Water Quality Criteria Report for Lambda-cyhalothrin

Updated Report

Prepared by:
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Central Valley Regional Water Quality Control Board

Updated May 2015

Original Report

Prepared for the Central Valley Regional Water Quality Control Board by:

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Original March 2010

Disclaimer

Funding for the original 2010 criteria report was project was provided by the California Regional Water Quality Control Board, Central Valley Region (CRWQCB-CVR). The contents of this document do not necessarily reflect the views and policies of the CRWQCB-CVR, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

Note on the Updated Report

The original report (March 2010) was prepared by the listed authors at UC Davis. This report was updated in May 2015 by CRWQCB-CVR staff in order to include recently generated toxicity data. The updates to the report were not prepared by or reviewed by UC Davis. The majority of the original report was unchanged; the sections that include updates are as follows: 7 Acute criterion calculation, 8 Chronic criterion calculation, 9.2 Mixtures, 10.1 Sensitive species, 12.1 Assumptions, Limitations and Uncertainties, 12.2 Comparison to National Standard Methods, and 12.3 Final criteria statement. The recently generated toxicity data included in the update led to changes in the final criteria. In order to compare the original report and criteria to the updated report and criteria, the original report will remain available at: http://www.waterboards.ca.gov/centralvalley/water_issues/tmdl/central_valley_projects/central_valley_pesticides/criteria_method/index.shtml.

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Table of Contents

Disclaimer 2
Note on the Updated Report 2
Table of Contents ii
List of Figures iii
List of Tables iii
List of acronyms and abbreviations iv
1 Introduction 1
2 Basic information 1
3 Physical-chemical data 2
4 Human and wildlife dietary values 4
5 Ecotoxicity data 4
6 Data reduction 5
7 Acute criterion calculation 6
8 Chronic criterion calculation 8
9 Water Quality Effects 9
9.1 Bioavailability 9
9.2 Mixtures 12
9.3 Temperature, pH, other water quality effects 13
10 Comparison of ecotoxicity data to derived criteria 15
10.1 Sensitive species 15
10.2 Ecosystem and other studies 16
10.3 Threatened and endangered species 17
11 Harmonization with other environmental media 18
11.1 Bioaccumulation 18
11.2 Harmonization with air or sediment criteria 20
12 Lambda-cyhalothrin Criteria Summary 20
12.1 Assumptions, Limitations and Uncertainties 20
12.2 Comparison to National Standard Methods 21
12.3 Final criteria statement 23
Acknowledgements 25
References 26
Data Tables 34
Appendix A: Fit Test Calculations A1
Appendix B: Data summary sheets B1

List of Figures

Figure 1 Structure of lambda-cyhalothrin, asterisks indicate stereocenters. 2
Figure 2 Histogram of the natural log of the lambda-cyhalothrin species mean acute values. 7
Figure 3 The fit of the Burr Type III distribution plotted with the acute toxicity values. .. 7

List of Tables

Table 1 Bioconcentration factors (BCF) for cyhalothrin and lambda-cyhalothrin. 3
Table 2 Lambda-cyhalothrin hydrolysis, photolysis, and biodegradation 4
Table 3 Final acute toxicity data set for lambda-cyhalothrin. 35
Table 4 Reduced acute data rated RR. 37
Table 5 Supplemental acute data rated RL, LR, LL. 40
Table 6 Final chronic toxicity data set for lambda-cyhalothrin. 42
Table 7 Acceptable reduced chronic data rated RR. 43
Table 8 Acute-to-Chronic Ratios used for derivation of the lambda-cyhalothrin chronic criterion. 44
Table 9 Supplemental chronic toxicity data from studies rated RL, LR, or LL. 45
Table 10 Acceptable multispecies field, semi-field, laboratory, microcosm, mesocosm studies. 46
Table 11 Threatened, Endangered, or Rare Species Predicted values by ICE. 46

List of acronyms and abbreviations

ACR	Acute-to-Chronic Ratio
APHA	American Public Health Association
ASTM	American Society for Testing and Materials
BAF	Bioaccumulation Factor
BCF	Bioconcentration Factor
BMF	Biomagnification Factor
CA	Concentration Addition
CAS	Chemical Abstract Service
CDFG	California Department of Fish and Game
CDPR	California Department of Pesticide Regulation
CDWR	California Department of Water Resources
CSIRO	Commonwealth Scientific and Industrial Research Organization, Australia
CVRWQCB	Central Valley Regional Water Quality Control Board
DOC	Dissolved Organic Carbon
DOM	Dissolved Organic Matter
EC_x	Concentration that affects x% of exposed organisms
FDA	Food and Drug Administration
FT	Flow-through test
GMAV	Genus Mean Acute Value
IA	Independent Action
IC_x	Inhibition concentration; concentration causing *x*% inhibition
ICE	Interspecies Correlation Estimation
IUPAC	International Union of Pure and Applied Chemistry
K	Interaction Coefficient
K_H	Henry's law constant
K_{ow}	Octanol-Water partition coefficient
K_p or K_d	Solid-Water partition coefficient
LC_x	Concentration lethal to *x*% of exposed organisms
LD_x	Dose lethal to *x*% of exposed organisms
LL	Less relevant, Less reliable study
LOEC	Lowest-Observed Effect Concentration
LOEL	Lowest-Observed Effect Level
LR	Less relevant, Reliable study
MATC	Maximum Acceptable Toxicant Concentration
N	Not relevant or Not reliable study
n/a	Not applicable
NOAEL	No-Observed Adverse Effect Level
NOEC	No-Observed Effect Concentration
NR	Not reported
OC	Organic Carbon

OECD	Organization for Economic Co-operation and Development
PBO	Piperonyl butoxide
QSAR	Quantitative Structure Activity Relationship
pK_a	Acid dissociation constant
RL	Relevant, Less reliable study
RR	Relevant and Reliable study
S	Static test
SMAV	Species Mean Acute Value
SMCV	Species Mean Chronic Value
SPME	Solid-phase Microextraction
SR	Static renewal test
SSD	Species Sensitivity Distribution
TES	Threatened and Endangered Species
TIE	Toxicity Identification Evaluation
US	United States
USEPA	United States Environmental Protection Agency

1 Introduction

A new methodology for deriving freshwater water quality criteria for the protection of aquatic life was developed by the University of California, Davis (TenBrook et al. 2009a). The need for a new methodology was identified by the California Central Valley Regional Water Quality Control Board (CVRWQCB 2006) and findings from a review of existing methodologies (TenBrook & Tjeerdema 2006, TenBrook et al. 2009b). This new methodology is currently being used to derive aquatic life criteria for several pesticides of particular concern in the Sacramento River and San Joaquin River watersheds. The methodology report (TenBrook et al. 2009a) contains an introduction (Chapter 1); the rationale of the selection of specific methods (Chapter 2); detailed procedures for criteria derivation (Chapter 3); and a chlorpyrifos criteria report (Chapter 4). This criteria report for lambda-cyhalothrin describes, section by section, the procedures used to derive criteria according to the UC-Davis methodology. Also included are references to specific sections of the methodology procedures detailed in Chapter 3 of the report so that the reader can refer to the report for further details (TenBrook et al. 2009a). The lambda-cyhalothrin water quality criteria were updated in 2015 to include additional data generated since the original report released in 2010.

2 Basic information

Chemical: Lambda-cyhalothrin (Figure 1)

CAS: [1α(*S**),3α (*Z*)]-(±)-cyano-(3-phenoxyphenyl)methyl 3-(2-chloro-3,3,3-trifluoro-1-propenyl)-2,2-dimethylcyclopropanecarboxylate

IUPAC: (*S*)-α-cyano-3-phenoxybenzyl (*Z*)-(1*R*,3*R*)-3-(2-chloro-3,3,3-trifluoropropenyl)-2,2-dimethylcyclopropanecarboxylate

Chemical Formula: $C_{23}H_{19}ClF_3NO_3$

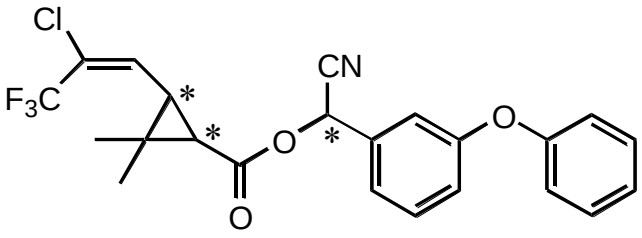
CAS Number: 91465-08-6

CA DPR Chem Code: 2297

USEPA PC Code: 128897

Trade names: Warrior, Phoenix, SFK, Charge, Excaliber, Grenade, Hallmark, Icon, Karate, Matador, OMS 0321, PP321, Saber, Samurai and Sentinel (ExToxNet 1995, Tomlin 2003).

l moiety



λ-Cyhalothrin (II)

Figure 1 Structure of lambda-cyhalothrin, asterisks indicate stereocenters.

3 Physical-chemical data

Molecular Weight

449.850 Mackay et al. 2006

Cypermethrin (II)

Composition

Equal quantities of (*S*)-α-cyano-3-phenoxybenzyl(*Z*)-(1*R*,3*R*)-3-(2-chloro-3,3,3-trifluoropropanyl)-2,2-dimethylcyclopropanecarboxylate and (*S*)-α-cyano-3-phenoxybenzyl(*Z*)-(1*S*,3*S*)-3-(2-chloro-3,3,3-trifluoropropanyl)-2,2-dimethylcyclopropanecarboxylate (Tomlin 2003).
Technical grade is ~81% pure (Tomlin 2003).

Cyfluthrin (II)

Density

1.33 g/mL at 25°C Mackay et al. 2006, Tomlin 2003

Water Solubility

0.005 mg/L at 20°C (mean, n=12)	Laskowski 2002
0.005 mg/L at 20°C (pH 6.5)	Mackay et al. 2006
0.005 mg/L at 20°C (pH 6.5, purified water)	Mackay et al. 2006, Tomlin 2003
0.004 mg/L (pH 5.0, buffered water)	Mackay et al. 2006

Geomean: 0.0047 mg/L

Melting Point

49.2°C	Tomlin 2003
Technical: 47.5-48.5°C	Tomlin 2003

Vapor Pressure

1.56 x 10^{-9} mm Hg at 20°C	Laskowski 2002
2.0 x 10^{-7} Pa at 20°C	Mackay et al. 2006
2.0 x 10^{-7} Pa at 20°C (estimated)	Mackay et al. 2006, Tomlin 2003
2.0 x 10^{-4} Pa at 60°C (interpolated)	Mackay et al. 2006, Tomlin 2003
7.80 x 10^{-6} Pa at 40°C	Mackay et al. 2006
19 x 10^{-6} Pa at 40°C (measured 40-80°C)	Mackay et al. 2006

Logistic Octanol-Water Partition Coefficient (Log K_{ow})

7.06 (slow-stir method – preferred) Dix 2014
7.0 at 20°C Laskowski 2002, Mackay et al. 2006, Tomlin 2003

Organic Carbon Sorption Partition Coefficients (log K_{oc})

Limited to data from studies that used a batch equilibrium experimental design with natural sediment and measured the freely dissolved aqueous concentrations. All units are L/kg.

2,077,949	Chickering 2014
2,160,946	Chickering 2014
1,929,773	Chickering 2014
2,300,000	Cui & Gan 2013
2,140,000	Cui & Gan 2013
1,860,000	Cui & Gan 2013
370,000	Cui & Gan 2013
12,130,000	Cui & Gan 2013

Median K_{oc}: 1,887,909 L/kg
Median log K_{oc}: **6.32**

Henry's constant (K_H)

1.9×10^{-7} atm m^3 mol^{-1} at 20°C Laskowski 2002
2×10^{-2} Pa m^3 mol^{-1} Tomlin 2003

pK_a

> 9 (hydrolysis prevents measurement) Tomlin 2003

Environmental Fate

Table 1 Bioconcentration factors (BCF) for cyhalothrin and lambda-cyhalothrin.

Species	**BCF**	**Exposure**	**Reference**
Cyprinus carpio (whole fish)	2240	Flow-through	Yamauchi et al. 1984 (cyhalothrin)
Cyprinus carpio (viscera)	7340	Flow-through	Yamauchi et al. 1984 (cyhalothrin)
Cyprinus carpio (muscle)	850	Flow-through	Yamauchi et al. 1984 (cyhalothrin)
Chironomus riparius	2000	Water only	Hamer et al. 1999
Chironomus riparius	2300 (mean)	Water-sediment	Hamer et al. 1999
Daphnia magna	194	Water-sediment	Hamer & Hill 1985 (cyhalothrin)
Ictalurus punctatus (whole fish)	19	Water-sediment	Hamer & Hill 1985 (cyhalothrin)
Ictalurus punctatus (muscle)	7	Water-sediment	Hamer & Hill 1985 (cyhalothrin)
Ictalurus punctatus (viscera)	66	Water-sediment	Hamer & Hill 1985 (cyhalothrin)

Table 2 Lambda-cyhalothrin hydrolysis, photolysis, and biodegradation

	Half- life (d)	Water	Temp (°C)	pH	Reference
Hydrolysis	Stable (0 d)	Sterile, buffered	25	5	Laskowski 2002
	Stable (0 d)	Sterile, buffered	25	7	Laskowski 2002
	8.66	Sterile, buffered	25	9	Laskowski 2002
Aqueous Photolysis	24.5	NR	25	5	Laskowski 2002
Biodegradation (aerobic)	21.9	Natural water	20	NR	Laskowski 2002

4 Human and wildlife dietary values

There are no FDA action levels for lambda-cyhalothrin (USFDA 2000). There are no food tolerances for human consumption of fish, but there are food tolerances for the meat of hogs at 0.1 ppm (USEPA 2007).

Wildlife LC_{50}s (dietary) for animals with significant food sources in water

The dietary LC_{50} for 8-d old mallard ducks was determined to be 3948 ppm (Roberts et al. 1985). In an acute oral toxicity test with young adult mallard ducks a dietary LD_{50} could not be determined because there were no effects observed at any of the concentrations. The single doses of pure lambda-cyhalothrin were administered via oral intubation and the highest concentration tested was 3950 mg/kg body weight (Roberts & Fairley 1984).

Wildlife dietary NOECs for animals with significant food sources in water

A dietary NOEC of 30 mg/kg feed for 20-week old mallard ducks was determined over a 20 week period (Beavers et al. 1990). A LOEC could not be determined in this study because no significant effects were observed at any concentration tested. The highest concentration of lambda-cyhalothrin in mallard feed was 30 mg/kg, which was reported as the NOEC for the study, but this is likely an underestimation because no toxicity was observed at any of the tested concentrations.

Lambda-cyhalothrin did not bioaccumulate in young adult mallard ducks over a 28-d exposure given by oral gavage (Knight & Leahey 1984).

5 Ecotoxicity data

Approximately 76 original studies on the effects of lambda-cyhalothrin on aquatic life were identified and reviewed. Several review articles were examined to find all relevant studies on lambda-cyhalothrin (Giddings 2006, Giddings et al. 2009, He et al. 2008, Maund et al. 1998, Van Wijngaarden et al. 2005). In the review process, many

parameters were rated for documentation and acceptability for each study, including, but not limited to: organism source and care, control description and response, chemical purity, concentrations tested, water quality conditions, and statistical methods (see Tables 3.6, 3.7, 3.8 in TenBrook et al. 2009a). Single-species effects studies that were rated relevant (R) or less relevant (L) according to the method (Table 3.6) were summarized in data summary sheets. Information in these summaries was used to evaluate each study for reliability using the rating systems described in the methodology (Tables 3.7 and 3.8, section 3-2.2, TenBrook et al. 2009a), to give a reliability rating of reliable (R), less reliable (L), or not reliable (N). Copies of completed summaries for all studies are included in Appendix B of this report. Lambda-cyhalothrin studies deemed irrelevant from an initial screening were not summarized (e.g., studies involving rodents or *in vitro* exposures). All data rated as acceptable (RR) or supplemental (RL, LR, LL) for criteria derivation are summarized in Table 3, Table 4, Table **5**, Table **6**, Table **7**, and Table **9**. Acceptable studies rated as RR are used for numeric criteria derivation, while supplemental studies rated as RL, LR or LL are used for evaluation of the criteria to check that they are protective of particularly sensitive species and threatened and endangered species. These considerations are reviewed in sections 10.1 and 10.3 of this report, respectively. Studies that were rated not relevant (N) or not reliable (RN or LN) were not used for criteria derivation.

Using the data evaluation criteria (section 3-2.2, TenBrook et al. 2009a), 21 acute toxicity studies, yielding 67 toxicity values, were judged reliable and relevant (RR; Table 3 and Table 4). Three chronic toxicity studies, yielding twelve toxicity values, were judged reliable and relevant (RR; Table **6** and Table **7**). Six acute and three chronic studies were rated RL, LL, or LR and were used as supplemental information for evaluation of the derived criteria in section 10.1 (Table **5** and Table **9**, respectively).

Twelve mesocosm, microcosm and ecosystem (field and laboratory) studies were identified and reviewed using Table 3.9 (TenBrook et al. 2009a). Nine of these studies were rated reliable (R) or less reliable (L) and were used as supporting data in section 10.2 to evaluate the derived criteria to ensure that they are protective of ecosystems (Table **10**). Four studies of lambda-cyhalothrin effects on wildlife were identified and reviewed using Table 3.10 (TenBrook et al. 2009a) for consideration of bioaccumulation in section 11.1.

6 Data reduction

Multiple toxicity values for lambda-cyhalothrin for the same species were reduced to one species mean acute toxicity value (SMAV) or one species mean chronic value (SMCV) according to procedures described in the methodology (section 3-2.4, TenBrook et al. 2009a). Acceptable acute and chronic data that were reduced, and the reasons for their exclusion, are shown in Table 4 and Table **7**, respectively. Reasons for reduction of data included: flow-through tests are preferred over static tests, a test with a more sensitive life-stage of the same species was available, more sensitive endpoints were available for the same test, and more appropriate or more sensitive test durations were available for the same test. The final acute and chronic data sets are shown in Table 3 and

Table **6**, respectively. The final acute data set contains 20 SMAVs, and the final chronic data set contains two SMCVs.

7 Acute criterion calculation

At least five acceptable acute toxicity values were available and fulfilled the five taxa requirements of the species sensitivity distribution (SSD) procedure (section 3-3.1, TenBrook et al. 2009a). The five taxa requirements are a warm water fish, a fish from the family Salmonidae, a planktonic crustacean, a benthic crustacean, and an insect. Acute values were plotted in a histogram (Figure 2); the data do not appear to be bimodal.

The Burr Type III SSD procedure (section 3-3.2.1, TenBrook et al. 2009a) was used for the acute criterion calculation because more than eight acceptable acute toxicity values were available in the lambda-cyhalothrin data set (Table 3). The Burr Type III SSD procedure was used to derive 5th percentile values (median and lower 95% confidence limit), as well as 1st percentile values (median value only, as the software could not provide a lower 95% confidence limit for the 1st percentile). The median 5th percentile value is recommended for use in criteria derivation by the methodology because it is the most robust of the distributional estimates (section 3-3.2, TenBrook et al. 2009a). Comparing the median estimate to the lower 95% confidence limit of the 5th percentile values, it can be seen that the first significant figures of the two values are different (0.001335 vs. 0.000049 µg/L). Because there is uncertainty in the first significant digit, the final criterion will be reported with one significant digit (section 3-3.2.6, TenBrook et al. 2009a).

The fit of the Burr III distribution from the BurrliOZ software (CSIRO 2000) is shown in Figure 3. This distribution provided a satisfactory fit (Appendix A) according to the fit test described in section 3-3.2.4 of TenBrook et al. (2009a). No significant lack of fit was found (χ^2_{2n} = 0.1662) using a fit test based on cross validation and Fisher's combined test (section 3-3.2.4, TenBrook et al. 2009a), indicating that the data set is valid for criteria derivation.

Burr III distribution
Fit parameters: b=0.353781; c=1.2388; k=0.43335 (likelihood= -5.832487)

5th percentile, 50% confidence limit: 0.001335 µg/L
5th percentile, 95% confidence limit: 0.000049 µg/L
1st percentile, 50% confidence limit: 0.000067 µg/L

Recommended acute value = 0.001335 µg/L (median 5th percentile value)

Acute criterion = acute value ÷ 2
= 0.001335 µg/L ÷ 2
= 0.000668 µg/L
Acute criterion = 0.0007 µg/L
= 0.7 ng/L

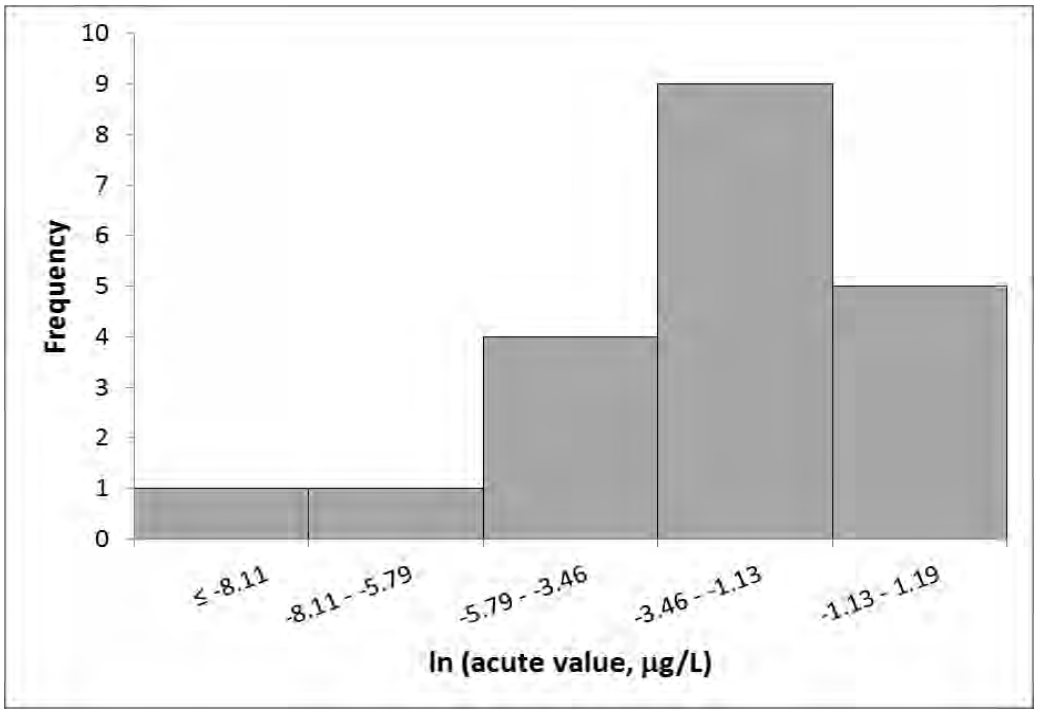


Figure 2 Histogram of the natural log of the lambda-cyhalothrin species mean acute values.

