskgrass or chara |
| | Duckweed |
| | Stonewort or nitella |
| | Berchtold's pondweed |

COLORADO

ATTACHMENT D

## POLICY CONCERNING THE USE OF GRASS CARP IN THE COLORADO RIVER BASIN

The grass carp (Ctenopharyngodon idella), also called white Amur, is a large Asian cyprinid that is endemic to eastern Asia from the Amur River basin to the West River. This species was imported into the United States in 1963 for testing as a biological control of aquatic vegetation. Since then, it has been introduced throughout much of the United States as a result of widely scattered research projects, stockings to solve aquatic weed problems, interstate importation from private hatcheries, and dispersal from stocking sites. By 1972, this species has been introduced into 40 of the 50 states.

The ability of this herbivorous fish to consume large quantities of aquatic plants is well documented. However, this attribute of vegetation control could also be a liability. In special circumstances, this species could prey upon and compete with exotic and native species for food and living space. In addition, under special circumstances, undigested plant material released in feces may cause water quality changes and subsequent increases in noxious phytoplankton blooms.

In recognition of the potential utility of grass carp to control nuisance aquatic vegetation, researchers have endeavored to resolve or reduce the undesirable qualities of the species by reducing its reproductive potential. Initially, efforts were directed at producing monosex (all female) grass carp in commercial quantities. However, these females remain fertile and capable of reproduction. In fact, an imbalance tilted toward females only enhances reproductive capability if males are introduced (inadvertently or purposely).

More recently, research efforts have focused on producing commercial quantities of triploid grass carp that are sterile. Triploidy in grass carp can be induced by a variety of methods, including heat shock, treatment of eggs with cytochalsin, and hybridization between female grass carp and the male bighead carp (Hypophthalmichthys nobilis). The effects of most other methods of imposing sterility (e.g., radiation or chemosterilants) are normally temporary. A rapid, economical, and reliable means of verifying triploidy is provided by use of the Coulter Counter. The results of this method compare favorably with those from electrophoresis and kariotyping. It is suggested that the U.S. Fish and Wildlife Service maintain the lead role in inspecting triploidy in commercially produced grass carp.

The importation and use of grass carp in the Colorado River basin is controlled by the respective basin states. The following criteria governing the use of the species in the basin were developed to: (1) provide a safe biological control program for the reduction of excessive aquatic vegetation in select lakes; and (2) control the use and distribution of grass carp with specific constraints relative to source, number, size, use, purpose, distribution, and protection of other aquatic resources. These conditions were developed after an extensive review of literature concerning grass carp.

Conditions for the Use of Grass Carp in the Colorado River Basin

A. Only certified triploid grass carp (100%) should be authorized for importation and stocking into waters of the Colorado River basin to prevent the spread and naturalization of the species there. Triploidy of individual grass carp must be verified utilizing the Coulter Counter. A notarized certificate of triploidy must accompany each shipment. Fertile (diploid) grass carp will not be authorized for importation, stocking, or possession in the basin under any circumstances.

B. Importation and stocking of triploid grass carp into Colorado River basin waters is allowed by permit only. The permitting process will be administered by the respective basin states. Applicant should be required to monitor triploid grass carp populations as required by respective basin states.

C. Triploid grass carp should be authorized for stocking in the Colorado River basin only in waters where escape of the species from that habitat is unlikely.

D. Triploid grass carp should be approved for stocking only in waters where aquatic weeds interfere with recreational, domestic, municipal, agricultural, or industrial use of water, or where aquatic weeds impair the quality of water.

E. Suggested stocking rates for triploid grass carp (at least eight inches total length) are as follows:

| PERCENT PLANT COVER | CONTROL DESIRED | NUMBER STOCKED PER SURFACE ACRE |
|---|---|---|
| 10-20 | Control not recommended | Stocking not Recommended |
| 20-40 | Minimum | 5 |
| | Maximum | 10 |
| 40-60 | Minimum | 10 |
| | Maximum | 15 |
| Over 60 | Minimum | 15 |
| | Maximum | 30 |

Triploid grass carp should not be stocked into waters more frequently than once every three years unless it can be demonstrated that a stock was decimated.

F. Triploid grass carp should not be approved for stocking in the Colorado River basin where endangered species of fish, mollusks, crustaceans or birds occur.

ATTACHMENT E

STATE OF COLORADO
WILDLIFE COMMISSION

POLICY NO. D-7

November 18, 1988

SUBJECT: GRASS CARP/GRASS CARP HYBRIDS

The Commission recognizes that the use of grass carp or grass carp hybrids as a biological tool for aquatic weed control has some benefit to the citizens of Colorado. There is an increasing public demand for the use of this fish to control aquatic weeds in situations where chemical or mechanical control is not possible. It is, therefore, the intent of the Commission to allow the use of grass carp or grass carp hybrids as a method for aquatic weed control within the following guidelines:

1. Possession, importation or use of grass carp or grass carp hybrids in standing waters east of the Continental Divide, except the San Luis Valley is permitted as long as imported fish meet all criteria for disease and import certification.

2. Possession, importation or use of certified triploid grass carp hybrids only in standing waters west of the Continental Divide and in the San Luis Valley may be authorized in writing by the Division of Wildlife in accordance with the "Policy concernig the use of grass carp" as approved by the Colorado River Wildlife Council.

3. No person may ship or transport into the state any grass carp or grass carp hybrids unless they comply with Division regulations on the Importation of Live Fish and Viable Fish Eggs. (Reference: Regulations Chapter General Provisions, Article VII, VIII and IX; #007, #008, #009, pages 10-16).

   In addition, any triploid grass carp hybrids must be certified as to their triploidy at their point of origin. A notarized certificate of triploidy must accompany each shipment.

4. Persons may apply in writing to the Division for a grass carp hybrid use permit. Each use permit application needs to be accompanied by a description of the body of water to be stocked; a site location map; and the source of grass carp hybrids.

# GENERAL IMPORTATION PERMIT

1. Any individual or vendor desiring to import any grass carp, triploid grass carp or any other warm water fish must first obtain an "Importation License" (Application Form Attached).

2. All requirements pertaining to transportation, importation, and release as described in Colorado Division of Wildlife Regulations, General Provisions Chapter, Articles VI, VII and VIII must be adhered to.

STATE OF COLORADO
*DEPARTMENT OF NATURAL RESOURCES*
DIVISION OF WILDLIFE
**AQUATIC ANIMAL HEALTH LABORATORY**
P.O. Box 128
Brush, Colorado 80723-0128
(970) 842-2819

**DATE:** May 5, 2000

**TO:** Linda Chittum, Dave Schnoor, Jim McKissick, Rick Swanson and Jeff Lee

**FROM:** Peter Walker

**SUBJECT:** New parasite alert

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At a fish health symposium in Baltimore in the fall of 1998 I became aware of a new and, at that time, unidentified trematode parasite that was causing grave concern in T&E fish recovery programs in Texas (Mitchell et al 1998b). Through recent information passed on to me by Chuck Loeffler and a phone conversation today with USDA Parasitologist Drew Mitchell in Stuttgart, Arkansas, I have learned many more details.

