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DEPARTMENT OF FISH AND GAME

HAZARD ASSESSMENT OF THE RICE HERBICIDES MOLINATE AND THIOBENCARB TO AQUATIC ORGANISMS IN THE SACRAMENTO RIVER SYSTEM

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PREFACE

The California Department of Fish and Game (CDFG) is exclusively responsible for fish and wildlife management programs in California and is the principal agency responsible for the protection of fish and wildlife. The CDFG protects fish and wildlife from damage caused by pesticides through consultation as a member on the mandated California Department of Food and Agriculture (CDFA) Pesticide Registration and Evaluation Committee and Pesticide Advisory Committee and through two memoranda of understanding with CDFA for investigations of fish and wildlife losses and protection of threatened and endangered species. In recognition of the need for applicable environmental standards for fish and wildlife, CDFA contracted with CDFG for the development of water quality criteria for pesticides which will protect fish and wildlife. This document is the first in a series of hazard assessments for pesticides which recommends conditions and studies necessary for the protection of fish and wildlife.

Hazard Assessment of the Rice Herbicides Molinate and Thiobencarb to Aquatic Organisms in the Sacramento River System[1,2]

by

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SUMMARY

Water quality criteria for the rice herbicides molinate (Ordram[R]) and thiobencarb (Bolero[R]) were developed for California's Sacramento River System. The discharge of rice herbicides into the Sacramento-San Joaquin Estuary lasts for 45 to 60 days from May through June. Seventy laboratory toxicity studies on the acute and chronic effects of molinate and thiobencarb to aquatic organisms were reviewed and evaluated. Procedures for evaluating data and determining water quality criteria are described.

The hazard assessment procedure was used to determine the effectiveness of the water quality criteria in protecting sensitive aquatic organisms in the Sacramento-San Joaquin Estuary. The hazard assessment procedure is a reiterative process by which new data are evaluated to refine water quality criteria. New criteria can be generated when more toxicity data become available on native species.

Fifty of the studies reviewed were determined acceptable for use in deriving water quality criteria. The Final Acute Values (FAV) for molinate and thiobencarb were 2.4 mg/L and 247 ug/L, respectively. The Final Chronic Values (FCV) for molinate and thiobencarb were 52 ug/L and 16 ug/L, respectively. The most sensitive species was the native California mysid *Neomysis mercedis* with 42-d no observable effect concentration (NOEC) values of 26 ug/L molinate and 6.2 ug/L thiobencarb. To protect this important species in the Sacramento-San Joaquin Estuary, the water quality criteria were lowered to 26 ug/L for molinate and 6.2 ug/L for thiobencarb; these concentrations are 50% and 61% lower than the calculated FCV. Molinate and thiobencarb in a

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mixture have simple additive toxicity. Therefore, the criteria were lowered further to one-half because the two herbicides are usually always present together, yielding the recommended criteria of 13 ug/L for molinate and 3.1 ug/L for thiobencarb. The recommended water quality criteria represent absolute maximum rather than average values. Maximum concentrations of rice herbicides are approximately twice the average concentrations and thus, provide for a two-fold margin of safety.

The recommended water quality criteria of 13 ug/L for molinate and 3.1 ug/L for thiobencarb indicate a current hazard to the mysid may exist in the agricultural drains but not in the Sacramento River. However, the mysid does not inhabit the agricultural drains. Concentrations of molinate and thiobencarb have steadily declined in recent years to levels well below those recorded in the early 1980's (highest recorded concentrations were 340 ug/L molinate and 60 ug/L thiobencarb in the drains and 27 ug/L molinate and 6 ug/L thiobencarb in the Sacramento River). Since 1986, concentrations have not exceeded 77 ug/L molinate and 7.4 ug/L thiobencarb in the drains and 11 ug/L molinate and 1.2 ug/L in the Sacramento River.

Chronic toxicity levels are the most critical values used for determining water quality criteria. This is especially true because the criteria were lowered to protect the important native mysid *Neomysis mercedis*. These data came from partial life-cycle tests done prior to the development of standardized test procedures for mysids. Therefore, additional chronic tests with *Neomysis mercedis* are recommended for refining the criteria for the Sacramento River.

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INTRODUCTION

For the past decade there has been concern over the hazard of rice herbicides molinate and thiobencarb to aquatic organisms in the Sacramento River system. Recently, the hazard assessment procedure was used to determine the hazard of rice herbicides to organisms in the Sacramento River system (Faggella and Finlayson 1987). The hazard assessment procedure compares estimated or measured environmental concentrations with toxic effects likely to result from those exposures. Environmental concentrations are determined through monitoring programs or prediction modeling based on the physicochemical properties of the substance. The toxicity of the substance is determined by tests listed in the published literature and public and corporate laboratory reports. Corporate laboratory reports were obtained through California Department of Food and Agriculture (CDFA) confidential files which are submitted to U.S. Environmental Protection Agency (EPA) in support of pesticide registration. These tests must follow stringent pesticide assessment guidelines established by the EPA (1988).

Considerable information has been collected on the concentrations of molinate and thiobencarb in the Sacramento River system (Finlayson and Lew 1983a; 1983b; 1984; 1985; 1986; Harrington and Lew 1989). Considerable information also exists on the toxicity of molinate and thiobencarb to aquatic organisms. This report evaluates the available toxicity data on molinate and thiobencarb and determines water quality criteria for the protection of aquatic organisms.

METHODS

The water quality criteria presented in this report were determined using a procedure modified from guidelines developed by the U.S. Environmental Protection Agency (EPA) (Stephan et al. 1985). All acceptable acute and chronic toxicity data on freshwater and saltwater organisms were used in determining a Final Acute Value (FAV), Final Chronic Value (FCV) and Final Plant Value (FPV). The water quality criteria were then derived from the lowest of these three values. Bioaccumulation of these herbicides were not considered important in deriving the criteria because of their relatively short half-lives and low residue values in fish from agricultural drains (Finlayson and Lew 1983(a), 1983(b), 1984, 1985, 1986; Harrington and Lew 1989). The EPA method allows for the criteria to be lowered further to protect important sensitive species.

Final Acute Value (FAV) was derived using the following procedure:

1. The Species Mean Acute Value (SMAV) was calculated for each species for which at least one acute value was available as the geometric mean of the results of all acceptable toxicity tests. (Note: When one or more life stages were available for the same species, the data for the more sensitive life stages were used in calculating the SMAV. Acute values that appeared to be questionable [i.e., differ by more than a factor of 10 in comparison with other acute data for the

same species and for other species in the same genus] were not used in calculating the SMAV).

2. The Genus Mean Acute Value (GMAV) was calculated for each genus for which one or more SMAV's were available as the geometric mean of the SMAV's available for the genus. (Note: rainbow trout and chinook salmon were considered separate genera in calculation of GMAV's even though the genus name for rainbow trout and steelhead was recently changed from *Salmo* to *Oncorhynchus*.

3. The GMAV's were ranked (R) from "1" for the lowest to "N" for the highest. (Note: GMAV's were arbitrarily assigned successive ranks when two or more were identical).

4. The cumulative probability (P) was calculated for each GMAV as R/(N+1).

5. The four GMAV's which had cumulative probabilities closest to 0.05 were selected (Note: When there are less than 59 GMAV's, these will always be the four lowest GMAV's).

6. The FAV was calculated using the selected GMAV's and P's, as:

$$S^2 = \frac{\Sigma((\ln GMAV)^2)-((\Sigma(\ln GMAV))^2/4)}{\Sigma(P) - ((\Sigma(\sqrt{P}))^2/4)}$$

$$L = (\Sigma(\ln GMAV) - S(\Sigma\sqrt{P}))/4$$

$$A = S(\sqrt{0.05}) + L$$

$$FAV = e^A$$

Final Chronic Value (FCV) could not be calculated using the same procedure as described for the FAV because of limited chronic data. The FCV was derived using the following procedure:

1. Chronic values were obtained by calculating the geometric mean of the NOEC and the LOEC from an acceptable chronic toxicity tests.

2. The Acute-Chronic Ratio (ACR) was calculated for each chronic value for which at least one corresponding appropriate acute value was available using for the numerator the geometric mean of the results of all acceptable acute tests. Whenever possible, the acute test(s) should have been part of the same study as the chronic test.

3. The species mean ACR was calculated for each species as the geometric mean of all ACR's available for that species.

4. The Final ACR was calculated as the geometric mean of all the species mean ACR's available for both freshwater and saltwater species.

5. The FCV was calculated by dividing the FAV by the Final ACR.

Final Plant Value (FPV) was derived using the following procedure:

1. A plant value should be the result of a 96-hour test conducted with an algae or a chronic test conducted with an aquatic vascular plant. (Note: Standardized testing procedures have not been established for algae or aquatic vascular plants, therefore all test durations were considered.)

2. The FPV was obtained by selecting the lowest result from a test with an important aquatic plant species in which the endpoint was biologically important.

For this report, seventy available studies on the acute and chronic toxicity of molinate and thiobencarb to aquatic organisms were assessed for their acceptability in determining water quality criteria. Procedures used in the studies to generate these indices were evaluated for conformity with accepted test standards and guidelines. Criteria for evaluating these procedures were derived from those used by EPA and outlined by the American Society for Testing and Materials (ASTM). California Department of Fish and Game (CDFG) summarized these criteria in a working format for use in this report and future hazard assessments (Appendix A).

The criteria for acute and chronic toxicity tests were divided into six categories (Appendix A): (i) test method; (ii) test type; (iii) test species; (iv) water quality maintenance and monitoring; (v) toxicant maintenance and monitoring; and (vi) test design. Within each category as many as nine criteria were used to evaluate test procedures. While it was not necessary to comply with every criterion, studies were rejected if they failed certain fundamental procedures such as maintaining proper survival of organisms in a control treatment and testing with disease and stress free organisms. Studies were also rejected if they had incomplete reports or demonstrated system instability.

ACUTE TOXICITY TO AQUATIC ANIMALS

Accepted Data

Forty-nine studies on the acute toxicity of molinate and thiobencarb to aquatic animals were evaluated for acceptability in deriving the FAV (Appendix B). Thirty-five of these studies were assessed as acceptable according to CDFG guidelines (Appendix A); unacceptable values are tabulated (Tables B.1, B.2, and B.3).

Acceptable acute values for molinate (Table 1) were available for 13 freshwater and one saltwater species and ranged from a 96-h LC_{50} of 42.8 mg/L for juvenile common carp *Cyprinus carpio* (Union Carbide 1978) to 1.3 mg/L for the juvenile mysid *Neomysis mercedis* (Faggella and Finlayson 1988). Woodard (1965) reported a 96-h LC_{50} of 1.3 mg/L for rainbow trout *Oncorhynchus mykiss* which was not used in calculating the FAV because it was lower by a factor of 10 than the other values for this species.

Acceptable acute values for thiobencarb (Table 2) were available for 12 freshwater and seven saltwater species and ranged from 6,500 ug/L for red crayfish *Procambarus clarki* (Sanders and Hunn 1982) to 101 ug/L for first instar *Daphnia magna* (Wheeler 1978b). Bailey (1984a) reported a 96-h LC_{50} of 26.6 ug/L for the mysid *Neomysis mercedis* which was not used in calculating the FAV because it was much lower (by more than a factor of 10) than the other four values reported for this species including a value

Table 1. Acceptable values for acute toxicity of molinate to aquatic animals

Species	Life Stage	Method[a]	Formulation	Salinity/ Hardness	Test Length	Effect	Values (mg/L) (95% confidence limits)	Reference
Rainbow trout <u>Oncorhynchus</u> <u>mykiss</u>	juvenile	F, M	Tech (97.6%)	---	96-h	LC_{50}	13.0 (10.6-15.7)	ICI 1988b
Rainbow trout <u>Oncorhynchus</u> <u>mykiss</u>	juvenile	S, U	Tech (99%)	35 mg/L $CaCO_3$	96-h	LC_{50}	7.0(5.2-9.3)	Bionomics EG&G Inc 1970
Steelhead <u>Oncorhynchus</u> <u>mykiss</u>	juvenile	F, M	Ordram® 8EC (90.3%)	20-21 mg/L $CaCO_3$	96-h	LC_{50}	14.0(4.7-23.3)	Finlayson and Faggella 1986
Chinook salmon <u>Oncorhynchus</u> <u>tshawytscha</u>	juvenile	F, M	Ordram® 8EC (90.3%)	20-21 mg/L $CaCO_3$	96-h	LC_{50}	13.0(10.8-15.2)	Finlayson and Faggella 1986
Striped bass <u>Morone</u> <u>saxatilis</u>	13-d old	F, M	Ordram® 8EC (90.3%)	1.7 ‰	96-h	LC_{50}	10.0(9.7-11.0)	Faggella and Finlayson 1988
Striped bass <u>Morone</u> <u>saxatilis</u>	15-d old	F, M	Ordram® 8EC (90.3%)	439 mg/L $CaCO_3$ 1.7 ‰	96-h	LC_{50}	8.8(8.1-9.7)	Faggella and Finlayson 1988
Striped bass <u>Morone</u> <u>saxatilis</u>	juvenile	F, M	Ordram® 8EC (90.3%)	20-21 mg/L $CaCO_3$	96-h	LC_{50}	8.1(6.4-9.3)[b] 12(8.4-15.6)[c]	Finlayson and Faggella 1986
Striped bass <u>Morone</u> <u>saxatilis</u>	6-d old	F, M	Ordram® 8EC (90.3%)	2.0 ‰	96-h	LC_{50}	6.6(6.1-7.1)	Faggella and Finlayson 1987
Striped bass <u>Morone</u> <u>saxatilis</u>	24-d old	F, M	Ordram® 8EC (90.3%)	2.1 ‰	96-h	LC_{50}	7.9(7.1-8.7)	Faggella and Finlayson 1987
Striped bass <u>Morone</u> <u>saxatilis</u>	90-d old	F, M	Ordram® 8EC (90.3%)	20-21 mg/L $CaCO_3$	96-h	LC_{50}	14.0(13.0-15.0)	Faggella and Finlayson 1987
Bluegill <u>Lepomis</u> <u>macrochirus</u>	juvenile	F, M	Tech (97.6%)	---	96-h	LC_{50}	24.7(20.7-29.2)	ICI 1988c
Bluegill <u>Lepomis</u> <u>macrochirus</u>	juvenile	S, U	Tech (99%)	35 mg/L $CaCO^3$	96-h	LC_{50}	18.8(16.7-21.1)	Bionomics EG&G Inc 1970

Table 1. continued ...

Species	Life Stage	Method[a]	Formulation	Salinity/ Hardness	Test Length	Effect	Values (mg/L) (95% confidence limits)	Reference
Bluegill <u>Lepomis macrochirus</u>	juvenile	S, U	Tech (97.8%)	48 mg/L $CaCO_3$	96-h	LC_{50}	29.0(20.4-39.7)	Woodard Research Corp. 1965
Channel catfish <u>Ictalurus punctatus</u>	juvenile	F, M	Ordram® 8EC (90.3%)	20-21 mg/L $CaCO_3$	96-h	LC_{50}	34.0(20.0-48.0)	Finlayson and Faggella 1986
Channel catfish <u>Ictalurus punctatus</u>	6-wk old	S, U	Tech (98.3%)	22mg/L $CaCO_3$	96-h	LC_{50}	33.2(31.8-35.0)[d] 29.4(19.7-46.4)[e]	Brown et al. 1979
White sturgeon <u>Acipenser transmontanus</u>	23-d old	F, M	Tech (--)	32 mg/L $CaCO_3$	96-h	LC_{50}	18.4(14.4-26.9)	Bailey 1985c
Waterflea <u>Daphnia magna</u>	1st instar	F, M	Tech (97.6%)	---	48-h	EC_{50}	14.9	ICI 1988a
Waterflea <u>Daphnia magna</u>	1st instar	F, M	Tech (--)	52 mg/L $CaCO_3$	48-h	LC_{50}	19.4(15.7-24.4)	Union Carbide 1977
Mysid <u>Neomysis mercedis</u>	juvenile	F, M	Ordram® 8EC (90.3%)	138 mg/L $CaCO_3$	96-h	LC_{50}	1.3(1.0-1.7)	Faggella and Finlayson 1988
Mysid <u>Neomysis mercedis</u>	---	F, M	Tech (--)	2.5 °/oo	96-h	LC_{50}	9.9(7.7-13.6)	Bailey 1985a
Mysid <u>Neomysis mercedis</u>	28-d old	F, M	Ordram® 8EC (90.3%)	224 mg/L $CaCO_3$	96-h	LC_{50}	1.3(1.1-1.6)	Faggella et al. 1990
Mysid <u>Neomysis mercedis</u>	juvenile	F, M	Ordram® 8EC (90.3%)	225 mg/L $CaCO_3$	96-h	LC_{50}	2.3(2.1-2.6)	Faggella et al. 1990
Red swamp crayfish <u>Procambarus clarki</u>	immature	S, U	---	4 mg/L	96-h	LC_{50}	14.0(11.0-16.0)	Cheah et al. 1980
Pacific oyster <u>Crassostrea gigas</u>	embryo	S, M	Tech (97.6%)	33.7 °/oo	48-h	EC_{50}	38.0(35.0-41.0)	Thompson et al. 1988
Fathead minnow <u>Pimephales promelas</u>	juvenile	S, U	Tech (99%)	35 mg/L $CaCO_3$	96-h	LC_{50}	26(20.5-32.9)	Bionomics EG&G 1970
Common carp <u>Cyprinus carpio</u>	juvenile	S, U	Tech (97.8%)	46 mg/L $CaCO_3$	96-h	LC_{50}	42.8	Union Carbide 1978

Table 1. continued ...

