Chloramine-T Clinical Field Trials - INAD 9321

Year 2005 Annual Summary Report on the Use of Chloramine-T in Clinical Field Efficacy Trials

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Summary

Chloramine-T has been used effectively in the U. S. under compassionate INAD Exemption #9321 to control mortality in a variety of fish caused by common fish bacterial pathogens. In calendar year 2005 (CY05), the efficacy of chloramine-T (CLT) was evaluated in 135 disease trials involving approximately 18.8 million fish to control mortality in a variety of fish species caused by a variety of infectious fish pathogens. Trials were conducted at 37 fish culture facilities, including nine U.S. Fish and Wildlife Service National Fish Hatcheries (NFH), 21 state fish hatcheries, four private fish hatcheries and three tribal hatcheries. The compassionate study protocol under which treatments were administered allowed the investigator to use chloramine-T on 1) either consecutive or alternate days three times/wk for 1h at dosages ranging from 10 - 20 mg/L; or 2) one day a week for 1 h at 15mg/L. Overall, results of trials conducted in CY05 indicated that treatments appeared efficacious in approximately 87% of the trials and ineffective in 2% of the trials. Treatments were characterized as inconclusive in the 7% of the trials. In the remaining 4% of the trials, the Investigators was not required to

report mortality data because the effectiveness technical section for the specific claim has been completed and accepted by CVM.

Introduction

Bacterial gill disease (BGD) is one of the most common diseases of hatchery reared salmonids (Bullock 1990) and causes more fish losses than any other bacterial disease (Bills et al. 1988). Fish mortality is generally not a direct result of the infection, but is a consequence of the infection. Mortality is most likely the result of asphyxiation from lack of adequate oxygen exchange in severely congested gills. Stressors associated with intense fish culture may predispose fish to infection. Although *Flavobacterium branchiophilum* is the bacteria responsible for causing most outbreaks of BGD (Wakabayashi, H, et al., 1989; Ferguson et al., 1991), other gram-negative bacteria have also been implicated. These “other” bacteria include *F. aquatile, F. psychrophilus, F. columnaris,* as well as other flavobacters and aeromonads and pseudomonads. Clinical signs of BGD have been well documented, and it is widely known that this disease can cause the rapid proliferation of gill epithelium and the production of excess mucus as the host responds defensively to the infection. This response can "smother" gills and cause severe losses if prompt measures are not taken. If BGD, which is horizontally transmitted, is not diagnosed and treated early, an epizootic may occur within a 24-h period (Bullock et al. 1990).

Historically, several chemicals including benzalkonium chloride (available as Hyamine 1622 and 3500), diquat, and chloramine-T have been used to control mortality caused by BGD (Bullock et al. 1990). However, none of these chemicals have been approved by the FDA to control mortality in freshwater fish caused by BGD. Because chloramine-T appears to be the most effective therapeutant when salmonids have BGD (From 1980; Bullock et al. 1990; Bowker et al, in press) it has become the prime candidate for approval with the U.S. Food and Drug Administration (FDA) as a bath treatment. Chl-T has been characterized as a non-selective sanitizing agent and has been shown to clean up gills infested with bacteria and coated with excess mucus.

Purpose of Report

The purpose of this report is to summarize the results of calendar year 2005 (CY05) supplemental chloramine-T field efficacy data. Similar data have been submitted by the Service in previous years. We anticipate that CY05 data will be used to enhance the existing chloramine-T database established from previous years, and will be considered in the “body of evidence” for the purpose of developing an appropriate label claim for the use of chloramine-T in aquaculture.

Facilities, Materials, Treatment Procedures

1. Facilities

A total of 135 field efficacy trials were conducted at 37 fish culture facilities, including nine U.S. Fish and Wildlife Service NFH's, 21 state fish hatcheries, four private fish hatcheries and three tribal hatcheries. Treatments were used to control/prevent mortality in a variety of fish species caused by various fish pathogens. Water temperature during treatments at the various testing facilities ranged from 34.0 - 70.0 °F, with a mean treatment temperature of 55.2°F.