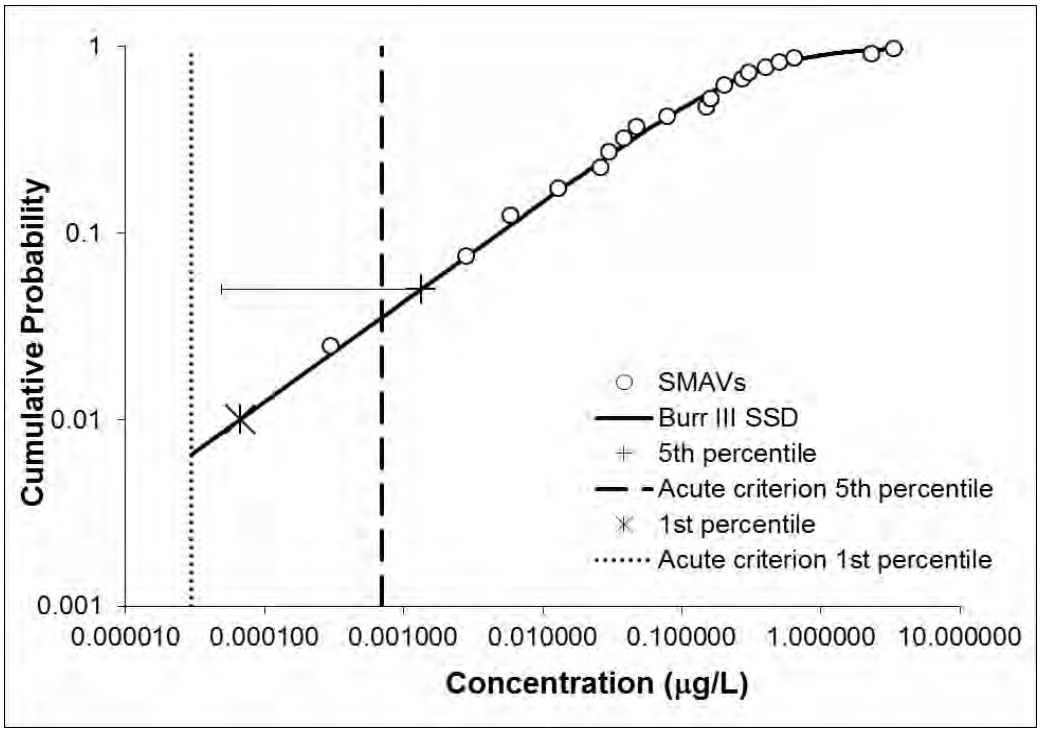


Figure 3 The fit of the Burr Type III distribution to the lambda-cyhalothrin acute data set. The median 5th percentile acute value with the lower 95% confidence limit and the median 1st percentile acute value are each displayed. The acute criteria calculated with the median 5th percentile and median 1st percentile value are displayed as vertical lines.

8 Chronic criterion calculation

Chronic toxicity values from fewer than five different families were available, thus the acute-to-chronic ratio (ACR) method was used to calculate the chronic criterion (section 3-4.2, TenBrook et al. 2009a). Two SMCVs are in the acceptable (rated RR) data set (Table **6**), satisfying two of the five taxa requirements (section 3-3.1, TenBrook et al. 2009a): warm water fish (*Pimephales promelas)* and planktonic crustacean (*Daphnia magna).*

Two of the chronic toxicity values could be paired with an appropriate corresponding acute toxicity value in order to calculate an ACR, satisfying two of the three family requirements: a fish and an invertebrate (section 3-4.2.1, TenBrook et al. 2009a). Data for one additional acutely sensitive species is required to derive an ACR based on measured data. Because there were only acceptable chronic data for two freshwater species, data from a saltwater species was used to fulfill the final requirement because freshwater and saltwater ACRs have been shown to be comparable (section 3-4.2.1, TenBrook et al. 2009a). Saltwater data in the supplemental data sets (Table **5** and Table **9**) contained acute and chronic toxicity values for Sheepshead minnow (*Cyprinodon variegatus)* from the same flow-through study conducted by the same laboratory in the same dilution water, which are appropriate data for ACR derivation (section 3-4.2.1, TenBrook et al. 2009a).

The species mean ACR (SMACR) for each of the three species was calculated by dividing the acute LC_{50} value by the chronic MATC value. The final multi-species ACR was obtained by calculating the geometric mean of the three SMACR values because all species were within a factor of ten and there was not an increasing or decreasing trend in SMACRs with the species mean acute values (step 2, section 3-4.2.1, TenBrook et al. 2009a). The individual species and final multi-species ACRs generated are shown in Table 8.

The chronic criterion was calculated using the acute median 5^{th} percentile value and the final multi-species ACR value as follows:

Chronic criterion = acute median 5^{th} percentile value ÷ ACR
= 0.001335 μg/L ÷ 4.73
= 0.000282 μg/L

Chronic criterion = 0.0003 μg/L
= 0.3 ng/L

The chronic criterion is rounded to one significant figure because the first significant digit of the acute median 5^{th} percentile value (used for chronic criterion calculation) is different than that of the lower 95% confidence limit, indicating that only one digit is significant.

9 Water Quality Effects

9.1 Bioavailability

Although lambda-cyhalothrin and other pyrethroids are not very soluble in water, aquatic organisms are very sensitive to pyrethroids and toxicity does occur. Pyrethroids have been found as the cause of toxicity in surface waters in the California Central Valley (Phillips et al. 2007, Weston et al. 2009, Weston and Lydy 2010). This toxicity is believed to occur primarily from the fraction of the compound that is dissolved in the water, not from the compound that is associated with the particulate phase.

Several studies suggest that the binding of lambda-cyhalothrin and other pyrethroids to suspended solids and dissolved organic matter will make the bound fraction unavailable and thus nontoxic to aquatic organisms. The effects of dissolved organic carbon (DOC) on the acute toxicity of cyhalothrin (not lambda-cyhalothrin) to *Daphnia magna* were examined by Day (1991). Significantly less cyhalothrin was accumulated by *D. magna* when the DOC concentration was 3.1 mg/L or higher. The 48-hr EC_{50} decreased with increasing DOC concentrations for all pyrethroids tested. For cyhalothrin, the 48-hr EC_{50} increased 1.74-fold as the DOC increased from 1.3 mg/L DOC (EC_{50}=0.19 µg/L) to 9.7 mg/L DOC (EC_{50}=0.33 µg/L); the trends were more pronounced for other the pyrethroids deltamethrin and fenvalerate.

Smith and Lizotte (2007) conducted lambda-cyhalothrin and gamma-cyhalothrin toxicity tests with *Hyalella azteca* and twelve unfiltered pond waters with varying concentrations of the following four water quality parameters: turbidity, suspended solids (TSS), DOC, and chlorophyll *a* (chl *a*). The EC_{50} values linearly increased as each parameter increased, indicating that bioavailability is directly related to the concentrations of these four parameters due to sorption of pyrethroids onto the particles, colloids or dissolved matter. The interaction of increased DOC and phytoplankton (as chl *a*) decreased toxicity of lambda-cyhalothrin to *H. azteca* by more than 10-fold. The following equations were derived from linear regression of the concentration of the given parameter and the lambda-cyhalothrin EC_{50} values (ng/L):

Turbidity (x, NTU):	$EC_{50} = 0.216x + 3.04$, $R^2 = 0.712$, $p = 0.0006$
TSS (x, mg/L):	$EC_{50} = 0.179x + 3.15$, $R^2 = 0.644$, $p = 0.0017$
DOC (x, mg/L):	$EC_{50} = 0.546x + 1.07$, $R^2 = 0.847$, $p < 0.0001$
Chlorophyll *a* (x, µg/L):	$EC_{50} = 0.123x + 2.61$, $R^2 = 0.742$, $p = 0.0003$

These equations present a limited approach to account for bioavailability of lambda-cyhalothrin because in typical water bodies all of these parameters co-occur, and other parameters affecting sorption may also occur. Moreover, these equations cannot be used to determine criteria compliance, but they do demonstrate the range of natural sorbents that affect bioavailability of lambda-cyhalothrin.

There are many studies on pyrethroids, not necessarily including lambda-cyhalothrin, that also demonstrate decreased toxicity of pyrethroids in the presence of

sediment, DOC, and other natural sorbents (Xu et al. 2007; Yang et al. 2006a, 2006b). These studies suggest that the freely dissolved concentration will be the most accurate predictor of toxicity and that bound lambda-cyhalothrin was unavailable to the organisms that were studied.

As a counterpoint, equilibrium partitioning would suggest that as organisms take up lambda-cyhalothrin, more lambda-cyhalothrin will desorb from particles, so the fraction absorbed to solids is likely not completely unavailable. According to the equilibrium partitioning model, lambda-cyhalothrin would continue to desorb from particles as organisms took it up, but the dissolved concentration would be constant if the system was at steady-state. This means that the duration of exposure could be increased, but not likely the magnitude. Benthic organisms, such a *Hyalella azteca,* may be at greater risk because of their exposure to porewater and close proximity to sediments.

Additionally, the role of dietary exposure on bioavailability of pyrethroids has not been considered. Organisms living in contaminated waters are also ingesting food with sorbed hydrophobic compounds that can be desorbed by digestive juices (Mayer et al. 2001). The effects of dietary exposure may also be species-specific, depending on typical food sources; some species may have greater interaction with particles, increasing their exposure. Palmquist et al. (2008) examined the effects due to dietary exposure of the pyrethroid esfenvalerate on three aqueous insects with different feeding functions: a grazing scraper (*Cinygmula reticulata* McDunnough), an omnivore filter feeder (*Brachycentrus americanus* Banks), and a predator (*Hesperoperla pacifica* Banks). The researchers observed adverse effects in *C. reticulata* and *B. americanus* after feeding on esfenvalerate-laced food sources and that none of the three insects avoided the contaminated food. The effects included reduced growth and egg production of *C. reticulata* and abandonment and mortality in *B. americanus*. These limited studies indicate that ingestion may be an important exposure route, but it is not currently possible to incorporate this exposure route into criteria compliance assessment.

Section 3-5.1 of the methodology (TenBrook et al. 2009a) suggests that if studies indicate that fewer than three phases of the pesticide (sorbed to solids, sorbed to dissolved solids, or freely dissolved in the water) are bioavailable, then compliance may be based on the concentration in the bioavailable phase(s). The studies above suggest that the freely dissolved fraction of lambda-cyhalothrin is the primary bioavailable phase, and that this concentration is the best indicator of toxicity, thus, it is recommended that the freely dissolved fraction of lambda-cyhalothrin be directly measured or calculated based on site-specific information for compliance assessment. Whole water concentrations are also valid for criteria compliance assessment, and may be used at the discretion of environmental managers, although the bioavailable fraction may be overestimated with this method.

The most direct way to determine compliance would be to measure the lambda-cyhalothrin concentration in the dissolved phase to determine the total bioavailable concentration. Solid-phase microextraction (SPME) has shown to be the best predictor of pyrethroid toxicity in several studies (Bondarenko *et al*. 2007, Bondarenko & Gan 2009, Hunter et al. 2008, Xu et al. 2007, Yang et al. 2006a, 2006b, 2007). Bondarenko & Gan

(2009) report a method detection limit of 2.4 ng/L for lambda-cyhalothrin, although method detection limits vary between laboratories. Filtration of sediments is another option. Glass fiber filters with a nominal pore size of 0.7 μm or 0.45 μm are often used to remove the suspended sediments or both suspended sediments and dissolved organic matter, but the filters can interfere with the detection of hydrophobic contaminants. Gomez-Gutierrez et al. (2007) found that adsorption to filters was positively correlated with the log K_{ow} and solubility values of the compounds, and that on average 58% of the one pyrethroid tested (a 50 ng/L solution of permethrin) was lost on the filter. House and Ou (1992) also tested several filter materials and found that glass fiber filters had the lowest losses of pyrethroids at 5-20%. This loss may be critical for determining compliance at environmental concentrations, thus syringe filters are not recommended for sample handling. However, the U.S. Geological Survey (USGS) has developed a filtration sample handling method specifically for pyrethroids (Hladik et al. 2009). This method involves filtering water through a diaphragm pump, with equipment made from specified materials and flow rates, and for the least losses samples should be filtered in the field. Approximately 3-5% of pyrethroids were lost to surface association in the filtration apparatus, which is considered minimal and acceptable by USGS.

Alternately, the following equation can be used to translate total lambda-cyhalothrin concentrations measured in whole water to the associated dissolved lambda-cyhalothrin concentrations:

$$C_{dissolved} = \frac{C_{total}}{1 + ((K_{OC} \cdot [SS]) / foc) + (K_{DOC} \cdot [DOC])} \quad (1)$$

where:
$C_{dissolved}$ = concentration of chemical in dissolved phase (μg/L);
C_{total} = total concentration of chemical in water (μg/L);
K_{OC} = organic carbon-water partition coefficient (L/kg);
[SS] = concentration of suspended solids in water (kg/L);
f_{oc} = fraction of organic carbon in suspended sediment in water;
[DOC] = concentration of dissolved organic carbon in water (kg/L);
K_{DOC} = organic carbon-water partition coefficient (L/kg) for DOC.

To determine compliance by this calculation, site-specific data are necessary, including: K_{OC}, K_{DOC}, the concentration of suspended solids, the concentration of DOC, and the fraction of organic carbon in the suspended solids. If all of these site-specific data, including the partition coefficients, are not available, then this equation should not be used for compliance determination. Site-specific data are required because the sorption of lambda-cyhalothrin to suspended solids and dissolved organic matter depends on the physical and chemical properties of the suspended solids.

The freely dissolved lambda-cyhalothrin concentration is recommended for determination of criteria compliance because the literature suggests that the freely dissolved concentrations are the most accurate predictor of toxicity. Environmental managers may choose an appropriate method for determination of the concentration of

freely dissolved lambda-cyhalothrin, or they may also choose to base compliance on whole water concentrations.

9.2 Mixtures

Lambda-cyhalothrin often occurs in the environment with other pyrethroid pesticides (Werner & Moran 2008), and the presence of chemicals in surface waters is ubiquitous. All pyrethroids have the same general toxicological mode of action, and several studies have demonstrated that the toxicity of pyrethroid mixtures is additive and is well-predicted by the concentration addition model (Barata et al. 2006, Brander et al. 2009, Trimble et al. 2009). Overall, the concentration addition model should be used by following either the toxic unit or relative potency factor approach to determine criteria compliance when multiple pyrethroids are present. Definitions of additivity, synergism, antagonism, and non-additivity are available in the literature (Lydy and Austin 2004) and more detailed descriptions of mixture models can be found in the methodology (section 3-5.2, TenBrook et al. 2009a).

The effects on *Daphnia magna* mortality and feeding due to binary mixtures of lambda-cyhalothrin with deltamethrin, copper, and cadmium were examined in a study by Barata et al. (2006). The two concepts of concentration addition (CA) and independent action (IA) were used to predict mixture toxicity at various tested mixture ratios. Most of the observed effects for survival were within a factor of two of the effects predicted by the concentration addition model. The researchers observed slight antagonism in several of the mixtures and they attributed this to a few unexpected extreme values for joint survival effects. To examine if pyrethroid mixture toxicity is additive with a more comprehensive study design, Trimble et al. (2009) performed sediment toxicity tests with *Hyalella azteca* in three binary combinations: type I-type I (permethrin-bifenthrin), type II-type II (cypermethrin-λ-cyhalothrin), and type I-type II (bifenthrin-cypermethrin). The toxicity of these combinations were predicted with the concentration addition model, with model deviations within a factor of two, indicating that in general, pyrethroid mixture toxicity is additive.

Callinan et al. (2012) tested pyrethroid mixtures with *Hyalella azteca* in aqueous exposures in the following binary combinations: type I-type I (bifenthrin-permethrin), type I-type II (bifenthrin-cyfluthrin, bifenthrin-lambda-cyhalothrin, permethrin-cyfluthrin, and permethrin-lambda-cyhalothrin) and type II-type II (cyfluthrin-lambda-cyhalothrin). These combinations were tested in 4-day exposures, and two of the combinations were also tested in 10-day chronic exposures. Both the concentration addition and the independent action models were fit to the observed toxicity data and the fits were compared with several statistical analyses. One way of comparing the fits indicated that all combinations of pyrethroids were additive following the concentration addition model. Another way of comparing the results indicated that there was slight antagonism in two of the pyrethroid combinations (bifenthrin-cyfluthrin and permethrin-cyfluthrin), but only in the 4-day tests, not in the 10-day tests.

Studies with pyrethroids not including lambda-cyhalothrin have also demonstrated approximately additive toxicity. Brander et al. (2009) tested mixture

toxicity of cyfluthrin and permethrin and found that the combined toxicity was nearly additive. Although the binary mixture demonstrated slight antagonism, additivity was demonstrated when piperonyl butoxide (PBO) was added. Brander et al. (2009) offered several explanations for the observed antagonism between the two pyrethroids. Permethrin is a type I pyrethroid, and cyfluthrin is a type II pyrethroid, and type II pyrethroids might be able to outcompete type I pyrethroids for binding sites, which is known as competitive agonism; or binding sites may be saturated, so that complete additivity is not observed. They also note that cyfluthrin is metabolized more slowly than permethrin, so cyfluthrin can bind longer, and permethrin may be degraded when binding sites open. PBO may remove this effect because the rate of metabolism of both pyrethroids is reduced in the presence of PBO.

PBO is commonly added to pyrethroid insecticide treatments because it is known to increase the toxic effects of pyrethroids (Weston et al. 2006). Brander et al. (2009) observed *Hyalella azteca* LC_{50} values decreased by a factor of 2 or 3.5 when a nonlethal concentration of PBO was mixed with cyfluthrin or permethrin, respectively. No interaction coefficients (K) have been derived with relevant species to describe synergism between lambda-cyhalothrin and PBO. Consequently, it is not possible to quantify this non-additive toxicity and there is no accurate way to account for this interaction in compliance determination.

Another study by Barata et al. (2007) tested binary mixture toxicity of lambda-cyhalothrin and cadmium to *Daphnia magna* and examined reproductive effects. The joint toxicity of cadmium and lambda-cyhalothrin was equally predicted by the CA and IA models, even though these two chemicals do not have similar modes of pharmacological action, they do have similar ecotoxicological modes of action (Barata et al. 2007).

No studies on aquatic organisms were found in the literature that could provide a quantitative means to consider mixtures of lambda-cyhalothrin with other classes of pesticides. Although there are examples of non-additive toxicity for lambda-cyhalothrin and other chemicals, a multispecies interaction coefficient is not available for any chemical with lambda-cyhalothrin, and therefore the concentrations of non-additive chemicals cannot be used for criteria compliance (section 3-5.2.2, TenBrook et al. 2009a).

9.3 Temperature, pH, other water quality effects

Temperature, pH, and other water quality effects on the toxicity of lambda-cyhalothrin were examined to determine if any effects are described well enough in the literature to incorporate into criteria compliance (section 3-5.3, TenBrook et al. 2009a). Temperature has been found to be inversely proportional to the aquatic toxicity and bioavailability of pyrethroids (Miller & Salgado 1985, Werner & Moran 2008). In fact, the increase of toxicity of pyrethroids with decreasing temperature has been used to implicate pyrethroids as the source of toxicity in environmental samples (Phillips et al. 2004). The inverse relationship between temperature and pyrethroid toxicity is likely due

to the increased sensitivity of an organism's sodium channels at low temperatures (Narahashi et al. 1998).

There is evidence of increased cyfluthrin toxicity to aquatic organisms at lower temperatures, but no studies were identified that directly tested lambda-cyhalothrin toxicity at multiple temperatures. In the acute RR data set, there are 48-hr EC_{50} data at 20 ˚C and 15 ˚C for *Gammarus pulex*, from two different tests that had immobility as the endpoint. They are not exactly comparable because the test at 20 ˚C was a static test that used nominal concentrations to calculate the EC_{50} (Hamer et al. 1998) and the test at 15 ˚C was a flow-through test that used measured concentrations (Hamer et al. 1985a). The test at 15 ˚C resulted in a EC_{50} of 0.008 µg/L, while the test at 20 ˚C resulted in a EC_{50} of 0.014 (0.0091-0.019) µg/L. The EC_{50} at 15 ˚C is a factor of 1.75 below the EC_{50} at 20 ˚C.