The parasite is called *Centrocestus formosanus*. It is a digenetic trematode with a typical life cycle involving three hosts. The cercaria parasitizes a snail. The metacercaria ("grub") parasitizes a fish. The adult trematode ("fluke") inhabits the throat of a fish-eating bird.

The parasite is native to India. It was first reported in the United States in tropical fish farms in Florida in the early 1980s. In 1990 it was reported as established at the San Antonio Zoo.

At first the yellow-crowned night-heron was accused of being the principal bird host and a major vector. Now it appears that virtually any bird that eats an infected fish may serve as the final host. These include all of the herons and other fish-eating birds and even grackles.

However, if only bird vectorship was necessary to spread this organism, we would be seeing it in Colorado already. The biological key to its spread is the first intermediate host – the snail. *C. formosanus* apparently is very host specific during this phase of its life cycle. The only known snail species to be parasitized by this organism is the red-rim melania (*Melanoides tuberculatus*), another introduction from Asia. Before the exotic parasite could establish, the snail had to be introduced first. Red-rim melania were first reported in North America in Mexico. Establishment in the United States first occurred in Florida and at the San Antonio Zoo in the early 1960s if not before. Red-rim melania have since been reported in Arizona, Louisiana and Oregon.

The reason for all the concern is the pathology that this parasite is capable of producing in an extremely broad range of native U.S. fishes. Drew Mitchell says *that C. formosanus* "makes the newly reported catfish trematode [*Bolbophorus confusus* Pasnik 1999)] look like minor stuff." According to Mitchell, the metacercariae encyst in the cartilage of the gill arches. This triggers up to 12 concentric layers of cartilage proliferation with proliferation of epithelium surrounding this lesion. There is tremendous damage to adjacent gill tissues with groups of filaments becoming nonfunctional and either displaced or lost. Parasitism by this worm is frequently lethal and even acutely so under the right circumstances. At the Baltimore symposium Mitchell anecdotally reported observing 100% mortalities overnight in small numbers of channel catfish fingerlings (*Ictaluras punctatus*) experimentally exposed to several infective units of *C. formosanus* per fish.

Very little fish host specificity has been observed. In the Comal River in Texas, 12 of 17 fish species were determined to be susceptible. Of those found negative, the sample size was not large enough to be conclusive in 4 species. Only the sailfin molly (*Poecilia lattipinna*) shows apparent resistance to infection. Among the species vulnerable to the parasite in that Texas drainage is the endangered fountain darter (*Etheostoma fonticola*) (Mitchell et al 1998b). Recovery biologists are understandably very concerned about the appearance of this parasite. Among the other species that displayed cysts of the new parasite in Texas was the orangespotted sunfish (*Lepomis humilis*), a native species under scrutiny in eastern Colorado. Mitchell et al (1998a) reports observation of the grub and its associated pathology in four commercially important species including hybrid striped bass (*Morone chrysops* X *M. saxatilis*), golden shiner (*Notemigonus chrysoleucas*), fathead minnow (*Pimephales promelas*) and channel catfish. In our telephone conversation, Drew Mitchell reported that goldfish, common carp and tilapia are also vulnerable to infection.

Since birds undoubtedly spread the parasite far and wide, the real danger is the introduction of the snail. The red-rim melania has a long, pointed, spiral shell which, when held point-down, has the opening on the left. According to Mitchell, it is easily confused with the quilted melania (*Tarebia granifera*), a closely related and apparently widespread snail from the same family (Thiaridae). A third species, the fawn melania (*M. turriculus*), is listed as resident in North America by Turgeon et al (1988). Mitchell told me that a fellow employee of the Stuttgart station found *M. melanoides* for sale in two Little Rock pet stores.

It is hoped, but by no means a certainty, that this snail will be limited to southern latitudes by temperature restriction. Nevertheless, geothermal and industrially heated waters could certainly be colonized in many northern states even if this snail does turn out to be temperature sensitive.

Literature cited:

Mitchell, A.J., A.E. Goodwin, M.J. Salmon and T.M. Brandt. 1998a. The potential for an exotic heterophyid trematode to invade and cause disease in four major aquatic

species. Abstract only. Proceedings of the Third International Symposium on Aquatic Animal
Health. Baltimore, MD.

Mitchell, A.J., A.E. Goodwin, M.J. Salmon, T.M. Brandt and D.G. Huffman. 1998 b. Pathogenicity of an exotic heterophyid trematode infecting the gills of the endangered species *Etheostoma fonticola* (Fountain Darter). Abstract only. Proceedings of the Third International Symposium on Aquatic Animal Health. Baltimore, MD.

Pasnik, David . 1999. Research of new trematode in channel catfish. Fish Farming News. Nov/Dec 1999.

Turgeon, D.D., A.E. Bogan, E.V. Coan, W.K. Emerson, W.G. Lyons, W.L. Pratt, C.F.E. Roper, A. Scheltema, F.G. Thompson and J.D. Williams. 1988. Common and scientific names of aquatic invertebrates from the United States and Canada: mollusks. American Fisheries Society Special Publication 16.

cc: Staff – Aquatics
Staff – Hatcheries
Todd Malmsbury, Public Information

NORTH DAKOTA

"VARIETY IN HUNTING AND FISHING"

NORTH DAKOTA GAME AND FISH DEPARTMENT

100 NORTH BISMARCK EXPRESSWAY BISMARCK, NORTH DAKOTA 58501-5095 PHONE 701-328-6300 FAX 701-328-6352

May 4, 2000

Dr. Dennis Scarnecchia
College of Forest, Wildlife & Range Science
University of Idaho
Moscow, ID 83843

Dear Dennis:

Sorry it took so long to respond to your request. It's that time of year and everybody is out of the office so the phone rings incessantly and reaction is the 'main course'. No excuse though. I've had it on my list of things to do for a couple weeks and should have gotten to it.

In any event, you wanted information on laws, regulations, policies, etc. regarding grass carp in North Dakota. Up until the last 10 years we really didn't do much with this or any other exotic other than react to situations or, in some cases, do it ourselves. We have a regulation that states "it shall be illegal to take, possess or transport any grass carp in North Dakota". This is part of our fishing proclamation, which I've enclosed with the appropriate portion flagged and highlighted. Even though we prohibit possession of grass carp we still have the authority to allow stocking with the appropriate permits.