Species	Life Stage	Method[a]	Formulation	Salinity/ Hardness	Test Length	Effect	Values (mg/L) (95% confidence limits)	Reference
Goldfish <u>Carrassius auratus</u>	juvenile	S, U	Tech (97.8%)	48 mg/L $CaCO_3$	96-h	LC_{50}	30.0(16.2-55.5)	Woodard Research Corp. 1965
Fowler's toad <u>Bufo woodhousii fowlerii</u>	4 to 5-wk old tadpole	S, U	Tech (--)	---	96-h	LC_{50}	14.0(4.2-36)	Sanders 1970a

[a] S = static, F = flow through, M = measured concentration, U = unmeasured concentration
[b] 17°C
[c] 12°C
[d] bioassay using tap water
[e] bioassay using paddy water

Table 2. Acceptable values for acute toxicity of thiobencarb to aquatic animals.

Species	Life Stage	Method[a]	Formulation	Salinity/ Hardness	Test Length	Effect	Values (ug/L) (95% confidence limits)	Reference
Rainbow trout *Oncorhynchus mykiss*	juvenile	S, M	Bolero® 10G (10%)	45 mg/L $CaCO_3$	96-h	LC_{50}	1500(1200-1900)	Thompson 1980a
Rainbow trout *Oncorhynchus mykiss*	juvenile	S, U	Bolero® 8EC (85.2%)	40 mg/L $CaCO_3$	96-h	LC_{50}	1200(700-1600)	Sanders and Hunn 1982
Steelhead *Oncorhynchus mykiss*	juvenile	F, M	Bolero® 8EC (85.2%)	20-21 mg/L $CaCO_3$	96-h	LC_{50}	790(680-900)	Finlayson and Faggella 1986
Chinook Salmon *Oncorhynchus tshawytscha*	juvenile	F, M	Bolero® 8EC (85.2%)	20-21 mg/L $CaCO_3$	96-h	LC_{50}	760(390-1100)	Finlayson and Faggella 1986
Striped bass *Morone saxatilis*	juvenile	F, M	Bolero® 8EC (85.2%)	20-21 mg/L $CaCO_3$	96-h	LC_{50}	760(620-900)	Finlayson and Faggella 1986
Striped bass *Morone saxatilis*	15-d old	F, M	Bolero® 8EC (85.2%)	472 mg/L $CaCO_3$ 1.7 °/oo	96-h	LC_{50}	920(830-1000)	Faggella and Finlayson 1988
Striped bass *Morone saxatilis*	12-d old	F, M	Bolero® 8EC (85.2%)	382 mg/L $CaCO_3$ 1.7 °/oo	96-h	LC_{50}	910(830-1000)	Faggella and Finlayson 1988
Striped bass *Morone saxatilis*	10-d old	F, M	Bolero® 8EC (85.2%)	431 mg/L $CaCO_3$ 1.7 °/oo	96-h	LC_{50}	480(440-530)	Faggella and Finlayson 1988
Striped bass *Morone saxatilis*	7-d old	F, M	Bolero® 8EC (85.2%)	471 mg/L $CaCO_3$ 1.7 °/oo	96-h	LC_{50}	570(500-650)	Faggella and Finlayson 1988
Striped bass *Morone saxatilis*	7-d old	F, M	Bolero® 8EC (85.2%)	2.5 °/oo	96-h	LC_{50}	720(660-780)	Chapman 1988
Striped bass *Morone saxatilis*	14-d old	F,M	Bolero® 8EC (85.2%)	2.5 °/oo	96-h	LC_{50}	1000(960-1100)	Chapman 1988
Striped bass *Morone saxatilis*	9-d old	F, M	Bolero® 8EC (85.2%)	131 mg/L $CaCO_3$	96-h	LC_{50}	440(400-500)	Faggella and Finlayson 1988
Striped bass *Morone saxatilis*	9-d old	F, M	Bolero® 8EC (85.2%)	332 mg/L $CaCO_3$ 1.7 °/oo	96-h	LC_{50}	840(740-950)	Faggella and Finlayson 1988
Striped bass *Morone saxatilis*	90-d old	F, M	Bolero® 8EC (85.2%)	20-21 mg/L $CaCO_3$	96-h	LC_{50}	670(600-750)	Faggella and Finlayson 1987

Table 2. continued...

Species	Life Stage	Method[a]	Formulation	Salinity/ Hardness	Test Length	Effect	Values (ug/L) (95% confidence limits)	Reference
Striped bass *Morone saxatilis*	43-d old	F, M	Bolero® 8EC (85.2%)	2.5 ‰	96-h	LC_{50}	880(830-940)	Chapman 1938
Striped bass *Morone saxatilis*	6-d old	F, M	Bolero® 8EC (85.2%)	491 mg/L $CaCO_3$	96-h	LC_{50}	1000 (870-1300)	Faggella et al. 1990
Striped bass *Morone saxatilis*	13-d old	F, M	Bolero® 8EC (85.2%)	454 mg/L $CaCO_3$	96-h	LC_{50}	830 (730-940)	Faggella et al. 1990
Striped bass *Morone saxatilis*	39-d old	F, M	Bolero® 8EC (85.2%)	360 mg/L $CaCO_3$	96-h	LC_{50}	760 (650-890)	Faggella et al. 1990
Striped bass *Morone saxatilis*	13-d old	F, M	Bolero® 8EC (85.2%)	490 mg/L $CaCO_3$	96-h	LC_{50}	640 (540-760)	Fujimura et al. (in press)
Striped bass *Morone saxatilis*	45-d old	F, M	Bolero® 8EC (85.2%)	396 mg/L $CaCO_3$	96-h	LC_{50}	770 (590-940)	Fujimura et al. (in press)
Striped bass *Morone saxatilis*	45-d old	F, M	Bolero® 8EC (85.2%)	379 mg/L $CaCO_3$	96-h	LC_{50}	690 (520-820)	Fujimura et al. (in press)
White sturgeon *Acipenser transmontanus*	28-d old	F, M	Tech (96.6%)	32 mg/L $CaCO_3$	96-h	LC_{50}	260(230-300)	Bailey 1985c
Bluegill *Lepomis macrochirus*	juvenile	S, U	Bolero® 8EC (85.2%)	40 mg/L $CaCO_3$	96-h	LC_{50}	1700(1200-2300)	Sanders and Hunn 1982
Bluegill *Lepomis macrochirus*	juvenile	S, M	Bolero® 10G (10%)	45 mg/L $CaCO_3$	96-h	LC_{50}	560(330-1200)	Thompson 1980b
Channel catfish *Ictalurus punctatus*	juvenile	F, M	Bolero® 8EC (85.2%)	20-21 mg/L $CaCO_3$	96-h	LC_{50}	1800	Finlayson and Faggella 1986
Channel catfish *Ictalurus punctatus*	juvenile	S, U	Bolero® 8EC (85.2%)	40 mg/L $CaCO_3$	96-h	LC_{50}	2300(1200-4400)	Sanders and Hunn 1982
Mosquitofish *Gambusia affinis*	adult	S, M	Tech (94.5%)	---	96-h	LC_{50}	3100(2590-3710)	Schaefer et al. 1982

Table 2. continued...

Life Species	Stage	Method[a]	Salinity/ Formulation	Test Hardness	Length	Effect	Values (ug/L) (95% confidence limits)	Reference
Mosquitofish *Gambusia affinis*	adult	S, M	Bolero® 8EC (85.5%)	---	96-h	LC_{50}	2600(2390-2780)	Schaefer et al. 1982
Mosquitofish *Gambusia affinis*	adult	F, M	Bolero® 8EC (85.5%)	---	96-h	LC_{50}	1300(1170-1580)	Schaefer et al. 1982
Waterflea *Daphnia magna*	1st instar	S, M	Bolero® 8EC (85.2%)	40 mg/L $CaCO_3$	48-h	LC_{50}	211(176-253)	Wheeler 1978a
Waterflea *Daphnia magna*	1st instar	S, M	Tech (94.4%)	40 mg/L $CaCO_3$	48-h	LC_{50}	101(74-139)	Wheeler 1978b
Waterflea *Daphnia magna*	1st instar	S, U	Bolero® 8EC (85.5%)	40 mg/L $CaCO_3$	48-h	EC_{50}	1200(400-3100)	Sanders and Hunn 1982
Waterflea *Daphnia magna*	adult	S, M	Bolero® 10G (10%)	45 mg/L $CaCO_3$	48-h	LC_{50}	1200(1100-1900)	Thompson 1980c
Waterflea *Daphnia magna*	adult	S, M	Tech (100%)	45 mg/L $CaCO_3$	48-h	EC_{50}	460(390-540)	Thompson 1980c
Amphipod *Gammarus pseudolimnaeous*	mature	S, U	Bolero® 8EC (85.2%)	40 mg/L $CaCO_3$	48-h	LC_{50}	1000(600-1700)	Sanders and Hunn 1982
Crayfish *Orconectes nais*	juvenile	S, U	Bolero® 8EC (85.5%)	40 mg/L $CaCO_3$	96-h	LC_{50}	2000(1400-3600)	Sanders and Hunn 1982
Red Crayfish *Procambarus clarki*	mature	S, U	Bolero® 8EC (85.5%)	40 mg/L $CaCO_3$	96-h	LC_{50}	6500(5700-7100)	Sanders and Hunn 1982
Mysid *Neomysis mercedis*	juvenile	F, M	Bolero® 8EC (85.2%)	139 mg/L $CaCO_3$	96-h	LC_{50}	300(250-390)	Faggella and Finlayson 1988
Mysid *Neomysis mercedis*	---	F, M	Tech (--)	2.5 ‰	96-h	LC_{50}	304(137-675)	Bailey 1985a
Mysid *Mysidopsis bahia*	1-d old	S, U	Tech (95.5%)	20 ‰	96-h	LC_{50}	370(317-433)	Borthwick and Walsh 1981
Mysid *Mysidposis bahia*	6 to 8-d old	S, U	Tech (100%)	30 ‰	96-h	LC_{50}	150(110-200)	Bionomics EG&G 1980

Table 2. continued...

Species	Life Stage	Method[a]	Formulation	Salinity/ Hardness	Test Length	Effect	Values (ug/L) (95% confidence limits)	Reference
Mysid *Mysidopsis bahia*	6 to 8-d old	F, M	Tech (95.1%)	25-28 °/oo	96-h	LC_{50}	288(237-356)	Bionomics EG&G 1979c
Tidewater silverside *Menidia peninsula*	1-d old	F, U	Tech (95.5%)	20 °/oo	96-h	LC_{50}	328(102-547)	Borthwick et al. 1985
Tidewater silverside *Menidia peninsula*	7-d old	F, U	Tech (95.5%)	20 °/oo	96-h	LC_{50}	383(344-850)	Borthwick et al. 1985
Tidewater silverside *Menidia peninsula*	14-d old	F, U	Tech (95.5%)	20 °/oo	96-h	LC_{50}	455(223-514)	Borthwick et al. 1985
Tidewater silverside *Menidia peninsula*	28-d old	F, U	Tech (95.5%)	20 °/oo	96-h	LC_{50}	865(415-∞)	Borthwick et al. 1985
Tidewater silverside *Menidia peninsula*	1-d old	S, U	Tech (95.5%)	20 °/oo	96-h	LC_{50}	560(257-750)	Borthwick et al. 1985
Tidewater silverside *Menidia peninsula*	7-d old	S, U	Tech (95.5%)	20 °/oo	96-h	LC_{50}	324(194-1500)	Borthwick et al. 1985
Tidewater silverside *Menidia peninsula*	14-d old	S, U	Tech (95.5%)	20 °/oo	96-h	LC_{50}	511(238-1100)	Borthwick et al. 1985
Tidewater silverside *Menidia peninsula*	28-d old	S, U	Tech (95.5%)	20 °/oo	96-h	LC_{50}	1405(450-2080)	Borthwick et al. 1985
Atlantic silverside *Menidia menidia*	1-d old	F, U	Tech (95.5%)	20 °/oo	96-h	LC_{50}	380(102-547)	Borthwick et al. 1985
Atlantic silverside *Menidia menidia*	7-d old	F, U	Tech (95.5%)	20 °/oo	96-h	LC_{50}	199(130-325)	Borthwick et al. 1985
Atlantic silverside *Menidia menidia*	14-d old	F, U	Tech (95.5%)	20 °/oo	96-h	LC_{50}	455(223-514)	Borthwick et al. 1985
Atlantic silverside *Menidia menidia*	28-d old	F, U	Tech (95.5%)	20 °/oo	96-h	LC_{50}	674(547-∞)	Borthwick et al. 1985

Table 2. continued...

Species	Life Stage	Method[a]	Formulation	Salinity/ Hardness	Test Length	Effect	Values (ug/L) (95% confidence limits)	Reference
Atlantic silverside *Menidia menidia*	1-d old	S, U	Tech (95.5%)	20 °/oo	96-h	LC_{50}	531(216-1000)	Borthwick et al. 1985
Atlantic silverside *Menidia menidia*	7-d old	S, U	Tech (95.5%)	20 °/oo	96-h	LC_{50}	400(194-1500)	Borthwick et al. 1985
Atlantic silverside *Menidia menidia*	14-d old	S, U	Tech (95.5%)	20 °/oo	96-h	LC_{50}	840(288-1200)	Borthwick et al. 1985
Atlantic silverside *Menidia menidia*	28-d old	S, U	Tech (95.5%)	20 °/oo	96-h	LC_{50}	703(0-1230)	Borthwick et al. 1985
California grunion *Leuresthes tenuis*	1-d old	F, U	Tech (95.5%)	25 °/oo	96-h	LC_{50}	267(235-310)	Borthwick et al. 1985
California grunion *Leuresthes tenuis*	7-d old	F, U	Tech (95.5%)	25 °/oo	96-h	LC_{50}	247(125-350)	Borthwick et al. 1985
California grunion *Leuresthes tenuis*	14-d old	F, U	Tech (95.5%)	25 °/oo	96-h	LC_{50}	386(220-755)	Borthwick et al. 1985
California grunion *Leuresthes tenuis*	28-d old	F, U	Tech (95.5%)	25 °/oo	96-h	LC_{50}	362(195-535)	Borthwick et al. 1985
California grunion *Leuresthes tenuis*	1-d old	S, U	Tech (95.5%)	20 °/oo	96-h	LC_{50}	269(170-700)	Borthwick et al. 1985
California grunion *Leuresthes tenuis*	7-d old	S, U	Tech (95.5%)	20 °/oo	96-h	LC_{50}	549(153-708)	Borthwick et al. 1985
California grunion *Leuresthes tenuis*	14-d old	S, U	Tech (95.5%)	20 °/oo	96-h	LC_{50}	660(0-1100)	Borthwick et al. 1985
California grunion *Leuresthes tenuis*	28-d old	S, U	Tech (95.5%)	20 °/oo	96-h	LC_{50}	522(325-977)	Borthwick et al. 1985
Sheepshead minnow *Cyprinodon variegatus*	28-d old	S, U	Tech (95.5%)	20 °/oo	96-h	LC_{50}	>1000	Borthwick and Walsh 1981
Sheepshead minnow *Cyprinodon variegatus*	juvenile	S, U	Tech (95.1%)	22 °/oo	96-h	LC_{50}	900(700-1200)	Bionomics EG&G 1979a

Table 2. continued...