The toxicities of six aqueous pyrethroids (cypermethrin, permethrin, fenvalerate, *d*-phenothrin, flucythrinate, and bioallethrin) were 1.33- to 3.63-fold greater at 20 ˚C compared to 30 ˚C for mosquito larvae (Cutkomp and Subramanyam 1986). Enhanced toxicity of cyfluthrin to larval fathead minnows (*Pimephales promelas*) at lower temperatures was demonstrated by Heath et al. (1994). Sublethal cyfluthrin concentrations reduced the ability of fish to tolerate temperatures both higher and lower than standard conditions. The enhanced toxic effects of pyrethroids at lower temperatures may not be as accurately represented by the results of typical laboratory toxicity tests, which tend to be run at warmer temperatures, 20-23 ˚C (USEPA 1996a, USEPA 1996b, USEPA 2000), than those of the habitats of coldwater fishes, about 15˚C or lower (Sullivan et al. 2000).

The toxicity of sediments contaminated with pyrethroids (including lambda-cyhalothrin) was more than twice as toxic when tested at 18 ˚C compared to 23 ˚C (Weston et al. 2008). Weston et al. (2008) used a toxicity identification evaluation (TIE) procedure to determine the effect of temperature reduction (18 vs. 23 ˚C) on toxicity of a particular environmental sediment sample to *Hyalella azteca*. These results are not directly applicable for use in water quality criteria compliance because they were sediment exposures, and used environmental samples, instead of an exposure to a pure compound. In studies that used topical exposures (more relevant to spray application exposure to target a pest), the difference in toxicity can increase by a factor of about 1.5 to a factor of 10, in the temperature range of about 10 to 27 ˚C (Kumaraguru & Beamish 1981; Punzo 1993; Schnitzerling 1985).

Unfortunately, there are limited data demonstrating increased toxicity at lower temperatures using aquatic exposures with relevant species, making it unfeasible to quantify the relationship between the toxicity of lambda-cyhalothrin and temperature for water quality criteria at this time (section 3-5.3, TenBrook et al. 2009a). Several studies that examined the effects of DOC, suspended solids, turbidity, and chlorophyll a concentrations are discussed in the bioavailability section 9 above. No other studies on lambda-cyhalothrin were identified that examined the effects of pH or other water quality parameters on toxicity, thus, there is no way to incorporate any of these parameters into criteria compliance.

10 Comparison of ecotoxicity data to derived criteria

10.1 Sensitive species

The derived criteria are compared to toxicity values for the most sensitive species in both the acceptable (RR) and supplemental (RL, LR, LL) data sets to ensure that these species will be adequately protected (section 3-6.1, TenBrook et al. 2009a). The lowest SMAV in the data sets rated RR, RL, LR, or LL (Table 3, Table 4, and Table **5**) is 0.3 ng/L for the amphipod *Hyalella azteca* (Bradley 2013). The derived acute criterion of 0.7 ng/L does not appear to be protective of *Hyalella azteca*, the most sensitive species in the data set. The acute derived criterion of 0.7 ng/L is higher than the *H. azteca* SMAV of 0.3 ng/L by a factor of 2.3. The next lowest acute toxicity value is recommended to derive the acute criterion in order to be protective of this sensitive species. The acute criterion is calculated as follows with the median 1st percentile estimate:

Recommended acute value = 0.000067 μg/L (median 1st percentile value)

Acute criterion = Recommended acute value ÷ 2
= 0.000067 μg/L ÷ 2
= 0.0000335 μg/L

Acute criterion = 0.00003 μg/L
= 0.03 ng/L

The ACR method for chronic criterion calculation uses the recommended acute value (section 3-4.2, TenBrook et al. 2009), thus, the chronic criterion will be re-calculated with the median 1st percentile value as follows:

Chronic criterion = recommended acute value ÷ ACR
= 0.000067 μg/L ÷ 4.73
= 0.00001416 μg/L

Chronic criterion = 0.00001 μg/L
= 0.01 ng/L

The derived chronic criterion (0.01 ng/L) is below the lowest chronic value in the data set rated RR (Table **6** and Table **7**), which is a MATC of 2.63 ng/L for *Daphnia magna* (Farrelly & Hamer 1989). The derived chronic criterion (0.01 ng/L) is also below the lowest chronic value in the data set rated RL, LR, or LL (Table **9**), which is an MATC of 0.32 ng/L for the mysid shrimp *Americamysis bahia* (formerly *Mysidopsis bahia*), a saltwater species, indicating that the recommended chronic criterion will be protective of these sensitive species.

10.2 Ecosystem and other studies

The derived criteria are compared to acceptable laboratory, field, or semi-field multispecies studies (rated R or L) to determine if the criteria will be protective of ecosystems (section 3-6.2, TenBrook et al. 2009a). Twelve studies describing effects of lambda-cyhalothrin on mesocosm, microcosm and model ecosystems were identified and rated for reliability according to the methodology (Table 3.9, TenBrook et al. 2009). Six of the studies were rated as reliable (R; Farmer et al. 1995, Hill et al. 1994, Roessink et al. 2005, Schroer et al. 2004, Van Wijngaarden et al. 2006, Wendt-Rasch et al. 2004), and three were rated as less reliable (L; Gu et al. 2007, Lauridsen & Friberg 2005, Rasmussen et al. 2008) and are used as supporting data. All of the studies rated R or L are listed in Table **10**. Three studies rated as not reliable (N) and are not discussed in this report (Heckmann et al. 2005, Lawler et al. 2007, Wang et al. 2007). These studies included ditch microcosms, pond meso- and micro-cosms, and microcosms mimicking small riverine (channel) environments; all exposures used commercial formulations of lambda-cyhalothrin. Several studies report a community NOEC to which the calculated criteria may be compared.

Roessink et al. 2005, Schroer et al. 2004, and Van Wijngaarden et al. 2006 examined the effects of lambda-cyhalothrin on macroinvertebrates in ditch microcosm systems in two seasons (spring and late summer) with two types of vegetation (eutrophic and mesotrophic), and compared them to laboratory tests for the same species. Van Wijngaarden et al. (2006) and Roessink et al. (2005) report various community-level NOEC values depending on the season and trophic system, the lowest being < 10 μg/L, and Schroer et al. (2004) reports a community-level NOEC of 10 ng/L. Schroer et al. (2004) also calculated a community-level criterion of 4.1 ng/L, while the criterion calculated based on laboratory single-species data was 2.7 ng/L. The derived acute and chronic criteria are below all of the reported NOEC values for this set of studies. The lowest community-level NOEC reported was 10 ng/L, which is three orders of magnitude larger than the chronic criterion of 0.01 ng/L.

Hill et al. (1994) investigated effects of lambda-cyhalothrin on artificial pond mesocosms containing microbes, algae, macrophytes, zooplankton, macroinvertebrates, and fish. Lambda-cyhalothrin was applied at three rates as a spray and as a soil-water slurry, to simulate runoff. Few effects were observed for most taxa, but macroinvertebrates and zooplankton were adversely affected at the highest rate; macroinvertebrates experienced some effects at the middle rate, as well. Measured aqueous concentrations of lambda-cyhalothrin ranged from 3-98 ng/L in the mesocosms treated at the highest rate, and 2-10 ng/L in those treated at the middle rate. Lambda-cyhalothrin was not detected in the ponds treated at the lowest rate. The method detection limit reported in this study ranges from 2-3 ng/L, so we cannot conclude that lambda-cyhalothrin was not present at lower concentrations when reported as non-detects. This study indicates that the derived chronic criterion of 0.01 ng/L should be protective of macroinvertebrates and zooplankton, because it is likely below the actual concentrations in the ponds treated at the lowest rate.

Several studies reported significant macroinvertebrate mortality and drift due to exposure to lambda-cyhalothrin (Farmer et al. 1995, Lauridsen and Friberg 2005, Rasmussen et al. 2008, Wendt-Rasch et al. 2004). *Gammarus* species were examined in several studies and it was found that they were particularly sensitive to lambda-cyhalothrin. Farmer et al. (1995) sprayed pond mesocosms with two levels of lambda-cyhalothrin; at the lower level *Gammarus* spp. abundance was significantly reduced compared to controls, and in the higher treatment they were completely eliminated, with no indication of recovery 3 months later. Lambda-cyhalothrin was measured in the water column 1 hr after application and was determined to be 2 ng/L in the lower treatment and 59 ng/L in the higher treatment. Rasmussen et al. (2008) demonstrated that *Gammarus pulex* exposed to 10.65 ng/L lambda-cyhalothrin (nominal) drifted significantly less than controls ($p< 0.0001$). In this study the organisms were exposed for 90 min, and then transferred to an artificial channel habitat containing clean water (no lambda-cyhalothrin). Phytoplankton and algae productivity increased in response to lambda-cyhalothrin exposure (Farmer et al. 1995 Rasmussen et al. 2008, Wendt-Rasch et al. 2004). The decrease in macroinvertebrate populations was likely the cause of the increase in phytoplankton and algae, as macroinvertebrates are known to graze on algae.

Lauridsen and Friberg (2005) examined macroinvertebrate drift in outdoor experimental channels with two insects (*Baetis rhodani* and *Leuctra fusca/digitata*) and the amphipod *Gammarus pulex.* Catastrophic drift was observed for all three species during the 1-hr pulse exposure and 2-3 h post-exposure. Drift of *G. pulex* was significantly affected at 1 ng/L (nominal), which is a factor of 100 above the derived chronic criterion of 0.01 ng/L; the insects were affected at 10 ng/L. The measured concentration of lambda-cyhalothrin may have been significantly lower than the nominal concentration of 1 ng/L, indicating that chronic toxicity of *G. pulex* likely occurred at a concentration below 1 ng/L. There are no single-species chronic data for *G. pulex*, but the LC_{50} for this species is reported as 5.9 ng/L (Table 3), and other ecosystem studies indicate that this is a sensitive species.

10.3 Threatened and endangered species

The derived criteria are compared to measured toxicity values for threatened and endangered species (TES), as well as to predicted toxicity values for TES, to ensure that they will be protective of these species (section 3-6.3, TenBrook et al. 2009a). Current lists of state and federally listed threatened and endangered plant and animal species in California were obtained from the California Department of Fish and Game (CDFG) website (http://www.dfg.ca.gov/biogeodata/cnddb/pdfs/TEAnimals.pdf; CDFG 2008). Two listed animal species are represented in the data set. Five Evolutionarily Significant Units of *Oncorhynchus mykiss* are listed as federally threatened or endangered throughout California. The acute data set includes a SMAV for *O. mykiss* of 0.27 μg/L, calculated from three studies rated RR. The unarmored threespine stickleback (*Gasterosteus aculeatus williamsoni*) is represented in the RR data set with a with an LC_{50} value of 0.40 (0.33-0.50) μg/L reported for *G. aculeatus*. Both of these values in the data set were included in the acute criterion calculation and are well above the recommended acute criterion.

Some of the listed species are represented in the acute toxicity data set by members of the same family or genus. *Oncorhynchus mykiss* can serve as a surrogate in estimates for other species in the same family using the USEPA interspecies correlation estimation website (WEB-ICE v. 2.0; Raimondo et al. 2007). Table **11** summarizes the results of the ICE analyses. The estimated acute toxicity values range from 0.277 μg/L for Coho salmon to 0.539 μg/L for Chinook salmon (Table **11**).

No single-species plant studies were found in the literature for use in criteria derivation, so no estimation could be made for plants on the state or federal endangered, threatened or rare species lists. There are also no aquatic plants listed as state or federal endangered, threatened or rare species so they are not considered in this section.

Based on the available data and estimated values for animals, there is no evidence that the calculated acute and chronic criteria will be underprotective of threatened and endangered species.

11 Harmonization with other environmental media

11.1 Bioaccumulation

Bioaccumulation was assessed to ensure that the derived criteria will not lead to unacceptable levels of lambda-cyhalothrin in food items (section 3-7.1, TenBrook et al. 2009a). Lambda-cyhalothrin has a log K_{ow} of 7.0 and a molecular weight of 449.85 (section 3), which indicates its bioaccumulative potential (section 3-7.1, TenBrook et al. 2009a). No biomagnification factor (BMF) values were found in the literature for lambda-cyhalothrin. Bioaccumulation of lambda-cyhalothrin has been measured in several studies (Table 1), which are briefly summarized here. The bioconcentration factor (BCF) in carp (*Cyprinus carpio*) varied from 850-7340 depending on what portion of the fish was analyzed (Yamauchi et al. 1984). The BCF values for channel catfish (*Ictalurus punctatus*) were lower than those for carp, ranging 7-66 depending on which portion was analyzed (Hamer and Hill 1985). Bioconcentration was examined by Hamer et al. (1999) in *Chironomus riparius* in water-only and water-sediment systems and the BCF values were very similar for the two systems (2000 and 2300, respectively). The BCF for *Daphnia magna* was significantly lower than those for *C. riparius* at 194 (Hamer and Hill 1985).

To check that these criteria are protective of terrestrial wildlife that may consume aquatic organisms, a bioaccumulation factor (BAF) was used to estimate the water concentration that would roughly equate to a reported toxicity value for consumption of fish by terrestrial wildlife. These calculations are further explained in section 3-7.1 of the methodology (TenBrook et al. 2009a). The BAF of a given chemical is the product of the BCF and a BMF, such that BAF=BCF*BMF. For a conservative estimate, the BCF value of 2240 L/kg for *Cyprinus carpio* was used (Table 1). A default BMF value of 10 was chosen based on the log K_{ow} of lambda-cyhalothrin (Table 3.15, TenBrook et al. 2009a). A chronic dietary NOEC value for an oral predator is preferred for this calculation

because it is the most realistic value for extrapolation to bioaccumulation in the environment (section 3-7.1, TenBrook et al. 2009), but the dietary NOEC value for mallard duck reported by Beavers et al. (1990) is likely an underestimation because there were no effects observed at any of the tested concentrations. We used the dietary NOEC of 30 mg/kg feed (Beavers et al. 1990), as well as a dietary LC_{50} value of 3948 mg/kg feed (Roberts et al. 1985) for this calculation to determine the range of aqueous concentrations which likely contains the true no-effect level for mallard ducks.

$$NOEC_{water} = \frac{NOEC_{oral\_predator}}{BCF_{food\_item} * BMF_{food\_item}}$$

Mallard:
$$NOEC_{water} = \frac{30\,{}^{mg}/_{kg}}{2240\,{}^{L}/_{kg} * 10} = 0.00134\,{}^{mg}/_{L} = 1.34\,{}^{\mu g}/_{L}$$

$$NOEC_{water} = \frac{LC_{50,oral\_predator}}{BCF_{food\_item} * BMF_{food\_item}}$$

Mallard:
$$NOEC_{water} = \frac{3948\,{}^{mg}/_{kg}}{2240\,{}^{L}/_{kg} * 10} = 0.176\,{}^{mg}/_{L} = 176\,{}^{\mu g}/_{L}$$

In this example, the calculated chronic criterion is five to seven orders of magnitude below the estimated $NOEC_{water}$ values for the mallard. Adverse effects due to bioaccumulation are not expected at either level. The higher level mallard $NOEC_{water}$ is actually above the water solubility of lambda-cyhalothrin (5 µg/L), and therefore, would not occur in an aqueous environment.

To check that these criteria are protective of humans that may consume aquatic organisms, a BAF will be used to estimate the water concentration that would roughly equate to a limit for human food consumption. An appropriate BAF was not available in the data set. The BCF value for carp muscle of 850 (Yamauchi et al. 1985, Table 1) and a default BMF are used to approximate a BAF. There are no tolerance or FDA action levels for fish tissue (USFDA 2000), but there is a food tolerance for hog meat at 0.1 ppm (USEPA 2007). This value can be used to roughly estimate if bioconcentration could cause lambda-cyhalothrin concentrations in fish tissues to be of concern to human health.

$$NOEC_{water} = \frac{NOEC_{oral\_predator}}{BCF_{food\_item} * BMF_{food\_item}}$$

Human: $$NOEC_{water} = \frac{0.1\,^{mg}/_{kg}}{850\,^{L}/_{kg} * 10} = 0.00001176\,^{mg}/_{L} = 0.01176\,^{\mu g}/_{L} = 12\,^{ng}/_{L}$$

In this example, the derived chronic criterion of 0.01 ng/L is a factor of 1,200 below the estimated water concentration of concern for humans (12 ng/L). Adhering to the derived lambda-cyhalothrin criteria should also prevent bioaccumulative exposure to terrestrial wildlife and humans.

11.2 Harmonization with air or sediment criteria

This section addresses how the maximum allowable concentration of lambda-cyhalothrin might impact life in other environmental compartments through partitioning (section 3-7.2, TenBrook et al. 2009a). However, there are no federal or state sediment or air quality standards for lambda-cyhalothrin (CARB 2005, CDWR 1995, USEPA 2006a, USEPA 2006b) to enable this kind of extrapolation. For biota, the limited data on bioconcentration or biomagnification of lambda-cyhalothrin was addressed in the bioaccumulation section (section 11.1).

12 Lambda-cyhalothrin criteria summary

12.1 Assumptions, Limitations and Uncertainties

The assumptions, limitations and uncertainties involved in criteria derivation should be available to inform environmental managers of the accuracy and confidence in the derived criteria (section 3-8.0, TenBrook et al. 2009a). Chapter 2 of the methodology discusses these points for each section as different procedures were chosen, such as the list of assumptions associated with using a SSD (section 2-3.1.5.1), and there is a review of the assumptions in section 2-7.0 (TenBrook et al. 2009a). This section summarizes any data limitations that affected the procedure used to determine the final lambda-cyhalothrin criteria. The different calculations of distributional estimates included in section 7 of this report may be used to consider the uncertainty in the resulting acute criterion.

There was enough highly rated acute lambda-cyhalothrin data to use a SSD to calculate the acute criterion, but one limitation in the data set is that not all of the data are from flow-through tests that use measured concentrations to calculate the toxicity values. Flow-through tests and measurement of concentrations are particularly important in tests with pyrethroid pesticides because they are highly sorptive. Eleven of the 20 acute RR data are from flow-through tests with measured concentrations, including the lowest value in the data set (*Hyalella azteca* SMAV=0.3 ng/L).

For lambda-cyhalothrin, the major limitation was in the chronic toxicity data set. Three of five taxa requirements were not met (the salmonid, benthic crustacean and insect), which precluded the use of a SSD; therefore, an ACR was used to derive the chronic criterion. There were measured data available for calculation of a multi-species

ACR (as specified in section 3-4.2.1, TenBrook et al. 2009a). Particularly of concern for the chronic toxicity data set was the lack of data on *Hyalella azteca* or another benthic organism, which was the most sensitive species in the acute toxicity data set. Uncertainty cannot be quantified for the chronic criterion because it was derived using an ACR, not an SSD.

Another concern that could not be accounted for quantitatively criteria compliance is the increase in toxicity from lower temperatures. Most of the toxicity data were from tests performed at standard temperature, usually around 20 ˚C. Tests for four of the 20 species in the acute data set used lower temperatures (*Gammarus pulex, Gasterosteus aculeatus, Leuciscus idus,* and *Oncorhynchus mykiss*) used lower temperatures. However, many streams in the California Central Valley often have lower water temperatures. If colder water bodies are impacted by concentrations of lambda-cyhalothrin, it may be appropriate to apply an additional safety factor to the lambda-cyhalothrin criteria for those areas, to ensure adequate protection. A rough factor of two could be estimated from a study by Weston et al. (2008), however, a study relating temperature to aqueous toxicity of lambda-cyhalothrin in multiple species, including *Hyalella azteca,* would be ideal to derive such an adjustment factor. We do not recommend an additional safety factor to account for temperature effects at this time, but environmental managers may want to consider this application if the criteria do not appear to be protective of organisms in a colder water body. If aquatic exposure data for multiple species demonstrating temperature effects becomes available in the future, a regression equation describing the effect should be incorporated into criteria compliance.

Although greater than additive effects have been observed for mixtures of pyrethroids and PBO, there is insufficient data to account for this interaction for compliance determination. This is a significant limitation because formulations that contain both pyrethroids and PBO are now available on the market. When additional highly rated data is available, the criteria should be recalculated to incorporate new research.

12.2 Comparison to National Standard Methods

This section is provided as a comparison between the UC-Davis methodology for criteria calculation (TenBrook et al. 2009a) and the current USEPA (1985) national standard. The following example lambda-cyhalothrin criteria were generated using the USEPA 1985 methodology with the data set generated in this lambda-cyhalothrin criteria report.

The USEPA acute methods have three additional taxa requirement beyond the five required by the methodology used in this criteria report (section 3-3.1, TenBrook et al. 2009a). They are:

1. A third family in the phylum Chordata (e.g., fish, amphibian);
2. A family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca);
3. A family in any order of insect or any phylum not already represented.

Two out of the three of these additional requirements are met as follows:

1. The other fish/amphibian requirement is met with data from zebra danio or any of six other fish species available.
2. This requirement is not met because all data are from organisms in the phylum Arthropoda or Chordata.
3. This requirement is met because *Cloeon dipterum* is an insect in a different family than *Chaoborus* sp.

Strictly speaking, the USEPA methodology cannot be used to calculate an acute criterion for lambda-cyhalothrin. However, since the California Department of Fish and Game have used data sets that met only seven of eight requirements in the USEPA methodology, this will be done here.

Using the log-triangular calculation (following the USEPA 1985 guidelines) and the lambda-cyhalothrin data set from Table 3 containing 20 species values, the following criterion was calculated (Note: USEPA methodology uses *genus* mean acute values, while *species* mean acute values are used in this methodology and are reported in Table 3. Since there is only one species from each genus in Table 3, this final data set would be the same in both schemes.):

Example Final Acute Value (5^{th} percentile value) = 0.0004113 μg/L

Example Acute Criterion = final acute value ÷ 2
= 0.0004113 μg/L ÷ 2
= 0.0002056 μg/L
= 0.21 ng/L

According to the USEPA (1985) methodology, the criterion is rounded to two significant digits. This value is a factor of 7 higher than the acute criterion calculated by the UC-Davis methodology of 0.03 ng/L.