As you know, the ND Game and Fish stocked grass carp into Spiritwood Lake in 1972. I believe the stock originated from Arkansas, which were obtained as fry and grown out in a rearing pond by Spiritwood Lake. Three hundred were released in an effort to control aquatic vegetation. To my knowledge, however, the effectiveness was never evaluated (other than a one year 'exclosure' experiment that was never reported)..

Dennis: 10,400 reared fish grown out to 300 no figures here TRS

The first grass carp were 'sampled' in the mid-1970's using a .357 Magnum (just happened to be there at the time) by the managing biologist. I don't remember the exact length and weight data but it was approximately 30 inches long and I'm guessing 8 pounds. They were never sampled with traditional sampling gear. The only sightings have been through periodic partial kills in back bays of the lake. They haven't been observed in approximately 4 years and given the few that were stocked it is doubtful that many, if any, remain in the lake. As you might guess, there are no present or future plans to re-introduce grass carp into North Dakota.

In the early 1990's we received some information that home owners surrounding a private lake in the eastern part of the state had purchased and stocked grass carp without our knowledge or permission. Upon investigation they admitted to doing so. We informed them of our concerns, the illegality of such actions, and potential international ramifications (it was very close to the Red River, which flows into Canada) and mandated that they eradicate the lake. We provided technical advice, they purchased rotenone and the lake was ultimately eradicated.

In late 1995 we received a request from the Garrison Diversion Conservancy District (GDCD) to stock grass carp into the Oakes Canal, a supply canal for irrigation waters in southeast North Dakota. The water originates from the James River and terminates in a blind ditch without direct flow connection back to the river. The purpose of the request for introduction was to find a cheaper solution for controlling vegetation in the canal. They had been using some pretty nasty aquatic herbicide (acrolein), which was becoming quite expensive for them and is very toxic to aquatic life as well as hazardous to humans.

Upon receipt of the request I immediately had concerns knowing some of the challenges with grass carp and other exotics across the country. Prior to serious consideration for allowing the introduction I contacted surrounding jurisdictions asking for their comments and concerns since any escapement had the potential to affect them. All expressed some level of concern to varying degrees. As a result of this coordination and some questions I had there were criteria to be met before I would issue any such permit. They were 1.) a certified guarantee that all stock would be triploid. This would entail the testing of individual fish brought into the state for triploidy; 2.) they had to develop a plan to prevent escapement into surrounding waters. This plan had to be reviewed and accepted by Game and Fish prior to issuance of any permit; 3.) disease free certification; and 4.) restrict the origin of the proposed stock. There was concern over the water supply in area of origin and in which they would undoubtedly be hauled. Knowing the majority of grass carp are propagated in areas with high potential for zebra mussel infestation (southeastern US) I restricted the origin to areas west of a vertical line running through Alexandria, MN.

The GDCD attempted to meet these requirement but ultimately decided to no longer pursue this proposal. I don't know if they felt the expense related to my restrictions wasn't worth it or simply the 'hassle'.

As a result of the experience with the GDCD I decided to develop a policy that addressed all fish introductions in North Dakota. As you read through the enclosed document on 'protocol for fish introductions' you will notice one of the 'guiding principles' is to prevent the introduction of undesirable aquatic species. It's certainly not perfect and we haven't had to use it to any large degree but I believe it is performing as intended.

I've tried to give you a thumbnail sketch on the history of grass carp in North Dakota and the minor experiences we've had. We've become quite careful in dealing with exotics and plan to do so in the future. I hope I've given you the information you requested. If not, or if you need more, please let me know and I'll get it to you (hopefully in quicker fashion than this response).

Hope to be in the Williston area sometime this paddlefish snagging season. With low flows and all it's shaping up to be a high harvest season. A little worrisome at this time.

Take care.

Sincerely,

Terry

Terry Steinwand, Chief
Fisheries Division

# PROTOCOL FOR
# FISH INTRODUCTIONS IN NORTH DAKOTA

POLICY, PRINCIPLES AND DECISION MAKING PROCESS

First Draft--June, 1996
Final Revision---January, 1997

## Introduction

North Dakota has, in it's fishery management program, used non-native introductions in concert with native species to enhance the recreational sport fishery of the state. These introductions have originated from within the state, other states, and other countries. However, some introductions were carried out well before the North Dakota Game and Fish Department decided to do so or in at least one instance prior to North Dakota becoming a state. Some of these introductions failed while others have resulted in the development of self-sustaining fish populations. Others have become popular and, although not self-sustaining, require annual stocking to provide a recreational fishery (e.g., trout and salmon).

The terms "exotic" and "non-native" have been used extensively yet sometimes erroneously. For the purpose of this protocol/policy the terms "exotic" and "non-native" will be consolidated into "introduced". The definition will follow that as described in **FISHERIES** (Vol. 11, No. 2, 1986). **INTRODUCED** is defined as the intentional (or accidental) transportation and release of the fish (or other aquatic organism) into an environment outside of its native range or where it had not been previously introduced.

In the past decade, increased attention has been given to the practice and impact of stocking introduced fish. North Dakota has utilized introductions since 1897 when lake trout were stocked at Oakes but stocking and introducing fish in North Dakota likely began before that time.

Stocking introduced species has become a common practice across the nation and North Dakota is no exception. The majority of sport fisheries in the state are a result of impoundments, a perturbation of the natural river systems in the state. The few remaining natural lakes managed for fisheries are also impacted by human activity. The result is a change in habitat that generally does not support angler desirable species at a level acceptable to anglers. As a result, species were introduced that would fulfill angler expectations, yet be able to sustain a population or were relatively cost effective to produce and stock.

Fish introductions have the capability of negatively impacting aquatic systems, regardless of political boundaries. This can occur by predation, competition for food and space, reduction in habitat through actions of the introduced species, introduction of diseases or parasites, or alteration of the genetic composition of natural fish populations.

Management and control of fish populations in North Dakota, native or introduced, are the responsibility of the North Dakota Game and Fish Department. Unless specifically authorized by permit, fish cannot be introduced into any water of the state. The purpose for this is to ensure that private, state, or federal introductions or fish stocking will not negatively impact existing fish populations in North Dakota or other potential jurisdictions.

**Justification/Need**

Fish stocking is a necessary management tool in North Dakota since natural reproduction of major game species is severely limited in most waters. As mentioned, historical fish introductions (as defined) have been an integral part of fish management in the state. Salmonid species, e.g., rainbow trout and chinook salmon are extremely valuable because of the ability to hatchery raise to a larger size and therefore more readily available and acceptable to the angling public. Over the past decade concerns have become increasingly apparent regarding the impact of introduced species on the well being of native species. This is a sometimes subjective opinion of the impact since most waters in the state have been impacted by humans and the resulting habitat has been drastically changed.