2. Chemical material

Chloramine-T (CAS No. 127-65-1) is a pure white crystal powder. All facilities used designated lots of chloramine-T provided by one of the following two manufactures: (1) Deerland Chemical, Corp., Littleton, Co. or (2) B.L. Mitchell, Inc., Greenville, MS. During CY05, a total of 3,158.6 kg of CLT was used in treatment trials conducted under INAD # 9321.

3. Treatment Methods

Chloramine-T treatments were administered using either a flow-through or standing bath treatment method. Both procedures called for accurately weighed amounts of dry chemical dissolved in an appropriate amount of non-chlorinated water. When using a flow-through system, dissolved chemical was metered into

rearing units at a rate to achieve the desired treatment concentration during a 1 h period. When using a standing bath method, water flow to the rearing unit was turned off and dissolved chemical added to the rearing unit and mixed thoroughly to ensure uniform chloramine-T concentration throughout the tank. Thorough mixing was essential to ensure there were no chloramine-T "hot spots." After the 1 h treatment, water flow was turned on again to flush the chemical out of the rearing unit.

4. Drug dosages

During CY05, various chloramine-T doses were used. Listed below are the doses and the number of trials conducted with each dose:

1.	6 mg/L:	1 trial
2.	10 mg/L:	8 trials
3.	12 mg/L:	2 trials
4.	12 & 15 mg/L:	1 trial
5.	15 mg/L:	103 trials
6.	20 mg/L:	20 trials
	Total	135 trials

5. Number of treatments per disease outbreak

According to the Study Protocol, Investigators were allowed to administer chloramine-T on three consecutive/alternate days when used to control mortality caused by BGD, and once/week when used to prevent mortality. During CY05, the most common treatment regimen was to administered CLT on three consecutive days to control mortality in fish caused by BGD.

Fish Species Treated and Fish Diseases Involved in CY 2005 Trials

1. Species and size of fish treated

Twenty fish species, including 12 species of salmonids and eight non-salmonids fish species, were treated during CY05. Treated fish ranged in length from 0.75 - 38.0 in. and the mean length of all treated fish was 4.5 in. Species treated included:

Salmonids: (1) Atlantic salmon *Salmo salar*, (2) brown trout *S. trutta*, (3) apache trout *Oncorhynchus apache*, (4) chinook salmon *O. tshawytscha*, (5) chum salmon *O. keta*, (6) coho salmon *O. kisutch*, (7) sockeye salmon *O. nerka*, (8) cutthroat trout *O. clarki*, (9) rainbow trout *O. mykiss*, (10) steelhead trout *O. mykiss*, (11) brook trout *Salvelinus fontinalis*, (12) lake trout *Salvelinus namaycush*

Non-salmonids: (1) channel catfish *Ictalurus punctatus*, (2) lake sturgeon *Acipenser fulvescens*, (3) largemouth bass *Micropterus salmoides*, (4) smallmouth bass *M. dolomieu*, (5) muskie *Esox masquinongy*, (6) northern pike *E. lucius,* (7) tiger musky *E. lucius x E. masquinongy,* (8) shovelnose sturgeon *Scaphirhynchus platorynchus*

2. Diseases treated

The disease treated most frequently was characterized as BGD. Other diagnosed diseases included external columnaris, external bacterial coldwater disease, external flavobacteriosis, branchiomyces, and tail rot.

Data Collected

1. Pathologist's report

In CY05 a pathologist's report was submitted for 44% of the studies. Pathology reports are important for accurate interpretation of study results because they typically contain the following information:

1. A description of how the identity of disease agent(s) was verified
2. Disease identification records that confirm the presence of the disease agent
3. The name and title of the individual performing the diagnosis.

Additionally, evidence would typically be provided to document that there were no secondary infections or infestations caused by unrelated disease agents in the population of test fish.