For the chronic criterion, the lambda-cyhalothrin data set only has data from two species, which are not enough for use in a SSD by either method. The USEPA 1985 methodology contains a similar ACR procedure as in the UC-Davis methodology, to be used when three acceptable ACRs are available. The same three ACR values calculated for this methodology (Table 8) were calculated according to the USEPA 1985 methodology to give a final ACR of 4.73. The chronic criterion is calculated by dividing the Final Acute Value by the Final ACR:

Example Chronic Criterion = Final Acute Value ÷ final ACR
= 0.0004113 μg/L ÷ 4.73
= 0.00008695 μg/L
= 0.087 ng/L

The example criterion was rounded to two significant digits, according to the USEPA methodology. The example chronic criterion is a factor of 8.7 higher than the chronic criterion calculated using the UC-Davis methodology of 0.01 ng/L.

12.3 Final criteria statement

The final criteria statement is:

Aquatic life in the Sacramento River and San Joaquin River basins should not be affected unacceptably if the four-day average concentration of lambda-cyhalothrin does not exceed 0.00001 μg/L (0.01 ng/L) more than once every three years on the average and if the one-hour average concentration does not exceed 0.00003 μg/L (0.03 ng/L) more than once every three years on the average. Mixtures of lambda-cyhalothrin and other pyrethroids should be considered in an additive manner (see Mixtures section 9.2).

While the aim of this criteria report was to derive criteria protective of aquatic life in the Sacramento and San Joaquin Rivers, these criteria would be appropriate for any freshwater ecosystem in North America, unless species more sensitive than are represented by the species examined in the development of these criteria are likely to occur in those ecosystems.

The final acute criterion was derived using the 1st percentile of the Burr Type III SSD procedure (sections 7 and 10.1) and the acute data used in criteria calculation are shown in Table 3. The chronic criterion was derived by use of an ACR calculated from measured data (sections 8 and 10.1); chronic data rated RR are shown in Table **6**, and the ACRs are shown in Table 8. It is recommended that the freely dissolved lambda-cyhalothrin concentration is measured for criteria compliance because this appears to be the best predictor of the bioavailable fraction (section 9.1).

To date, there are no established criteria for lambda-cyhalothrin to which the criteria calculated in this report can be compared, except those example criteria calculated by the USEPA 1985 method above in section 12.2 of this report. The example acute and chronic criteria calculated by the USEPA 1985 method are higher than the criteria derived using the UC Davis methodology. Solomon et al. (2001) performed a probabilistic risk assessment with pyrethroids. Saltwater and freshwater toxicity data were combined so the lowest toxicity value in the data set was 4 ng/L (for mysid, a saltwater species). The 5th percentile value for lambda-cyhalothrin, based on a log-normal distribution, was < 4 ng/L, although much of the authors discussion centered on the 10th percentile as the protective limit, which was 10 ng/L for lambda-cyhalothrin. For compounds that had larger toxicity data sets, separate analyses were performed for freshwater and saltwater data. Differences were found especially for invertebrates, which suggested that the risk to freshwater and saltwater organisms should be assessed separately.

The derived criteria appear to be protective considering bioaccumulation, ecosystem level toxicity and threatened and endangered species as discussed above in the report, but the criteria calculations should be updated whenever new data is available.

Acknowledgements

The authors of the original 2010 criteria report thank the following reviewers of the original 2010 criteria report: Daniel McClure (CVRWQCB), Joshua Grover (CVRWQCB), Stella McMillan (CDFG), John P. Knezovich (Lawrence Livermore National Laboratory), and Xin Deng (CDPR). The original 2010 report was funded through a contract with the Central Valley Regional Water Quality Control Board of California. Mention of specific products, policies, or procedures do not represent endorsement by the Regional Board.

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Data Tables

Table 3 Final acute toxicity data set for lambda-cyhalothrin.
All studies were rated RR and were conducted at standard temperature. S: static; SR: static renewal; FT: flow-through.

Species	Common Identifier	Family	Test type	Meas/ Nom	Chemical grade	Duration	Temp (°C)	Endpoint	Age/size	LC/EC_{50} (µg/L) (95% CI)	Reference
Asellus aquaticus	Isopod	Aselloidea	S	Nom	88.0%	48 h	20	Immobility	NR	**0.026** (0.018-0.036)	Hamer et al. 1998
Brachydanio rerio	Zebra danio	Cyprinidae	FT	Meas	88.7%	96 h	25	Mortality	0.70 g, 36 mm	**0.64** (0.48-0.90)	Kent & Shillabeer 1997c
Ceriodaphnia dubia	Daphnid	Daphniidae	S	Nom	97.0%	48 h	25	Mortality	< 24 h	**0.200** ± 0.090	Wheelock et al. 2004
Chaoborus sp.	Phantom midge	Chaoboridae (Insecta)	S	Nom	88.0%	48 h	20	Maintenance of body shape/equil.	larvae	**0.0028** (0.0018-0.0041)	Hamer et al. 1998
Cloeon dipterum	Mayfly nymph	Baetidae (Insecta)	S	Nom	88.0%	48 h	20	Immobility	nymph	**0.038** (0.023-0.093)	Hamer et al. 1998
Corixa sp.	Hemipteran	Corixidae	S	Nom	88.0%	48 h	20	Immobility	NR	**0.030** (0.021-0.042)	Hamer et al. 1998
Cyclops sp.	Copepod	Cyclopidae	S	Nom	88.0%	48 h	20	Immobility	NR	**0.300** (0.200-0.460)	Hamer et al. 1998
Daphnia magna	Daphnid	Daphniidae	FT	Meas	94.3%	72 h	20	Mortality	< 24 h	**0.013** (0.010-0.017)	Farrelly & Hamer 1989
Gammarus pulex	Amphipod	Gammaridae	FT	Meas	99.2%	96 h	15	Immobility	5 mm, > 3 weeks old	**0.0059**	Hamer et al. 1985a
Gasterosteus aculeatus	3 spined stickleback	Gasterosteidae	FT	Meas	87.7%	96 h	12	Mortality	0.41 g, 34 mm	**0.40** (0.33-0.50)	Long & Shillabeer 1997a
Hyalella azteca	Amphipod	Hyalellidae	FT	Meas	93.2%	96 h	23	Mortality	9 d	**0.0003** (0.00024-0.00037)	Bradley 2013
Hydracarina (Class)	Water mite	NR	S	Nom	88.0%	48 h	20	Immobility	NR	**0.047** (0.033-0.062)	Hamer et al. 1998

Species	Common Identifier	Family	Test type	Meas/ Nom	Chemical grade	Duration	Temp (°C)	Endpoint	Age/size	LC/EC_{50} (µg/L) (95% CI)	Reference
Ictalurus punctatus	Channel catfish	Ictaluridae	FT	Meas	87.7%	96 h	17	Mortality	1.57 g, 48 mm	**0.16** (0.13-0.20)	Long & Shillabeer 1997b
Lepomis macrochirus Rafinesque	Bluegill sunfish	Centrarchidae	FT	Meas	99.0%	96 h	21.9	Mortality	juvenile	0.106 (0.0855-0.140)	Marino & Rick 2001
Lepomis macrochirus	Bluegill sunfish	Centrarchidae	FT	Meas	98.0%	96 h	22	Mortality	1.51 g, 38.2 mm	0.21 (0.18-0.25)	Hill 1984b
Geomean										**0.15**	
Leuciscus idus	Golden orfe	Cyprinidae	FT	Meas	88.7%	96 h	12	Mortality	2.15 g, 53 mm	**0.078** (0.056-0.11)	Kent & Shillabeer 1997a
Oncorhynchus mykiss	Rainbow trout	Salmonidae	FT	Meas	99.0%	96 h	12	Mortality	39 mm, 0.52 g	0.19 (0.16-0.20)	Machado 2001b
Oncorhynchus mykiss	Rainbow trout	Salmonidae	FT	Meas	81.5%	96 h	12	Mortality	43 mm, 1.12 g	0.44 (0.38-0.51)	Tapp et al. 1989
Oncorhynchus mykiss	Rainbow trout	Salmonidae	FT	Meas	98.0%	96 h	12	Mortality	38.3mm, 0.83 g	0.24 (0.08-0.70)	Hill 1984a
Geomean										**0.27**	
Ostracoda (class)	Seed shrimp	NR	S	Nom	88.0%	48 h	20	Immobility	NR	**3.300** (2.100-6.600)	Hamer et al. 1998
Pimephales promelas	Fathead minnow	Cyprinidae	FT	Meas	97.0%	96 h	25	Mortality	larvae	0.360 (0.252-0.765)	Tapp et al. 1990
Pimephales promelas	Fathead minnow	Cyprinidae	FT	Meas	88.7%	96 h	25	Mortality	0.37 g, 28 mm	0.70 (0.38-1.3)	Kent & Shillabeer 1997e
Geomean										**0.50**	
Poecilia reticulata	Guppy	Poeciliidae	FT	Meas	88.7%	96 h	25	Mortality	0.62 g, 33 mm	**2.3** (1.8-3.1)	Kent & Shillabeer 1997b
Procambarus clarkii	Crayfish	Cambaridae	SR	Nom	99.1%	96 h	21.7	Mortality	3 months old	**0.16** (0.06-0.27)	Barbee & Stout 2009

Table 4 Reduced acute data rated RR.
S: static; SR: static renewal; FT: flow-through.

Species	Common Identifier	Test type	Meas/ Nom	Chemical grade	Duration	Temp (°C)	Endpoint	Age/size	LC/EC_{50} (µg/L) (95% CI)	Reference	Reason
Brachydanio rerio	Zebra danio	FT	Meas	88.7%	24 h	25	Mortality	0.70 g, 36 mm	0.97 (0.74-1.4)	Kent & Shillabeer 1997c	A
Brachydanio rerio	Zebra danio	FT	Meas	88.7%	48 h	25	Mortality	0.70 g, 36 mm	0.80 (0.62-1.1)	Kent & Shillabeer 1997c	A
Brachydanio rerio	Zebra danio	FT	Meas	88.7%	72 h	25	Mortality	0.70 g, 36 mm	0.64 (0.48-0.90)	Kent & Shillabeer 1997c	A
Daphnia magna	Daphnid	S	Meas	99.0%	48 h	NR	Immobility	4th instar juveniles	0.39 (0.38-0.40)	Barata et al. 2006	B
Daphnia magna	Daphnid	S	Meas	96.5%	24 h	20	Immobility	< 24 h	5.04	Farrelly et al.1984	B
Daphnia magna	Daphnid	S	Meas	96.5%	48 h	20	Immobility	< 24 h	0.36	Farrelly et al.1984	B
Daphnia magna	Daphnid	SR	Meas	99.0%	48 h	21	Immobility	$\leq$ 24 h	0.051 (0.034-0.10)	Machado 2001a	B
Gammarus pulex	Amphipod	S	Nom	88.0%	48 h	20	Immobility	NR	0.014 (0.0091-0.019)	Hamer et al. 1998	B
Gammarus pulex	Amphipod	FT	Meas	99.2%	24 h	15	Immobility	5 mm, > 3 weeks old	0.0102	Hamer et al. 1985a	A
Gammarus pulex	Amphipod	FT	Meas	99.2%	48 h	15	Immobility	5 mm, > 3 weeks old	0.008	Hamer et al. 1985a	A
Gammarus pulex	Amphipod	FT	Meas	99.2%	72 h	15	Immobility	5 mm, > 3 weeks old	0.0064	Hamer et al. 1985a	A
Gammarus pulex	Amphipod	FT	Meas	99.2%	24 h	15	Mortality	5 mm, > 3 weeks old	0.665	Hamer et al. 1985a	C
Gammarus pulex	Amphipod	FT	Meas	99.2%	48 h	15	Mortality	5 mm, > 3 weeks old	0.0712	Hamer et al. 1985a	C
Gammarus pulex	Amphipod	FT	Meas	99.2%	72 h	15	Mortality	5 mm, > 3 weeks old	0.0313	Hamer et al. 1985a	C
Gammarus pulex	Amphipod	FT	Meas	99.2%	96 h	15	Mortality	5 mm, > 3 weeks old	0.0127	Hamer et al. 1985a	C

Species	Common Identifier	Test type	Meas/ Nom	Chemical grade	Duration	Temp (°C)	Endpoint	Age/size	LC/EC_{50} (µg/L) (95% CI)	Reference	Reason
Gasterosteus aculeatus	3 spined stickleback	FT	Meas	87.7%	24 h	12	Mortality	0.41 g, 34 mm	0.73 (0.68-0.79)	Long & Shillabeer 1997a	A
Gasterosteus aculeatus	3 spined stickleback	FT	Meas	87.7%	48 h	12	Mortality	0.41 g, 34 mm	0.44 (0.36-0.56)	Long & Shillabeer 1997a	A
Gasterosteus aculeatus	3 spined stickleback	FT	Meas	87.7%	72 h	12	Mortality	0.41 g, 34 mm	0.43 (0.35-0.54)	Long & Shillabeer 1997a	A
Hyalella azteca	Amphipod	S	Nom	88.0%	48 h	20	Immobility	NR	**0.0023** (0.0010-0.0078)	Hamer et al. 1998	B
Ictalurus punctatus	channel catfish	FT	Meas	87.7%	24 h	17	Mortality	1.57 g, 48 mm	0.82 (0.67-11)	Long & Shillabeer 1997b	A
Ictalurus punctatus	channel catfish	FT	Meas	87.7%	48 h	17	Mortality	1.57 g, 48 mm	0.43 (0.25-0.73)	Long & Shillabeer 1997b	A
Ictalurus punctatus	channel catfish	FT	Meas	87.7%	72 h	17	Mortality	1.57 g, 48 mm	0.18 (0.15-0.23)	Long & Shillabeer 1997b	A
Lepomis macrochirus Rafinesque	Bluegill sunfish	FT	Meas	99.0%	24 h	21.9	Mortality	juvenile	0.224 (0.152-1.742)	Marino & Rick 2001	A
Lepomis macrochirus Rafinesque	Bluegill sunfish	FT	Meas	99.0%	48 h	21.9	Mortality	juvenile	24 (0.0944-0.1	Marino & Rick 2001	A
Lepomis macrochirus Rafinesque	Bluegill sunfish	FT	Meas	99.0%	72 h	21.9	Mortality	juvenile	0.118 (0.0944-0.155)	Marino & Rick 2001	A
Lepomis macrochirus	Bluegill sunfish	FT	Meas	98.0%	24 h	22	Mortality	1.51 g, 38.2 mm	0.45 (0.38-0.52)	Hill 1984b	A
Lepomis macrochirus	Bluegill sunfish	FT	Meas	98.0%	48 h	22	Mortality	1.51 g, 38.2 mm	0.28 (0.23-0.32)	Hill 1984b	A
Lepomis macrochirus	Bluegill sunfish	FT	Meas	98.0%	72 h	22	Mortality	1.51 g, 38.2 mm	0.28 (0.23-0.32)	Hill 1984b	A
Leuciscus idus	Golden orfe	FT	Meas	88.7%	72 h	12	Mortality	2.15 g, 53 mm	0.078 (0.056-0.11)	Kent & Shillabeer 1997a	A

Species	Common Identifier	Test type	Meas/ Nom	Chemical grade	Duration	Temp (°C)	Endpoint	Age/size	LC/EC_{50} (µg/L) (95% CI)	Reference	Reason
Oncorhynchus mykiss	Rainbow trout	FT	Meas	99.0%	48 h	12	Mortality	39 mm, 0.52 g	0.29 (0.25-0.33)	Machado 2001b	A
Oncorhynchus mykiss	Rainbow trout	FT	Meas	99.0%	72 h	12	Mortality	39 mm, 0.52 g	0.22 (0.20-0.38)	Machado 2001b	A
Oncorhynchus mykiss	Rainbow trout	FT	Meas	81.5%	48 h	12	Mortality	43 mm, 1.12 g	0.57 (0.50-0.66)	Tapp et al. 1989	A
Oncorhynchus mykiss	Rainbow trout	FT	Meas	81.5%	72 h	12	Mortality	43 mm, 1.12 g	0.49 (0.43-0.58)	Tapp et al. 1989	A
Oncorhynchus mykiss	Rainbow trout	FT	Meas	98.0%	24 h	12	Mortality	38.3mm, 0.83 g	0.52 (0.46-0.60)	Hill 1984a	A
Oncorhynchus mykiss	Rainbow trout	FT	Meas	98.0%	48 h	12	Mortality	38.3mm, 0.83 g	0.40 (0.35-0.45)	Hill 1984a	A
Oncorhynchus mykiss	Rainbow trout	FT	Meas	98.0%	72 h	12	Mortality	38.3mm, 0.83 g	0.27 (0.09-0.80)	Hill 1984a	A
Pimephales promelas	Fathead minnow	FT	Meas	97.0%	72 h	25	Mortality	larvae	0.407 (0.316-0.675)	Tapp et al. 1990	A
Pimephales promelas	Fathead minnow	FT	Meas	88.7%	24 h	25	Mortality	0.37 g, 28 mm	0.89 (0.73-1.1)	Kent & Shillabeer 1997e	A
Pimephales promelas	Fathead minnow	FT	Meas	88.7%	48 h	25	Mortality	0.37 g, 28 mm	0.89 (0.73-1.1)	Kent & Shillabeer 1997e	A
Pimephales promelas	Fathead minnow	FT	Meas	88.7%	72 h	25	Mortality	0.37 g, 28 mm	0.70 (0.38-1.3)	Kent & Shillabeer 1997e	A
Poecilia reticulata	guppy	FT	Meas	88.7%	24 h	25	Mortality	0.62 g, 33 mm	2.9 (1.6-5.1)	Kent & Shillabeer 1997b	A
Poecilia reticulata	guppy	FT	Meas	88.7%	48 h	25	Mortality	0.62 g, 33 mm	2.9 (1.6-5.1)	Kent & Shillabeer 1997b	A
Poecilia reticulata	guppy	FT	Meas	88.7%	72 h	25	Mortality	0.62 g, 33 mm	2.5 (1.9-3.4)	Kent & Shillabeer 1997b	A

Reduction Reasons

A. Not the most sensitive or appropriate duration

B. FT test preferred over S or SR

C. Not the most sensitive endpoint

Table 5 Supplemental acute data rated RL, LR, LL.
S: static; SR: static renewal; FT: flow-through. NR: not reported; 95% CI: 95% confidence interval.

Species	Common Identifier	Test type	Meas/ Nom	Chemical grade	Duration	Temp (°C)	Endpoint	Age/size	LC/EC_{50} (µg/L) (95% CI)	Reference	Rating/ Reason
Americamysis bahia	mysid shrimp	FT	Meas	97.0%	24 h	25	Mortality	<48 h	> 0.017	Thompson 1985b	RL 2, 4
Americamysis bahia	mysid shrimp	FT	Meas	97.0%	48 h	25	Mortality	<48 h	0.0075 (0.0061-0.0096)	Thompson 1985b	RL 2, 4
Americamysis bahia	mysid shrimp	FT	Meas	97.0%	72 h	25	Mortality	<48 h	0.0049 (0.0041-0.0058)	Thompson 1985b	RL 2, 4
Americamysis bahia	mysid shrimp	FT	Meas	97.0%	96 h	25	Mortality	<48 h	0.0041 (0.0034-0.0049)	Thompson 1985b	RL 2, 4
Brachydanio rerio	Zebra fish	SR	Nom	formulation	24 h	25	Mortality	30-45 d old	8.26 (5.93-11.51)	Wang et al. 2007	LL 1, 7
Brachydanio rerio	Zebra fish	SR	Nom	formulation	48 h	25	Mortality	30-45 d old	3.91 (2.62-5.84)	Wang et al. 2007	LL 1, 7
Brachydanio rerio	Zebra fish	SR	Nom	formulation	72 h	25	Mortality	30-45 d old	2.05 (1.40-3.01)	Wang et al. 2007	LL 1, 7
Brachydanio rerio	Zebra fish	SR	Nom	formulation	96 h	25	Mortality	30-45 d old	1.94 (1.33-2.84)	Wang et al. 2007	LL 1, 7
Caridina laevis	Atyid shrimp	S	Nom	formulation	24 h	26	Mortality	Adult, 15-20 mm	0.87 (0.76-0.98)	Sucahyo et al. 2008	RL 1, 7
Caridina laevis	Atyid shrimp	S	Nom	formulation	96 h	26	Mortality	Adult, 15-20 mm	0.33 (0.30-0.37)	Sucahyo et al. 2008	RL 1, 7
Channa punctatus	Snakehead fish	SR	Nom	5.0%	96 h	27	Mortality	Teleost, 11-3 cm, 23 g	7.92	Kumar et al. 2007	LL 1, 7
Cyprinodon variegatus	Sheepshead minnow	FT	Meas	96.5%	24 h	22	Mortality	0.60 g, 27.4 mm	1.34	Hill 1985	RL 2
Cyprinodon variegatus	Sheepshead minnow	FT	Meas	96.5%	48 h	22	Mortality	0.60 g, 27.4 mm	1.14	Hill 1985	RL 2
Cyprinodon variegatus	Sheepshead minnow	FT	Meas	96.5%	72 h	22	Mortality	0.60 g, 27.4 mm	0.85	Hill 1985	RL 2

Species	Common Identifier	Test type	Meas/ Nom	Chemical grade	Duration	Temp (°C)	Endpoint	Age/size	LC/EC_{50} (µg/L) (95% CI)	Reference	Rating/ Reason
Cyprinodon variegatus	Sheepshead minnow	FT	Meas	96.5%	96 h	22	Mortality	0.60 g, 27.4 mm	0.81	Hill 1985	RL 2
Ischnura elegans	Damselfly nymph	S	Nom	88.0%	48 h	20	Immobility	nymph	0.130 (0.092-0.190)	Hamer et al. 1998	RL 1, 4
Macrobrachium nippoensis	shrimp	SR	Nom	formulation	24 h	16	Mortality	90 d old, 5.0 g, 4.5 cm	0.05 (0.04-0.07)	Wang et al. 2007	LL 1, 7
Macrobrachium nippoensis	shrimp	SR	Nom	formulation	48 h	16	Mortality	90 d old, 5.0 g, 4.5 cm	0.05 (0.04-0.06)	Wang et al. 2007	LL 1, 7
Macrobrachium nippoensis	shrimp	SR	Nom	formulation	72 h	16	Mortality	90 d old, 5.0 g, 4.5 cm	0.04 (0.03-0.06)	Wang et al. 2007	LL 1, 7
Macrobrachium nippoensis	shrimp	SR	Nom	formulation	96 h	16	Mortality	90 d old, 5.0 g, 4.5 cm	0.04 (0.03-0.05)	Wang et al. 2007	LL 1, 7
Oryzias latipes	Japanese rice fish	FT	Meas	88.7%	24 h	25	Mortality	0.22g, 25 mm	2.1 (1.5-3.3)	Kent & Shillabeer 1997d	LR 3
Oryzias latipes	Japanese rice fish	FT	Meas	88.7%	48 h	25	Mortality	0.22g, 25 mm	1.5 (1.0-2.6)	Kent & Shillabeer 1997d	LR 3
Oryzias latipes	Japanese rice fish	FT	Meas	88.7%	72 h	25	Mortality	0.22g, 25 mm	1.4 (0.93-2.3)	Kent & Shillabeer 1997d	LR 3
Oryzias latipes	Japanese rice fish	FT	Meas	88.7%	96 h	25	Mortality	0.22g, 25 mm	1.4 (0.93-2.3)	Kent & Shillabeer 1997d	LR 3

Exclusion Reasons

1. Not a standard method
2. Saltwater
3. Family not found in N. America
4. Unacceptable control response
5. Control response not reported
6. Low reliability score
7. Low chemical purity

Table 6 Final chronic toxicity data set for lambda-cyhalothrin.
All studies were rated RR. S: static; SR: static renewal; FT: flow-through. NR: not reported

Species	Common identifier	Test type	Meas/ Nom	Chemical grade	Duration	Temp (°C)	Endpoint	Age/ size	NOEC (µg/L)	LOEC (µg/L)	MATC (µg/L)	Reference
Daphnia magna	Daphnid	FT	Meas	94.3%	21 d	20	Reproduction (young/female/d)	< 24 h	0.00198	0.00350	0.00263	Farrelly & Hamer 1989
Daphnia magna	Daphnid	SR	Meas	94.3%	21 d	20	Reproduction (young/female/d)	< 24 h	0.00375	0.00490	0.00429	Hamer et al. 1985b
											0.00336	
Pimephales promelas	Fathead minnow	FT	Meas	97.0%	56 d	25	F1 Survival	F1 larvae	0.031	0.062	**0.044**	Tapp et al. 1990

Table 7 Acceptable reduced chronic data rated RR.
S: static; SR: static renewal; FT: flow-through. NR: not reported.