North Dakota contains two major drainage basins, the Missouri River and Hudson Bay, both of which travel through other jurisdictions that may be impacted by introduced species. Responsible fishery management mandates that a review of introduced species or previously unknown species in that particular watershed be carefully reviewed prior to actual stocking of the fish.

A protocol/policy for future introductions of fish in North Dakota is needed to assist in the decision making process. The process must be based on biological rationale to support the introduction and a risk analysis to determine and prevent any negative impacts from the introduction. The following narrative describes guiding principles for future fish introductions, provides a policy and basic outline for development and evaluation of fish introduction proposals, and establishes a risk assessment.

**Guiding Principles**

*1. Prevent the introduction of undesirable aquatic species.*

Undesirable aquatic species have the ability to disturb ecosystems, are ineffective in meeting fish management objectives or negatively impact sport fishing opportunities in the receiving waters. In most cases, undesirable aquatic species cannot be effectively removed once introduced. Species considered desirable in one body of water my be undesirable in another. The following commitments must be made in support of this principle:

a. the water body where the introduction is being considered and its surrounding watershed must be considered together to assess the risks of potential impacts to existing fish populations.

b. incidental introduction of undesirable species should be prevented during the stocking or transfer of an intended species. Fish should be sorted, when practical, to prevent transferring unwanted species.

c. accidental introductions resulting from aquaculture facilities must be prevented through adequate safeguards, e.g., review of species for aquaculture, zero discharge to public waters, disinfection of effluent water leaving an aquaculture facility, timing of discharges.

d. fish introductions must be supported with valid rationale and adequate information independent of public pressure.

*2. Prevent the spread of fish diseases and fish parasites.*

Fish diseases and parasites have the ability to negatively impact fish populations through mortality or reduced production. This can result in the reduction of recreational use and subsequently economic losses. To support this principle the following are recommended:

a. routine disease health inspections for salmonids must be conducted on fish culture operations within the state and imported salmonids must have disease free certificates prior to importation.

b. when non-salmonid species are imported or transferred within the state, care must be taken to insure that non-indigenous diseases are not imported or transferred with the intended species.

c. adequate care should be used with equipment used to transport fish to ensure that the water or equipment does not also unintentionally transfer disease organisms.

d. the following pathogens/parasites will cause rejection for importation, if present:
Ceratomyxosis of salmonids Ceratomyxa shasta
Infectious Hematopoetic Necrosis - IHN virus
Infectious Pancreatic Necrosis of Salmonids - IPN virus
Bacterial Kidney Diseases Renibacterium salmoninarum
Rhabdovirus disease of northern pike fry - RBD virus
Spring viremia of carp Rhabdovirus carpio
OMV of salmonids Oncorhynchus masou
Whirling disease of salmonids Myxobolus cerebralis
Enteric redmouth of salmonids Yersinia ruckeri
Asian tape worm
Channel catfish virus - CCV

*3. Prevent the depletion or extirpation of any fish species.*

Much emphasis has been placed on introductions as a primary cause of threatened, endangered or extinct species. Although information supporting such concerns are lacking, it is irresponsible to knowingly introduce a species that would cause the depletion or extirpation of a fish species in North Dakota.

a. fish introductions must not occur where they will cause a native species to become rare or endangered as determined by an Environmental Assessment.

*4. The proposed introduced fish species must be consistent with habitat and biological needs in the water body and to the general well being of the resident fish community.*

a. species having wide distribution ranges such as walleye, northern pike, and yellow perch are suitable for introduction statewide when they do not interfere with another fishery in the watershed or impact a species of concern.

b. species that are not widely distributed such as white bass, rainbow smelt, and other non-native species are only suitable for stocking into specific habitats/lakes.

c. disease free certified rainbow trout can be used extensively in put and grow and put and take fisheries.

d. species from outside of North Dakota that are not considered to pose a threat to North Dakota's fishery can be considered for importation only after risk assessment is completed.

e. species from outside of North Dakota that are considered to pose a high risk to resident fish populations or habitats will not be permitted.

f. any fish species identified as being non-native but previously introduced to the state can be introduced in to another water body not previously stocked with that species only with approval under this protocol and policy.

*5. Support the demand and need for the fish introduction.*

The need to fill angler demand or enhance an existing fishery through forage enhancement provide the impetus and justification for an introduction and should provide the basis for determining whether or not an introduction should be considered. Fisheries management must be based on sound biological and ecological knowledge. To meet this principle the following are recommended:

a. there should be sufficient need based on a vacant niche and/or relatively scarce fish resource in the water body to warrant consideration of a fish introduction.

*6. Consultation: Resolve potential problems concerning environmental impacts and adjoining jurisdictional issues through management planning prior to approving a fish introduction.*

Management decisions to introduce fish should not result in conflict concerning the resource or the resource of other water bodies. Support of the public and potentially affected interests is needed before the introduction occurs. Various segments of the public often have different values and opinions concerning what fishery is appropriate and what fish species should be used. Potentially affected interests are those jurisdictions that may feel their aquatic resources may be harmed by the introduction. Following are considerations to address this principle:

a. potential conflicts concerning the introduction should be addressed and review is required prior to approval of introduction or collection of fish for transfer.

## POLICY ON FISH INTRODUCTIONS

Introduction of fish species have come under increased scrutiny in recent years and justifiably so in some instances. Although habitat is undoubtedly the major reason for the decline of most fish species, introductions have the potential to incur negative impacts, e.g., sea lamprey into the Great Lakes. This policy is in effect for all aquatic introductions into North Dakota waters with the exception of:

1. Species native to North Dakota.
2. Species previously introduced and self sustaining without negative impacts.
   a. largemouth bass, smallmouth bass
3. Species previously introduced, not self sustaining and without negative impacts.
   a. rainbow trout, chinook salmon, brown trout, muskellunge, tiger muskie, and possibly lake trout.

All other proposed introductions must meet the following requirements, complete the risk assessment worksheet and be approved by the committee in the **Decision Making Process**.

### Introduction Proposal

Proposals for fish introductions into state waters must contain succinct, yet sufficient, information to assist the decision-making process and allow managers to determine which introductions should proceed. The proposal should not exceed two pages. A **Fisheries Management Plan** for the water body must describe how the introduction will safely meet the objectives. Clearly stated rationale must be included that supports the introduction.

Positive impacts, as well as possible negative impacts, should be provided. Objectives of the proposal (e.g., increased angler usage, more available forage) must be included as well as cost effectiveness and special attributes of the proposed species, e.g., survive well, have the potential to naturally reproduce, grow rapidly, resist disease,angler acceptable and accessible, etc. A Risk Assessment must be completed and the narrative should outline the potential problems that states the level of risk, with preventative and contingency plans to overcome the risk.