2. Treatment response and drug accountability data

Drug receipt reports, drug use reports, diagnosis, treatment, and mortality reports (including adverse effects/toxicity observations), and fish disposition reports were prepared by study Investigators. Such reports were routed through the Study Monitor for review, and then sent to the Bozeman AADAP Office for review, data analysis and report writing, entering data into a database, and archiving in permanent files.

Based on correspondence with FDA, the following efficacy and safety technical sections have been completed:

1. Effectiveness of chloramine-T at a concentration of 12 ppm administered as a 60 min bath once per day every other day for a total of three treatments to control mortality associated with bacterial gill disease in freshwater-reared salmonids (we refer to your file number INAD 4000 H-0071 dated July 11, 2000).

2. Safety of chloramine-T at a concentration of 20 ppm administered as a 60 min bath on three consecutive or alternate days for the control of mortality

associated with bacterial gill disease in freshwater-reared salmonids (we refer to your file number INAD 4000 P-0093 dated September 13, 2002).

As a result of the completed technical sections, mortality data are no longer required when Investigators administer chloramine-T at a dosage of 12 - 20 ppm on three alternate or consecutive days for 60 min to control mortality associated with bacterial gill disease in freshwater-reared salmonids. In all other cases, collection of mortality data is still required and efforts were made to collect all such data. However, for a variety of reasons, mortality data were not always collected for the entire required data collection period. Reasons for incomplete mortality data included : 1) splitting fish into additional rearing units; and 2) stocking early life stage fish shortly after final treatment.

Discussion of Study Results

1. Relevance of study to a proposed label claim for chloramine-T

Results of CY05 trials conducted under Compassionate INAD exemption #9321 are similar to results detailed in reports previously submitted to FDA under INAD's #9321 and #4000.

2. General observations on the efficacy of CLT for the control of bacterial diseases in salmonid and non-salmonid fish (Note: Table 1 provides a summary of

all trials in which treatment appeared efficacious; Table 2 provides a summary of all trails in which treatment appeared ineffective; Table 3 provides a summary of all inconclusive trials; Table 4 provides a summary of all trials where mortality data was not required; Table 5 provides summary data for all trials; and Tables 6a and 6b provide a brief description of all trials conducted during CY05 under INAD #9321; Table 6a lists trials sorted by study number; Table 6b is a list of trials sorted first by disease treated, second by whether treatments were efficacious or not, and lastly by fish species).

A. Efficacy at 6 mg/L chloramine-T

One trial was conducted using 6 mg/L chloramine-T (Table 3) to control mortality in steelhead trout associated with BGD. The Investigator noted the treated fish also had a secondary infection of bacterial kidney disease. As a result of the concomitant disease, this trial was characterized as inconclusive.

B. Efficacy at 10 mg/L chloramine-T

Fish were treated with 10 mg/L chloramine-T in eight trials (Tables 1 & 2). Included in these eight trials were five trials in which chinook salmon, sockeye salmon, cutthroat trout, rainbow trout, and shovelnose sturgeon were treated to control mortality associated with BGD; and three trials in which steelhead trout were treated to control mortality associated with external flavobacteriosis. Treatment resulted in the following:

1) Of the five trials in which BGD was diagnosed in chinook salmon, sockeye salmon, cutthroat trout, rainbow trout, and shovelnose sturgeon; treatment in three (60%) of the trials appeared efficacious; while treatment in two (40%) trials (involving cutthroat trout and shovelnose sturgeon) did not appear to be efficacious.

2) All three trials in which external flavobacteriosis was diagnosed in steelhead trout appeared to be efficacious.

C. Efficacy at 12 mg/L chloramine-T

Two trials were conducted using 12 mg/L chloramine-T (Table 1) to control mortality in coho salmon associated with external bacterial coldwater disease. Both trials appeared efficacious.