Species	Life Stage	Method[a]	Formulation	Salinity/ Hardness	Test Length	Effect	Values (ug/L) (95% confidence limits)	Reference
Sheepshead minnow *Cyprinodon variegatus*	juvenile	S, U	Bolero® 8EC (85.2%)	22 °/oo	96-h	LC_{50}	1400(1100-1800)	Bionomics EG&G 1979b
Sheepshead minnow *Cyprinodon variegatus*	juvenile	F, M	Bolero® Tech (95.1%)	30 °/oo	96-h	LC_{50}	690(600-800)	Bionomics EG&G 1979g
Fiddler crab *Uca pugilator*	---	S, U	Bolero® 8EC (85.2%)	27 °/oo	96-h	LC_{50}	4400(3500-5800)	Bionomics EG&G 1979e
Eastern oyster *Crassostrea virginica*	<2-h old larvae	S, U	Tech (95.5%)	20 °/oo	48-h	EC_{50}	1000 < x < 10000	Borthwick and Walsh 1981
Eastern oyster *Crassostrea virginica*	larvae	S, U	Bolero® 8EC (85.2%)	26 °/oo	48-h	EC_{50}	320(200-510)	Bionomics EG&G 1979f
Eastern oyster *Crassostrea virginica*	larvae	S, U	Tech (95.1%)	26 °/oo	48-h	EC_{50}	560(230-1300)	Bionomics EG&G 1979d

[a] S = static, F = flow through, M = measured concentration, U = unmeasured concentration

reported by the same researcher a year later (Bailey 1985a). Acceptable acute values for mixtures of molinate and thiobencarb (Table 3) were available for five freshwater species and ranged from 18.0 (molinate) and 0.99 mg/L (thiobencarb) for juvenile channel catfish *Ictalurus punctatus* (Finlayson and Faggella 1986) to 0.19 (molinate) and 0.06 mg/L (thiobencarb) for 28-d old Mysid *Neomysis mercedis* (Faggella et al. 1990). In all studies on mixtures, molinate and thiobencarb had additive toxicity.

Technical and Formulated Toxicity

Comparison of toxicity data on technical molinate and thiobencarb and formulated products Ordram[R] and Bolero[R] did not show any systematic difference (Table 4). This could probably be attributed to the high percent of technical material (84 to 92%) in the commercial products.

Final Acute Values

There were twenty-eight acceptable acute values and fourteen Genus Mean Acute Values (GMAV) available for calculating the FAV for molinate (Table 5). The FAV for molinate based on acceptable data was 2.4 mg/L. There were seventy-three acceptable acute values and nineteen GMAV available for calculating the FAV for thiobencarb (Table 5). The FAV for thiobencarb based on acceptable data was 247 ug/L.

Table 3. Acceptable values for acute toxicity of molinate and thiobencarb mixtures to aquatic animals.

Species	Life Stage	Method[a]	Formulation	Salinity/ Hardness	Test Length	Effect	Values (mg/L) (95% confidence limits)	Reference
Steelhead *Oncorhynchus mykiss*	juvenile	F, M	Ordram^{R} (90.3%) Bolero^{R} (85.2%)	20-23 mg/L $CaCO_3$	96-h	LC_{50}	Mol. 6.8(2.7-11) Thio. 0.36(0.35-0.37)	Finlayson and Faggella 1986
Chinook salmon *Oncorhynchus tshawytscha*	juvenile	F, M	Ordram^{R} (90.3%) Bolero^{R} (85.2%)	20-23 mg/L $CaCO_3$	96-h	LC_{50}	Mol. 9.3(8.6-10) Thio. 0.43(0.40-0.46)	Finlayson and Faggella 1986
Channel catfish *Ictalurus punctatus*	juvenile	F, M	Ordram^{R} (90.3%) Bolero^{R} (85.2%)	20-23 mg/L $CaCO_3$	96-h	LC_{50}	Mol. 18 (13-23) Thio. 0.99(0.88-1.1)	Finlayson and Faggella 1986
Striped bass *Morone saxatilis*	6-d old	F, M	Ordram^{R} (90.3%) Bolero^{R} (85.2%)	2.0 ‰	96-h	LC_{50}	Mol. 3.8(3.5-4.2) Thio. 0.33(0.30-0.37)	Faggella and Finlayson 1987
Striped bass *Morone saxatilis*	13-d old	F, M	Ordram^{R} (90.3%) Bolero^{R} (85.2%)	1.6 ‰	96-h	LC_{50}	Mol. 3.0(2.7-3.3) Thio. 0.24(0.21-0.26)	Faggella and Finlayson 1987
Striped bass *Morone saxatilis*	24-d old	F, M	Ordram^{R} (90.3%) Bolero^{R} (85.2%)	2.1 ‰	96-h	LC_{50}	Mol. 3.1(2.6-3.6) Thio. 0.24(0.21-0.28)	Faggella and Finlayson 1987
Striped bass *Morone saxatilis*	90-d old	F, M	Ordram^{R} (90.3%) Bolero^{R} (85.2%)	20-23 mg/L $CaCO_3$	96-h	LC_{50}	Mol. 7.9(7.4-8.6) Thio. 0.52(0.49-0.56)	Faggella and Finlayson 1987
Striped bass *Morone saxatilis*	13-d old	F, M	Ordram^{R} (90.3%) Bolero^{R} (85.2%)	382 mg/L $CaCO_3$	96-h	LC_{50}	Mol. 4.5(3.4-5.8) Thio. 0.47(0.33-0.62)	Faggella and Finlayson 1988
Striped bass *Morone saxatilis*	15-d old	F, M	Ordram^{R} (90.3%) Bolero^{R} (85.2%)	421 mg/L $CaCO_3$	96-h	LC_{50}	Mol. 3.6(3.2-4.1) Thio. 0.23(0.21-0.26)	Faggella and Finlayson 1988
Striped bass *Morone saxatilis*	9-d old	F, M	Ordram^{R} (90.3%) Bolero^{R} (85.2%)	437 mg/L $CaCO_3$	96-h	LC_{50}	Mol. 6.4(5.4-7.1) Thio. 0.35(0.32-0.39)	Faggella and Finlayson 1988
Mysid *Neomysis mercedis*	---	F, M	Molinate Tech Thiobencarb Tech	2.5 ‰	96-h	LC_{50}	Mol. 4.6 Thio. 0.16	Bailey 1985a
Mysid *Neomysis mercedis*	28-d old	F, M	Ordram^{R} (90.3%) Bolero^{R} (85.2%)	245 mg/L $CaCO_3$	96-h	LC_{50}	Mol. 0.19(0.11-0.20) Thio. 0.06(0.04-0.07)	Faggella et al. 1990
Mysid *Neomysis mercedis*	juvenile	F, M	Ordram^{R} (90.3%) Bolero^{R} (85.2%)	233 mg/L $CaCO_3$	96-h	LC_{50}	Mol. 0.8(0.68-0.96) Thio. 0.17(0.14-0.20)	Faggella et al. 1990
Mysid *Neomysis mercedis*	juvenile	F, M	Ordram^{R} (90.3%) Bolero^{R} (85.2%)	244 mg/L $CaCO_3$	96-h	LC_{50}	Mol. 0.88(0.7-1.1) Thio. 0.18(0.16-0.22)	Faggella et al. 1990

[a] S = static, F = flow through, M = measured concentration, U = unmeasured concentration

Table. 4 Comparison of acceptable 96-h LC_{50} values for technical molinate and Ordram® 8EC and technical thiobencarb and Bolero® 8EC.

Molinate (mg/L)

Species	Technical	Reference	Formulated	Reference
Rainbow Trout *Oncorhynchus mykiss*	13.0 (97.6%) 7.0 (99%)	ICI 1988b Bionomics 1970	14.0 (90.3%)	Finlayson and Faggella 1986
Channel Catfish *Ictalurus punctatus*	33.2 (98.3%) 29.4 (98.3%)	Brown et al. 1979 Brown et al. 1979	34.0 (90.3%)	Finlayson and Faggella 1986
Mysid *Neomysis mercedis*	9.9 (Tech)	Bailey 1985a	1.3 (90.3%) 1.3 (90.3%) 2.3 (90.3%)	Faggella and Finlayson 1988 Faggella et al. 1990 Faggella et al. 1990

Thiobencarb (ug/L)

Species	Technical	Reference	Formulated	Reference
Waterflea *Daphina magna*	101 (94.4%)	Wheeler 1978b	211 (85.2%)	Wheeler 1978a
Mysid *Neomysis mercedis*	304 (Tech)	Bailey 1985a	300 (85.2%)	Faggella and Finlayson 1988
Sheepshead Minnow *Cyprinodon variegatus*	>1000 (95.5%) 900 (95.1%) 690 (85.2%)	Borthwick and Walsh 1981 Bionomics EG&G 1979c Bionomics 1979g	1400 (85.2%)	Bionomics 1979b
Eastern Oyster *Crassostrea virginica*	100< x <10,000 560 (95.1%)	Borthwick and Walsh 1981 Bionomics 1979d	320 (85.2%)	Bionomics 1979f

Table 5. Acceptable acute values used for calculating Final Acute Value (FAV) for molinate and thiobencarb

Molinate (mg/L)

Rank	Value	Species
14	42.8	Common carp *Cyprinus carpio*
13	38	Pacific oyster *Crassostrea gigas*
12	33.6	Channel catfish *Ictalurus punctatus*
11	30	Goldfish *Carassius auratus*
10	26	Fathead minnow *Pimephales promelas*
9	23.8	Bluegill *Lepomis macrochirus*
8	18.4	White sturgeon *Acipenser transmontanus*
7	17	Waterflea *Daphnia magna*

Thiobencarb (ug/L)

Rank	Value	Species
19	6500	Red Crayfish *Procambarus clarki*
18	4400	Fiddler crab *Uca pugilator*
17	2188	Mosquitofish *Gambusia affinis*
16	2035	Channel catfish *Ictalurus punctatus*
15	2000	Crayfish *Oroconectes nais*
14	1124	Rainbow trout *Oncorhynchus mykiss*
13	1000	Amphipod *Gammarus pseudolimnaeous*
12	966	Sheepshead minnow *Cyprinodon variegatus*
11	975	Bluegill *Lepomis macrochirus*

Table 5. continued ...

Molinate (mg/L)

Rank	Value	Species
6	14	Red swamp crawfish *Procambarus clarki*
5	14	Fowler's toad *Bufo woodhousii fowlerii*
4	13	Chinook Salmon *Oncorhynchus tshawytscha*
3	10.8	Rainbow trout *Oncorhynchus mykiss*
2	9.4	Striped bass *Morone saxatilis*
1	2.5	Mysid *Neomysis mercedis*

Thiobencarb (ug/L)

Rank	Value	Species
10	760	Chinook salmon *Oncorhynchus tshawytscha*
9	742	Waterflea (adult) *Daphnia magna*
8	739	Striped bass *Morone saxatilis*
7	507	Silversides *Menidia spp.*
6	423	Eastern oyster *Crassostrea virginica*
5	383	California grunion *Leutesthes tenuis*
4	302	Mysid *Neomysis mercedis*
3	295	Waterflea (1st instar) *Daphnia magna*
2	260	White sturgeon *Acienser transmontanus*
1	252	Mysid *Mysidopsis bahia*

CHRONIC TOXICITY TO AQUATIC ANIMALS

Accepted Data

Twenty studies on the chronic toxicity of molinate and thiobencarb to aquatic animals were evaluated for acceptability of data for use in deriving the FCV (Appendix C). Eleven of these studies were assessed as acceptable according to CDFG guidelines (Appendix A); unacceptable values are tabulated (Tables C.1 and C.2).

Acceptable chronic values for molinate (Table 6) were available for nine freshwater species and ranged from a 28-d NOEC of 6.05 mg/L for juvenile bluegill *Lepomis macrochirus* (Stauffer 1984a) to a 42-d NOEC of 0.026 mg/L for the mysid *Neomysis mercedis* (Bailey 1985b).

Acceptable chronic values for thiobencarb (Table 7) were available for four freshwater and one saltwater species of animals and ranged from a 44-d NOEC of 58 ug/L for larvae-to-fry striped bass *Morone saxatilis* (Faggella and Finlayson 1988) to a 42-d NOEC of 6.2 ug/L for the mysid *Neomysis mercedis* (Bailey 1985b).

Acceptable chronic values for mixtures of molinate and thiobencarb were available for three freshwater species of animals (Table 8) and ranged from a 44-d NOEC of 290 ug/L

Table 6. Acceptable values for chronic toxicity of molinate to aquatic animals.

Species	Life Stage	Method[a]	Formulation	Salinity/ Hardness	Test Length	Effect	Values (mg/L) (95% confidence limits)	Reference
Rainbow trout *Oncorhynchus mykiss*	egg-to-fry	F, M	Tech (--)	386 mg/L $CaCO_3$	60-d	NOEC LOEC	0.39 0.83	McAllister 1988
Chinook salmon *Oncorhynchus tshawytscha*	egg-to-fry	F, M	Ordram® 8EC (90.3%)	18-22 mg/L $CaCO_3$	90-d	LC_{50} NOEC LOEC	0.74(0.67-0.83) 0.42 0.73	Faggella and Finlayson 1988
Striped bass *Morone saxatilis*	larvae-to-fry	F, M	Ordram® 8EC (90.3%)	473 mg/L $CaCO_3$ 1.7 ‰	44-d	LC_{50} NOEC LOEC	0.64(0.59-0.70) 0.22 0.38	Faggella and Finlayson 1988
White sturgeon *Acipenser transmontanus*	75-d old	F, M	Tech (--)	33 mg/L $CaCO_3$	22-d	LC_{50}	2.7(2.1-3.3)	Bailey 1985c
Bluegill *Lepomis macrochirus*	juvenile	F, M	Ordram® 8EC (92.1%)	300 mg/L $CaCO_3$	28-d	NOEC	6.05	Stauffer 1984a
Channel catfish *Ictalurus punctatus*	juvenile	F, M	Ordram® 8EC (90.3%)	20-21 mg/L $CaCO_3$	28-d	NOEC LOEC	1.7 2.6	Finlayson and Faggella 1986
Channel catfish *Ictalurus punctatus*	adult	F, M	Ordram® 8EC (92.1%)	300 mg/L $CaCO_3$	28-d	LC_{50} NOEC LOEC	6.1(4.5-8.1) 0.9 1.6	Stauffer 1984b
Common carp *Cyprinus carpio*	juvenile	F, M	Ordram® 8EC (90.3%)	20-21 mg/L $CaCO_3$	28-d	LC_{50} NOEC LOEC	0.21 0.09 0.13	Finlayson and Faggella 1986
Mysid *Neomysis mercedis*	1 to 14-d old	F, M	Tech (--)	approx. 2.0-2.5 ‰	42-d	NOEC LOEC	0.026 0.045	Bailey 1985b
Waterflea *Daphia magna*	1st instar	F, M	Tech (--)	225-275 mg/L $CaCO_3$	21-d	NOEC LOEC	0.38 0.90	Forbis 1987

[a] S = static, F = flow through, M = measured concentration, U = unmeasured concentration

Table 7. Acceptable values for chronic toxicity of thiobencarb to aquatic animals.