Species	mmon na	Test type	eas/ N	Chemical grade	Duration	Temp (°C)	Endpoint	Age/ size	NOEC (µg/L)	LOEC (µg/L)	MATC (µg/L)	Reference	Reason
Daphnia magna	Daphnid	FT	Meas	94.3%	21 d	20	Reproduction (total young)	<24 h	0.00198	0.00350	0.00263	Farrelly & Hamer 1989	
Daphnia magna	Daphnid	SR	Meas	94.3%	21 d	20	Reproduction (total young)	<24 h	0.00490	0.00850	0.00645	Hamer et al. 1985b	
											0.00412		A
Daphnia magna	Daphnid	SR	Meas	94.3%	21 d	20	Reproduction (# of female repro days)	<24 h	0.00850	0.01830	**0.01247**	Hamer et al. 1985b	A
Daphnia magna	Daphnid	SR	Meas	94.3%	9 d	20	Length	<24 h	0.01830	0.03720	0.02609	Hamer et al. 1985b	
Daphnia magna	Daphnid	FT	Meas	94.3%	21 d	20	Length	<24 h	0.00937	0.01910	0.01338	Farrelly & Hamer 1989	
											0.0187		A
Pimephales promelas	Fathead minnow	FT	Meas	97.0%	3-5 d	25	F1 Hatching success	F1 eggs	0.062	0.139	0.093	Tapp et al. 1990	B
Pimephales promelas	Fathead minnow	FT	Meas	97.0%	28 d	25	F0 Survival	F0 eggs	0.062	0.139	0.093	Tapp et al. 1990	B
Pimephales promelas	Fathead minnow	FT	Meas	97.0%	56 d	25	F0 Survival	F0 eggs	0.062	0.139	0.093	Tapp et al. 1990	B
Pimephales promelas	Fathead minnow	FT	Meas	97.0%	300 d	25	F0 Egg Production	F0 eggs	0.062	0.139	0.093	Tapp et al. 1990	B

Reasons for Exclusion

A. Less sensitive endpoint

B. Less sensitive life-stage

C. Test type not preferred (static vs. flow-through)

Table 8 Acute-to-Chronic Ratios used for derivation of the lambda-cyhalothrin chronic criterion.

Species	Common identifier	Test type	Meas/ Nom	Chemical grade	MATC (µg/L)	LC_{50} (µg/L)	ACR (LC_{50}/MATC)	Reference
Cyprinodon variegatus	Sheepshead minnow	FT	Meas	96.6%	0.31	0.81	2.6129	Hill et al. 1985
Daphnia magna	Daphnid	FT	Meas	94.3%	0.00263	0.013	4.9430	Farrelly & Hamer 1989
Pimephales promelas	Fathead minnow	FT	Meas	97.0%	0.044	0.36	8.1818	Tapp et al. 1990
Multi-species ACR = geomean (individual ACR**s)**							**4.73**	

Table 9 Supplemental chronic toxicity data from studies rated RL, LR, or LL.
S: static; SR: static renewal; FT: flow-through. NR: not reported, NC: not calculable.

Species	Common identifier	Test type	Meas/ Nom	Chem. grade	Duration	Temp (°C)	Endpoint	Age/ size	NOEC (µg/L)	LOEC (µg/L)	MATC (µg/L)	Reference	Rating/ Reason
Americamysis bahia	Mysid	FT	Meas	98.5%	28 d	25	Reproduction (# of young/ female repro. day)	<24 h	0.00022	0.00046	0.00032	Thompson 1987	RL 2, 5
Cyprinodon variegatus	Sheepshead minnow	FT	Meas	96.6%	28 d	25.1	Weight	embryos	0.25	0.38	0.31	Hill et al. 1985	RL 1, 2
Pimephales promelas	Fathead minnow	FT	Meas	97.0%	3-5 d	25	F0 Hatching success	eggs	≥ 0.273	> 0.273	NC	Tapp et al. 1990	LR 4
Pimephales promelas	Fathead minnow	FT	Meas	97.0%	300 d	25	F0 Survival	eggs	≥ 0.139	> 0.139	NC	Tapp et al. 1990	LR 4
Pimephales promelas	Fathead minnow	FT	Meas	97.0%	28 d	25	F0 Length	eggs	≥ 0.139	> 0.139	NC	Tapp et al. 1990	LR 4
Pimephales promelas	Fathead minnow	FT	Meas	97.0%	56 d	25	F0 Length	eggs	≥ 0.139	> 0.139	NC	Tapp et al. 1990	LR 4
Pimephales promelas	Fathead minnow	FT	Meas	97.0%	300 d	25	F0 Length	eggs	≥ 0.139	> 0.139	NC	Tapp et al. 1990	LR 4
Pimephales promelas	Fathead minnow	FT	Meas	97.0%	56 d	25	F1 Length	larvae	≥ 0.139	> 0.139	NC	Tapp et al. 1990	LR 4
Pimephales promelas	Fathead minnow	FT	Meas	97.0%	300 d	25	F0 Weight	eggs	≥ 0.139	> 0.139	NC	Tapp et al. 1990	LR 4
Pimephales promelas	Fathead minnow	FT	Meas	97.0%	56 d	25	F1 Weight	larvae	≥ 0.139	> 0.139	NC	Tapp et al. 1990	LR 4

Exclusion Reasons

1. Not a standard method
2. Saltwater
3. Low chemical purity or purity not reported
4. Toxicity value not calculable
5. Control response not reported
6. Low reliability score
7. Endpoint not linked to growth, reproduction or survival (Ch. 3, Section 3-2.1.3)
8. Inappropriate test duration (Ch. 3, Section 3-2.1.1)

Table 10 Acceptable multispecies field, semi-field, laboratory, microcosm, mesocosm studies.
R= reliable; L= less reliable.

Reference	Habitat	Rating
Farmer et al. 1995	Outdoor artificial mesocosm	R
Gu et al. 2007	Indoor rice paddy-field ecosystem	L
Hill et al. 1994	Outdoor mesocosm ponds	R
Lauridsen & Friberg 2005	In-stream experimental channels	L
Rasmussen et al. 2008	Outdoor artificial stream channels	L
Roessink et al. 2005	Outdoor artificial ditch microcosm	R
Schroer et al. 2004	Outdoor artificial ditch microcosm	R
Van Wijngaarden et al. 2006	Outdoor artificial ditch microcosm	R
Wendt-Rasch et al. 2004	Outdoor pond microcosms	R

Table 11 Threatened, Endangered, or Rare Species Predicted values by ICE.

Surrogate		Predicted	
Species	**LC_{50} (µg/L)**	**Species**	**LC_{50} (µg/L)**
Rainbow trout (*Oncorhynchus mykiss)*	0.27	Chinook salmon *(O. tshawytscha)*	0.539 (0.176-1.65)*
		Coho salmon (*O. kisutch)*	0.277 (0.180-0.426)
		Lahontan cutthroat trout (*O. clarki henshawi)*	0.397 (0.197-0.789)*

* Input toxicity value was less than model minimum

Appendix A: Fit Test Calculations

	Omit one												
all LC50s	1	2	3	4	5	6	7	8	9	10	11	12	13
0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
0.0059	0.0059	0.0059	0.0059	0.0059	0.0059	0.0059	0.0059	0.0059	0.0059	0.0059	0.0059	0.0059	0.0059
0.0130	0.0130	0.0130	0.0130	0.0130	0.0130	0.0130	0.0130	0.0130	0.0130	0.0130	0.0130	0.0130	0.0130
0.0260	0.0260	0.0260	0.0260	0.0260	0.0260	0.0260	0.0260	0.0260	0.0260	0.0260	0.0260	0.0260	0.0260
0.0300	0.0300	0.0300	0.0300	0.0300	0.0300	0.0300	0.0300	0.0300	0.0300	0.0300	0.0300	0.0300	0.0300
0.0380	0.0380	0.0380	0.0380	0.0380	0.0380	0.0380	0.0380	0.0380	0.0380	0.0380	0.0380	0.0380	0.0380
0.0470	0.0470	0.0470	0.0470	0.0470	0.0470	0.0470	0.0470	0.0470	0.0470	0.0470	0.0470	0.0470	
0.0780	0.0780	0.0780	0.0780	0.0780	0.0780	0.0780	0.0780	0.0780	0.0780	0.0780	0.0780		0.0780
0.1492	0.1492	0.1492	0.1492	0.1492	0.1492	0.1492	0.1492	0.1492	0.1492	0.1492		0.1492	0.1492
0.1600	0.1600	0.1600	0.1600	0.1600	0.1600	0.1600	0.1600	0.1600	0.1600		0.1600	0.1600	0.1600
0.1600	0.1600	0.1600	0.1600	0.1600	0.1600	0.1600	0.1600	0.1600		0.1600	0.1600	0.1600	0.1600
0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000		0.2000	0.2000	0.2000	0.2000	0.2000
0.2717	0.2717	0.2717	0.2717	0.2717	0.2717	0.2717		0.2717	0.2717	0.2717	0.2717	0.2717	0.2717
0.3000	0.3000	0.3000	0.3000	0.3000	0.3000		0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000
0.4000	0.4000	0.4000	0.4000	0.4000		0.4000	0.4000	0.4000	0.4000	0.4000	0.4000	0.4000	0.4000
0.5020	0.5020	0.5020	0.5020		0.5020	0.5020	0.5020	0.5020	0.5020	0.5020	0.5020	0.5020	0.5020
0.6400	0.6400	0.6400		0.6400	0.6400	0.6400	0.6400	0.6400	0.6400	0.6400	0.6400	0.6400	0.6400
2.3000	2.3000		2.3000	2.3000	2.3000	2.3000	2.3000	2.3000	2.3000	2.3000	2.3000	2.3000	2.3000
3.3000		3.3000	3.3000	3.3000	3.3000	3.3000	3.3000	3.3000	3.3000	3.3000	3.3000	3.3000	3.3000

	Omit one continued from above						
all LC 50s	14	15	16	17	18	19	20
0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	
0.0028	0.0028	0.0028	0.0028	0.0028	0.0028		0.0028
0.0059	0.0059	0.0059	0.0059	0.0059		0.0059	0.0059
0.0130	0.0130	0.0130	0.0130		0.0130	0.0130	0.0130
0.0260	0.0260	0.0260		0.0260	0.0260	0.0260	0.0260
0.0300	0.0300		0.0300	0.0300	0.0300	0.0300	0.0300
0.0380		0.0380	0.0380	0.0380	0.0380	0.0380	0.0380
0.0470	0.0470	0.0470	0.0470	0.0470	0.0470	0.0470	0.0470
0.0780	0.0780	0.0780	0.0780	0.0780	0.0780	0.0780	0.0780
0.1492	0.1492	0.1492	0.1492	0.1492	0.1492	0.1492	0.1492
0.1600	0.1600	0.1600	0.1600	0.1600	0.1600	0.1600	0.1600
0.1600	0.1600	0.1600	0.1600	0.1600	0.1600	0.1600	0.1600
0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000
0.2717	0.2717	0.2717	0.2717	0.2717	0.2717	0.2717	0.2717
0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000
0.4000	0.4000	0.4000	0.4000	0.4000	0.4000	0.4000	0.4000
0.5020	0.5020	0.5020	0.5020	0.5020	0.5020	0.5020	0.5020
0.6400	0.6400	0.6400	0.6400	0.6400	0.6400	0.6400	0.6400
2.3000	2.3000	2.3000	2.3000	2.3000	2.3000	2.3000	2.3000
3.3000	3.3000	3.3000	3.3000	3.3000	3.3000	3.3000	3.3000

Omitted point, xi:	**3.3**	**2.3**	**0.64**	**0.5020**	**0.4**	**0.3**	**0.2717**	**0.2**	**0.16**	**0.16**	**0.1492**	**0.078**	**0.047**
median 5th percentile Burr III	0.0011	0.0012	0.0013	0.0013	0.0013	0.0012	0.0012	0.0012	0.0011	0.0011	0.0011	0.0011	0.0011
percentile	0.77	2.01	14.26	18.17	22.31	28.2	30.38	37.5	42.87	42.87	41.37	41.37	35.95
F-i(xi)	0.0077	0.0201	0.1426	0.1817	0.2231	0.282	0.3038	0.375	0.4287	0.4287	0.4137	0.4137	0.3595
1-F(xi)	0.9923	0.9799	0.8574	0.8183	0.7769	0.718	0.6962	0.625	0.5713	0.5713	0.5863	0.5863	0.6405
Min of F-i(xi) or 1-F(xi)	0.0296	0.0077	0.0201	0.1426	0.1817	0.2231	0.282	0.3038	0.375	0.4287	0.4287	0.4137	0.3595
p_i =2(min)	0.0154	0.0402	0.2852	0.3634	0.4462	0.564	0.6076	0.75	0.8574	0.8574	0.8274	0.8274	0.719

Continued from above

Omitted point, xi:	**0.038**	**0.03**	**0.026**	**0.013**	**0.0059**	**0.0028**	**0.0003**
median 5th percentile Burr III	0.0012	0.0012	0.0013	0.0015	0.0018	0.0022	0.0045
percentile	71.45	74.8	76.67	84.22	90.33	94.24	99.4
F-i(xi)	0.7145	0.748	0.7667	0.8422	0.9033	0.9424	0.994
1-F(xi)	0.2855	0.252	0.2333	0.1578	0.0967	0.0576	0.006
Min of F-i(xi) or 1-F(xi)	0.2855	0.252	0.2333	0.1578	0.0967	0.0576	0.006
p_i =2(min)	0.571	0.504	0.4666	0.3156	0.1934	0.1152	0.012

p_i	$\ln(p_i)$	Fisher test statistic: -2*Sum of ln (pi)	X^2_{2n}
0.0154	-4.1734	48.5585	0.1662
0.0402	-3.2139		
0.2852	-1.2546		
0.3634	-1.0123		
0.4462	-0.8070		
0.5640	-0.5727		
0.6076	-0.4982		
0.7500	-0.2877		
0.8574	-0.1539		
0.8574	-0.1539		
0.891	-0.1154		
0.8206	-0.1977		
0.6372	-0.4507		
0.571	-0.5604		
0.504	-0.6852		
0.4666	-0.7623		
0.3156	-1.1533		
0.1934	-1.6430		
0.1152	-2.1611		
0.012	-4.4228		

0.1662 is > 0.05 so the distribution fits the lambda-cyhalothrin acute data set

if $X^2 < 0.05$ significant lack of fit

if $X^2 > 0.05$ fit (no significant lack of fit)

Appendix B: Data summary sheets

Abbreviations used in this appendix:
NR = Not Reported

Study Ratings:
RR = Relevant, Reliable
RL = Relevant, Less Reliable
LR =Less Relevant, Reliable
LL = Less Relevant, Less Reliable
RN = Relevant, Not Reliable
LN = Less Relevant, Not Reliable
N = Not Relevant

Unused lines deleted from tables

Summary sheets are in alphabetical order according to species

Toxicity Data Summary

Aedes aegypti

Study: Rodriguez MM, Bisset JA, Fernandez D. 2007. Levels of insecticide resistance and resistance mechanisms in *Aedes aegypti* from some Latin American countries. Journal of the American Mosquito Control Association. 23(4): 420-429.

Relevance
Score: 92.5 (No control response)
Rating: R

Reliability
Score: 57
Rating: N

Reference	**Rodriguez et al. 2007**	***A. aegypti***
Parameter	**Value**	**Comment**
Test method cited	WHO 1981	
Phylum	Arthropoda	
Class	Insecta	
Order	Diptera	
Family	Culicidae	
Genus	*Aedes*	
Species	*aegypti*	
Family in North America?	Yes	
Age/size at start of test/growth phase	Early 4th instar larvae	
Source of organisms	Lab culture	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	24 h	
Data for multiple times?	No	
Effect 1	Survival	
Control response 1	NR	
Temperature	NR	
Test type	Static	
Photoperiod/light intensity	NR	
Dilution water	Tap water	
pH	NR	
Hardness	NR	
Alkalinity	NR	
Conductivity	NR	
Dissolved Oxygen	NR	
Feeding	No	
Purity of test substance	λ-Cyhalothrin: Technical	

Reference	**Rodriguez et al. 2007**	***A. aegypti***
Parameter	**Value**	**Comment**
Concentrations measured?	No	
Measured is what % of nominal?	NR	
Chemical method documented?	NR	
Concentration of carrier (if any) in test solutions	1 mL acetone /100 mL water	
Concentration 1 Nom/Meas (μg/L)	5 concentrations	20/rep x 2
Control	Water and methanol control	20/rep x 2
λ-Cyhalothrin LC50 (95% Confidence interval) for 8 strains* in ug/L	Rockefellar (susceptible): 1 (0.8-1) Santiago de Cuba: 6 (5-6) Havana City: 30 (20-30) Jamaica: 5 (4-6) Panama: 0.5 (0.4-0.5) Costa Rica: 4 (3-4) Nicaragua: 0.3 (0.3-0.4) Peru: 0.1 (0.1-0.2) Venezuela: 0.6 (0.4-0.7)	Probit (Finney 1971)

***Rockefellar**: laboratory susceptible strain of Caribbean origin, colonized in the early 1930s, provided by the CDC laboratory in San Juan, Puerto Rico.
Santiago de Cuba: natural population collected from Santiago de Cuba, Cuba in 2002 during last dengue epidemic
Havana City: natural population collected from Havana City, Cuba in 2002 during last dengue epidemic
Jamaica: collected in 1998 and maintained in laboratory without exposure to insecticides
Costa Rica: collected in 1998 and maintained in laboratory without exposure to insecticides
Panama: collected in 1998 and maintained in laboratory without exposure to insecticides
Nicaragua: collected in 1998 and maintained in laboratory without exposure to insecticides
Peru: collected in 1998 and maintained in laboratory without exposure to insecticides
Venezuela: collected in 1998 and maintained in laboratory without exposure to insecticides

Reliability points taken off for:
Documentation: Analytical method (4), Nominal concentrations (3), Measured concentrations (3), Hardness (2), Alkalinity (2), Dissolved Oxygen (4), Temperature (4), Conductivity (2), pH (3), Photoperiod (3), Hypothesis tests (8)
Acceptability: Control response (9), Meas. Concentrations 20% Nom (4), Concentrations not ≥ 2x water solubility (4), Carrier solvent ≤ 0.5 mL/L (4), Organisms randomized (1), Dilution water (2), Hardness (2), Alkalinity (2), Dissolved oxygen (6), Temperature (6), Conductivity (1), pH (2), Photoperiod (2), Test vessels randomized (2), Appropriate spacing between concentrations (2), Hypothesis tests (3)

Toxicity Data Summary

Americamysis bahia (formerly *Mysidopsis bahia*)

Study: Thompson RS. 1985b. PP321: Determination of acute toxicity to mysid shrimp (*Mysidopsis bahia*). DPR study number 50907-0087, 160359.