D. Efficacy at 12 & 15 mg/L chloramine-T

One trial was conducted using 12 & 15 mg/L chloramine-T (Table 1) to control mortality in coho salmon associated with BGD. The Investigator noted the drug dose was decreased from 15 ppm after treatment day 2 to 12 ppm on treatment day 3. This trial appeared efficacious.

E. Efficacy at 15 mg/L chloramine-T

Fish were treated with 15 mg/L chloramine-T in 103 trials (Tables 1 & 3). Included in these 103 trials were 85 trials in which treatments were administered to apache trout, Atlantic salmon, brook trout, brown trout, chinook salmon, chum salmon, cutthroat trout, lake trout, rainbow trout, steelhead trout, and musky to control mortality associated with BGD; seven trials in which treatments were administered to chinook salmon, steelhead trout, channel catfish, and lake sturgeon to control mortality associated with external columnaris; five trials in which treatments were administered to Atlantic salmon and steelhead trout to control mortality associated with external bacterial coldwater disease, three trials in which treatments were administered to musky and northern pike to control mortality associated with branchiomyces, two trials in which treatments were administered to rainbow trout and steelhead trout to control mortality associated with external flavobacteriosis, and one trial in which treatment was administered to brown trout to control mortality associated with tail rot (see Tables 1 & 3). Treatment resulted in the following:

1) Of the 85 trials in which BGD was diagnosed in apache trout, Atlantic salmon, brook trout, brown trout, chinook salmon, chum salmon, cutthroat trout, lake trout, rainbow trout, steelhead trout, and musky, treatments in 84 (99%) of the trials appeared efficacious, while treatment in the remaining trial involving brown trout was characterized as inconclusive.

2) Treatments in all of the trials in which chinook salmon, steelhead trout, channel catfish, and lake sturgeon were diagnosed with external columnaris appeared to be efficacious.

3) Treatments in all of the trials in which Atlantic salmon and steelhead trout were diagnosed with external CWD were characterized as inconclusive.

4) Of the three trials in which branchiomyces was diagnosed in musky and northern pike, treatments in two (67%) of the trials appeared efficacious, while treatments in one (33%) trial involving musky was characterized as inconclusive.

5) Treatments in all of the trials in which musky and northern pike were diagnosed with external flavobacteriosis appeared to be efficacious.

6) Treatments in the trial in which brown trout were diagnosed with tail rot appeared to be efficacious.

F. Efficacy at 20 mg/L chloramine-T

Fish were treated with 20 mg/L chloramine-T in 20 trials (Tables 1 - 4). Included in these 20 trials were 17 trials in which treatments were administered to chinook salmon, sockeye salmon, rainbow trout, steelhead trout, northern pike and tiger musky to control mortality associated with BGD; and three trials in which

treatments were administered to musky, largemouth bass, and smallmouth bass to control mortality associated with external columnaris. Treatment resulted in the following results:

1) Of the 20 trials in which BGD was diagnosed in chinook salmon, sockeye salmon, rainbow trout, steelhead trout, northern pike and tiger musky, treatment in 11 (65%) of the trials appeared efficacious, treatment in one (6%) of the trials involving chinook salmon did not appear to be efficacious, and treatment in five (29%) of the trials involving rainbow trout were trials in which mortality collection and reporting were not required.

2) Of the three trials in which external columnaris was diagnosed in musky, largemouth bass, and smallmouth bass, treatment in two (67%) of the trials involving largemouth bass and musky appeared efficacious, while treatment in the one (33%) trial involving smallmouth bass was characterized as inconclusive.

3. Observed Toxicity

No toxicity or adverse effects relating to CLT treatment were reported in any of the trials conducted in CY05.