Species	Life Stage	Method[a]	Formulation	Salinity/ Hardness	Test Length	Effect	Values (ug/L) (95% confidence limits)	Reference
Chinook salmon *Oncorhynchus tshawytscha*	eggs-to-fry	F, M	Bolero® 8EC (85.2%)	18-22 mg/L $CaCO_3$	60-d	LC_{50}	200(130-230)	Faggella and Finlayson 1988
Chinook salmon *Oncorhynchus tshawytscha*	eggs-to-fry	F, M	Bolero® 8EC (85.2%)	18-22 mg/L $CaCO_3$	90-d	NOEC LOEC	28 49	Faggella and Finlayson 1988
Striped bass *Morone saxatilis*	larvae-to-fry	F, M	Bolero® 8EC (85.2%)	454 mg/L $CaCO_3$	44-d	LC_{50} NOEC LOEC	130(120-150) 58 91	Faggella and Finlayson 1988
Striped bass *Morone saxatilis*	larvae-to-fry	F, M	Bolero® 8EC (85.2%)	478 mg/L $CaCO_3$	36-d	NOEC LOEC	<23 23	Fujimura et al. (in press)
Striped bass *Morone saxatilis*	eggs-to-fry	F, M	Bolero® 8EC (85.2%)	454 mg/L $CaCO_3$	46-d	NOEC LOEC	21 36	Fujimura et al. (in press)
White sturgeon *Acipenser transmontanus*	75-d old	F, M	Tech (--)	33 mg/L $CaCO_3$	21-d	LC_{50}	221(185-287)	Bailey 1985c
Mysid *Neomysis mercedis*	1 to 14-d old	F, M	Tech (--)	approx. 2.0 to 2.5 ‰	42-d	NOEC LOEC	6.2 13	Bailey 1985b
Mysid *Mysidopsis bahia*	24-48 hours old	F, M	Tech (95.2%)	16-26‰	28-d	NOEC LOEC	19 30	Bionomics EG&G 1979c

[a] S = static, F = flow through, M = measured concentration, U = unmeasured concentration

Table 8. Acceptable values for chronic toxicity of molinate and thiobencarb mixtures to aquatic animals.

Species	Life Stage	Method[a]	Formulation	Salinity/ Hardness	Test Length	Effect	Values (ug/L) (95% confidence limits)	Reference
Chinook salmon <u>Oncorhynchus tshawytscha</u>	eggs-to-fry	F, M	Ordram[R] 8EC (90.3%) Bolero[R] 8EC (85.2%)	18-22 mg/L $CaCO_3$	90-d	LC_{50} LC_{50} NOEC/LOEC NOEC/LOEC	Mol. 580(530-670) Thio. 36(32-43) Mol. 160/230 Thio. 9/13	Faggella and Finlayson 1988
Striped bass <u>Morone saxatilis</u>	larvae-to-fry	F, M	Ordram[R] 8EC (90.3%) Bolero[R] 8EC (85.2%)	430 mg/L $CaCO_3$	44-d	LC_{50} LC_{50} NOEC/LOEC NOEC/LOEC	Mol. 720(520-940) Thio. 49(36-62) Mol. 290/520 Thio. 20/36	Faggella and Finlayson 1988
Mysid <u>Neomysis mercedis</u>	---	F, M	Molinate Tech (-) Thiobencarb Tech (-)	---	18-d	LC_{50}	Mol. 290 Thio. 9	Bailey 1985a

[a] S = static, F = flow through, M = measured concentration, U = unmeasured concentration

molinate and 20 ug/L thiobencarb for larvae-to-fry striped bass *Morone saxatilis* to a 90-d NOEC of 160 ug/L molinate and 9 ug/L thiobencarb for eggs-to-fry chinook salmon *Oncorhynchus tshawytcha* (Faggella and Finlayson 1988).

Final Chronic Values

The ACR was used to determine the FCV for molinate and thiobencarb. The Final ACR of 45 for molinate was based on accompanying acute and chronic GMAV for six species (Table 9). The FCV for molinate based on acceptable data was 52 ug/L. The Final ACR of 16 for thiobencarb was based on accompanying acute and chronic GMAV for four species (Table 9). The FCV for thiobencarb based on acceptable data was 16 ug/L.

Table 9. Acute-chronic ratio using EPA methodology (Stephan 1985) for molinate and thiobencarb. Acute-chronic ratio based on those GMAV's for acceptable chronic values (Table 6 and 7) which have corresponding acceptable acute values (Table 1 and 2).

Species	Chronic Value	Acute Value	Acute/Chronic
	Molinate mg/L		
Striped bass	0.29	9.4	32
Rainbow trout	0.57	10.8	19
Channel catfish	1.6	34	21
Common carp	0.11	43	390
Mysid (N. mercedis)	0.034	2.5	74
Chinook salmon	0.55	13	24
		Geometric Mean	45
	Thiobencarb ug/L		
Chinook salmon	37.0	760	20
Striped bass	72.6	739	10
Mysid (N. mercedis)	8.9	302	34
Mysid (M. bahia)	23.9	252	10
		Geometric Mean	16

Table 10. Acceptable values for acute toxicity of thiobencarb to aquatic plants.

Species	Life Stage	Method[a]	Formulation	Salinity/ Hardness	Test Length	Effect	Values (mg/L) (95% confidence limits)	Reference
Algae <u>Skeletonema costatum</u>	---	S, U	Tech (95.5%)	30 °/oo	48-h	EC_{50}	459(327-692)	Borthwick and Walsh 1981
Algae <u>Skeletonema costatum</u>	---	S, U	Tech (95.5%)	30 °/oo	48-h	EC_{50}	410(368-461)	Borthwick and Walsh 1981
Algae <u>Skeletonema costatum</u>	---	S, U	Tech (95.5%)	30 °/oo	48-h	EC_{50}	327(290-368)	Borthwick and Walsh 1981
Algae <u>Skeletonema costatum</u>	---	S, U	Tech (95.5%)	30 °/oo	48-h	EC_{50}	377(326-439)	Borthwick and Walsh 1981
Algae <u>Skeletonema costatum</u>	---	S, U	Tech (95.5%)	30 °/oo	48-h	EC_{50}	389(338-452)	Borthwick and Walsh 1981
Algae <u>Chlorella pyrenoidosa</u>	---	S, U	Tech (--)	---	7-d	IL_{50} NOEC LOEC	1600 30 60	Yoo 1979

TOXICITY TO AQUATIC PLANTS

Three studies on the acute and chronic toxicity of thiobencarb (plant toxicity data was not available for molinate) to aquatic plants were evaluated for acceptability of data for use in deriving the FPV (Appendix B). Two studys were assessed as acceptable according to CDFG guidelines; unacceptable values are tabulated (Table B.4). Acceptable toxicity values for thiobencarb (Table 10) were available for two algal species, and ranged from 48-h EC_{50} of 459 to 327 ug/L based on growth inhibitions for *Skeletonema costatum* (Borthwick and Walsh 1981) to a NOEC of 30 ug/L based on maximum specific growth rate for *Chlorella pyrenoidosa* (Yoo 1979).

Final Plant Value

The FPV based on acceptable data was 30 ug/L for thiobencarb and could not be determined for molinate because there were no data available.

HAZARD ASSESSMENT

Water Quality Criteria

The most sensitive species tested was the mysid *Neomysis mercedis* with 42-d NOEC values of 26 ug/L for molinate and 6.2 ug/L for thiobencarb. This zooplankton serves as an important food item for many young fish including striped bass in the Sacramento-San Joaquin Estuary (Stevens et al. 1985; Knutson and Orsi 1983). To protect this important native species in the Sacramento-San Joaquin Estuary, the water quality criteria were lowered according to EPA methodology (Stephan et al. 1985) to 26 ug/L for molinate and 6.2 ug/L for thiobencarb; these concentrations are 50% and 61% lower than the calculated FCV's of 52 and 16 ug/L, respectively. Molinate and thiobencarb in mixtures have been demonstrated to be additive, so these criteria are reduced by one-half since the two herbicides are usually always present together, yielding recommended criteria of 13 ug/L for molinate and 3.1 ug/L for thiobencarb. The recommended criteria are essentially the same numbers recommended as guidelines by Faggella and Finlayson (1987) for the protection of the mysid in the Sacramento-San Joaquin Estuary.

These recommended water criteria represent maximum rather than average concentrations. Maximum concentrations of rice herbicides are approximately twice the average concentrations and thus, provide for a two-fold margin of safety.

The recommended water quality criteria of 13 ug/L for molinate and 3.1 ug/L for thiobencarb indicate a hazard to the mysid may exist in the agricultural drains but not the Sacramento River. However, the mysid does not inhabit the agricultural drains. Concentrations of molinate and thiobencarb have steadily declined in recent years to levels well below those recorded in the early 1980's (highest recorded concentrations were 340 ug/L molinate and 60 ug/L thiobencarb in the drains and 27 ug/L molinate and 6 ug/L thiobencarb in the Sacramento River (Harrington and Lew 1989)). Since 1986 concentrations have not exceeded 77 ug/L molinate and 7.4 ug/L thiobencarb in the drains and 11 ug/L molinate and 1.2 ug/L in the Sacramento River, well below effect levels for the mysid.

Recommended Data Needs

Many of the aquatic organisms inhabiting the Sacramento-San Joaquin River system are not represented in the available toxicity database for molinate and thiobencarb. The following acute tests for the more common freshwater organisms would better define the criteria: (1) molinate with amphipods *Gammarus sp*; (2) molinate and thiobencarb with mayflies *Hexagenia sp*; and (3) molinate and thiobencarb with midges *Chironomus sp.*. Tests should also be conducted, if possible, using those freshwater and estuarine species which inhabit the Sacramento-San Joaquin Estuary system.

Chronic toxicity tests are the most critical values used for determining water quality criteria. This is especially true because the criteria were lowered to protect the important native mysid *Neomysis mercedis*. These data came from partial life-cycle tests done prior to the development of a standardized test procedure for mysids. Therefore, complete life-cycle chronic tests with *Neomysis mercedis* on molinate and thiobencarb are recommended for refining the criteria for the Sacramento River. In addition, subsequent new information may reveal the need for testing other important sensitive species.

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Appendix A. Toxicity Test Evaluation Form and description of criteria used in determining acceptability of acute and chronic toxicity tests for use in water quality criteria and hazard assessment.

INTRODUCTION

The following criteria descriptions are to be used in conjunction with the Toxicity Test Evaluation Form (last page of appendix) to evaluate the acceptability of toxicity test. These criteria which can be used to evaluate both acute and chronic toxicity tests are divided into six categories:

I. Test Method
II. Test Type
III. Test Species
IV. Water Quality Maintenance and Monitoring
V. Toxicant Maintenance and Monitoring
VI. Test Design

Within each category as many as nine criteria are used to evaluate test procedures. While it is not necessary that a study comply with every criterion, tests are rejected if they fail certain fundamental procedures such as maintaining proper survival of organisms in a control treatment or testing with diseased or stressed organisms. Studies are also rejected if they contain insufficient information to be properly evaluated or demonstrate bad testing practices. American Society for Testing and Materials (ASTM) standard guides (ASTM 1980; 1987; 1988a; 1988b) should be used for detailed requirements of particular test type and species.

CRITERIA DESCRIPTION

Reference

Author(s)

Title

Source (journal)

Toxicant (Common name of pesticide.)

Formulation (Formulation of pesticide and percent active ingredient.)

I. Test Method

A. Reference Guide (ASTM, APHA, EPA or other established guide which was used in carrying out test.)

B. Test Date(s) (Beginning and completion dates of test.)

II. Test Type

A. Duration (Note hours or days of testing.)

B. Dynamics (Note whether static, renewal, or flow-through design was used. Static is acceptable if test was less than or equal to 96 hours. Flow-through preferred if test was 96 hours or greater.)

III. Test Species

A. Common Name

B. Scientific Name

C. Life Stage (Note life stage description. Should be detailed description such as daphnid <24 hr old, or mysids <24 hr post-release from brood sac and appropriate for particular test and species as outlined by ASTM.)

D. Size (Note weight and length.)

E. Disease (Organisms should be observed for disease and stress. Signs of disease, stress, discoloration, death, etc. must be less than 10% during acclimation.)

F. Acclimation (Organisms should be acclimated at least 48 hr before testing.)

G. Feeding (Note feeding regime of test organisms.)

H. Source (Note origin of test organisms.)

IV. Water Quality Maintenance and Monitoring

A. Dissolved Oxygen (Note method and monitoring frequency. Should be recorded at beginning, end, and every 48 hr in a static and at least twice weekly in a chronic test. Every measured DO concentration should be between 60 and 100% of saturation during a renewal or flow-through test or during the first 48 hr in a static test.)

B. Temperature (Note method and monitoring frequency. Should be recorded every hour, or high and low recorded. There should be no more than 3 °C change. Temperature should be maintained at ASTM recommended temperature for species.)

C. pH (Note method and monitoring frequency.)

D. Ammonia (Note method and monitoring frequency. It should be <35 ug/L.)

E. Hardness (Note method and monitoring frequency.)

F. Salinity (Note method and monitoring frequency. Test should maintain required level for particular organism.)

G. Conductivity (Note method and monitoring frequency.)

H. Alkalinity (Note method and monitoring frequency.)

I. Dilution Water Source (Note source and type of dilution water used.)

V. Toxicant Maintenance and Monitoring

A. Measured Concentration (Note whether toxicant concentration was measured.)

B. Frequency (Note frequency of toxicant sampling for analysis.)

C. Spike Recovery/QA (Note percent recovery of spiked samples or other quality assurance program.)

D. Analytical Precision (Note procedure and result of intralaboratory quality control.)

VI. Test Design

A. Solvent Control/Water Control (Note whether control was used and what type. If solvent used with test chemical, there should be a control treatment using identical solvent at highest concentration used.)

B. Control Survival (Note percent survival in dilution water and solvent controls. Survival should generally be 90% or greater for acute tests and 80-65% for chronic tests, depending on species and life-stage of test organisms.)

C. Test Chamber Type and Size (Note type and size of test chambers. All test chambers should be identical and at least 3 times the size of the largest test species.)

D. Concentration Scale (Note number of treatments or concentration levels and their relationship to each other. Also note whether levels are nominal or measured. Must be 4-5 concentrations other than control with each 60% of the next highest concentration.)

E. Replicate/Treatment (Note number of replicates per treatment or concentration. Should be at least two.)

F. Organisms/Replicate (Note number of test organisms per replicate; generally, each replicate should have 10 organisms.)

G. Loading (Note organism loading rate in g/L (static) or g/L/d (flow-through). Loading rate for static test should no exceed 0.5 to 0.8 g/L and for flow-through test, not exceed 5 to 10 g/L/d.)

H. Statistical Methods (Note statistical tests used to analyze data. Should use log-probit, moving average, or Litchfield-Wilcoxon methods for LC_{50} values and parametric [Dunnet's] or nonparametric (Kruskal-Wallis) ANOVA tests for determining significant differences among treatment levels.)

Test Summary

A. LC_{50} (Lethal concentration to 50% of test organisms. Should be calculated with 95% confidence limits. At least one treatment other than a control should kill or affect less than 37% of the organisms and at least one treatment should kill or affect more than 63%.)

B. EC_{50} (Concentration that elicited an effect to 50% of test organisms with 95% confidence limits. Must indicate effect criteria and meet the requirements for LC_{50} calculations.)

C. NOEC (No observable effect concentration. The highest concentration which did not have an effect significantly different than control. Must indicate effect criteria.)

D. LOEC (Lowest observable effect concentration. The lowest concentration which did have an effect significantly differently than control. Must indicate effect.)

E. Effect (Note significant biological effect to test organisms. Use with EC_{50}, NOEC, and LOEC.)

F. Frequency (Note frequency and method of observations to determine effect; and the precision of measurements if applicable).

Other Notes

A. Uncontrollable Incidents (Note unexpected problems which occurred during tests and possible ramifications.)

B. Literature Cited (Note important studies which were listed in Literature Cited section to aid future literature research.)

C. Table of Data (Include data which could be used to better interpret work.)

REFERENCES

American Society for Testing and Materials, 1989 (1980a). Standard practice for conducting static acute toxicity tests with larvae of four species of bivalve molluscs. ASTM Committee E-47 Publication E724-89 (E724-80), Philadelphia, Pennsylvania

ASTM. 1988a. Standard guide for conducting early life-stage toxicity tests with fishes. ASTM Committee E-47 Publication E1241-88, Philadelphia, Pennsylvania.

ASTM. 1988b (1980b). Standard practice for conducting acute toxicity tests with fishes, macroinvertebrates, and amphibians. ASTM Committee E-47 (E729-80), Publication E729-88, Philadelphia, Pennsylvania.

ASTM. 1987. Standard guide for conducting life-cycle toxicity tests with saltwater mysids. ASTM Committee E-47 Publication E1191-87, Philadelphia, Pennsylvania.