**Decision Making Process**

The decision making process refers to the steps required to evaluate a proposal/risk assessment to reach a decision for approval (or modification), rejection or deference of proposals for fish introductions. A four person committee comprised of the Fisheries Division Chief, the individual proposing the introduction and two members from outside the Fisheries Division will review the proposal and a decision made within one month of the completed proposal submission.

In some instances, i.e., a new species to the state, an in depth environmental assessment (EA) will be required. At a minimum, the EA will be composed of the following information:

1. Existing condition of the water body.
2. Purpose and need of the introduction.
3. Affected environments.
4. Proposed action.
5. Species proposed for introduction
    a. in include life history
6. Potential environmental impacts of proposed introductions.
7. Alternatives to introduction.
8. Threatened and endangered species or species of concern.
9. Public and agency contacts relative to the proposed introduction.
10. Evaluation methodology.

## RISK ASSESSMENT CHECKLIST

1. Species previously introduced in proposed site without negative impact?
   YES ___ (Approved)    NO ___(---->#2)

2. Stated purpose and need.
   a. if new species to the state, an EA with described components must be completed.
   b. if it is a new species to the lake/watershed, go to #3.

3. Has a Lake Management Plan been developed for the water body into which the introduction will occur?
   YES ___ (---->#4)    NO ___ (reject until plan is developed and approved)

4. Is public access available?
   a. for public agency:  YES ____ (---->#5)  NO ____ (reject)
   b. for aquaculture:  YES ____ (reject)  NO ____ (---->#5)

5. Is the proposed species compatible with existing species at the water body, such that it will not cause the displacement of important fish production through predation, or through competition for food and space?
   YES ____ (---->#8)    NO ____ (---->#6)

6. Would the displacement of the existing species be acceptable to achieve an overall net gain in fish production at the proposed water body or to provide a new species of higher priority for recreational opportunity?
   YES ____ (---->#7)    NO ____ (reject)

7. Would the proposed species become a nuisance to the enjoyment and use of other preferred species at the water body (e.g., yellow perch in trout lake)?
   YES ____ (reject)    NO ____ (---->#8)

8. Will the species be able to perpetuate its existence without further stocking?
   YES ____ (---->#9)    NO ____ (---->#10)

9. Can the species be strictly contained at the water body and/or ensured not to be a risk to fish production in connecting or adjoining waters?
   YES ____ (---->#9)    NO ____ (reject)

10. Is the proposed introduction pathogen and parasite free (as defined in document)?
   YES ____ (---->#10)  NO ____ (reject)

11. Are any species of special concern present in the water body or watershed?
   YES ____ (EA required)    NO ____ (---->#11)

11. Is there expected to be any opposition or substantial controversy associated with the proposed introduction?
   YES ____ (public/agency contacts mandatory)  NO ____ (approved)

Attachment

# SOUTH DAKOTA

**Dept. Game, Fish and Parks**
**Guidelines and Precautions**
**Introduction of Triploid (sterile) Grass Carp**

The South Dakota Department of Game, Fish and Parks regulates all introductions of fish or fish eggs to South Dakota waters (SDCL 41-13-3). This authority includes the introduction of grass carp for weed control purposes.

Grass carp research was initiated in 1981 by GF&P in cooperation with South Dakota State University to determine the feasibility of biological control of nuisance aquatic vegetation in South Dakota waters and to develop management strategies. The initial study results indicated that significant differences in vegetation density and control exist between test ponds stocked with sterile grass carp. Additional research and use of Triploid grass carp as a management tool for aquatic weed control also showed variable results. The results of these two research studies were used to develop these guidelines.

The following are to be used to define the conditions and precautions for the use of Triploid grass carp in South Dakota waters.

1. Aquatic vegetation over abundance must be a major factor limiting recreational uses such as fishing, swimming, skiing, boating, or other beneficial uses of the waters.

2. The potential for increased recreational use and good fishing must exist if aquatic vegetation is controlled.

3. The history of the water should indicate that over abundant aquatic vegetation is a long term (5 or more years) or reoccurring problem, and not a temporary condition.

4. The water should not have a history of reoccurring high populations of european carp which cause increased turbidity and resultant reductions in recreational uses.

5. In public waters, user groups must be informed that a "weed problem" exists and be presented alternative actions. In private waters, downstream landowners must be informed in writing of the upstream landowners intent to stock.

6. Waters considered for grass carp stocking should be relatively small in size (less than 250 acres) so they are cost effective to treat and capable of being scientifically monitored. The water must be of a size and configuration that could be harvested (netting, chemicals, etc.) should it be determined that the grass carp must be removed.

7. The waters inlet, outlet, or any other watershed connection must be controlled or closed at all times to prevent escarpment of grass carp. Waters subject to flooding which could bypass control structures will not be considered.

8. Only certified triploid grass carp can be used following inspection and authorization by the Department. Only a few suppliers are equipped to test and certify their stocks at this time. Proof of origin and certification shall accompany shipment of fish to be introduced.

9. An official request with the intent to sponsor the cost of stocking triploid grass carp for control of aquatic vegetation must be received by the Department 90 days prior to the date of introduction. Stocking rates vary from 10 to 20 fish per surface acre. Fifteen per acre is recommended for Farm Pond application. Detailed plans shall be submitted to and approved by the Director of the Wildlife Division before any introduction of Triploid grass carp are made.

10. A permit is required for each water to be stocked. Fish cannot be moved from one pond to another without a permit.

11. Precaution recommended for use with management for game fish:

    a. Grass carp should not be used for waters in which largemouth bass are managed, because complete removal of all vegetative cover is likely. Habitat conditions and productivity for largemouth bass and panfish will be greatly deminished because grass carp effects on vegetation can't be closely managed. Either the control is complete or non effective.

    b. In natural ponds and marshes, the use of grass carp is not recommended. These waters are generally shallow and the longevity of fish life maybe very short.

    c. Waters that contain large predator fish (e.i. northern pike) should not be stocked with grass carp. Research has shown very low survival of the newly stocked grass carp under these conditions.

    d. The capability of grass carp to control vegetation varies with the size of the fish and number per acre (biomass). When first stocked the young fish may have no apparent effect on the vegetation. After a few years growth, they may eat most of the weeds in the pond during the summer and after they mature, they may eat themselves out of food by mid summer. Grass Carp are long lived. Barring predation or die off because of disease and/or environmental conditions they could live for fifteen or twenty years.

       When they become big and food becomes limited, it may be necessary to thin their number. We suggest you contact the Dept. of GF&P for advise in these situations.