Summary of Study Results

Chloramine-T was used at doses ranging from 6 - 20 mg/L in 135 treatment trials in which fish were treated one, two, or three times to control mortality, and once per week when used to prevent mortality. Twenty different species of fish were treated and trials involved approximately 18.8 million fish. Treated fish ranged in size from 0.75 - 38.0 in. Water temperature during treatment ranged from 34.0 - 70.0^{o}F, with a mean treatment temperature of 55.2^{o}F. Overall, results showed that treatment appeared effective in approximately 87% of trials and ineffective in 2% of the trials. Treatment results in 7% of the trials were characterized as inconclusive. In the remaining 4% of the trials, mortality data collection and reporting were not required. There was no evidence of toxicity or adverse effects related to CLT treatment reported in all trials. Data from the CY05 trials support the results of previous Annual Report submissions under INAD #9321 and INAD #4000 that indicate that the chloramine-T treatment regimen recommended in INAD Protocol #9321 is safe and effective to control/prevent mortality in a variety of fish species caused by external bacterial infections such as BGD. As a result of the lack of quality criteria, such as dose verification, use of controls, replicates, and randomization, it is understood that these data will be considered as ancillary data, and that pivotal efficacy studies are needed to definitively demonstrate chloramine-T efficacy for the treatment of BGD. However, the ancillary data described above should provide useful, corroborative data to help support a label claim for the use of chloramine-T to control mortality associated with BGD in a variety of fish species. Although it is anticipated that the majority of future efficacy data collected under INAD

#9321 will also be ancillary data, efforts will be made to improve the quality of data whenever possible, with particular attention paid to the use of untreated control fish, dose verification, and the inclusion of fish pathologist reports.

References

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Table 1. Summary of Year 2005 Chloramine-T Efficacy Results - Efficacious Studies

Hatchery	Number of efficacious trials	Fish Size (in.)	Fish Species	Number of Fish	Disease	Number of treatment days	Dose (mg/L)	Temp. (°F)
Lyons Ferry SFH	1	2.01	FCS	125,000	BGD	3	10	53.0
Hayspur SFH	1	13.75	RBT	6,000	BGD	3	10	52.0
Eagle SFH	1	14.00	SOS	319	BGD	3	10	52.7
Cowlitz Trout SFH	3	4.20	STT	1,056,000	External Flavobacteriosis	3	10	53.0
Quilcene NFH	2	4.26	COS	822,000	CWD	2	12	47.7
Solomon Gulch Hatchery	1	1.41	COS	1,635,500	BGD	3	12 & 15	41.9
Crystal Lake Hatchery	1	4.50	CKS	333,400	BGD	1	15	36.1
Cowlitz Trout SFH	1	4.20	STT	113,500	External Flavobacteriosis	1	15	53.0
Dworshak NFH	2	5.70	STT	179,740	BGD	1	15	46.4 - 47.2
Darrah Springs SFH	1	5.00	RBT	90,000	BGD	2	15	57.0
Alchesay-Williams Creek NFH	4	3.8 - 7.0	APT	111,651	BGD	3	15	52.0
Thompson SFH	1	2.40	ATS	52,667	BGD	3	15	56.0
Alchesay-Williams Creek NFH	1	3.43	BKT	25,200	BGD	3	15	52.0
London SFH	2	2.00	BNT	204,000	BGD	3	15	52.0

Table 1. Summary of Year 2005 Chloramine-T Efficacy Results - Efficacious Studies - cont.

Hatchery	Number of efficacious trials	Fish Size (in.)	Fish Species	Number of Fish	Disease	Number of treatment days	Dose (mg/L)	Temp. (°F)
Thompson SFH	1	2.74	BNT	100,454	Tail Rot	3	15	52.0
Diru Creek Hatchery	1	1.90	CHS	692,000	BGD	3	15	52.0
Keta Creek Hatchery	2	1.38	CHS	1,216,250	BGD	3	15	46.0 - 48.0
Keta Creek Hatchery	1	1.70	FCS	600,000	BGD	3	15	43.0
Pendillis Creek NFH	2	1.8 - 2.9	LAT	497,000	BGD	3	15	52.0 - 56.0
Wolf Lake SFH	1	2.50	NOP	21,436	Branchiomyces	3	15	56.0
Alchesay-Williams Creek NFH	5	3.4 - 5.7	RBT	588,754	BGD	3	15	52.0 - 64.0
Chelan SFH	1	4.70	RBT	173,213	BGD	3	15	56.0
Darrag Springs SFH	1	2.50	RBT	80,000	BGD	3	15	59.0
Garrison Dam NFH	1	1.60	RBT	150,000	BGD	3	15	55.0
Idaho Trout Company	34	0.8 - 8.9	RBT	2,194,457	BGD	3	15	56.3 - 59.0
Mossyrock SFH	1	6.50	RBT	45,700	External Flavobacteriosis	3	15	52.0
Pequest SFH	1	3.40	RBT	80,000	BGD	3	15	50.0
Thompson SFH	1	3.91	RBT	67,381	BGD	3	15	48.0
Bodine SFH	5	1.5 - 2.0	STT	657,743	BGD	3	15	54.0