TOXICITY TEST EVALUATION FORM

Reference
Author(s) ____
Title ____
Source (Journal) ____

Toxicant
Formulation ____

I. Test Method
Reference Guide ____
Test Date(s) ____

II. Test Type
Duration ____
Dynamics ____

III. Test Species
Common Name ____
Scientific Name ____
Reference ____
Life Stage ____
Size ____
Disease ____
Acclimation ____
Feeding ____
Source ____

IV. Water Quality Maintenance & Monitoring

	Method	Frequency	Average & Range
DO			
Temperature			
pH			
Ammonia			
Hardness			
Salinity			
Conductivity			
Alkalinity			
Dilution Water Source			

V. Toxicant Maintenance & Monitoring
Measured Concentration ____
Frequency ____
Spike Recovery/QA ____
Analytical Precision ____

VI. Test Design
Solvent Control/Water Control ____
Control Survival ____
Test Chamber Type & Size ____
Concentration Scale ____
Replicates/Treatment ____
Organisms/Replicate ____
Loading ____
Statistical Methods ____

Test Summary
LC50 (Confidence Limits) ____
EC50 (Confidence Limits) ____
NOEC ____
LOEC ____
Effect Criteria ____
Frequency ____
Other ____

Other Notes
Uncontrollable Incidents ____
Literature Cited ____
Table of Data ____

Appendix B. Study descriptions for accepted and unaccepted data used in deriving Final Acute Values for molinate and thiobencarb.

ACUTE TOXICITY TO AQUATIC ORGANISMS

Accepted Data - The following studies were accepted toxicity tests used in deriving the Final Acute Values for molinate and thiobencarb.

Bailey (1985a; 1985c) - In 1985, 96-h flow-through toxicity tests were conducted by SRI International for the State Water Resources Control Board on molinate and thiobencarb technical (% not given) and molinate-thiobencarb mixtures (1:1 LC_{50} value ratios) with the mysid *Neomysis mercedis* (Bailey 1985a) and 28-day old white sturgeon *Acipenser transmontanus* (Bailey 1985c). Concentrations were replicated and there was a control treatment and a series of four concentrations (dilution factor of 0.6). Water quality parameters during the mysid tests were: temperature 17-18 °C, pH 8.0-8.3, salinity 2.5 °/$_{oo}$, and dissolved oxygen 7.7-9.5 mg/L. Water quality parameters during the sturgeon tests were: temperature 15-17.5 °C, pH 6.7-8.6, hardness 32 mg/L $CaCO_3$, alkalinity 34 mg/L $CaCO_3$, dissolved oxygen 7.6-9.9 ppm. Toxicant concentrations were measured at 24, 48 and 96 hours during the test and were close to 100% of expected concentrations. There was 100% survival of controls. The 96-h LC_{50} values for molinate and thiobencarb with mysid were 9.9 mg/L (Table 1) and 304 ug/L (Table 2), respectively and with white sturgeon were 18.4 mg/L (Table 1) and 260 ug/L (Table 2), respectively. The mixture exhibited additive toxicity to mysids with a LC_{50} value of 4.6 mg/L for molinate and 0.16 mg/L for thiobencarb (Table 3).

Bionomics EG&G (1970) - In 1970, 96-h static toxicity tests were conducted on molinate technical (99%) with bluegill sunfish *Lepomis macrochirus*, rainbow trout *Oncorhynchus mykiss* and fathead minnow *Pimephales promelas*. Test procedures outlined by APHA (1971) were followed. Tests had a control (no solvent control used) and a series of six (bluegill and trout test) and eight (minnow test) concentrations. Water quality parameters were: temperature 18 °C (bluegill and minnow test) and 13 °C (trout test), pH 7.1, hardness 35 mg/L and dissolved oxygen 4.9-8.4 mg/L. Toxicant concentration was not measured. Control survival was 100%. The 96-h LC_{50} values were 18.8, 7.0 and 26.0 mg/L for sunfish, trout and minnow, respectively (Table 1).

Bionomics EG&G (1979g) - In 1978, 96-h flow-through toxicity test was conducted by Bionomics EG&G for Chevron Chemical Company on thiobencarb technical (95.1%) with juvenile sheepshead minnow *Cyprinodon variegatus*. Testing procedures outlined by ASTM (E729) were followed. The test had dilution water and solvent control treatment and a geometric series of five concentrations.

Water quality parameters during the test were: temperature 25±1 °C, pH 7.7-8.0, salinity 30±3 °/oo and dissolved oxygen 59-94% saturation. Toxicant concentrations were measured at day 0 and 4 and were 41-55% of expected concentrations. Spiked recovery was 98%. Control survival was 100% for water and 95% for solvent. The 96-h LC_{50} value was 690 ug/L (Table 2).

Bionomics EG&G (1979a; 1979b) - In 1979, 96-h static toxicity tests were conducted by Bionomics EG&G for Chevron Chemical Company on thiobencarb technical (95.1%) (Bionomics EG&G Inc. 1979a) and Bolero[R] 8EC (85.2%) (Bionomics EG&G Inc. 1979b) with sheepshead minnows *Cyprinodon variegatus*. Concentrations were replicated and there was a dilution water and solvent control treatment and a geometric series of five concentrations. Water quality parameters with thiobencarb technical were: temperature 22 °C, pH 7.5-7.6, salinity 22 °/oo, and dissolved oxygen 55-93% saturation; and with Bolero[R] 8EC were: temperature 22 °C, pH 7.7-8.0, salinity 22 °/oo, and dissolved oxygen 78-90% saturation. Toxicant concentrations were not measured. Control survival was 100%. The 96-h LC_{50} values were 900 ug/L (technical) and 1,400 ug/L (Bolero[R] 8EC) (Table 2).

Bionomics EG&G (1979c) - In 1979, 96-h flow through toxicity test was conducted by Bionomics EG&G for Chevron Chemical Company on thiobencarb technical (95.1%) with 6-8 day old mysid *Mysidopsis bahia*. Testing procedures outlined by ASTM (E729) were followed. Each test had a dilution water and solvent control treatment and a geometric series of five concentrations. Water quality parameters during the test were: temperature 25 °C, pH 7.9, salinity 25-28 °/$_{oo}$ and dissolved oxygen 87-94% saturated. Toxicant concentrations were measured at day 0 and 4 and were 62-102% of expected concentrations. Spiked recovery was 98%. Control survival was 100%. The 96-h LC_{50} value was 288 ug/L (Table 2).

Bionomics EG&G (1979d; 1979f) - In 1979, 48-h static toxicity test were conducted by Bionomics EG&G for Chevron Chemical Company on thiobencarb technical (95.1%) (Bionomics EG&G Inc. 1979d) and Bolero^R 8EC (85.2%) (Bionomics EG&G Inc. 1979f) with larval eastern oysters *Crassostrea virginica*. Testing procedures outlined by ASTM (E724) were followed. Concentrations were replicated three times and there was a dilution water and solvent control treatment and a geometric series of five concentrations. Water quality parameters during the tests with thiobencarb technical and Bolero^R 8EC were: temperature 22 °C, pH 7.7-7.8, salinity 26 °/$_{oo}$ and dissolved oxygen 82% saturated. Toxicant concentrations were not measured. Control survival was 100% for dilution water and 96% for solvent. The 48-h LC_{50} values were 560 ug/L (technical) and 320 ug/L (Bolero^R 8EC) (Table 2).

Bionomics EG&G (1979e) - In 1979, 96-h static toxicity test was conducted by Bionomics EG&G for Chevron Chemical Company on Bolero^R 8EC (85.2%) with subadult fiddler crabs *Uca pugilator*. Testing procedures outlined by ASTM (E729) were followed. Each test had a dilution water and solvent control treatment and a geometric series of five concentrations. Water quality parameters during the tests were: temperature 22 °C, pH 7.8-8.0, salinity 27 ‰ and dissolved oxygen 89-92% saturated. Toxicant concentrations were not measured. Control survival was 100%. The 96-h LC_{50} value was 4,400 ug/L (Table 2).

Bionomics EG&G (1980) - In 1980, 96-h static toxicity test was conducted on thiobencarb technical (100%) 6-8 day old mysid shrimp *Mysidopsis bahia*. Testing procedures outlined by Chevron Chemical Company (1980) were followed. Each test had a dilution water and solvent control and a series of five concentrations. Water quality parameters during the test were: temperature 22±1 °C, pH 7.9, salinity 30 ‰ and dissolved oxygen >78% saturation. Toxicant level monitoring was not mentioned. Survival of the controls was 100%. The 96-h LC_{50} value was 150 ug/L (Table 2).

Borthwick and Walsh (1981) - In 1981, 48-h and 96-h static toxicity tests were conducted on thiobencarb (95.5%) with algae *Skeletonema costatum*, eastern oyster larvae *Crassostrea virginica*, juvenile mysid shrimp *Mysidopsis bahia*, and 28-day old sheepshead minnow *Cyprinodon variegatus*. Testing procedures outlined by ASTM (E724; E729) were followed. Water quality parameters for algae culture during the test were: temperature 20.0±0.5 °C, salinity 30 ‰ and photo period 14 hours/day. Water quality parameters for animal tests were: temperature 25±1 °C and salinity 20 ‰. Concentrations were replicated three times and there was a control. Number of exposure concentrations were not given. The 96-h LC_{50} for mysid was 370 ug/L and for sheepshead minnow was >1,000 ug/L (Table 2). The 48-h EC_{50} for Eastern oyster was 1,000< <10,000 ug/L (Table 2). The 48-h EC_{50} for algae ranged from 327 to 459 ug/L (Table 10). The EC_{50} for algae was determined using growth inhibition as the effect.

Borthwick et al. (1985) - In 1985, 96-h static and flow-through toxicity tests were conducted on technical thiobencarb (95.5%) with four ages (day-of-hatch, 7-day, 14-day, 28-day) of three estuarine fishes: California grunion *Leuresthes tenuis*, Atlantic silverside *Menidia menidia*, and tidewater silverside *Menidia peninsula*. Testing procedures outlined by ASTM (E729) were followed. Tests had solvent and dilution water control treatments and a geometric series of five exposure concentrations. Water quality parameters during the tests were: temperature 25 °C and salinity 20-25 $^{o}/_{oo}$. Toxicant concentrations were measured at 48-h and 96-h during the test and recovery of spiked samples was 96%. Survival of controls averaged 95%. The 96-h LC_{50} values for flow-through tests ranged from 199-865 ug/L and for static tests ranged from 269-1,405 ug/L (Table 2).

Brown et al. (1979) - In 1978, 96-h static acute toxicity tests were conducted on molinate technical (98.3%) with 6-wk old channel catfish *Ictalurus punctatus*. Testing procedures outlined by APHA (1971) were followed. Tap and rice paddy water were used as dilution water. Concentrations were replicated and there was a solvent (acetone) control. Water quality parameters during the test were: temperature 23±2 °C, pH 6.4-8.5, alkalinity 22 mg/L $CaCO_3$ and test vessels were aerated. There was no specific mention of toxicant concentration levels, toxicant level monitoring, or analytical quality control. Survival of controls was greater than 90%. The 96-h LC_{50} values were 29.4 mg/L for rice paddy water and 33.2 mg/L for tap water (Table 1).

Cheah et al. (1980) - In 1979, 96-h static toxicity test was conducted on molinate (% not given) with juvenile crayfish *Procambarus clarkii*. Test procedures outlined by the Environmental Protection Agency (U.S. EPA 1975) were followed with some modifications. Concentrations were replicated three times and there was a dilution water and solvent controls. Water quality parameters during the test were: temperature 20±3 °C, pH 8.4, and hardness 100 mg/L. Specific toxicant concentrations and analytical quality control were not monitored. Survival of controls averaged 95%. The 96-h LC_{50} value was 14 mg/L (Table 1).

Faggella et al. 1990 - In 1988, 96-h flow-through toxicity tests were conducted on Bolero[R] 8EC (85.2% thiobencarb), Ordram[R] 8EC (90.3% molinate), and mixtures of the two with juvenile striped bass *Morone saxatilis* and juvenile mysid *Neomysis mercedis*.

Test method outlined by ASTM (E729) was followed. Five toxicant concentrations (dilution factor 0.56) were tested in duplicate with a water control. Water quality parameters during the tests were: temperature 16.5-18.8 °C, dissolved oxygen 8.43-9.40 mg/L, pH 8.06-8.43, conductivity 1353-3587 usemens, hardness 215-491 mg/L $CaCO_3$, and alkalinity 115-168 mg/L $CaCO_3$. Control survival was >90% for the values used. Toxicant level was monitored at 24 and 72 hours and ranged from 74-145% of nominal for thiobencarb and 60-76% of nominal for molinate. The 96-h LC_{50} values were 1.3 mg/L for molinate with 28-d old mysid and 2.3 mg/L for molinate with juvenile mysid (Table 1); 760-1000 ug/L for thiobencarb with juvenile striped bass and 350 ug/L for thiobencarb with 28-d old mysid (Table 2); and 0.19 mg/L molinate and 0.06 mg/L thiobencarb for the mixture with 28-d mysid and 0.8 mg/L molinate and 0.17 mg/L thiobencarb for the mixture with juvenile mysid (Table 3).

Faggella and Finlayson (1987) - From 1984 through 1986, 96-h and 144-h toxicity tests were conducted by CDFG on Ordram[R] 8EC (90.3%) and Bolero[R] 8EC (85.2%) with larval and juvenile striped bass *Morone saxatilis*. Testing procedures outlined by ASTM (E729) were followed. CDFG had a varying degree of success in testing this difficult species and listed several factors contributing to poor survival. Concentrations were replicated and there was a control treatment and a geometric series of five concentrations (dilution factor of 0.6). Water quality parameters during the tests with larvae were: temperature 17 to 20 °C and dissolved oxygen >90% saturated. Tests with juvenile bass were conducted in freshwater at a temperature of 17.4 °C. Toxicant concentrations were measured at 24-h, 72-h, and 96-h during the test and average 86% of expected concentrations for molinate and 77% for thiobencarb. The tests which were successful (<10% control mortality) showed 96-h LC_{50} of 6.6 to 14 mg/L for molinate (Table 1), 670 ug/L for thiobencarb (Table 2) and the mixture was found to exhibit additive toxicity with LC_{50} values ranging from 3.0-7.9 mg/L for molinate and 0.24-0.52 mg/L for thiobencarb (Table 3).

Faggella and Finlayson (1988) and Chapman (1988) - In 1987, 96-h flow-through toxicity tests were conducted by CDFG (at Aquatic Toxicology Laboratory) and EPA on Ordram[R] 8EC (90.3%) and Bolero[R] 8EC (85.2%) with striped bass *Morone saxatilis*. CDFG also conducted tests with the mysid *Neomysis mercedis*. Testing procedures outlined by ASTM (E749) were followed. Concentrations were replicated and there was a control treatment and a geometric series of five concentrations. Water quality parameters during the CDFG tests averaged: temperature 18.5 °C, pH 8.3, hardness 443 mg/L $CaCO_3$, alkalinity 154 mg/L $CaCO_3$, salinity 1.7 °/₀₀ and dissolved oxygen 8.8 mg/L. Water quality parameters during the EPA tests ranged: temperature 16.2-19.0 °C, pH 7.8-8.0, salinity 2.5 °/₀₀ and dissolved oxygen 9.1-9.6 mg/L. Toxicant concentrations were measured at 24-h and 72-h during the test and averaged 107% of expected concentrations for molinate and 109% for thiobencarb. EPA followed testing procedures outlined by CDFG. Toxicant concentrations for EPA tests averaged 76% of expected concentrations for thiobencarb. Survival of controls in CDFG tests with juvenile striped bass averaged 95% and the mysid 91%. EPA reported survival of the striped bass controls at 92-100%. The 96-h LC_{50} values for CDFG and EPA tests ranged from 8.8-10 mg/L for molinate and 440-1,000 ug/L for thiobencarb with juvenile striped bass and 1.3 mg/L for molinate and 300 ug/L for thiobencarb with the juvenile mysid (Tables 1 and 2).

Finlayson and Faggella (1986) - In 1983 and 1984, 96-h flow-through toxicity tests were conducted on Ordram[R] 8EC (90.3% molinate) and Bolero[R] 8EC (85.2% thiobencarb), and molinate-thiobencarb mixtures (approximately 1:1 LC_{50} value ratios) with juvenile steelhead *Oncorhynchus mykiss*, chinook salmon *Oncorhynchus tshawtscha*, channel catfish *Ictalurus punctatus*, and striped bass *Morone saxatilis*. Testing procedures outlined by ASTM (E749) were followed. Concentrations were replicated and there was a control treatment and a geometric series (dilution factor of 0.6) of five concentrations. Water quality parameters during the tests were: temperature 11-18 °C, pH 6.9-7.2, alkalinity 18-19 mg/L $CaCO_3$, and dissolved oxygen 90% saturated. Toxicant concentrations were measured at 24-h and 72-h during the test and averaged 95% of expected concentrations for molinate and 64% for thiobencarb. Analytical precision was ± 10% with 90% recovery of spiked samples. Survival of controls with juvenile fish averaged 97%. The LC_{50} ranged from 8.1-34.0 mg/L for molinate (Table 1), 760-1,800 ug/L for thiobencarb (Table 2) and the mixture was found to exhibit additive toxicity with LC_{50} ranging from 6.8-18 mg/L for molinate and 0.36-0.99 mg/L for thiobencarb (Table 3).