Relevance
Score: 77.5 (Saltwater, low solv. control response)
Rating: L

Reliability
Score: 79
Rating: R

Reference	**Thompson 1985b**	***A. bahia***
Parameter	**Value**	**Comment**
Test method cited	EPA GLP	
Phylum	Arthropoda	
Class	Malacostraca	
Order	Mysida	
Family	Vespoidea	
Genus	*Americamysis*	Formerly *Mysidopsis*
Species	*bahia*	*bahia*
Family in North America?	Yes	
Age/size at start of test/growth phase	< 48 h	
Source of organisms	Commercial supplier, Sea Plantations, Inc.	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	Yes	
Test vessels randomized?	NR	
Test duration	96 h	
Data for multiple times?	24, 48, 72 h	
Effect 1	Mortality	
Control response 1	Dil: 0%, Solv: 15%	
Temperature	25 ± 1°C	
Test type	FT	
Photoperiod/light intensity	14 L: 10 D	
Dilution water	Natural seawater diluted with freshwater	Seawater from Tor Bay, UK
pH	8.12-8.22	
Hardness	NR	
Alkalinity	NR	
Salinity	20 o/oo	

Reference	**Thompson 1985b**	***A. bahia***
Parameter	**Value**	**Comment**
Dissolved Oxygen	6.6-7.4 mg/L	
Feeding	Yes, twice daily	
Purity of test substance	97%	
Concentrations measured?	Yes	
Measured is what % of nominal?	29-81%	
Chemical method documented?	Yes, LSC	
Concentration of carrier (if any) in test solutions	0.022 mL/L	
Concentration 1 Nom/Meas (μg/L)	0.0032/0.0026	1 rep, 20 orgs/rep
Concentration 2 Nom/Meas (μg/L)	0.0056/0.0026	1 rep, 20 orgs/rep
Concentration 3 Nom/Meas (μg/L)	0.010/0.0059	1 rep, 20 orgs/rep
Concentration 4 Nom/Meas (μg/L)	0.018/0.0052	1 rep, 20 orgs/rep
Concentration 5 Nom/Meas (μg/L)	0.032/0.011	1 rep, 20 orgs/rep
Concentration 6 Nom/Meas (μg/L)	0.056/0.0166	1 rep, 20 orgs/rep
Control	Dilution water and solvent	1 rep, 20 orgs/rep
LC_{50} (95% confidence interval) (μg/L)	24 h: >0.017 48 h: 0.0075 (0.0061-0.0096) 72 h: 0.0049 (0.0041-0.0058) 96 h: 0.0041 (0.0034-0.0049)	Method: Probit

Notes:

LC_{50} calculated based on mean measured concentrations.

Reliability points taken off for:
Documentation: Hardness (2), Alkalinity (2), Conductivity (2), Hypothesis tests (8).
Acceptability: Control response not acceptable (9), Measured concentrations w/in 20% nominal (4), Organism feeding (3), Hardness (2), Alkalinity (2), Conductivity (1), Random design (2), Adequate replication (2), Hypothesis tests (3).

Toxicity Data Summary

Americamysis bahia (formerly *Mysidopsis bahia*)

Study: Thompson RS. 1987. PP321 (Lambda-cyhalothrin): Determination of chronic toxicity to mysid shrimps (*Mysidopsis bahia).* DPR study 50907-089.

Relevance
Score: 77.5 (Saltwater, Control Response)
Rating: L

Reliability
Score: 79
Rating: R

Reference	**Thompson 1987**	***A. bahia***
Parameter	**Value**	**Comment**
Test method cited	ASTM 1986	
Phylum	Arthropoda	
Class	Malacostraca	
Order	Mysida	
Family	Mysidae	
Genus	*Americamysis*	Formerly *Mysidopsis*
Species	*bahia*	*bahia*
Family in North America?	Yes	
Age/size at start of test/growth phase	< 24 g	
Source of organisms	Continuous lab culture at testing facility	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	Yes	
Test vessels randomized?	NR	
Test duration	28 d	
Data for multiple times?	yes, 14, 12 d	
Effect 1	Mortality	
Control response 1	Dil water: 22.5%, Solvent: 12.5%	
Effect 2	Dry weight	
Control response 2	Female: 0.96 mg, Male: 0.81 mg	
Effect 3	Reproduction	
Control response 3	0.9 young/available female/day	
Temperature	25 ± 1°C	
Test type	Flow-through	

Reference	**Thompson 1987**	***A. bahia***
Parameter	**Value**	**Comment**
Photoperiod/light intensity	14 L: 10 D	
Dilution water	Mixture of filtered seawater and freshwater	
pH	7.90-8.20	
Hardness	NR	
Alkalinity	NR	
Salinity	20 o/oo	
Dissolved Oxygen	6.35-7.55 mg/L	
Feeding	Daily	
Purity of test substance	98.5%	
Concentrations measured?	Yes	
Measured is what % of nominal?	48-74%	
Chemical method documented?	Yes, LSC	
Concentration of carrier (if any) in test solutions	0.00037% triethylene glycol	
Concentration 1 Nom/Meas (µg/L)	0.00033/0.00022	2 reps, 20 orgs/rep
Concentration 2 Nom/Meas (µg/L)	0.00065/0.00046	2 reps, 20 orgs/rep
Concentration 3 Nom/Meas (µg/L)	0.0013/0.00070	2 reps, 20 orgs/rep
Concentration 4 Nom/Meas (µg/L)	0.0025/0.0017	2 reps, 20 orgs/rep
Concentration 5 Nom/Meas (µg/L)	0.005/0.0037	2 reps, 20 orgs/rep
Concentration 6 Nom/Meas (µg/L)	0.010/0.0048	2 reps, 20 orgs/rep
Control	Solvent and dilution water	2 reps, 20 orgs/rep
NOEC (µg/L)	Reproduction, mortality, dry weight: 0.00022	Method: Dunnett's test, Student t-test p: 0.05 MSD: NR
LOEC (µg/L)	Reproduction: 0.00046	Same as above
MATC (GeoMean NOEC,LOEC)	Reproduction: 0.00032 µg/L	

Notes:

NOEC/LOEC calculated based on mean measured concentrations.

Reliability points taken off for:
Documentation: Hardness (2), Alkalinity (2), Conductivity (2), Minimum significant difference (2), Point estimates (8)
Acceptability: Control response (9), Measured concentrations w/in 20% of nominal (4), Hardness (2), Alkalinity (2), Conductivity (1), Random design (2), Adequate replication (2), Minimum significant difference (1), Point estimates (3)

Toxicity Data Summary

Asellus aquaticus

Study: Bundschuh M, Appeltauer A, Dabrunz A, Schulz R. 2012. Combined effect of invertebrate predation and sublethal pesticide exposure on the behavior and survival of *Asellus aquaticus* (Crustacea; Isopoda). Arch Environ Contam Toxicol 63:77-85.

Relevance	Reliability
Score: 45*	Score: not scored
Rating: N	Rating: not rated

*No acceptable standard method (10), endpoint not linked to survival, growth, or reproduction (15), low chemical purity (15), toxicity value not calculable (15).

Toxicity Data Summary

Asellus aquaticus

Study: Hamer MJ, Ashwell JA, Gentle WE. 1998. Lambda-cyhalothrin Acute Toxicity to Aquatic Arthropods. ZENECA Agrochemicals, Jealott's Hill Research Station Bracknell, Berkshire, UK. DPR study number 50907-093.

Relevance
Score: 100
Rating: R

Reliability
Score: 83.5
Rating: R

Reference	**Hamer et al. 1998**	***A. aquaticus***
Parameter	**Value**	**Comment**
Test method cited	USEPA, OECD	
Phylum	Arthropoda	
Class	Malacostraca	
Order	Isopoda	
Family	Aselloidea	
Genus	*Asellus*	
Species	*aquaticus*	
Family in North America?	Yes	
Age/size at start of test/growth phase	NR	
Source of organisms	Experimental ponds at research stations	
Have organisms been exposed to contaminants?	Maybe	
Animals acclimated and disease-free?	NR	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	48 h	
Data for multiple times?	No	
Effect 1	Immobility	
Control response 1	0%	
Effect 2	Mortality	
Control response 2	0%	
Temperature	20 ± 2°C	
Test type	Static	
Photoperiod/light intensity	16 L:8 D, 700-1000 lux	
Dilution water	Mixture of dechlorinated and RO filtered tap water	
pH	7.4-8.4	
Hardness	179 mg/L	
Alkalinity	150 mg/L	

Reference	**Hamer et al. 1998**	***A. aquaticus***
Parameter	**Value**	**Comment**
Conductivity	NR	
Dissolved Oxygen	7.9-8.3 mg/L	
Feeding	None during test	
Purity of test substance	≥ 88% radiochemical purity	
Concentrations measured?	Yes	
Measured is what % of nominal?	t_0: 75-126%; 48 h: 56-58%	
Chemical method documented?	Yes, LSC	
Concentration of carrier (if any) in test solutions	0.05%	
Concentration 1 Nom/Meas t_0/48 h (µg/L)	0.49/<10/<10	1 rep, 10 orgs/rep
Concentration 2 Nom/Meas t_0/48 h (ng/L)	1.0/<10/<10	1 rep, 10 orgs/rep
Concentration 3 Nom/Meas t_0/48 h (ng/L)	2.0/10/<10	1 rep, 10 orgs/rep
Concentration 4 Nom/Meas t_0/48 h (ng/L)	3.9/<10/<10	1 rep, 10 orgs/rep
Concentration 5 Nom/Meas t_0/48 h (ng/L)	7.8/<10/<10	1 rep, 10 orgs/rep
Concentration 6 Nom/Meas t_0/48 h (ng/L)	16/12/<10	1 rep, 10 orgs/rep
Concentration 7 Nom/Meas t_0/48 h (ng/L)	31/33/18	1 rep, 10 orgs/rep
Concentration 8 Nom/Meas t_0/48 h (ng/L)	62/78/35	1 rep, 10 orgs/rep
Control (ng/L)	Dil. water and solvent: <10	1 rep, 10 orgs/rep
EC_{50} (95% confidence interval)	26 (18-36) ng/L	Method: Iteratively re-weighted linear regression

Notes:
LC_{50} values not calculated.
EC_{50} calculated based on nominal concentrations.

Reliability points taken off for:
Documentation: Organism age (5), Conductivity (2), Hypothesis tests (8)
Acceptability: No standard method (5), Measured concentrations w/in 20% of nominal (4), Appropriate organism age (3), Organisms randomized (1), Acclimation (1), Exposure type (2), Temperature variance (3), Conductivity (1), Random design (2), Appropriate statistical method (2), Hypothesis tests (3).

Toxicity Data Summary

Brachydanio rerio
Macrobrachium nippoensis

Study: Gu BG, Wang HM, Chen WL, Cai DJ, Shan ZJ. 2007. Risk assessment of lambda-cyhalothrin on aquatic organisms in paddy field in China. Regulatory Toxicology and Pharmacology, 48: 69-74.

Relevance
Score: 67.5 (No std method, Low chemical purity, No control response)
Rating: N

Toxicity Data Summary

Brachydanio rerio

Study: Kent SJ, Shillabeer N. 1997c. Lambda-cyhalothrin: Acute toxicity to zebra danio (*Brachydanio rerio*). ZENECA Agrochemicals. DPR study number 50907-085.

Relevance
Score: 100
Rating: R

Reliability
Score: 84
Rating: R

Reference	**Kent & Shillabeer 1997c**	***B. rerio***
Parameter	**Value**	**Comment**
Test method cited	US EPA, OECD	
Phylum	Chordata	
Class	Osteichthyes	
Order	Cypriniformes	
Family	Cyprinidae	
Genus	*Brachydanio*	
Species	*rerio*	
Family in North America?	Yes	
Age/size at start of test/growth phase	NR ➢ >11 d old ➢ mean control weight and length 0.70 g and 36 mm at end of test.	
Source of organisms	Lab culture	Aquatic Research Organisms, Hampton, NH, USA
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	11 d acclimation in facility
Animals randomized?	Yes	
Test vessels randomized?	NR	
Test duration	96 h	
Data for multiple times?	Yes; 24, 48, 72 h	
Effect 1	Mortality	
Control response 1	0%	
Temperature	25 ± 1°C	
Test type	Flow-through	
Photoperiod/light intensity	NR	
Dilution water	Dechlorinated tap water	
pH	7.01-7.43	
Hardness	42.3-46.7 mg/L	
Alkalinity	25.6 mg/L	

Reference	**Kent & Shillabeer 1997c**	***B. rerio***
Parameter	**Value**	**Comment**
Conductivity	207-225 µS/cm	
Dissolved Oxygen	7.4-8.4 mg/L, > 90% sat	
Feeding	None during test	
Purity of test substance	87.7%	
Concentrations measured?	Yes	
Measured is what % of nominal?	35-75%	
Chemical method documented?	Yes, GC-ECD	
Concentration of carrier (if any) in test solutions	0.01% dimethylformamide	
Concentration 1 Nom/Meas (µg/L)	0.10/0.035	1 rep, 20 org/rep
Concentration 2 Nom/Meas (µg/L)	0.20/0.070	1 rep, 20 org/rep
Concentration 3 Nom/Meas (µg/L)	0.40/0.21	1 rep, 20 org/rep
Concentration 4 Nom/Meas (µg/L)	0.8/0.40	1 rep, 20 org/rep
Concentration 5 Nom/Meas (µg/L)	1.6/1.2	1 rep, 20 org/rep
Concentration 6 Nom/Meas (µg/L)	3.2/1.8	1 rep, 20 org/rep
Control	Solvent and Dilution water	1 rep, 20 org/rep
LC_{50} (95% confidence interval) (µg/L)	24 h: 0.97 (0.74-1.4) 48 h: 0.80 (0.62-1.1) 72 h: 0.64 (0.48-0.90) 96 h: 0.64 (0.48-0.90)	Method: Moving average angle

Notes:

LC_{50} calculated based on measured concentrations.

Reliability points taken off for:
Documentation: Organism age (5), Photoperiod (3), Hypothesis tests (8)
Acceptability: Measured concentrations w/in 20% of nominal (4), Appropriate organism age (3), Photoperiod (2), Random design (2), Adequate replication (2), Hypothesis tests (3).

Toxicity Data Summary

Brachydanio rerio

Study: Wang W, Cai DJ, Shan ZJ, Chen WL, Poletika N, Gao XW. 2007. Comparison of the acute toxicity for gamma-cyhalothrin and lambda-cyhalothrin to zebra fish and shrimp. Regulatory Toxicology and Pharmacology, 47: 184-188.

Relevance	Reliability
Score: 75 (No standard method, low chemical purity)	Score: 61
Rating: L	Rating: L

Reference	**Wang et al. 2007**	***B. rerio***
Parameter	**Value**	**Comment**
Test method cited	None cited	
Phylum	Chordata	
Class	Osteichthyes	
Order	Cypriniformes	
Family	Cyprinidae	
Genus	*Brachydanio*	
Species	*rerio*	
Family in North America?	Yes	
Age/size at start of test/growth phase	30-45 d old, 0.38 g, 3.5 cm	
Source of organisms	Lab culture	Nanjing Institute of Environmental Sciences
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	96 h	
Data for multiple times?	Yes, 24, 48, 72 h	
Effect 1	Mortality	
Control response 1	0%	
Temperature	25 ± 2°C	
Test type	Static renewal, renewed every 24 h	
Photoperiod/light intensity	NR	
Dilution water	NR	
pH	7.1	
Hardness	6.8-8.0 °HG	
Alkalinity	NR	
Conductivity	NR	

Reference	**Wang et al. 2007**	***B. rerio***
Parameter	**Value**	**Comment**
Dissolved Oxygen	NR	
Feeding	None during test	
Purity of test substance	Kung Fu 25 EW formulation	
Concentrations measured?	Yes, but NR	
Measured is what % of nominal?	NR	
Chemical method documented?	Yes, GC-ECD	
Concentration of carrier (if any) in test solutions	None used	
Concentration 1 Nom/Meas (a.i. µg/L)	0.5	1 rep, 10 orgs/rep
Concentration 2 Nom/Meas (a.i. µg/L)	1.0	1 rep, 10 orgs/rep
Concentration 3 Nom/Meas (a.i. µg/L)	2.0	1 rep, 10 orgs/rep
Concentration 4 Nom/Meas (a.i. µg/L)	4.0	1 rep, 10 orgs/rep
Concentration 5 Nom/Meas (a.i. µg/L)	6.0	1 rep, 10 orgs/rep
Concentration 6 Nom/Meas (a.i. µg/L)	10	1 rep, 10 orgs/rep
Concentration 7 Nom/Meas (a.i. µg/L)	20	1 rep, 10 orgs/rep
Control	Dilution water	1 rep, 10 orgs/rep
LC_{50} (95% confidence interval) (µg/L)	24 h: 8.26 (5.93-11.51) 48 h: 3.91 (2.62-5.84) 72 h: 2.05 (1.40-3.01) 96 h: 1.94 (1.33-2.84)	Method: NR

Notes:

LC_{50} calculated based on nominal concentrations.

Reliability points taken off for:
Documentation: Chemical purity (5), Measured concentrations (3), Dilution water (3), Alkalinity (2), Dissolved oxygen (4), Conductivity (2), Photoperiod (3), Statistical methods (5), Hypothesis tests (8),
Acceptability: Standard method (5), Chemical purity (10), Measured concentrations w/in 20% nominal (4), Concentrations > 2x solubility (4), Organisms randomized (1), Alkalinity (2), Dissolved oxygen (6), Conductivity (1), Photoperiod (2), Random design (2), Adequate replication (2), Statistical method (2), Hypothesis tests (3).

Toxicity Data Summary

Caridina laevis

Study: Sucahyo D, van Straalen NM, Krave A, van Gestel CAM. 2008. Acute toxicity of pesticides to the tropical freshwater shrimp *Caridina laevis.* Ecotoxicology and Environmental Safety, 69: 421-427.

Relevance	Reliability
Score: 75 (No standard method, Low chemical purity)	Score: 73
Rating: L	Rating: R

Reference	**Sucahyo et al. 2008**	***C. laevis***
Parameter	**Value**	**Comment**
Test method cited	None cited	
Phylum	Arthropoda	
Class	Malacostraca	
Order	Decapoda	
Family	Atyidae	
Genus	*Caridina*	
Species	*laevis*	
Family in North America?	Yes	
Age/size at start of test/growth phase	Adults, 15-20 mm	
Source of organisms	Freshwater lake, Indonesia	
Have organisms been exposed to contaminants?	Possibly	
Animals acclimated and disease-free?	Yes	
Animals randomized?	Yes	
Test vessels randomized?	NR	
Test duration	96 h	
Data for multiple times?	Yes, 24 h	
Effect 1	Mortality	
Control response 1	< 10%	
Temperature	26 ± 1°C	
Test type	Static	
Photoperiod/light intensity	12 L: 12 D	
Dilution water	Dechlorinated tapwater	
pH	6.9-7.2	
Hardness	128-136 mg/L	
Alkalinity	NR	
Conductivity	NR	
Dissolved Oxygen	6.8-7. 2 mg/L	
Feeding	None during test	
Purity of test substance	25 g/L formulation	

Reference	**Sucahyo et al. 2008**	***C. laevis***
Parameter	**Value**	**Comment**
Concentrations measured?	No	
Measured is what % of nominal?	NR	
Chemical method documented?	No	
Concentration of carrier (if any) in test solutions	None used	
Concentration 1 Nom/Meas (µg/L)	NR	5 reps, 20 orgs/rep
Concentration 2 Nom/Meas (µg/L)	NR	5 reps, 20 orgs/rep
Concentration 3 Nom/Meas (µg/L)	NR	5 reps, 20 orgs/rep
Concentration 4 Nom/Meas (µg/L)	NR	5 reps, 20 orgs/rep
Concentration 5 Nom/Meas (µg/L)	NR	5 reps, 20 orgs/rep
Concentration 6 Nom/Meas (µg/L)	NR	5 reps, 20 orgs/rep
Control	Dilution water	5 reps, 20 orgs/rep
LC_{50} (95% confidence interval) (µg/L)	24 h: 0.87 (0.76-0.98) 96 h: 0.33 (0.30-0.37)	Method: trimmed Spearman-Karber
NOEC (µg/L)	0.1	Method: Tukey's test p: NR MSD: NR
LOEC (µg/L)	0.2	Same as above
MATC (GeoMean NOEC,LOEC)	0.14 µg/L	

Notes:

LC_{50} or NOEC/LOEC calculated based on nominal active ingredient concentrations.

Reliability points taken off for:
Documentation: Analytical method (4), Nominal concentrations (3), Measured concentration (3), Alkalinity (2), Conductivity (2), Hypothesis tests (8).
Acceptability: Standard method (5), Measured concentrations w/in 20% nominal (4), Prior contamination (4), Exposure type appropriate (2), Alkalinity (2), Conductivity (1), Random design (2), Hypothesis tests (3).