Table 1. Summary of Year 2005 Chloramine-T Efficacy Results - Efficacious Studies - cont.

Hatchery	Number of efficacious trials	Fish Size (in.)	Fish Species	Number of Fish	Disease	Number of treatment days	Dose (mg/L)	Temp. (ºF)
Mixsawbah SFH	3	2.4 - 3.7	STT	398,210	BGD	3	15	51.0 - 52.0
Thompson SFH	6	1.7 - 2.4	STT	772,378	BGD	3	15	56.0 - 57.0
Wells SFH	1	32.00	STT	483	Columnaris	3	15	52.0
Pendills Creek NFH	2	2.2 - 2.7	LAT	382,000	BGD	4	15	53.0 - 55.0
Genoa NFH	1	1.50	LST	42,000	Columnaris	5	15	68.0
Wells SFH	2	32.00	STT	479	Columnaris	5	15	52.0
Sun River Cutthroat Hatchery	1	1.75	CUT	588	BGD	6	15	49.0
Pendills Creek NFH	1	3.22	LAT	195,000	BGD	6	15	56.0
Jordan River NFH	1	1.65	LAT	3,300,000	BGD	8	15	48.0
Wolf Lake SFH	1	2.00	MUE	58,000	Branchiomyces	10	15	67.0
London SFH	1	2.50	BNT	84,000	BGD	11	15	55.0
Eastbank SFH	1	38.00	SCS	284	Columnaris	12	15	54.9
London SFH	1	0.75	MUE	42,000	BGD	14	15	68.0
	1	2.50	RBT	141,000	BGD	14	15	55.0
Genoa NFH	1	8.00	CCF	280	Columnaris	19	15	53.0

Table 1. Summary of Year 2005 Chloramine-T Efficacy Results - Efficacious Studies - cont.

Hatchery	Number of efficacious trials	Fish Size (in.)	Fish Species	Number of Fish	Disease	Number of treatment days	Dose (mg/L)	Temp. (°F)
Eastbank SFH	1	38.00	SUS	1,057	Columnaris	20	15	54.9
Genoa NFH	1	1.50	LMB	16,000	Columnaris	3	20	70.0
Hackettstown SFH	1	7.80	MUE	9,000	Columnaris	3	20	68.0
	1	2.00	MUH	7,500	BGD	3	20	69.0
	2	2.1 - 2.6	NOP	9,700	BGD	3	20	69.0
Alsea SFH	2	5.8 - 7.1	RBT	89,000	BGD	3	20	55.0
Sawtooth SFH	1	3.24	SOS	39,660	BGD	3	20	46.0
Alsea SFH	3	3.9 - 4.4	STT	258,000	BGD	3	20	55.0 - 60.0
Trask SFH	2	2.00	STT	52,000	BGD	3	20	56.0

Table 2. Summary of Year 2005 Chloramine-T Efficacy Results - Ineffective Studies