Fujimura et al. (in press) - In 1989, 96-h flow-through toxicity tests were conducted on Bolero[R] 8EC (85.2% thiobencarb) with juvenile striped bass *Morone saxatilis.* Test methods outlined by ASTM (E749) were followed. Five toxicant concentrations (dilution factor 0.56) were tested in duplicate with a water control. Water quality parameters during the tests were: temperature 18.0-18.5 °C, dissolved oxygen 7.17-7.37 mg/L, pH 7.53-7.80, conductivity 2600-2975 usemens, hardness 379-490 mg/L $CaCO_3$, and alkalinity 152-154 mg/L $CaCO_3$. Control survival ranged from 97-100%. Toxicant level was monitored at 24 and 72 hours and ranged from 71-103% of nominal. The 96-h LC_{50} values ranged from 640-770 ug/L (Table 2).

ICI (1988a) - In 1988, 48-h flow-through toxicity test was conducted by ICI America, Inc. (formerly Stauffer Chemical Company) on molinate technical (97.6%) with *Daphnia magna.* Testing procedures outlined by ASTM (E749) and U.S. EPA (1975) were followed. Concentrations were replicated and there was a control treatment and a series of six concentrations (dilution factor 0.6). Water quality parameters during the tests were: temperature 19.5-20.5 °C, pH 8.2-8.3, and dissolved oxygen 92% saturated. Toxicant concentrations were measured at 0 and 48 hours and were 87-106% of expected concentrations. Survival of controls was 100%. The 48-h LC_{50} value was 14.9 mg/L (Table 1).

ICI (1988b; 1988c) - In 1988, 96-h flow-through toxicity tests were conducted by ICI America, Inc. on molinate technical (97.6%) with juvenile bluegill sunfish *Lepomis macrochirus* (ICI 1988c) and rainbow trout *Oncorhynchus mykiss* (ICI 1988b). Testing procedures were outlined in a Stauffer Chemical Company protocol which closely resembled those of ASTM (E749). Concentrations were replicated and there was a control treatment and a geometric series of five concentrations (dilution factor 0.5). Water quality parameters during the bluegill tests were: temperature 22 °C, pH 7.1, dissolved oxygen 7.0-8.4 mg/L (90% of saturated). Water quality parameters during the trout test were: temperature 12.3-12.5 °C, pH 7.1-7.2, and dissolved oxygen 7.6-8.4 mg/L (74% of saturated). Toxicant concentrations were measured at 24 and 96 hours during the test and averaged between 62 and 103% of expected concentrations. Survival of controls was 100% for both species. The 96-h LC_{50} values for bluegill and rainbow trout were 24.7 and 13.0 mg/L, respectively (Table 1).

Sanders (1970a) - In 1970, 96-h static toxicity test was conducted on molinate technical (% not given) with four and five-week old Fowler's toads *Bufo woodhousii fowlerii*. Tests had solvent control treatment and a series of four or five (varied with test) concentrations. Water quality parameters were: temperature 15.5±0.5 °C, pH 7.1, alkalinity 30 mg/L $CaCO_3$, and the water was aerated. Specific toxicant concentrations, and toxicant level monitoring were not mentioned. Control survival was 100%. The 96-h LC_{50} value was 14.0 mg/L (Table 1).

Sanders and Hunn (1982) - In 1981, 48-h and 96-h static toxicity tests were conducted on Bolero[R] (85.2%) with first instar *Daphnia magna*, amphipod *Gammarus pseudolimnaeous*, juvenile and mature crayfish *Oronectus nais*, and *Procambrus clarki*, rainbow trout *Oncorhynchus mykiss*, channel catfish *Ictalurus punctatus*, and bluegill *Lepomis macrochirus*. Test procedures outlined by the U.S. EPA (1975) were followed. Water quality parameters during the test were: temperature varied per species from 12-21 °C, pH 7.4, alkalinity 35 mg/L $CaCO_3$, and hardness 40 mg/L $CaCO_3$. Specific concentration levels, toxicant level monitoring, analytical quality control, and control survival were not mentioned but verified as acceptable by authors (personal communication with J. Hunn). The 96-h LC_{50} and 48-h EC_{50} values ranged from 1,000-6,500 ug/L (Table 2). These values are about one and a half times those obtained for rainbow trout and channel catfish in flow through tests by Finlayson and Faggella (1986).

Schaefer et al. (1982) - In 1982, 96-h static and flow-through toxicity tests were conducted on thiobencarb technical (94.5%) and Bolero[R] 8 EC (85.2%) with mosquitofish *Gambusia affinis*. Each test had a solvent (acetone) control and a series of five concentrations. Dissolved oxygen and pH were monitored continuously during the tests though values were not given. Toxicant concentrations were measured at 0 and 96-h and averaged 28% and 106% of expected concentrations for static and flow-through tests, respectively. Percent recoveries of spiked samples were greater than 92%. Control survival was not mentioned but stated as acceptable by authors (personal communication, B. Schaefer). The 96-h LC_{50} values ranged from 1,300-3,100 ug/L (Table 2). The value obtained in the static test on the Bolero[R] 8EC was twice the value obtained in the flow through test.

Thompson (1980a; 1980b; 1980c) - In 1980, 48-h and 96-h static toxicity tests were conducted by Analytical Bio Chemistry (ABC) Laboratories, Inc. for Chevron Chemical Company on Bolero[R] 10G (10%) with rainbow trout *Oncorhynchus mykiss* (Thompson 1980a), bluegill *Lepomis macrochirus*, (Thompson 1980b), and *Daphnia magna* (Thompson 1980c). Testing procedures outlined by the APHA (1976) were followed. Each test had a control treatment and a geometric series of five concentrations (six for daphnia). Water quality parameters during the tests were: temperature 12-22 °C, pH 7.6, hardness 25 mg/L $CaCO_3$, and dissolved oxygen 40-100% saturated. Toxicant concentrations were measured at 0 and 96 hours of testing and averaged 88-118% of expected concentrations. Survival of controls was 100%. The LC_{50} values are based on measured thiobencarb concentration and the media for the granules was assumed to have no influence on toxicity. The 96-h LC_{50} values ranged from 560 ug/L for bluegill to 1,500 ug/L for trout. The 48-h EC_{50} for daphnia based on clumping effect (adherence of two or more daphnids to each other) was 460 ug/L (Table 2).

<u>Thompson et al. (1988)</u> - In 1988, 48-h static toxicity test was conducted on molinate technical (97.6%) with pacific oyster *Crassostrea gigas* embryos. The embryos were 2.3 hours post-fertilization at the start of the test. Testing procedures outlined by ASTM (E724) were followed. Concentrations were replicated four times and there was a control and a series of eight concentrations. Water quality parameters during the test were: temperature 20+1 °C, pH 7.09-8.10, salinity 33.7 °/$_{oo}$, and dissolved oxygen 7.07-7.6 mg/L. Toxicant concentrations were measured at the start and finish of each test and ranged from 94 to 99% of expected concentrations. Control survival was 86% and 75% of the embryos developed normally. The 48-h EC_{50} based on abnormal larvae development as effect was 38 mg/L (Table 1).

<u>Union Carbide (1977)</u> - In 1977, 48-h static toxicity test was conducted on molinate technical (% not given) with *Daphnia magna*. Tests procedures outlined by the U.S. EPA (1975) were followed. Concentrations were replicated four times and there was a dilution water and solvent control and a series of five concentrations. Water quality parameters were: temperature 17±1 °C, pH 7.5-7.6, hardness 52 mg/L $CaCO_3$, alkalinity 27 mg/L $CaCO_3$, and dissolved oxygen 7.8-8.4. Control survival was 100% for water and 95% for solvent. The 48-h LC_{50} was 19.4 mg/L (Table 1).

<u>Union Carbide (1978)</u> - In 1978, 96-h static toxicity test was conducted on molinate technical (97.8%) with common carp

Cyprinus carpio. Test procedures outlined by the U.S. EPA (1975) were followed. Tests had a dilution water and solvent controls and a series of five concentrations. Dilution water quality parameters were: temperature 22±0.5 °C, pH 6.2-7.3, hardness 46 mg/L, and dissolved oxygen 1.3-8.7 mg/L. Specific concentration levels and toxicant level monitoring were not mentioned. Dilution water and solvent control survival were 100%. The 96-h LC_{50} value was 42.8 mg/L (Table 1).

Wheeler (1978a; 1978b) - In 1978, 48-h static toxicity tests were conducted by Chevron Chemical Company on thiobencarb technical (94.4%) (Wheeler 1978b) and Bolero[R] 8EC (85.5%) (Wheeler 1978a) with first instar *Daphnia magna*. Concentrations were replicated three times and there was a control treatment and a geometric series (dilution factor of 0.6) of three concentrations. Water quality parameters during the test were: temperature 17+1.5 °C, pH 8.0-8.1, hardness 36-39 mg/L $CaCO_3$, and dissolved oxygen 94-100% saturation. Toxicant concentrations were measured at 0 and 48 hours and were 88-109% of expected concentrations with an average 13% loss of active thiobencarb in the test solutions after 48 hours. Survival of controls was 100%. The 48-h EC_{50} values for daphnia were 101 ug/L (technical) and 211 ug/L (Bolero[R] 8EC) (Table 2).

Woodard Research Company (1965) - In 1965, 96-h static toxicity tests were conducted on molinate technical (97.8%) with goldfish *Carrassius auratus* and bluegill *Lepomis macrochirus*.

Concentrations were replicated and had a dilution water and solvent (acetone) control and geometric series of five (goldfish test) and four (sunfish test) concentrations. Water quality parameters were: temperature 61-66 °F (for all species) and hardness 48 mg/L $CaCO_3$ (no other parameters were mentioned). Toxicant concentrations were not measured. Dilution water and solvent control survival was 100% for tests with the two species. The 96-h LC_{50} values were 30.0 and 29.0 mg/L for goldfish and sunfish, respectively (Table 1).

Yoo (1979) - In 1978, approximately 7-d toxicity tests were conducted on thiobencarb technical (% not given) with the algae *Chlorell pyrenoidosa*. This was a Ph.D. research study which did not follow standard procedures outline by ASTM or APHA. Concentrations were replicated three times, there was a solvent (acetone) control and a series (dilution factor of 0.5) of eight concentrations. Water quality parameters were: temperature 22+2 °C, pH 8.2-9.2, and culture aeration. Toxicant was introduced to growth culture every 3 days through nutrient medium. The Medium Inhibitory Limit (IL_m), LOEC and NOEC based on maximum specific growth rate were 1,600, 60 and 40 ug/L, respectively (Table 10). The IL_m based on 3-d production was 30 ug/L and based on standing crop was 60 ug/L. Experiments on continuous cultures indicated an increase in the lag phase of batch culture *Chlorella p.* at a concentration of 10 ug/L, however the increase was not significant at 95%. The IL_m based on increase in lag phase was 30 ug/L.

Unaccepted Data - The following studies were unaccepted toxicity tests and therefore not used in deriving Final Acute Values for molinate and thiobencarb.

Bailey (1984b) - In 1983, 96-h flow-through toxicity tests were conducted on thiobencarb technical (96.6%) with white sturgeon fry *Acipenser transmontanus*. Tests had water control treatment (solvent control not mentioned) and a series of five concentrations. Water quality parameters were: temperature 15 °C, pH 7.4-7.5, hardness 42 mg/L $CaCO_3$, alkalinity 36 mg/L $CaCO_3$ and dissolved oxygen 9.4-10.2 mg/L. Toxicant concentration was measured at 0 and 96 hours of testing and averaged 51-218% of expected concentrations. Control survival was 90%. The 96-h LC_{50} value was 1,050 ug/L (Table B2). This value was unacceptable because of the instability with toxicant concentrations.

Bailey (1984c) - In 1983, 96-h flow-through toxicity tests were conducted on thiobencarb technical (96.6%) with steelhead fry *Oncorhynchus mykiss*. Tests had water control treatment (solvent control not mentioned) and a series of five concentrations. Water quality parameters were: temperature 12 °C, pH 7.2-7.4, hardness 42 mg/L $CaCO_3$, alkalinity 36 mg/L $CaCO_3$ and dissolved oxygen 9.2-10.0 mg/L. Toxicant concentration was measured at 0 and 96 hours of testing and averaged 9-35% of expected concentrations. Control survival was 100%. The LC_{50} value was

840 ug/L (Table B2). This value was unacceptable because of instability with toxicant concentrations.

Bailey (1984a) - In 1985, 96-h flow-through toxicity tests were conducted on thiobencarb technical (96.6%) with mysid *Neomysis mercedis*. Tests had water control treatment (solvent control not mentioned) and a series of six concentrations. Water quality parameters were: temperature 15-16 °C, pH 7.7 and dissolved oxygen 9.7-10.0 mg/L. Toxicant concentrations were measured at 0 to 96 hours of testing and averaged 86-138% of expected concentrations. Control survival was 100%. The 96-h LC_{50} value was 26.6 ug/L (Table B2). This value was unacceptable because it was off by a factor of 10 from other acute toxicity values for this species.

Chaiyarach et al. (1975) - In 1975, 96-h static toxicity tests were conducted on molinate (% not given) with mosquitofish *Gambusia affinis*, grass shrimp *Palaemonetes kadiakensis*, crayfish *Oronectus nais*, and mactrid clam *Rangia cuneata*. Testing procedures outlined in APHA (1971) were followed. Specific toxicant concentrations, toxicant level monitoring, water quality parameters and control survival were not mentioned. The 96-h LC_{50} values ranged from 15.9 mg/L for grass shrimp to 197 mg/L for mactrid clam (Table B1). These values were unacceptable because the report lacked essential information including control survival.

Crosby and Tucker (1966) - In 1966, 26-h static toxicity tests was conducted by the Agricultural Toxicology and Residue Research Laboratory at U. C. Davis on technical molinate (% not given) with *Daphnia magna*. Concentrations were replicated three times and there was a solvent (acetone) control. Water quality parameters during the test were: temperature 21±10.05 °C, pH 8.12, alkalinity 40 mg/L $CaCO_3$, and continuous aeration. Number of treatments and specific toxicant concentrations were not mentioned. There was 100% survival of controls. The 26-h IC_{50} value based on immobility as the effect was 0.70 mg/L (Table B1). This value was unacceptable because only 48-h toxicant test results were used to derive the FAV.

Davey et al. (1976) - In 1975, 72-h static toxicity tests were conducted at the University of Arkansas on molinate (% not given) with mature mosquitofish *Gambusia affinis* and green sunfish *Lepomis cyanellus*. Concentrations were replicated three times and there were solvent controls. Water quality parameters, specific concentration levels, toxicant level monitoring, and control survival were not mentioned. The 72-h LC_{50} values ranged from 17-34 mg/L (Table B1). These values were unacceptable because the report lacked information on water quality and control survival and only 96-h LC_{50} values were used in deriving the FAV.

Faggella and Finlayson (1987) - From 1984 through 1986, 96-h and 6-d toxicity tests were conducted by CDFG on Ordram[R] 8EC (90.3%)

and Bolero[R] 8EC (85.2%) with larval and juvenile striped bass *Morone saxatilis*. Testing procedures outlined by ASTM (E749) were followed. Concentrations were replicated and there was a control treatment and a geometric series of five concentrations (dilution factor of 0.6). Water quality parameters during the tests were: temperature 17 °C to 20 °C, 1.6-4.0 ‰ salinity, and dissolved oxygen >90% saturated. Toxicant concentrations were measured at 24-h, 72-h, and 96-h during the test and average 86% of expected concentrations for molinate and 77% for thiobencarb. The 96-h LC_{50} values for molinate, thiobencarb and the mixture ranged from 2.1 to 11 mg/L (Table B1), 350 to 670 ug/L (Table B2) and >4.4 and 7.5 mg/L (molinate) and >0.26 to 0.65 mg/L (thiobencarb) (Table B3), respectively. These values were unacceptable because of low survival (<90%) of controls.