Toxicity Data Summary

Ceriodaphnia dubia

Study: Wheelock CE, Miller JL, Miller MJ, Gee SJ, Shan G, Hammock BD. 2004. Development of toxicity identification evaluation procedures for pyrethroid detection using esterase activity. Environmental Toxicology and Chemistry 23(11): 2699-2708

Relevance
Score: 100
Rating: R

Reliability
Score: 74
Rating: R

Reference	**Wheelock et al. 2004**	***C. dubia***
Parameter	**Value**	**Comment**
Test method cited	EPA	
Phylum	Arthropoda	
Class	Branchiopoda	
Order	Cladocera	
Family	Daphniidae	
Genus	*Ceriodaphnia*	
Species	*dubia*	
Family in North America?	Yes	
Age/size at start of test/growth phase	< 24 h	
Source of organisms	Lab culture; AQUA-Science, Davis, CA	
Have organisms been exposed to contaminants?	Probably not	
Animals acclimated and disease-free?	Yes	
Animals randomized?	Yes	
Test vessels randomized?	Yes	
Test duration	48 h	
Data for multiple times?	No	
Effect 1	Survival	
Control response 1	> 90%	
Temperature	25 +/- 1 ºC	
Test type	Static	
Photoperiod/light intensity	16:8 light: dark	
Dilution water	EPA moderately hard	
pH	7.4-7.8	
Hardness	80-100 mg/L	
Alkalinity	60-70 mg/L	
Conductivity	Measured but NR	
Dissolved Oxygen	Measured but NR	
Feeding	None during test	

Reference	**Wheelock et al. 2004**	***C. dubia***
Parameter	**Value**	**Comment**
Purity of test substance	>97%	
Concentrations measured?	No	
Measured is what % of nominal?	NR	
Chemical method documented?	NR	
Concentration of carrier (if any) in test solutions	<0.1%	
Concentration 1 Nom/Meas (μg/L)	5-7 concentrations	2-4 w/ 5 neonates each, distributed in 'stratified random assortment'
Control	Water and methanol control	2-4 w/ 5 neonates each
LC50; indicate calculation method	48 h: 0.200 +/- 0.090 ug/L	ToxCal software, but no stat method reported

Reliability points taken off for:
Documentation: Nominal concentrations (3), Measured concentrations (3), Dissolved Oxygen (4), Conductivity (2), Statistical methods identified (5), Hypothesis tests (8)

Acceptability: Meas. Concentrations 20% Nom (4), Carrier solvent ≤ 0.5 mL/L (4), Exposure type (2), Appropriate spacing between concentrations (2), Appropriate statistical method (2), Hypothesis tests (3)

Toxicity Data Summary

Ceriodaphnia dubia
Daphnia magna

Study: Mokry, LE & Hoagland KD. 1990. Acute toxicities of five synthetic pyrethroid insecticides to *Daphnia magna* and *Ceriodaphnia dubia*. Environmental Toxicology & Chemistry 9 (8): 1045-1051.

Relevance
Score: 67.5 (purity-25.4 %, no std method, control response NR)
Rating: N

Toxicity Data Summary

Channa punctatus

Study: Kumar A, Sharma B, Pandey RS. 2007. Preliminary evaluation of the acute toxicity of cypermethrin and lambda-cyhalothrin to *Channa punctatus.* Bull Environ Contam Toxicol, 79: 613-616.

Relevance
Score: 75 (No std method, Low chemical purity)
Rating: L

Reliability
Score: 67
Rating: L

Reference	**Kumar et al. 2007**	***C. punctatus***
Parameter	**Value**	**Comment**
Test method cited	None cited	
Phylum	Chordata	
Class	Actinopterygii	
Order	Perciformes	
Family	Channidae	
Genus	*Channa*	
Species	*punctatus*	
Family in North America?	Not native, but is an invasive species	
Age/size at start of test/growth phase	Teleosts, 11-13 cm, 23 ± 2 g	
Source of organisms	Local fish market in India	
Have organisms been exposed to contaminants?	Possibly	
Animals acclimated and disease-free?	Yes, 2 week acclimation	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	96 h	
Data for multiple times?	No	
Effect 1	Mortality	
Control response 1	0%	
Temperature	27 ± 1°C	
Test type	SR, 24 h renewal	
Photoperiod/light intensity	NR	
Dilution water	Dechlorinated tap water	
pH	6.8 ± 2°C	
Hardness	113.3 ± 2 mg/L	
Alkalinity	NR	
Conductivity	NR	
Dissolved Oxygen	6.9 ± 0.4 mg/L	
Feeding	None	

Reference	**Kumar et al. 2007**	***C. punctatus***
Parameter	**Value**	**Comment**
Purity of test substance	5%	
Concentrations measured?	No	
Measured is what % of nominal?	NR	
Chemical method documented?	NR	
Concentration of carrier (if any) in test solutions	NR, acetone	
Concentration 1 Nom/Meas (µg/L)	2.5	1 rep, 12 org/rep
Concentration 2 Nom/Meas (µg/L)	5	1 rep, 12 org/rep
Concentration 3 Nom/Meas (µg/L)	7.5	1 rep, 12 org/rep
Concentration 4 Nom/Meas (µg/L)	10	1 rep, 12 org/rep
Concentration 5 Nom/Meas (µg/L)	12.5	1 rep, 12 org/rep
Concentration 6 Nom/Meas (µg/L)	15	1 rep, 12 org/rep
Control	Solvent	1 rep, 12 org/rep
LC_{50} (95% confidence interval) (µg/L)	7.92	Method: Karber arithmetic method

Notes:

LC_{50} calculated based on nominal concentrations.
The three highest concentrations tested are $\geq$ 2x the water solubility of lambda-cyhalothrin.
Behavioral effects were also observed.

Reliability points taken off for:
Documentation: Analytical method (4), Measured concentrations (3), Alkalinity (2), Conductivity (2), Photoperiod (3), Hypothesis tests (8).
Acceptability: Standard method (5), Chemical purity (10), Measured concentrations w/in 20% of nominal (4), Concentrations exceed 2x solubility (4), Carrier solvent concentration (4), Prior contamination of organism (4), Organisms randomized (1), Alkalinity (2), Conductivity (1), Photoperiod (2), Random design (2), Adequate replication (2), Hypothesis tests (3).

Toxicity Data Summary

Channa punctatus

Study: Kumar A, Sharma B, Pandey RS. 2008. Cypermethrin and l-cyhalothrin induced alterations in nucleic acids and protein contents in a freshwater fish, *Channa punctatus*. Fish Physiol Biochem, 34:331-338.

Relevance	Reliability
Score: 45*	Score: not rated
Rating: N	Rating:

*No standard method, Endpoint not linked to survival/growth/reproduction, Low chemical purity, No calculable toxicity values.

Toxicity Data Summary

Channa punctatus (Bloch)

Study: Kumar A, Rai DK, Sharma B, Pandey RS. 2009. λ-cyhalothrin and cypermethrin induced *in vivo* alterations in the activity of acetylcholinesterase in a freshwater fish, *Channa punctatus* (Bloch). Pesticide Biochemistry and Physiology, 93:96-99.

Relevance	Reliability
Score: N	Score: not rated
Rating: 45*	Rating:

*No standard method, Endpoint not linked to survival/growth/reproduction, Low chemical purity, No calculable toxicity values.

Toxicity Data Summary

Chaoborus sp.

Study: Hamer MJ, Ashwell JA, Gentle WE. 1998. Lambda-cyhalothrin Acute Toxicity to Aquatic Arthropods. ZENECA Agrochemicals, Jealott's Hill Research Station Bracknell, Berkshire, UK. DPR study number 50907-093.

Relevance
Score: 100
Rating: R

Reliability
Score: 81.5
Rating: R

Reference	**Hamer et al. 1998**	***Chaoborus* sp.**
Parameter	**Value**	**Comment**
Test method cited	USEPA, OECD	
Phylum	Arthropoda	
Class	Insecta	
Order	Diptera	
Family	Chaoboridae	
Genus	*Chaoborus*	
Species	NR	
Family in North America?	Yes	
Age/size at start of test/growth phase	NR	
Source of organisms	Experimental ponds at research station	
Have organisms been exposed to contaminants?	Maybe	
Animals acclimated and disease-free?	NR	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	48 h	
Data for multiple times?	No	
Effect 1	Immobility	
Control response 1	0%	
Effect 2	Mortality	
Control response 2	0%	
Temperature	20 ± 2°C	
Test type	Static	
Photoperiod/light intensity	16 L:8 D, 700-1000 lux	
Dilution water	Mixture of dechlorinated and RO filtered tap water	
pH	7.4-8.4	
Hardness	179 mg/L	
Alkalinity	150 mg/L	

Reference	**Hamer et al. 1998**	***Chaoborus* sp.**
Parameter	**Value**	**Comment**
Conductivity	NR	
Dissolved Oxygen	8.0-8.8 mg/L	
Feeding	None during test	
Purity of test substance	≥ 88% radiochemical purity	
Concentrations measured?	Yes	
Measured is what % of nominal?	t_0: 100-113%; 48 h: 52-63%	
Chemical method documented?	Yes, LSC	
Concentration of carrier (if any) in test solutions	0.05%	
Concentration 1 Nom/Meas t_0/48 h (µg/L)	0.49/<10/<10	1 rep, 10 orgs/rep
Concentration 2 Nom/Meas t_0/48 h (ng/L)	1.0/<10/<10	1 rep, 10 orgs/rep
Concentration 3 Nom/Meas t_0/48 h (ng/L)	2.0/<10/<10	1 rep, 10 orgs/rep
Concentration 4 Nom/Meas t_0/48 h (ng/L)	3.9/<10/<10	1 rep, 10 orgs/rep
Concentration 5 Nom/Meas t_0/48 h (ng/L)	7.8/<10/<10	1 rep, 10 orgs/rep
Concentration 6 Nom/Meas t_0/48 h (ng/L)	16/16/<10	1 rep, 10 orgs/rep
Concentration 7 Nom/Meas t_0/48 h (ng/L)	31/35/16	1 rep, 10 orgs/rep
Concentration 8 Nom/Meas t_0/48 h (ng/L)	62/70/39	1 rep, 10 orgs/rep
Control (ng/L)	Dil. water and solvent: <10	1 rep, 10 orgs/rep
EC_{50} (95% confidence interval)	2.8 (1.8-4.1) ng/L	Method: Iteratively re-weighted linear regression

Notes:

EC_{50} calculated based on nominal concentrations.

Reliability points taken off for:
Documentation: Organism age (5), Conductivity (2), Hypothesis tests (8)
Acceptability: No standard method (5), Measured concentrations w/in 20% of nominal (4), Appropriate organism age (3), No prior contamination exposure (4), Organisms randomized (1), Acclimation (1), Exposure type (2), Temperature variance (3), Conductivity (1), Random design (2), Appropriate statistical method (2), Hypothesis tests (3).

Toxicity Data Summary

Cloeon dipterum

Study: Hamer MJ, Ashwell JA, Gentle WE. 1998. Lambda-cyhalothrin Acute Toxicity to Aquatic Arthropods. ZENECA Agrochemicals, Jealott's Hill Research Station Bracknell, Berkshire, UK. DPR study number 50907-093.

Relevance
Score: 100
Rating: R

Reliability
Score: 81.5
Rating: R

Reference	**Hamer et al. 1998**	***C. dipterum***
Parameter	**Value**	**Comment**
Test method cited	USEPA, OECD	
Phylum	Arthropoda	
Class	Insecta	
Order	Ephemeroptera	
Family	Baetidae	
Genus	*Cloeon*	
Species	*dipterum*	
Family in North America?	Yes	
Age/size at start of test/growth phase	NR	
Source of organisms	Experimental ponds at research stations	
Have organisms been exposed to contaminants?	Maybe	
Animals acclimated and disease-free?	NR	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	48 h	
Data for multiple times?	No	
Effect 1	Immobility	
Control response 1	0%	
Effect 2	Mortality	
Control response 2	0%	
Temperature	20 ± 2°C	
Test type	Static	
Photoperiod/light intensity	16 L:8 D, 700-1000 lux	
Dilution water	Mixture of dechlorinated and RO filtered tap water	
pH	8.2-8.7	
Hardness	179 mg/L	
Alkalinity	150 mg/L	

Reference	**Hamer et al. 1998**	***C. dipterum***
Parameter	**Value**	**Comment**
Conductivity	NR	
Dissolved Oxygen	8.6-9.0 mg/L	
Feeding	None during test	
Purity of test substance	≥ 88% radiochemical purity	
Concentrations measured?	Yes	
Measured is what % of nominal?	t_0: 94-116%; 48 h: 45-47%	
Chemical method documented?	Yes, LSC	
Concentration of carrier (if any) in test solutions	0.05%	
Concentration 1 Nom/Meas t_0/48 h (µg/L)	0.49/<10/<10	1 rep, 10 orgs/rep
Concentration 2 Nom/Meas t_0/48 h (ng/L)	1.0/<10/<10	1 rep, 10 orgs/rep
Concentration 3 Nom/Meas t_0/48 h (ng/L)	2.0/10/<10	1 rep, 10 orgs/rep
Concentration 4 Nom/Meas t_0/48 h (ng/L)	3.9/<10/<10	1 rep, 10 orgs/rep
Concentration 5 Nom/Meas t_0/48 h (ng/L)	7.8/<10/<10	1 rep, 10 orgs/rep
Concentration 6 Nom/Meas t_0/48 h (ng/L)	16/16/<10	1 rep, 10 orgs/rep
Concentration 7 Nom/Meas t_0/48 h (ng/L)	31/29/14	1 rep, 10 orgs/rep
Concentration 8 Nom/Meas t_0/48 h (ng/L)	62/72/29	1 rep, 10 orgs/rep
Control (ng/L)	Dil. water and solvent: <10	1 rep, 10 orgs/rep
EC_{50} (95% confidence interval)	38 (23-93) ng/L	Method: Iteratively re-weighted linear regression

Notes:
LC_{50} values not calculated.
EC_{50} calculated based on nominal concentrations.

Reliability points taken off for:
Documentation: Organism age (5), Conductivity (2), Hypothesis tests (8)
Acceptability: No standard method (5), Measured concentrations w/in 20% of nominal (4), Appropriate organism age (3), Organisms randomized (1), Prior contamination (4), Acclimation (1), Exposure type (2), Temperature variance (3), Conductivity (1), Random design (2), Appropriate statistical method (2), Hypothesis tests (3).

Toxicity Data Summary

Corixa sp.

Study: Hamer MJ, Ashwell JA, Gentle WE. 1998. Lambda-cyhalothrin Acute Toxicity to Aquatic Arthropods. ZENECA Agrochemicals, Jealott's Hill Research Station Bracknell, Berkshire, UK. DPR study number 50907-093.

Relevance
Score: 100
Rating: R

Reliability
Score: 81.5
Rating: R

Reference	**Hamer et al. 1998**	***Corixa* sp.**
Parameter	**Value**	**Comment**
Test method cited	USEPA, OECD	
Phylum	Arthropoda	
Class	Insecta	
Order	Hemiptera	
Family	Corixidae	
Genus	*Corixa*	
Species	NR	
Family in North America?	Yes	
Age/size at start of test/growth phase	NR	
Source of organisms	Experimental ponds at research station	
Have organisms been exposed to contaminants?	Maybe	
Animals acclimated and disease-free?	NR	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	48 h	
Data for multiple times?	No	
Effect 1	Immobility	
Control response 1	Solvent: 10%	
Effect 2	Mortality	
Control response 2	Solvent: 10%	
Temperature	20 ± 2°C	
Test type	Static	
Photoperiod/light intensity	16 L:8 D, 700-1000 lux	
Dilution water	Mixture of dechlorinated and RO filtered tap water	
pH	8.4-8.6	
Hardness	179 mg/L	
Alkalinity	150 m6g/L	

Reference	**Hamer et al. 1998**	***Corixa* sp.**
Parameter	**Value**	**Comment**
Conductivity	NR	
Dissolved Oxygen	8.4-9.1 mg/L	
Feeding	None during test	
Purity of test substance	≥ 88% radiochemical purity	
Concentrations measured?	Yes	
Measured is what % of nominal?	t_0: 114-125%; 48 h: 50-75%	
Chemical method documented?	Yes, LSC	
Concentration of carrier (if any) in test solutions	0.05%	
Concentration 1 Nom/Meas t_0/48 h (µg/L)	16/20/12	1 rep, 10 orgs/rep
Concentration 2 Nom/Meas t_0/48 h (ng/L)	31/37/20	1 rep, 10 orgs/rep
Concentration 3 Nom/Meas t_0/48 h (ng/L)	62/74/31	1 rep, 10 orgs/rep
Concentration 4 Nom/Meas t_0/48 h (ng/L)	125/143/67	1 rep, 10 orgs/rep
Control (ng/L)	Dil. water and solvent: <10	1 rep, 10 orgs/rep
EC_{50} (95% confidence interval)	30 (21-42) ng/L	Method: Iteratively re-weighted linear regression

Notes:
LC_{50} values not calculated.
EC_{50} calculated based on nominal concentrations.

Reliability points taken off for:
Documentation: Organism age (5), Conductivity (2), Hypothesis tests (8)
Acceptability: No standard method (5), Measured concentrations w/in 20% of nominal (4), Appropriate organism age (3), Organisms randomized (1), Acclimation (1), Prior contaminant exposure (4), Exposure type (2), Temperature variance (3), Conductivity (1), Random design (2), Appropriate statistical method (2), Hypothesis tests (3).

Toxicity Data Summary

Crassostrea gigas

Study: Thompson RS. 1985a. PP321: Determination of the acute toxicity to larvae of the Pacific oyster (*Crassostrea gigas*). ICI Agrochemicals. DPR study 50907-087.

Relevance
Score: n/a
Rating: N → because all concentrations tested were > 2x solubility

Toxicity Data Summary

Culex quinquefasciatus

Study: Halliday WR Georghiou GP. 1985. Cross-resistance and dominance relationships of pyrethroids in a permethrin-selected strain of Culex quinquefasciatus (Diptera: Culicidae). Journal of Economic Entomology 78: 127-1232.

Relevance	Reliability
Score: 82.5 (No std method, Control not described)	Score: 47
Rating: L	Rating: N

Reference	**Halliday & Georghiou 1985**	***C. quinquefasciatus***
Parameter	**Value**	**Comment**
Test method cited	Ref Georghiou 1966	
Phylum	Arthropoda	
Class	Insecta	
Order	Diptera	
Family	Culicidae	
Genus	*Culex*	
Species	*quinquefasciatus*	
Family in North America?	Yes	
Age/size at start of test/growth phase	4th instar	
Source of organisms	Lab culture	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	24 h	
Data for multiple times?	No	
Effect 1	Mortality	Susceptible and resistant strains tested
Control response 1	< or = 15%	
Temperature	NR	
Test type	static	
Photoperiod/light intensity	NR	
Dilution water	tap	
pH	NR	
Hardness	NR	
Alkalinity	NR	

Reference	**Halliday & Georghiou 1985**	***C. quinquefasciatus***
Parameter	**Value**	**Comment**
Conductivity	NR	
Dissolved Oxygen	NR	
Feeding	NR	
Purity of test substance	'Technical' no%	
Concentrations measured?	NR	
Measured is what % of nominal?	NR	
Chemical method documented?	NR	
Concentration of carrier (if any) in test solutions	10 mL/L	
Concentration 1 Nom/Meas (μg/L)	4 levels, but concentrations not reported	4 reps and 20 organisms per rep
Control	yes	
LC50; indicate calculation method	0.73 ug/L - susceptible 220 ug/L - resistant	probit

Reliability points taken off for:
Documentation: Control Type (8), Analytical method (4), Nominal concentrations (3), Measured concentrations (3), Hardness (2), Alkalinity (2), Dissolved Oxygen (4), Temperature (4), Conductivity (2), pH (3), Photoperiod (3) Hypothesis tests (8)

Acceptability: Standard method (5), Control appropriate type (6), Meas. Concentrations 20% Nom (4), Concentrations do not exceed 2x water solubility (4), Carrier solvent ≤ 0.5 mL/L (4), Appropriate age/ size (3), Organisms randomly assigned to containers (1), Dilution water (2), Hardness (2), Alkalinity (2), Dissolved Oxygen (6), Temperature (6), Conductivity (1), pH (2), Photoperiod (2), Adequate number of concentrations (3), Appropriate spacing between concentrations (2), Random / block design (2), Hypothesis tests (3)

Toxicity Data Summary

Cyclops sp.

Study: Hamer MJ, Ashwell JA, Gentle WE. 1998. Lambda-cyhalothrin Acute Toxicity to Aquatic Arthropods. ZENECA Agrochemicals, Jealott's Hill Research Station Bracknell, Berkshire, UK. DPR study number 50907-093.

Relevance
Score: 100
Rating: R

Reliability
Score: 81.5
Rating: R

Reference	**Hamer et al. 1998**	***Cyclops* sp.**
Parameter	**Value**	**Comment**
Test method cited	USEPA, OECD	
Phylum	Arthropoda	
Class	Maxillopoda	
Order	Cyclopoida	
Family	Cyclopidae	
Genus	*Cyclops*	
Species	NR	
Family in North America?	Yes	
Age/size at start of test/growth phase	NR	
Source of organisms	Experimental ponds at research station	
Have organisms been exposed to contaminants?	Maybe	
Animals acclimated and disease-free?	NR	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	48 h	
Data for multiple times?	No	
Effect 1	Immobility	
Control response 1	Dil Water: 0% Solvent: 20%	
Effect 2	Mortality	
Control response 2	Dil Water: 0% Solvent: 20%	
Temperature	20 ± 2°C	
Test type	Static	
Photoperiod/light intensity	16 L:8 D, 700-1000 lux	
Dilution water	Mixture of dechlorinated and RO filtered tap water	
pH	8.1-8.7	

Reference	**Hamer et al. 1998**	***Cyclops* sp.**
Parameter	**Value**	**Comment**
Hardness	179 mg/L	
Alkalinity	150 mg/L	
Conductivity	NR	
Dissolved Oxygen	7.9-8.9 mg/L	
Feeding	None during test	
Purity of test substance	$\geq$ 88% radiochemical purity	
Concentrations measured?	Yes	
Measured is what % of nominal?	t_0: 83-109%; 48 h: 35-53%	
Chemical method documented?	Yes, LSC	
Concentration of carrier (if any) in test solutions	0.05%	
Concentration 1 Nom/Meas t_0/48 h (µg/L)	62/65/29	1 rep, 10 orgs/rep
Concentration 2 Nom/Meas t_0/48 h (ng/L)	125/117/57	1 rep, 10 orgs/rep
Concentration 3 Nom/Meas t_0/48 h (ng/L)	250/207/88	1 rep, 10 orgs/rep
Concentration 4 Nom/Meas t_0/48 h (ng/L)	500/485/266	1 rep, 10 orgs/rep
Concentration 5 Nom/Meas t_0/48 h (ng/L)	1000/1031/419	1 rep, 10 orgs/rep
Concentration 6 Nom/Meas t_0/48 h (ng/L)	2000/2184/726	1 rep, 10 orgs/rep
Control (ng/L)	Dil. water and solvent: <10	1 rep, 10 orgs/rep
EC_{50} (95% confidence interval)	300 (200-460) ng/L	Method: Iteratively re-weighted linear regression

Notes:
LC_{50} values not calculated.
EC_{50} calculated based on nominal concentrations.