Hatchery	Number of non-efficacious trials	Fish Size (in.)	Fish Species	Number of Fish	Disease	Number of treatment days	Dose (mg/L)	Temp. (°F)
Hayspur SFH	1	10.37	CUT	1,742	BGD	3	10	52.0
Kincaid SFH	1	.79	SNS	6,879	BGD	3	10	67.1
South Santiam SFH	1	4.50	CKS	38,000	BGD	3	20	43.0

Table 3. Summary of Year 2005 Chloramine-T Efficacy Results - Inconclusive Studies

Hatchery	Number of inconclusive trials	Fish Size (in.)	Fish Species	Number of Fish	Disease	Number of treatment days	Dose (mg/L)	Temp. (°F)
Dworshak NFH	1	1.5	STT	18,000	BGD	1	6	54.0
Pittsford NFH	1	3	ATS	86,000	BGD	3	15	34.0
London SFH	1	2.60	BNT	24,000	BGD	3	15	52.0
Wolf Lake SFH	1	2.00	MUE	58,000	Branchiomyces	3	15	67.0
Lonesome Creek Hatchery	4	1.3 - 2.1	STT	534,982	CWD	3	15	47.0 - 50.0
Genoa NFH	1	4.80	SMB	2,500	Columnaris	3	20	53.0

Table 4. Summary of Year 2005 Chloramine-T Efficacy Results -Studies where efficacy data was not needed

Hatchery	Number of trials where mortality was not needed	Fish Size (in.)	Fish Species	Number of Fish	Disease	Number of treatment days	Dose (mg/L)	Temp. (°F)
Jones Hatchery	5	5.4 - 12.7	RBT	175,000	BGD	3	20	59.0

Table 5. Summary Data Regarding Year 2005 Chloramine-T Efficacy Studies

Total Number of Fish Treated:	**18,763,087**
Number of fish treated in efficacious studies	18,763,087
Number of fish treated in non-efficacious studies	46,621
Number of fish treated in inconclusive studies	723,482
Number of fish where efficacy was not needed	175,000
Total Number of Studies:	**135**
Rearing Units in Efficacious Studies	118
Rearing Units in Non-efficacious Studies	3
Rearing Units in Inconclusive Studies	9
Rearing Units where efficacy was not needed	5

Treatment Regimens and Frequency Used:

6 mg/L - one time	1 trial
10 mg/L - three times	8 trials
12 mg/L - two times	2 trials
12 & 15mg/L - three times	1 trial
15 mg/L - one time	4 trials
15 mg/L - two times	1 trial
15 mg/L - three times	83 trials
15 mg/L - four times	2 trials
15 mg/L - five times	3 trials
15 mg/L - six times	2 trials
15 mg/L - eight times	1 trial
15 mg/L - ten times	1 trial
15 mg/L - eleven times	1 trial
15 mg/L - twelve times	1 trial
15 mg/L - fourteen times	2 trials
15 mg/L - nineteen times	1 trial
15 mg/L - twenty times	1 trial
20 mg/L - three times	20 trials

Treatment Water Temperature (^{o}F):

Temperature Range	34.0 - 70.0
Mean Temperature	55.2

Size of Treated Fish (in.):

Size Range	0.75 - 38.0
Mean Length	4.5

Species Treated:

Salmonids:
Atlantic salmon *Salmo salar*
brown trout *S. trutta*
apache trout *Oncorhynchus apache*
chinook salmon *O. tshawytscha*
chum salmon *O. keta*
coho salmon *O. kisutch*
sockeye salmon *O. nerka*
cutthroat trout *O. clarki*
rainbow trout *O. mykiss*
steelhead trout *O. mykiss*
brook trout *Salvelinus fontinalis*
lake trout *Salvelinus namaycush*

Non-salmonids:
channel catfish *Ictalurus punctatus*
lake sturgeon *Acipenser fulvescens*
largemouth bass *Micropterus salmoides*
smallmouth bass *M. dolomieu*
muskie *Esox masquinongy*
northern pike *E. lucius*
tiger musky *E. lucius x E. masquinongy*
shovelnose sturgeon *Scaphirhynchus platorynchus*