Faggella and Finlayson (1988) - In 1987, 96-h flow through toxicity tests were conducted by CDFG on Bolero[R] 8EC (85.2%) with striped bass *Morone saxatilis* and the mysid *Neomysis mercedis*. Testing procedures outlined by ASTM (E749) were followed. Concentrations were replicated and there was a control treatment and a geometric series of five concentrations. Thiobencarb concentrations were measured at 24-h and 72-h during the test and averaged 109%. The 96-h LC_{50} values were 430 and 550 ug/L thiobencarb for striped bass and 230 ug/L thiobencarb for the mysid (Table B2). These values are unacceptable because of low survival (<90%) of controls.

Faggella et al. (1990) - In 1988, 96-h flow through toxicity test was conducted on Bolero[R] 8EC (85.2% thiobencarb) with mysid *Neomysis mercedis*. Test method outlined by ASTM (E729) was followed. The LC_{50} value was 350 ug/L thiobencarb (Table B2). This toxicity value is unacceptable because control survival was <90%.

Hirata et al. (1984) - In 1984, 4-d growth rate toxicity tests were conducted by a Japanese researcher on thiobencarb with algae *Chlorella saccharophila* and rotifer *Brachionus plicatilis*. Concentrations were replicated and there was a water and solvent (ethanol) control treatment and a series of five concentrations. Water quality parameters during the test were: temperature 23 °C, pH 7.7-8.2, and constant aeration. Growth rate and population density were monitored. The LC_{50} value for the rotifer was not generated for this test because there was a significant difference between water and ethanol control treatments; similar effects were seen with the algae control treatments. The report stated plankton growth rates were affected by thiobencarb at 100 and 300 ug/L but the effect was not statistically significant (Table B2). Both zooplankton (Table B2) and phytoplankton (Table B4) toxicity values were unacceptable because of significant effects between controls.

Rausina (1975) - In 1975 Industrial Bio-Test Laboratories conducted acute toxicity tests on Bolero[R] 8EC (% not given) with grass shrimp *Palaemonetes vulgaris*. The 96-h LC_{50} of 910 ug/L

(Table B2) was given but test procedures were unavailable. These values were unacceptable because the report lacked essential information necessary to properly evaluate the study.

Sanders (1969) - In 1969, 96-h static toxicity tests were conducted by USFWS on 70 different pesticides including molinate (% not given) with *Gammarus lacustris*. A series of four or five (not specified for molinate test) concentrations were used. Water quality parameters were: temperature 21 °C, pH 7.1, alkalinity 30.0 mg/L $CaCO_3$, and no aeration (dissolved oxygen not mentioned). Specific toxicant concentrations, toxicant level monitoring, and control survival were not mentioned. The 96-h LC_{50} value was 4.5 mg/L (Table B1). This value was unacceptable because the report lacked essential information including control survival.

Sanders (1970b) - In 1970, 48-h and 96-h static toxicity tests were conducted on molinate technical (% not given) with six species of freshwater crustaceans: scud *Gammarus fasciatus*, grass shrimp *Palaemonetes kadiakensis*, sowbug *Asellus brevicaudus*, crayfish *Oronectus nais*, waterflea *Daphnia magna*, and seed shrimp *Cypridopsis vidua*. Each test had a solvent control and four or five (not specified) concentration levels. Water quality parameters during the test were: temperature 15.5±1 °C (seed shrimp test) and 21±0.5 °C (other tests), pH 7.4, total alkalinity 260 mg/L $CaCO_3$, and total hardness 272 mg/L $CaCO_3$. Specific toxicant concentrations, toxicant level monitoring, and control survival were not mentioned. The 48-h LC_{50} with scud was 0.39 mg/L and LC_{50} and EC_{50} values based on immobility as effect criteria ranged from 0.18 to 5.6 mg/L (Table B1). These values were unacceptable because the report lacked essential information including control survival.

Stauffer (1968) - In 1968, 96-h static toxicity tests were conducted on Ordram^{R} 6E (71.0%) with mosquitofish *Gambusia affinis*. Tests had water controls and a series of four concentrations. Temperature (20-22 °C) was the only water parameter monitored. Control survival was 96%. The 97-h LC_{50} value was 17.0 mg/L (Table B1). This value was unacceptable because the report lacked essential information and the formulated compound (Ordram^{R} 6E) was not close enough in purity to technical grade.

Stauffer (1972) - In 1972, 96-h static toxicity tests were conducted on molinate technical (% not given) with channel catfish *Ictalurus punctatus* (Stauffer 1972). Test procedures outlined by APHA (1971) were followed. Tests had a series of five concentrations. Water quality parameters were: temperature 60-62 °F and pH 7.0. (No other parameters were mentioned). Toxicant concentrations were measured and ranged from 90-140% of expected concentrations. Control treatment was not mentioned. The 96-h LC_{50} value was 13.0 mg/L (Table B1). These values were unacceptable because the report lacked information on control survival.

Woodard Research Company (1965) - In 1965, 96-h static toxicity test was conducted on molinate technical (97.8%) with rainbow trout *Oncorhynchus mykiss*. Concentrations were replicated and had a dilution water and solvent (acetone) control and a geometric series of eight concentrations. Water quality parameters were: temperature 61 °F and hardness 48 mg/L $CaCO_3$. Toxicant concentrations were not measured. Dilution water and solvent control survival were 100%. The 96-h LC_{50} value was 1.3 mg/L (Table B1). This value was unacceptable because it was off by a factor of 10 from other toxicity values for this species.

Table B1. Unacceptable values for acute toxicity of molinate to aquatic animals.

Species	Life Stage	Method[a]	Formulation	Salinity/ Hardness	Test Length	Effect	Values (mg/L) (95% confidence limits)	Reference
Rainbow trout *Oncorhynchus mykiss*	juvenile	S, U	Tech (97.8%)	48 mg/L $CaCO_3$	96-h	LC_{50}	1.3(0.9-1.9)	Woodard Research Corp. 1965
Striped bass *Morone saxatilis*	6-d old	F, M	Ordram® 8EC (90.3%)	1.6-4.0 ‰	96-h	LC_{50}	2.1(1.8-2.4)	Faggella and Finlayson 1987
Striped bass *Morone saxatilis*	13-d old	F, M	Ordram® 8EC (90.3%)	1.6-4.0 ‰	96-h	LC_{50}	11.0(8.0-16.0)	Faggella and Finlayson 1987
Green sunfish *Lepomis cyanellus*	juvenile	S, U	Ordram® 8EC (--)	---	72-h	LC_{50}	34.5(28.2-36.9)	Davey et al. 1976
Mosquitofish *Gambusia affinis*	mature	S, U	Ordram® 8EC (--)	---	96-h	LC_{50}	17.0(15.3-18.2)	Davey et al. 1976
Mosquitofish *Gambusia affinis*	mature	S, U	Ordram® 6E (71%)	---	96-h	LC_{50}	17.0	Stauffer 1968
Mosquitofish *Gambusia affinis*	mature	S, U	---	---	96-h	LC_{50}	16.4	Chaiyarach et al. 1975
Channel catfish *Ictalurus punctatus*	30-d old	S, M	Tech (--)	---	96-h	LC_{50}	13.0(10.6-16)	Stauffer 1972
Waterflea *Daphnia magna*	1st instar	S, U	Tech (--)	40 mg/L $CaCO_3$	26-h	IC_{50}	0.7(0.46-1.05)	Crosby and Tucker 1966
Waterflea *Daphnia magna*	early instar	S, U	Tech (--)	272 mg/L $CaCO_3$	48-h	EC_{50}	0.6	Sanders 1970b
Scud *Gammarus fasciatus*	early instar	S, U	Tech (--)	272 mg/L $CaCO_3$	48-h 96-h	LC_{50} LC_{50}	0.39(0.21-0.56) 0.30(0.10-0.70)	Sanders 1970b
Scud *Gammarus lacustris*	2 mo. old	S, U	Tech (--)	88 mg/L $CaCO_3$	96-h	LC_{50}	4.5(3.5-5.8)	Sanders 1969
Sowbug *Asellus breviacaudus*	early instar	S, U	Tech (--)	272 mg/L $CaCO_3$	48-h	LC_{50}	0.4	Sanders 1970b
Crayfish *Orconectes nais*	early instar	S, U	Tech (--)	272 mg/L $CaCO_3$	48-h	LC_{50}	5.6	Sanders 1970b
Crayfish *Procambarus simulans*	mature	S, U	---	---	96-h	LC_{50}	21.8	Chaiyarach et al. 1975
Grass shrimp *Palaemonetes kadiakensis*	instar	S, U	Tech (--)	272 mg/L $CaCO_3$	48-h	LC_{50}	1.0	Sanders 1970b

Table B1. continue ...

Species	Life Stage	Method[a]	Formulation	Salinity/ Hardness	Test Length	Effect	Values (mg/L) (95% confidence limits)	Reference
Grass shrimp *Palaemonetes Kadiakensis*	---	S, U	---	---	96-h	LC_{50}	15.9	Chaiyarach et al. 1975
Seed shrimp *Cypridopsis vidua*	early instar	S, U	Tech (--)	272 mg/L $CaCO_3$	48-h	EC_{50}	0.18	Sanders 1970b
Mactrid clam *Rangia cuneata*	mature	S, U	---	---	96-h	LC_{50}	197	Chaiyarach et al. 1975

[a] S = static, F = flow through, M = measured concentration, U = unmeasured concentration
[b] 17°C
[c] 12°C
[d] bioassay using tap water
[e] bioassay usind paddy water

Table B2. Unacceptable values for acute toxicity of thiobencarb to aquatic animals.

Species	Life Stage	Method[a]	Formulation	Salinity/ Hardness	Test Length	Effect	Values (ug/L) (95% confidence limits)	Reference
Steelhead <u>Oncorhynchus</u> <u>mykiss</u>	fry	F, M	Tech (96.6%)	42 mg/L $CaCO_3$	96-h	LC_{50}	840(750-940)	Bailey 1984c
Striped bass <u>Morone</u> <u>saxatilis</u>	6-d old	F, M	Bolero® 8EC (85.2%)	2.0 ‰	96-h	LC_{50}	350(300-390)	Faggella and Finlayson 1987
Striped bass <u>Morone</u> <u>saxatilis</u>	13-d old	F, M	Bolero® 8EC (85.2%)	1.6 ‰	96-h	LC_{50}	510(440-860)	Faggella and Finlayson 1987
Striped bass <u>Morone</u> <u>saxatilis</u>	24-d old	F, M	Bolero® 8EC (85.2%)	02.1 ‰	96-h	LC_{50}	670(610-790)	Faggella and Finlayson 1987
Striped bass <u>Morone</u> <u>saxatilis</u>	14-d old	F, M	Bolero® 8EC (85.2%)	531 mg/L $CaCO_3$	96-d	LC_{50}	550(400-740)	Faggella and Finlayson 1988
Striped bass <u>Morone</u> <u>saxatilis</u>	41-d old	F, M	Bolero® 8EC (85.2%)	371 mg/L $CaCO_3$	96-d	LC_{50}	430(400-470)	Faggella and Finlayson 1988
White sturgeon <u>Acipenser</u> <u>transmontanus</u>	fry	F, M	Tech (96.6%)	42 mg/L $CaCO_3$	96-h	LC_{50}	1050(880-1260)	Bailey 1984b
Mysid <u>Neomysis</u> <u>mercedis</u>	---	F, M	Tech (96.6%)	---	96-H	LC_{50}	26.6(18.8-38.1)	Bailey 1984a
Mysid <u>Neomysis</u> <u>mercedis</u>	28-d	F, M	Bolero® 8EC (85.2%)	215 mg/L $CaCO_3$	96-H	LC_{50}	350(270-460)	Faggella et al. 1990
Mysid <u>Neomysis</u> <u>mercedis</u>	juvenile	F, M	Bolero® 8EC (85.2%)	121 mg/L $CaCO_3$	96-H	LC_{50}	230(170-290)	Finlayson and Faggella 1988
Grass shrimp <u>Palaemonetes</u> <u>vulgaris</u>	---	S, U	Bolero® 8EC (85.5%)	---	96-h	LC_{50}	910	Rausina 1975
Rotifer <u>Brachionus</u> <u>plicatilis</u>	---	S, U	Tech (100%)	---	96-h	---	100	Hirata et al. 1984

[a] S = static, F = flow through, M = measured concentration, U = unmeasured concentration

Table B3. Unacceptable values for acute toxicity of a molinate and thiobencarb mixture to aquatic animals.

Species	Life Stage	Method[a]	Formulation	Salinity/ Hardness	Test Length	Effect	Values (mg/L) (95% confidence limits)	Reference
Striped bass _Morone saxatilis_	6-d old	F, M	Ordram[R] (90.3%) Bolero[R] (35.4%)	1.6 °/oo	96-h	LC_{50}	Mol.>4.4 Thio.>0.26	Faggella and Finlayson 1987
Striped bass _Morone saxatilis_	45-d old	F, M	Ordram[R] (90.3%) Bolero[R] (85.4%)	2.5 °/oo	96-h	LC_{50}	Mol.7.5(7.0-8.3) Thio.0.65(0.60-0.72)	Faggella and Finlayson 1987

a S = static, F = flow through, M = measured concentration, U = unmeasured concentration

Table B4. Unacceptable values for acute and chronic toxicity of thiobencarb to aquatic plants.

Species	Life Stage	Method[a]	Formulation	Salinity/ Hardness	Test Length	Effect	Values (ug/L) (95% confidence limits)	Reference
Phytoplankton Chlorella saccarophilia	---	S, U	Tech (100%)	---	96-h	LOEC	100	Hirata et al. 1984

Appendix C. Study descriptions for accepted and unaccepted data used in deriving Final Chronic Values for molinate and thiobencarb.

Accepted Data - The following studies were accepted toxicity tests used in deriving the Final Chronic Values for molinate and thiobencarb.

Bailey (1985b) - In 1985, 42-d flow-through toxicity tests were conducted by SRI International for the State Water Resources Control Board on thiobencarb and molinate technical (% not given) with mysid *Neomysis mercedis*. Young mysids were obtained from gravid females for 14 days and pooled. Tests were conducted on molinate, thiobencarb, and molinate/thiobencarb mixture with one to 14-d old mysids. Concentrations were replicated and there was a control treatment and a series of five concentrations. Water quality parameters during the test were: temperature 17.5-18.5 °C, pH 6.9-7.9, salinity 2.5 $^{o}/_{oo}$, and dissolved oxygen 8.3-9.4 mg/L. Toxicant concentrations were measured twice weekly and averaged 97 to 135% of expected concentrations. The NOEC value for molinate was 0.026 mg/L and the LOEC value was 0.045 mg/L (Table 6) and for thiobencarb the NOEC was 6.2 ug/L and the LOEC value was 13 ug/L (Table 7) based on growth and survival.

Bailey (1985c) - In 1985, time-independent studies were conducted as part of acute toxicity tests by SRI International for the State Water Resources Control Board on molinate and thiobencarb (% not given) with white sturgeon *Acipenser transmontanus*. Tests were conducted for 14-d or until a period of 48 hours passed with no mortality. Concentrations were replicated and there was a control treatment and a series of five concentrations. Water quality parameters during the test were: temperature 18-19 °C, pH 6.0-7.0, conductivity 45-80 umhos, and dissolved oxygen 4.4-11.8 ppm. Toxicant concentrations were measured twice weekly and were close to 100% of expected values. There was 90-100% survival of controls. NOEC values were not calculated because all concentrations tested had significant mortality. The 22-d LC_{50} value for molinate was 2.7 mg/L (Table 6) and 21-d LC_{50} value for thiobencarb was 221 ug/L (Table 7).

Bionomics EG&G (1979c) - In 1979, 28-d flow-through toxicity tests were conducted on thiobencarb technical (95.2%) with mysid *Mysidopsis bahia*. Test procedures outlined by Chevron Chemical Company (1980) were followed. Concentrations were replicated and there was a dilution water and solvent control and a series of five concentrations. Water quality parameters were: temperature 25±1 °C , pH 7.6-8.0, salinity 16-26% and dissolved oxygen 71-101% saturated. Toxicant concentrations were measured nine times during the test and ranged 83-96% of expected concentrations. Control survival was 90% for both controls. The

NOEC and LOEC based on survival were 19.0 and 30.0 ug/L, respectively (Table 7).