ALBERTA

Beck (1996)



**FINAL RATING FOR CONSEQUENCE OF ESTABLISHMENT:**

| | |
|---|---|
| **PONDS:** | **LOW** |
| **CANALS:** | **LOW** |
| **NATURAL WATERS:** | **MEDIUM** |

**OVERALL RISK:**

| | | | |
|---|---|---|---|
| **PONDS:** | **(LOW) AND (LOW)** | = | **LOW** |
| **CANALS:** | **(LOW) AND (LOW)** | = | **LOW** |
| **NATURAL WATERS:** | **(LOW) AND (MEDIUM)** | = | **MEDIUM** |

∴ **The overall risk posed by the introduction of diploid grass carp has been rated as MEDIUM.**

∴ **The introduction of ~~triploid~~ diploid grass carp poses an unacceptable risk to indigenous aquatic species and their habitats and thus warrants the imposition of major mitigation measures in order to be acceptable.**

## 6.4 Recommendations Concerning the Proposed Introduction of Grass Carp

1. __All__ grass carp used for vegetation control or any other purpose must be produced within rearing facilities within the province of Alberta.

2. __All__ fish leaving the rearing facilities must be certified as to being genetic triploids. The certification process will be undertaken by and at the expense of the proponent and will be subject to verification by on-site quality control/quality insurance inspectors.

3. __All__ fish leaving the rearing facilities must be certified as free of known fish pathogens, diseases and/or parasites. The certification process will be undertaken by and at the expense of the proponent and will be subject to verification by on-site quality control/quality insurance inspectors.

4. DNA typing of all stocks within the rearing facility must be established.

5. All fish used for operational or experimental purposes are to be marked with a long-term, readily identifiable mark.

6. The project proponents (Alberta Agriculture, Food and Rural Development) will test any unmarked grass carp (see above) caught in any contiguous natural surface water for ploidy and genetic stock identity.

7. The Department of Fisheries and Oceans and the Province of Alberta, Fish and Wildlife Services, Environmental Protection should initiate legislative changes to prevent the unrestricted importation of <u>both</u> diploid and triploid grass carp to Canada and Alberta. Such legislation must contain provision for substantial penalties for any person possessing or dealing in un-authorized or un-registered grass carp. The Province of Alberta should promulgate the new Alberta Fisheries Act as quickly as possible.

8. The proponent should proceed with a "pre-commercial phase" of the project. This should address but not be limited to the following issues:
   - All rights for the importation, breeding, distribution and stocking site selection for grass carp must remain under the direct control of the provincial government.
   - There will be no private importation or breeding of grass carp.
   - The proponent will continue to investigate the market potential of grass carp for vegetation control and/or as a food fish.
   - The proponent will address all other proposals contained within the pre-commercial phase management plan prepared in June 1996.

9. Grass carp may be used for the purpose of vegetation control in ponds and dugouts. Such ponds and dugouts will be approved <u>only</u> if the following terms and conditions are met:
   - The pond or dugout must be located outside the flood plain as defined by the 1/100 year flood event .
   - The pond or dugout must be approved by a biological/engineering selection team.

10. Grass carp may be used for vegetation control in irrigation canals under the following terms and conditions:
    - The canal must be 'dead ending' with no return flows to natural surface waters.
    - Double downstream and single upstream barriers must be installed so as to minimize the possible risk of escape of fish from the area. Such barriers should be a minimum of 1 metre in height so as to negate the jumping ability of grass carp. In addition, barriers should be installed near the inlet of all supply canals to prevent the movement of wild fish into the irrigation canal system.
    - There will be no public salvage harvest of fish from reaches of any canal containing grass carp.

11. Grass Carp **<u>may not</u>** be used for vegetation control in any irrigation canal having direct return flows to natural surface waters.

12. Only certified triploid/certified disease free grass carp may enter the live food fish market system. In addition, any fish for the food trade must be dispatched before leaving the retail facility.

13. The distribution of all rare and/or endangered aquatic plants should be considered in candidate areas.

14. The project proponents must develop a contingency plan describing actions to be undertaken in the event that grass carp are taken from unauthorized waters - including all natural waters contiguous to the area of introduction.

15. The proponent should continue research as to the applicability of grass carp for vegetation control in dugouts and ponds in other geographic areas of the province of Alberta.

16. The proponent should develop a detailed public education program to inform Alberta residents about the importance of allowing the use of certified disease free triploid grass carp only. The information program should be especially concentrated in those areas of the Province where the extensive use of grass carp occurs or is anticipated.

## Grass Carp Stocking Model

| | | | | |
|---|---|---|---|---|
| Obtaining the standard density of fish for your pond size | **Measure the length and width of your pond** in meters. **Multiply length X width, then divide this number by 10,000** (since there are 10,000 square meters in one hectare) This figure gives you the number of hectares. Then, **multiply this number by 400** (since the standard stocking rate is 400 - 25 cm. sized grass carp per hectare of water) | | | Standard number of fish |
| Water temperature units (dependent on pond location in Alberta) | high<br>medium/high<br>medium<br>medium/low<br>low | South - Medicine Hat to Calgary<br>Northeast - Provost to St. Paul<br>Central - Hanna to Stettler<br>Northwest - Leduc to Athabasca<br>Peace - Valleyview to Fort Vermillion | 1.00<br>1.25<br>1.30<br>1.35<br>1.40 | ⇦Select factor multiply with above number and enter at right⇨ |
| Aquatic plant density | low<br>medium<br>high | sparse, few patches, limited vegetation<br>routine plant growth on bottom to top<br>heavy stands emerging through water | 0.40<br>0.60<br>1.00 | ⇦Select factor multiply with above number and enter at right⇨ |
| Aquatic plant distribution | low<br>medium<br>high | shoreline only, less than 1/3 of pond area<br>plants throughout, less than 1/2 of pond area<br>plant abundant, greater than 1/2 of pond area | 0.40<br>0.80<br>1.00 | ⇦Select factor multiply with above number and enter at right⇨ |
| Aquatic plant types – feeding perference of grass carp | low<br>medium<br>high | rushes, cattails, watermilfoil, water buttercup<br>coontail, filamentous algae, reed grass<br>chara, duckweed, pondweed, water plantain | 1.30<br>1.10<br>1.00 | ⇦Select factor multiply with above number and enter at right⇨ |
| Per cent of aquatic vegetation needing to remain | 20 to 25%<br>10 to 20%<br>0 to 10% | ideal cover for fish, wildlife habitat<br>swimming, minimal cover for fish<br>water storage, aesthetics, fish farming | 0.75<br>0.85<br>1.00 | ⇦Select factor multiply with above number and enter at right⇨ |
| Time necessary to achieve aquatic weed control | 3-4 years<br>2-3 years<br>1 year | recreational fishery, wildlife habitat<br>water storage, decoration, aesthetics<br>water storage, fish farming | 0.80<br>0.90<br>1.00 | ⇦Select factor multiply with above number and enter at right⇨ |
| Size of grass carp being stocked* | 7.6 - 15 cm.<br>20 - 30 cm.<br>36 - 50 cm.<br>50+ cm. | 3 to 6 inches in length<br>8 to 12 inches in length<br>14 to 20 inches in length<br>20 plus inches in length | 1.5<br>1.0<br>0.7<br>0.6 | ⇦Select factor multiply with above number and enter at right⇨ |
| **Total Number of Triploid Grass Carp Required for Stocking Your Pond** | | | | |

* This model takes into consideration the fact that small grass carp consume vegetation at a faster rate than larger fish and that they also suffer greater mortality due to predators.