Faggella and Finlayson (1988) - In 1985 and 1986 chronic toxicity tests were conducted on Ordram[R] 8EC (90.3%) and Bolero[R] 8EC (85.2%) with chinook salmon *Oncorhynchus tshawytscha* eggs-to-fry. The fish were challenged in a continuous-flow system for a total of 60 (1985) and 90 (1986) days using proposed ASTM (E1241) guidelines. The tests were terminated at 60 days after hatch, 30 days after the swim-up fry stage and commencement of feeding. Concentrations were replicated and there was a control treatment and a geometric series (dilution factor of 0.6) of five concentrations. Water quality parameters during the test were: temperature 12±0.8 °C (60-d), 10.4±0.7 °C (90-d); pH 7.0±0.3; hardness 20±2 mg/L $CaCO_3$; and dissolved oxygen 9.1±4 mg/L (60-d), 9.4±1.5 mg/L (90-d). Toxicant concentrations were measured twice weekly during the test and averaged 96% of expected concentrations for molinate and 89% for thiobencarb. Analytical precision was 88-89% with 95-101% recovery of spiked samples. Survival of controls averaged 97%. Chronic LC_{50} values were 0.74 mg/L for molinate (Table 6) and 200 ug/L for thiobencarb (Table 7). The NOEC and LOEC ranges based on survival and growth were 0.42 and 0.73 mg/L for molinate (Table 6) and 28 and 49 ug/L for thiobencarb (Table 7), respectively. The LC_{50} values for the mixture were 580 and 36 ug/L for molinate and thiobencarb, respectively (Table 8). The NOEC and LOEC ranges for the molinate-thiobencarb mixture were 160 and 230 ug/L for molinate and 9 and 13 ug/L for thiobencarb, respectively (Table 8).

Faggella and Finlayson (1988) - In 1987, 44-d flow-through toxicity tests were conducted by California Department of Fish and Game (CDFG) (at Aquatic Toxicology Laboratory) on Ordram[R] 8EC (90.3%) and Bolero[R] 8EC (85.2%) with striped bass *Morone saxatilis* larvae-to-fry. Water quality parameters during the tests averaged: temperature 18.5 °C, pH 8.3, hardness 443 mg/L $CaCO_3$, salinity 1.7 $^o/_{oo}$, and dissolved oxygen 8.8 mg/L. Concentrations were replicated and there was a control treatment and a geometric series of five concentrations. Toxicant concentrations were measured twice weekly during the test and averaged 107% of expected concentrations for molinate and 109% for thiobencarb. Survival of controls after 42 days ranged from 80 to 82%. Survival and growth were used as effect criteria. The LC_{50} values for striped bass were 0.64 mg/L for molinate (Table 6) and 130 ug/L for thiobencarb (Table 7). The NOEC and LOEC values for molinate were 0.22 and 0.38 mg/L (Table 6), respectively and for thiobencarb were 58 and 91 ug/L (Table 7), respectively. The LC_{50} values for the mixture were 720 and 49 ug/L for molinate and thiobencarb, respectively (Table 8). The NOEC and LOEC values for the mixture (Table 8) were 290 and 520 ug/L for molinate and 20 and 36 ug/L for thiobencarb, respectively (Table 8).

Finlayson and Faggella (1986) - In 1983 and 1984, 28-d flow-through toxicity tests were conducted on Ordram[R] 8EC (90.3%) with juvenile channel catfish *Ictalurus punctatus* and common carp *Cyprinus carpio*. Testing procedures outlined by ASTM (E729) were followed. Concentrations were replicated and there was a control treatment and a geometric series (dilution factor of 0.6) of five concentrations. Water quality parameters during the tests were: temperature 15-17 °C for catfish and 20-22 °C for carp, pH 6.9-7.2, alkalinity 18-19 mg/L $CaCO_3$, and dissolved oxygen at 90% saturated. Toxicant concentrations were measured twice weekly during the test and averaged 95% of expected concentrations for molinate. Analytical precision was ±10% with 90% recovery of spiked samples. There was 100% survival of controls for both species of fish. The 28-d LC_{50} value for common carp was 0.21 mg/L (Table 6). Survival and hemoglobin and hematocrit levels were used as effect. The NOEC and LOEC values for channel catfish were 1.7 and 2.6 mg/L, respectively and for common carp were 0.09 and 0.13 mg/L, respectively (Table 6).

Forbis (1987) - In 1987, 21-d flow-through toxicity test was conducted by ABC Laboratories, Inc. on molinate technical (% not given) with *Daphnia magna*. Test procedures outlined by ASTM (E729) and U.S. EPA (1975b) were followed. Concentrations were replicated four times and there was a water and solvent control and a series of five concentrations. Water quality parameters were: temperature 20±2 °C, pH 8.1-8.4, hardness 225-275 mg/L $CaCO_3$ and dissolved oxygen 76-95% saturated.

Toxicant concentrations were measured weekly and averaged 88-92% of expected values. Control survival was 100% for water and 98% for solvent. The NOEC and LOEC values based on growth as the effect were 0.38 and 0.90 mg/L, respectively (Table 6).

Fujimura et al. (in press) - In 1989, 46-d and 36-d flow-through toxicity tests were conducted on Bolero[R] 8EC (85.2% thiobencarb) with juvenile Striped Bass *Morone saxatilis* (Fujimura et al. in press). Test methods outlined by ASTM (E1241) were followed. Five toxicant concentrations (dilution factor 0.56) were tested in duplicate with a water control. Water quality parameters during the tests were: temperature 18.0 oC, dissolved oxygen 8.16-8.19, pH 7.87-7.89, conductivity 2,924-4,642 usemens, hardness 454-478 mg/L $CaCO_3$, and alkalinity 156-157 mg/L $CaCO_3$. Control survival ranged from 60-85%. Toxicant level was monitored twice weekly and ranged from 88-91% of nominal. The NOEC and LOEC values were 21 and 36 ug/L, respectively for the 46-d eggs-to-fry test and <23 ug/L for the 36-d larvae-to-fry test (Table 7).

McAllister (1988) - In 1987 ABC Laboratories Inc. conducted a 60-day early life stage (egg-to-fry) toxicity test with rainbow trout *Oncorhynchus mykiss*. The fish were challenged in a flow-through system using molinate technical (% not given). Test procedures outlined by ASTM (E1241) were followed. Fish eggs were incubated in exposure aquaria. On day 14, 10 fish were transferred to growth chambers and the 60-day post-hatch growth period commenced. Concentrations were replicated four times and there was a water and solvent control treatment and a series of five concentrations. Water quality parameters during the test were: temperature 8-13 °C, pH 8.0-8.2, alkalinity 386 mg/L $CaCO_3$, and dissolved oxygen 8.2-10.0 mg/L (62-90% saturated). Toxicant concentrations were measured every seven days and averaged 98 to 104% of expected concentrations. Survival of controls after 60 days averaged 90%. The NOEC was 0.39 mg/L and LOEC was 0.83 mg/L (Table 6).

Stauffer (1984a; 1984b) - In 1984, 28-d flow-through toxicity tests were conducted by the Stauffer Chemical Company on Ordram[R] 8EC (92.1%) with channel catfish *Ictalurus punctatus* (Stauffer 1984b) and bluegill *Lepomis macrochirus* (Stauffer 1984a). Concentrations were replicated and there was a control treatment and a series of five concentrations. Water quality parameters during the test were: temperature 17-19 °C, pH 6.8-7.5, hardness 300 mg/L $CaCO_3$, and dissolved oxygen 5.1-8.5 mg/L. Toxicant concentrations were measured weekly during the test and averaged 66-103% of expected concentrations. There was 100% survival of controls. Survival and hemoglobin and hematocrit levels were used as effect criteria. There was no effect in any treatments with bluegill. The NOEC value for sunfish was reported as 6.05 mg/L which was the highest exposure level tested. The channel catfish LC_{50} value was 6.1, and NOEC of 0.9 and LOEC of 1.6 mg/L (Table 6).

Unaccepted Data - The following studies were unaccepted toxicity tests and therefore, not used in deriving Final Chronic Values for molinate and thiobencarb.

Bailey (1985a) - In 1985, time-independent studies were conducted as part of acute toxicity tests conducted by SRI International for the State Water Resources Control Board, on molinate and thiobencarb with mysid *Neomysis mercedis*. Tests were conducted for 14-d or until a period of 48 hours passed with no mortality. Concentrations were replicated and there was a control treatment and a series of five concentrations. Water quality parameters during the test were: temperature 16-20 °C, pH 8.6-8.9, conductivity 3,650-3,850 umhos and dissolved oxygen 8.1-9.2 mg/L. Toxicant concentrations were measured twice weekly and were close to 100% of expected values. There was 80-100% survival of controls. No Observable Effect Concentration (NOEC) values were not calculated because each concentration tested had significant mortality. The 28-d LC_{50} for molinate was 0.23 mg/L (Table C1) the 18-d LC_{50} for thiobencarb was 53 ug/L (Table C2), and the 18-d LC_{50} for the mixture was 290 and 9 ug/L (Table 8) for molinate and thiobencarb, respectively. These values were unacceptable because LC_{50} values could not be used in deriving the FCV.

Bailey (1985b) - In 1985, 42-d flow-through toxicity tests were conducted by SRI International for the State Water Resources Control Board on thiobencarb and molinate technical (% not given) with mysid *Neomysis mercedis*. Young mysids were obtained from gravid females in exposure dishes which were producing young for 14 days of the test. After 14 days the adults were removed and the young tested for survival. Tests were conducted on molinate, thiobencarb, and molinate/thiobencarb mixture. Concentrations were replicated and there was a control treatment and a series of five concentrations. Water quality parameters during the test were: temperature 17.5-18.5 °C, pH 6.9-7.9, salinity 2.5 °/₀₀, and dissolved oxygen 8.3-9.4 mg/L. Toxicant concentrations were measured twice weekly and averaged 97 to 135% of expected concentrations. Results of mixture tests were not accepted because survival of young was less than the control values by day 14 due to failure of the bioassay room's temperature-control system.

Bionomics EG&G (1979g) - In 1979, 28-d flow-through toxicity test was conducted on thiobencarb technical (95.1%) with sheepshead minnows *Cyprinodon variegatus*. Test procedures outlined by Chevron Chemical Company (1980) were followed. Concentrations were replicated and there was a dilution water and solvent control and a series of five concentrations. Water quality parameters were: temperature 25+1 °C, pH 7.3-8.1, salinity 18-26 °/₀₀ and dissolved oxygen 4-115% saturated. Toxicant concentrations were measured twice weekly during the test and ranged 68-83% of expected concentrations. Control survival was 81% for both controls. The NOEC and LOEC values based on survival were 180 and 230 ug/L, respectively (Table C2). These values were unacceptable because dissolved oxygen in the solvent control and other test concentrations varied considerably and reached levels as low as 0.3 mg/L due to algal growth. The problem with algae growth in test chambers probably contributed to the low control survival (81%).

Browne (1979) - In 1979, 21-d flow-through toxicity test was conducted by Union Carbide Corporation on thiobencarb technical (95.2-95.9%) with *Daphnia magna*. Each test had a solvent and dilution water control and a series of five concentrations. Water quality parameters during the test were: temperature 18.9-24.3 °C, pH 7.6-8.1, alkalinity 141 mg/L $CaCO_3$, and dissolved oxygen 9.2 mg/L. Toxicant concentrations were measured seven times during the test and averaged 90% of expected values. Survival of the controls was 90% for water and 78% for solvent. The 21-d LC_{50} value was 9.0 ug/L, respectively (Table C2). These values were unacceptable because of the significant differences between the water and solvent controls.

Kawatsu (1977) - In 1977, 21-d flow-through toxicity test was conducted by a Japanese researcher on molinate (% not given) with carp (scientific name not given). Water temperature was maintained at 23-25 °C. Each test had three concentration levels. Toxicant level monitoring, water quality parameters and test animal descriptions were not mentioned. Survival of controls was 100%. Survival, growth and hemoglobin content were used as effect criteria. The 21-d LC_{50} value was 0.18 mg/L and NOEC and LOEC values were 0.032 and 0.10 mg/L (Table C1). This value was unacceptable because the study lacked essential information necessary to evaluate stability of the testing system.

McKenney (1985) - In 1985, 24-d static toxicity test was conducted on thiobencarb (% not given) with *Mysidopsis bahia*. This was a research study which did not follow standard procedures outline by ASTM or APHA. Concentrations were replicated three times and there was a solvent (triethylene glycol) control and a series (dilution factor 0.4 to 0.6) of six concentrations. Water quality parameters were: temperature 25+1 °C and salinity 20+2% (no other parameters were given). Toxicant concentrations were measured weekly during the test and ranged 6% to 46% of expected concentrations. There was 96% recovery of spiked samples. The LOEC based on survival as the effect was 76 ug/L and based on production of young as the effect was 35 ug/L (Table C2). These values could not be used because NOEC was necessary to calculate FCV.

Nishiuchi et al. (1982) - In 1982, 29-d flow-through toxicity test was conducted by a Japanese researcher on technical molinate (97.6%) with common carp *Cyprinus carpio*. Test had a control treatment (unable to determine if solvent control was used) a series of four concentrations and unable to determine numbers of individuals in each treatment. Toxicant concentrations were measured 12 times during the 29 day test and varied considerably around expected concentrations. There was no mention of test replication, statistical procedure or study design. The article was in Japanese so much of the detail was incomprehensible. Survival, hemoglobin and hematocrit levels were used as the effect. A remarkable (not stated as statistically significant) decrease in RBC, Hgb, and Hct values was reported at an 0.01 mg/L molinate exposure level after 15 days (Table C1). These toxicity values were unacceptable because there was high variability in blood chemistry with test groups, unknown replication, and control group measurements overlapped the treatment group.

Rao et al. (1983) - In 1983, 10-d toxicity test was conducted on thiobencarb (98%) with the African cichlid *Sarotheradon mossambicus* (Rao et al. 1983). The LC_{50} was 9500 ug/L (Table 11). Specific toxicant concentrations, toxicant level monitoring, water quality parameters, and control survival were not mentioned. This value was unacceptable because the study lacked essential information necessary to evaluate stability of the testing system and control survival.

Table C1. Acceptable values for acute toxicity of molinate to aquatic animals.

Species	Life Stage	Method[a]	Formulation	Salinity/ Hardness	Test Length	Effect	Values (mg/L) (95% confidence limits)	Reference
Common carp *Cyprinus carpio*	---	F, U	Commercial Ordram® (--)	---	21-d	LC_{50} NOEC 0.032 LOEC 0.10	0.18	Kawatsu 1977
Common carp *Cyprinus carpio*	---	F, M	Tech (97.6%)	---	29-d	LOEC	0.01	Nishiuchi et al. 1982
Mysid *Neomysis mercedis*	---	F, M	Tech (--)	---	28-d	LC_{50}	0.23(0.15-0.34)	Bailey 1985a

[a] S = static, F = flow through, M = measured concentration, U = unmeasured concentration

Table C2. Unacceptable values for chronic toxicity of thiobencarb to aquatic animals.

Species	Life Stage	Method[a]	Formulation	Salinity/ Hardness	Test Length	Effect	Values (ug/L) (95% confidence limits)	Reference
Africian cichlid <u>Sarotheradon mossambicus</u>	---	S, U	98% w/v	---	10-d	LC_{50}	9500	Rao et al. 1983
Waterflea <u>Daphnia magna</u>	1st instar	F, M	Tech (95.2-95.5%)	212 mg/L $CaCO_3$	21-d	LC_{50}	9(5-15)	Browne 1979
Mysid <u>Mysidopsis bahia</u>	juvenile	S, M	---	20 °/oo	24-d	LOEC LOEC	76 (survival) 35 (reproduction)	McKenney 1985
Mysid <u>Neomysis mercedis</u>	---	F, M	Tech (--)	---	18-d	LC_{50}	53(23-100)	Bailey 1985a
Sheepshead minnow <u>Cyprinodon varigatus</u>	juvenile	F, M	Tech (95.1%)	---	28-d	NOEC LOEC	180 230	Bionomics EG&G 1979g

[a] S = static, F = flow through, M = measured concentration, U = unmeasured concentration