1998. Alberta Agriculture, Food & Rural Development

# American Fisheries Society Position on Introductions of Aquatic Species

Christopher C. Kohler and Walter R. Courtenay, Jr.

## A. Issue Definition

The increased frequency of inter- and intranational transfers of aquatic species carried out over the last 2 decades has prompted concern relative to the potential for debasement of integrity of aquatic communities. Past introductions, intentional or otherwise, have run the full gamut from spectacular booms (e.g., Pacific salmon to the Great Lakes) to spectacular busts (e.g., the waterweed hydrilla to portions of the United States). Considering the manifestations of such extremes in terms of ecological and economical impacts, it is not surprising that opposing viewpoints exist with respect to the relative pros and cons of effectuating introductions of aquatic species. Nevertheless, natural resource managers concur that substantially improved measures can and should be taken to increase the odds that benefits of a given introduction will exceed risks. Currently, a number of international commissions have adopted or are considering adopting formal "codes of practice" for regulating the introduction of aquatic species (see Sindermann 1986; Welcome 1986; Kohler and Courtenay 1986). Implementation of such codes (protocols, guidelines, etc.) can ensure that decisions regarding future introductions are based on sound ecological evidence, and that introductions effectuated are properly evaluated.

## B. Negative Impacts on Aquatic Communities

The impacts of introduced aquatic organisms on native aquatic communities in North America have been summarized by Contreras and Escalante (1984) for Mexico, by Taylor et al. (1984) for the continental United States, and by Crossman (1984) for Canada. These impacts can be classified into five broad categories: habitat alteration, trophic alteration, spatial alteration, gene pool deterioration, and introduction of diseases.

*Habitat Alteration*

Introduced plants such as water hyacinth (see Table 1 for scientific names of organisms cited in text), Eurasian was termilfoil, alligator weed, and hydrilla have seriously infested a number of water bodies in North America (Shireman 1984). Excessive vegetation interferes with swimming and fishing activities, upsets predator-prey relationships by providing too much cover, causes water quality problems during growth and decomposition, and is aesthetically unpleasing (Noble 1980). Ironically, exotic fishes, particularly grass carp and the tilapias, are frequently used as biological controls. Both the grass carp and the tilapias have reproducing populations in North America, although the habitat requirement for larval grass carp has so far proved to be limiting and the tilapias are basically limited to the southern extreme of the United States and to Mexico.

Although grass carp have proven to be an excellent bio logical control for aquatic vegetation, a risk exists that aquatic plants (including native forms) might become overly decimated as a result of grass carp predation which in turn would limit nursery areas for juvenile fishes, cause bank erosion, and accelerate eutrophication through release of nutrients previously stored in the plants. A risk also exists that grass carp could adversely impact waterfowl habitat and rice fields. However, no major adverse impacts associated with grass carp have yet been documented.

Although common carp was not introduced to North America for aquatic weed control, its foraging behavior results in vegetation removal both by direct consumption and by uprooting due to its proclivity to dig through substrate in search of food. The latter activity also results in increased water turbidity. The common carp is the most often cited nuisance introduced fish in North America (Kohler and Stanley 1984) with millions of dollars having been spent for control and eradication, but with little success (Laycock 1966; Courtenay and Robins 1973).

Besides grass carp, only the redbelly tilapia has been widely used in weed control programs in North America. No effects on native communities have yet been attributed to vegetation removal by any of the tilapias (Taylor et al. 1984), though increases in turbidity have been attributed to digging activities of the blue tilapia (Noble et al. 1975) and to organic enrichment through fecal decomposition by redbelly tilapia (Hickling 1961; Phillippy 1969).

*Trophic Alteration*

Taylor et al. (1984) speculated that the introduction of any species into a novel environment should alter community trophic structure, with the nature and extent of such changes being complex and unpredictable. Though this aspect is not well documented, there is little doubt that when an introduced fish exhibits explosive population increases, as has occurred with the tilapias (Germany 1977; Knaggs 1977; Shafland 1979), substantial changes in native communities must occur. Likewise, several dozen studies have documented dietary overlap between introduced and native fishes (see Taylor et al. 1984). However, these studies only demonstrate that the potential for competition exists. Linking dietary overlap to competition has proven to be a difficult task for all but the most controlled ecological studies regardless of whether non-native species are involved.

Documentation of predation by introduced species on native species serves as the most definitive example of impacts on communities. The most frequently cited example in North America concerns declines in populations of native trouts attributable to brown trout predation (see Moyle 1976a,b; Sharpe 1962; Alexander 1977, 1979). Several other introduced fishes have been implicated as major causes of mortality among native fishes, including pike killifish (Miley 1978; Turner 1981; Anderson 1981, 1982), oscar (Hogg 1976), and the bairdiella (Quast 1961). Though frequently cited as a potential threat of considerable consequence, predation on eggs or young by introduced fishes has not been demonstrated to be a common occurrence (Taylor et al. 1984).

*Spatial Alteration*

Concommittant overlap in usage of space by non-native and native fishes may lead to competitive interaction if space is in limited supply or of variable quality. Evidence exists implicating displacement of brook trout by brown trout, but in general, displacements are largely inferential (Taylor et al. 1984). Conversely, high densities of introduced fishes have been shown to exert negative effects on native fishes. For example, Noble et al. (1975) observed that largemouth bass populations in Trinidad Lake, Texas, declined with no evidence of recruitment as densities of blue tilapia rose to approximately 2,240 kg ha~' during the period 1972-1975.

*Gene Pool Deterioration*

Though reduction of heterogeneity through inbreeding is clearly a threat to any species being produced in a hatchery (Philipp et al. 1983), the risk is most acute with species of intercontinental origin because the initial broodstock invariably represent limited gene pools at the outset. The larger the stocking program, the more inbreeding among original broodstock is necessary. Thus species introduced to a novel habitat may or may not have the genetic characteristics necessary for them to adapt and/or perform as predicted.

Fortunately, hybridization events among introduced and native species in open waters are rare (Taylor et al. 1984). Nevertheless, the possibility of native gene pools being altered through such hybridization does exist. For example, brown trout are known to hybridize with native forms in North America (Schwartz 1972, 1981; Dangel et al. 1973; Chevassus 1979).

*Introduction of Diseases*

Diseases caused by bacteria, viruses, and parasites are all too often conveyed along with introduced aquatic species (see Hoffman and Schubert 1984; Shotts and Gratzek 1984 for reviews). This aspect represents one of the most severe threats that an introduced species may pose to a native community. Transfer of diseased fish was no doubt responsible for introduction of whirling~ disease into North America

from Europe. Recently, infectious hypodermal and hematopoietic necrosis virus (IHHNV) has been spread to a number of countries in conjunction with shipments of live penaeid shrimp. IHHNV was first diagnosed in 1981 at shrimp culture facilities in Hawaii among shrimp introduced from Panama (Sindermann 1986). Even "ich," one of the most common fish diseases worldwide, caused by a ciliated protozoan, is thought to have been transferred from Asia throughout the temperate zone with shipments of fishes (Hoffman 1970, 1981).

Table 1. Organisms cited in text.

| Common Name | Scientific Name |
|---|---|
| Plants | |
| hydrilla | Hydrilla verticillata |
| water hyacinth | Eichornia crassipes |
| Eurasian watermilfoil | Myriophyllum spicatum |
| alligator weed | Alternanthera philoxeroides |
| Fish | |
| Pacific salmon | Oncorhyncus sp. |
| grass carp | Ctenopharyngodon idella |
| common carp | Cyprinus carpio |
| tilapias | Oreochromis, Sarotherodon and Tilapia sp. |
| blue tilapia | Oreochromis aureus ( = Tilapia aurea) |
| redbelly tilapia | Tilapia zilli |
| brown trout | Salmo trutta |
| pike killifish | Belonesox belizanus |
| oscar | Astronotus ocellatus |
| bairdiella | Bairdiella icistia |
| brook trout | Salvelinus fontinalis |
| largemouth bass | Micropterus salmoides |
| coho salmon | Oncorhyncus kisutch |
| striped bass | Morone saxatilis |
| walking catfish | Clarias batrachus |
| Other | |
| whirling disease | Myxosoma cerebralis |
| "ich" | Ichthyopthirius multifiliis |

## C. Courses of Action

Introductions of species to aquatic communities are commonly employed as a fisheries management tool or occur as a result of escapes from aquaculture or ornamental fish holding facilities. It is not feasible, nor desirable, to legislate against all such introductions. What is needed is more education on the role that introduced species can and should play in the context of aquatic resources management. The more informed natural resources managers are about such issues, the less likely that mistakes will be made or that legislation will be necessary to enforce an "attitude of caution." The following actions toward that end are recommended.

A. The membership reaffirms its endorsement of the 1972 "Position of the American Fisheries Society on Introductions of Exotic Aquatic Species" with modifications as indicated:

### Position of American Fisheries Society on Introductions of `Introduced' Aquatic Species:

Our purpose is to formulate a broad mechanism for planning, regulating, implementing, and monitoring all introductions of aquatic species.

Some introductions of species into ecosystems in which they are not native have been successful (e.g., coho salmon and striped bass) and others unfortunate (e.g., common carp and walking catfish).

Species not native to an ecosystem will be termed "introduced." Some introductions are in some sense, planned and purposeful for management reasons; others are accidental or are simply ways of disposing of unwanted pets or research organisms.

It is recommended that the policy of the American Fisheries Society be:

1. Encourage fish importers, farmers, dealers, and hobbyists to prevent and discourage the accidental or purposeful introduction of aquatic into their local ecosystems.

2. Urge that no city, county, state, province, or federal agency introduce, or allow to be introduced, any exotic species into any waters within its jurisdiction which might contaminate any waters outside its jurisdiction without official sanction of the exposed jurisdiction.

3. Urge that only ornamental aquarium fish dealers be permitted to import such fishes for sale or distribution to hobbyists. The "dealer" would be defined as a firm or per son whose income derives from live ornamental aquarium fishes.

4. Urge that the importation of e*e~e fishes for purposes of research not involving introduction into a natural ecosystem, or for display in public aquaria by individuals or organizations, be made under agreement with responsible governmental agencies. Such importers will be subject to investigatory procedures currently existing and/or to be developed, and species so imported shall be kept under conditions preventing escape or accidental introduction. Aquarium hobbyists should be encouraged to import rare ornamental fishes through such importers. No fishes shall be released into any natural ecosystem upon termination of research or display.

5. Urge that all species of exotics considered for release be prohibited and considered undesirable for any purposes of introduction into any ecosystem unless that ~sh species shall have been evaluated upon the following bases and found to be desirable:

a. RATIONALE. Reasons for seeking an import should be clearly stated and demonstrated. It should be clearly noted what qualities are sought that would make the import more desirable than native forms.

b. SEARCH. Within the qualifications set forth under RATIONALE, a search of possible contenders should be made, with a list prepared of those that appear most likely to succeed, and the favorable and unfavorable aspects of each species noted.

c. PRELIMINARY ASSESSMENT OF THE IMPACT. This should go beyond the area of rationale to consider impact on target aquatic ecosystems, general~ effect on game and food fishes or waterfowl, on aquatic plants and public health. The published information on the species should be reviewed and the species should be studied in preliminary fashion in its biotope.

d. PUBLICITY AND REVIEW. The subject should be entirely open and expert advice should be sought. It is at this point that thoroughness is in order. No importation is so urgent that it should not be subject to careful evaluation.

e. EXPERIMENTAL RESEARCH. If a prospective import passes the first four steps, a research program should be initiated by an appropriate agency or organization to test the import in confined waters (experimental ponds, etc.).

f. EVALUATION OR RECOMMENDATION. Again publicity is in order and complete reports should be circulated amongst interested scientists and presented for publication. in the Transactions of the American Fisheries Society.

g. INTRODUCTION. With favorable evaluation, the re lease should be effected and monitored, with results published or circulated.

Because animals do not respect political boundaries, it would seem that an international, national, and regional agency should either be involved at the start er and have the veto power at the end. Under this procedure there is no doubt that fewer introductions would be accomplished, but quality and not quantity is desired and many mistakes might be avoided.

B. The Society encourages international, national, and regional natural resource agencies to endorse and follow the intent of the above position.

C. The Society encourages international harmonization of guidelines, protocols, codes of practice, etc., as they apply to introductions of aquatic species. D. Fishenes professionals and other aquatic specialists are urged to become more aware of issues relating to introduced species.

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