Reliability points taken off for:
Documentation: Organism age (5), Conductivity (2), Hypothesis tests (8)
Acceptability: No standard method (5), Measured concentrations w/in 20% of nominal (4), Appropriate organism age (3), Organisms randomized (1), Acclimation (1), Prior contaminant exposure (4), Exposure type (2), Temperature variance (3), Conductivity (1), Random design (2), Appropriate statistical method (2), Hypothesis tests (3).

Toxicity Data Summary

Cyprinodon variegatus

Study: Hill RW. 1985. PP321: Determination of acute toxicity to sheepshead minnow (*Cyprinodon variegatus*). ICI Agrochemicals. DPR Study 50907-085.

Relevance
Score: 85 (saltwater)
Rating: L

Reliability
Score: 77
Rating: R

Reference	**Hill 1985**	***C. variegatus***
Parameter	**Value**	**Comment**
Test method cited	USEPA 1982	
Phylum	Chordata	
Class	Actinopterygii	
Order	Cyprinodontiformes	
Family	Cyprinodontidae	
Genus	*Cyprinodon*	
Species	*variegatus*	
Family in North America?	Yes	
Age/size at start of test/growth phase	0.60 g, 27.4 mm	
Source of organisms	Commercial lab	Sea Plantations, Inc. Salem MA
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	96 h	
Data for multiple times?	Yes; 24, 48, 72 h	
Effect 1	Mortality	
Control response 1	0%	
Temperature	17 ± 1°C	
Test type	Flow-through	
Photoperiod/light intensity	NR	
Dilution water	Seawater from Torbay, Devon, UK	
pH	8.0-8.1	
Hardness	NR	
Alkalinity	NR	
Salinity	34.97 o/oo	
Dissolved Oxygen	6.2-6.8 mg/L, >82% sat	
Feeding	NR	

Reference	**Hill 1985**	***C. variegatus***
Parameter	**Value**	**Comment**
Purity of test substance	96.5%	
Concentrations measured?	Yes	
Measured is what % of nominal?	51.8-75%	
Chemical method documented?	Yes, GC-ECD	
Concentration of carrier (if any) in test solutions	16 mg/L acetone	
Concentration 1 Nom/Meas (µg/L)	0.56/0.29	1 rep, 20 org/rep
Concentration 2 Nom/Meas (µg/L)	1.0/0.55	1 rep, 20 org/rep
Concentration 3 Nom/Meas (µg/L)	1.8/1.35	1 rep, 20 org/rep
Concentration 4 Nom/Meas (µg/L)	2.4/1.72	1 rep, 20 org/rep
Concentration 5 Nom/Meas (µg/L)	3.2/2.37	1 rep, 20 org/rep
Control	Solvent and dilution water	1 rep, 20 org/rep
LC_{50} (95% confidence interval) (µg/L)	24 h: 1.34 48 h: 1.14 72 h: 0.85 96 h: 0.81	Method: Probit

Notes:

LC_{50} calculated based on mean measured concentrations.

Reliability points taken off for:
Documentation: Hardness (2), Alkalinity (2), Conductivity (2), Photoperiod (3), Hypothesis tests (8).
Acceptability: Carrier solvent (4), Organisms randomized (1), Feeding (3), Acceptable dilution water (2), Hardness (2), Alkalinity (2), Conductivity (1), Photoperiod (2), Random design (2), Adequate replication (2), Hypothesis tests (3).

Toxicity Data Summary

Cyprinodon variegatus

Study: Hill RW, Caunter JE, Cumming RI. 1985. PP321: Determination of the chronic toxicity to sheepshead minnow (*Cyprinodon variegatus*) embryos and larvae. DPR study number 50907-088.

Relevance
Score: 75 (No standard method, saltwater)
Rating: L

Reliability
Score: 81
Rating: R

Reference	**Hill et al. 1985**	***C. variegatus***
Parameter	**Value**	**Comment**
Test method cited	None cited	
Phylum	Chordata	
Class	Actinopterygii	
Order	Cyprinodontiformes	
Family	Cyprinodontidae	
Genus	*Cyprinodon*	
Species	*variegatus*	
Family in North America?	Yes	
Age/size at start of test/growth phase	Embryos and larvae (just hatched – 28 d posthatch)	
Source of organisms	Lab stock culture	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	Yes	
Test vessels randomized?	Yes	
Test duration	28 d	
Data for multiple times?	No	
Effect 1	Embryo % hatch	
Control response 1	Solvent cont: 91.6% Dil water:88.6%	
Effect 2	Length at 28 d post-hatch	
Control response 2	Solvent cont: 18.4 mm Dil water: 18.4 mm	
Effect 3	Weight at 28 d post-hatch	
Control response 3	Solvent cont: 181.7 mg Dil water: 172 mg	
Effect 4	28 d Survival (from initial embryos)	
Control response 4	Solvent: 83.1% Dil water: 85.3%	

Reference	**Hill et al. 1985**	***C. variegatus***
Parameter	**Value**	**Comment**
Effect 5	28 d Survival (from hatched embryos only)	
Control response 5	Solvent: 90.8% Dil water: 96.5%	
Temperature	25.1 ± 1°C	
Test type	Flow-through	
Photoperiod/light intensity	12 L: 12 D, 2800-3300 lux	
Dilution water	Filtered seawater mixed with freshwater	
pH	8.2-8.3	
Hardness	NR	
Alkalinity	NR	
Salinity	23.5-26.7 o/oo	
Dissolved Oxygen	6.0-7.6 mg/L	
Feeding	2-3x daily	
Purity of test substance	96.6%	
Concentrations measured?	Yes	
Measured is what % of nominal?	Mean: 41%	Range: 36-46.9%
Chemical method documented?	Yes, GC	
Concentration of carrier (if any) in test solutions	NR	
Concentration 1 Nom/Meas (µg/L)	1.0/0.38	2 reps, 30 orgs/rep
Concentration 2 Nom/Meas (µg/L)	0.56/0.25	2 reps, 30 orgs/rep
Concentration 3 Nom/Meas (µg/L)	0.32/0.14	2 reps, 30 orgs/rep
Concentration 4 Nom/Meas (µg/L)	0.18/0.07	2 reps, 30 orgs/rep
Concentration 5 Nom/Meas (µg/L)	0.010/0.04	2 reps, 30 orgs/rep
Control	Solvent and Dil. water	2 reps, 30 orgs/rep
NOEC (µg/L)	Weight: 0.25	Method: 1 way ANOVA and Dunnett's test p: 0.05 (and 0.01) MSD: NR
LOEC (µg/L)	Weight: 0.38	Same as above
MATC (GeoMean NOEC,LOEC)	Weight: 0.31 µg/L	
% control at NOEC	Weight: 99.0%	Solvent control used in calculation
% of control LOEC	Weight: 86.8%	Solvent control used in calculation

Notes:

Weight was the only endpoint that was significantly affected at any concentration and the NOEC/LOEC were calculated based on weight data only.

NOEC/LOEC calculated based on measured concentrations.

Reliability points taken off for:
Documentation: Hardness (2), Alkalinity (2), Conductivity (2), Hypothesis tests (4), Point estimates (8)
Acceptability: Standard method (5), Measured concentrations w/in 20% of nominal (4), Carrier solvent % (4), Hardness (2), Alkalinity (2), Conductivity (1), Adequate replication (2), Minimum significant difference (1), Point estimates (3).

Toxicity Data Summary

Danio rerio

Study: Xu C, Wang J, Liu W, Sheng GD, Tu Y, Ma Y. 2008. Separation and aquatic toxicity of enantiomers of the pyrethroid insecticide lambda-cyhalothrin. Environmental Toxicology and Chemistry, 27: 174-181.

Relevance	Reliability
Score: Fish – 85 (No control info)	Score: Fish - 56
Rating: Fish – L	Rating: Fish - N
Eggs – N (all concentrations tested > 2x water solubility)	

Toxicity Data Summary

Daphnia magna

Study: Barata C, Baird DJ, Nogueira AJA, Soares AMVM, Riva MC. 2006. Toxicity of binary mixtures of metals and pyrethroid insecticides to *Daphnia magna* Straus. Implications for multi-substance risks assessment. Aquatic Toxicology 78: 1-14.

Relevance
Score: A: 100, C: 60
Rating: A: R, C: N

Reliability
Score: A: 78.5
Rating: A: R

C: No std method, Endpoint, Toxicity value

Reference	**Barata et al. 2006**	***D. magna***
Parameter	**Value**	**Comment**
Test method cited	A: OECD, C: None	
Phylum	Arthropoda	
Class	Branchiopoda	
Order	Cladocera	
Family	Daphniidae	
Genus	*Daphnia*	
Species	*magna*	
Family in North America?	Yes	
Age/size at start of test/growth phase	4^{th} instar juveniles	
Source of organisms	Lab culture	
Have organisms been exposed to contaminants?	Probably not	
Animals acclimated and disease-free?	Yes	
Animals randomized?	A: NR, C: Yes	
Test vessels randomized?	NR	
Test duration	A: 48 h, C: 24 h	
Data for multiple times?	No	
Effect 1	A: Immobility	
Control response 1	100% survival	
Effect 2	C: Feeding rate	
Control response 2	Dil. $5.25 \pm 0.38 \times 10^5$ cells/ind/h	Sol: $5.27 \pm 0.54 \times 10^5$ cells/ind/h
Temperature	NR	
Test type	Static	
Photoperiod/light intensity	A: NR, C: 24h dark	
Dilution water	ASTM hard synthetic water	
pH	8.3 ± 0.2	
Hardness	NR	
Alkalinity	NR	

Reference	**Barata et al. 2006**	***D. magna***
Parameter	**Value**	**Comment**
Conductivity	NR	
Dissolved Oxygen	≥ 91%	
Feeding	A: None during test, C: yes	
Purity of test substance	99%	
Concentrations measured?	Yes	
Measured is what % of nominal?	Mean 85.5% (Table 2)	
Chemical method documented?	Ref. McWilliam & Baird 2002	
Concentration of carrier (if any) in test solutions	<0.5% acetone	
Concentration 1 Nom (nmol/L)	A: 0.15 (Fig 2)	A: 3 x 10/conc C: 5 x 5/conc
Concentration 2 Nom (nmol /L)	A: 0.25 (Fig 2)	A: 3 x 10/conc C: 5 x 5/conc
Concentration 3 Nom (nmol /L) Meas	A: 0.56 0 h: 0.43 (0.09), 48 h: 0.23 (0.06)	A: 3 x 10/conc C: 5 x 5/conc
Concentration 4 Nom (nmol /L)	A: 0.8 (Fig 2)	A: 3 x 10/conc C: 5 x 5/conc
Concentration 5 Nom (nmol /L) Meas	A: 1 (Fig 2)	A: 3 x 10/conc C: 5 x 5/conc
Concentration 6 Nom (nmol /L) Meas	A: 1.33 0h: 1.03 (0.11), 48 h: 0.52 (0.08)	A: 3 x 10/conc C: 5 x 5/conc
Concentration 7 Nom (nmol /L) Meas	A: 2.22 0 h: 1.73 (0.18), 48 h: 0.83 (0.13)	A: 3 x 10/conc C: 5 x 5/conc
Control	Solvent control	A: 3 x 10/conc C: 5 x 5/conc
EC50; indicate calculation method	A: 0.87 (0.86-0.88) nmol/L 0.39 ug/L C: 0.22 (0.21-0.23) nmol/L 0.10 ug/L	A: linear regression, $p<0.05$, calc. w/ meas conc. C: $p<0.05$

Reliability points taken off for:
Acute Documentation: Hardness (2), Alkalinity (2), Temperature (4), Conductivity (2), Photoperiod (3), Hypothesis tests (8)

Acute Acceptability: Meas. Concentrations 20% Nom (4), Organisms randomly assigned (1), Hardness (2), Alkalinity (2), Temperature (6), Conductivity (1), Photoperiod (2), Test vessels randomized (2), Hypothesis tests (3)

Toxicity Data Summary

Daphnia magna

Study: Barata C, Baird DJ, Nogueira AJA, Soares AMVM, Riva MC. 2007. Life-history responses of *Daphnia magna* Straus to binary mixtures of toxic substances: Pharmacological versus ecotoxicological modes of action. Aquatic Toxicology 84: 439-449.

Relevance
Score: 90 (No std method)
Rating: R

Reliability
Score: 80
Rating: R

Reference	**Barata et al. 2007**	***D. magna***
Parameter	**Value**	**Comment**
Test method cited	None	
Phylum	Arthropoda	
Class	Branchiopoda	
Order	Cladocera	
Family	Daphniidae	
Genus	*Daphnia*	
Species	*magna*	
Family in North America?	Yes	
Age/size at start of test/growth phase	**Egg production:** < 24 h neonates, exposed until 8-9 d old, when egg production of 2nd and 3rd clutches began (1st clutch not measured because they were not exposed for entire lifetime) **Feeding:** female adults (after 2nd brood, to avoid molting)	
Source of organisms	Lab culture	
Have organisms been exposed to contaminants?	Probably not	
Animals acclimated and disease-free?	Yes	
Animals randomized?	Yes	
Test vessels randomized?	NR	
Test duration	Egg production: 6 d Feeding: 24 h	
Data for multiple times?	no	
Effect 1	Egg production	
Control response 1	Exp 1: 52.2 ± 2.6 eggs/female Exp 2: 37.1 ± 7.7 eggs/female	
Effect 2	Feeding rate	
Control response 2	Exp 1: $10.27 \pm 0.11 \times 10^5$ cells/ind/h	

Reference	**Barata et al. 2007**	***D. magna***
Parameter	**Value**	**Comment**
	Exp 2: 8.67 ± 1.28 x 10^5 cells/ind/h	
Temperature	20 ± 1°C	
Test type	NR, probably Static	
Photoperiod/light intensity	14 L: 10 D	
Dilution water	ASTM hard synthetic water	
pH	8.3 ± 0.2	
Hardness	NR	
Alkalinity	NR	
Conductivity	NR	
Dissolved Oxygen	≥ 91%	
Feeding	Yes with algae (*C. vulgaris*)	
Purity of test substance	99%	
Concentrations measured?	Yes – only 3 highest	
Measured is what % of nominal?	~60%	
Chemical method documented?	Yes, HPLC	
Concentration of carrier (if any) in test solutions	< 0.05% acetone	
Concentration 1 Nom (nmol/L)	0.1	
Concentration 2 Nom/t_0 Meas/24 h Meas (nmol/L)	0.31/0.22 ± 0.04/0.16 ± 0.07	
Concentration 3 Nom/t_0 Meas/24 h Meas (nmol/L)	0.56/0.39 ± 0.07/0.28 ± 0.07	
Concentration 4 Nom/t_0 Meas/24 h Meas (nmol/L)	0.9/0.62 ± 0.07/0.46 ± 0.09	
Control	Solvent control	
EC_{50} (95% confidence interval)	Feeding: 0.27 (0.15-0.39) nmol/L 0.12 ug/L Egg production: 0.43 (0.39-0.47) nmol/L 0.2 ug/L	Method: nonlinear allosteric decay regression and least squares

Point estimates calculated with measured concentrations.
Chronic EC50 values do not appear in data tables because they could not be incorporated into criteria derivation.

Reliability points taken off for:
Documentation: Exposure type (5), Hardness (2), Alkalinity (2), Conductivity (2), Hypothesis tests (8)
Acceptability: Acceptable standard (5), Measured concentrations w/in 20% of nominals (4), Adequate #/rep (2), Exposure type (2), Conductivity (1), Test vessels randomized (2), Statistical method (2), Hypothesis tests (3).

Toxicity Data Summary

Daphnia magna

Study: Farrelly E, Hamer MJ. 1989. PP321: *Daphnia magna* life-cycle study using a flow-through system. ICI Agrochemicals. MRID 41217501.

Relevance
Score: 100
Rating: R

Reliability
Score: 90.5
Rating: R

Reference	**Farrelly & Hamer 1989**	***D. magna***
Parameter	**Value**	**Comment**
Test method cited	USEPA 1986	EPA 540/9-86-141
Phylum	Arthropoda	
Class	Branchiopoda	
Order	Cladocera	
Family	Daphniidae	
Genus	*Daphnia*	
Species	*magna*	
Family in North America?	Yes	
Age/size at start of test/growth phase	Adults < 24 hr old	
Source of organisms	Lab culture	Jealott's Hill facility
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	NR	
Test vessels randomized?	Yes	
Test duration	21 d	
Data for multiple times?	Yes	3, 7, 14, 21 d
Effect 1	Survival	
Control response 1	3, 7, 14 d: 100% survival 21 d: 80% (solvent), 60% (Dil water)	
Effect 2	Growth (length)	
Control response 2	3.48 mm (solvent), 3.51 mm (Dil water)	
Effect 3	Reproduction	Total young produced & # of young/female/day
Control response 3	Total Young: 67.7 (solvent), 78.9 (Dil water) Young/female/d: 5.5 (solvent), 6.1 (Dil water)	

Reference	**Farrelly & Hamer 1989**	***D. magna***
Parameter	**Value**	**Comment**
Temperature	20 ± 2°C	
Test type	FT	
Photoperiod/light intensity	16L:8d, 1200 lux	
Dilution water	Hard reconstituted water	Salts added to DI water
pH	8.1-8.2	Meas. at 0, 7, 14, 21 d
Hardness	165-175 mg/L	
Alkalinity	115-125 mg/L	
Conductivity	555-590 uS/cm	
Dissolved Oxygen	> 89% sat (> 8.2 mg/L)	Meas. at 0, 7, 14, 21 d
Feeding	Yes, 2x/d	0.25 ml Chlorella vulgaris & 0.25 ml active dried yeast
Purity of test substance	94.3%	
Concentrations measured?	Yes	
Measured is what % of nominal?	48-81%	
Chemical method documented?	Yes; LSC & HPLC	meas 1x/wk
Concentration of carrier (if any) in test solutions	NR %	Triethylene glycol
Concentration 1 Nom/Meas (µg/L)	1.024/0.83	Growth/Repro: 7 reps, 1 org/rep Survival: 3 reps, 5 orgs/rep
Concentration 2 Nom/Meas (ng/L)	2.56/1.98	Same as above
Concentration 3 Nom/Meas (ng/L)	6.4/3.50	Same as above
Concentration 4 Nom/Meas (ng/L)	16/9.37	Same as above
Concentration 5 Nom/Meas (ng/L)	40/19.1	Same as above
Control	Solvent and Dil water	Same as above
LC_{50} (95% CI, if calculable)	3d: 13 ng/L (10-17) 7d: 8.3 ng/L 14d: 6.9 ng/L (5.3-8.9) 21 d: 3.6 ng/L*	Method: Probit
NOEC	**Repro: 1.98 ng/L** Growth: 9.27 ng/L	Method: ANOVA p: 0.05 MSD: NR
LOEC	Repro: 3.5 ng/L	Same as above
MATC (GeoMean NOEC,LOEC)	Repro: 2.63 ng/L	
% control at NOEC	NR	
% of control LOEC	NR	

Notes:

*unacceptable control response at 21 d for survival

- LC_{50} values calculated with measured concentrations
- In the flow-through system, the pumps were not pumping the set uL/d, so the nominal concentrations are not representative.
- Some isomerization was observed by day 21 of the study.

Reliability points taken off for:
Documentation: Hypothesis tests (6)
Acceptability: Measured conc w/in 20% of nominal (4), Carrier solvent (4), Organisms randomized (1), Temperature variance (3), Minimum significant difference (1)

Toxicity Data Summary

Daphnia magna

Study: Farrelly E, Hamer MJ, Hill IR. 1984. PP321: Toxicity to first instar *Daphnia magna*. DPR study number 50907-008. ICI Agrochemicals, Plant Protection Division.

Relevance
Score: 100
Rating: R

Reliability
Score: 86
Rating: R

Reference	**Farrelly et al. 1984**	***D. magna***
Parameter	**Value**	**Comment**
Test method cited	USEPA, OECD, ASTM	
Phylum	Arthropoda	
Class	Branchiopoda	
Order	Cladocera	
Family	Daphniidae	
Genus	*Daphnia*	
Species	*magna*	
Family in North America?	Yes	
Age/size at start of test/growth phase	< 24 h, 1st instar	
Source of organisms	Continuous lab culture at test facility	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	48 h	
Data for multiple times?	Yes; 24 h	
Effect 1	Immobility	
Control response 1	0%	
Temperature	20 ± 1°C	
Test type	Static	
Photoperiod/light intensity	16 L: 8 D	
Dilution water	EPA reconstituted hard water	
pH	8.0-8.6	
Hardness	NR	
Alkalinity	NR	
Conductivity	NR	
Dissolved Oxygen	> 7.6 mg/L, >82% sat	
Feeding	None during test	
Purity of test substance	96.5%	

Reference	**Farrelly et al. 1984**	***D. magna***
Parameter	**Value**	**Comment**
Concentrations measured?	Yes	
Measured is what % of nominal?	51-68%	
Chemical method documented?	Yes, GC-ECD	
Concentration of carrier (if any) in test solutions	0.01% acetone	
Concentration 1 Nom/Meas (μg/L)	32/17.2	2 tests, 3 reps/test, 10 orgs/rep
Concentration 2 Nom/Meas (μg/L)	16/8.4	Same as above
Concentration 3 Nom/Meas (μg/L)	8.0/4.1	Same as above
Concentration 4 Nom/Meas (μg/L)	4.0/2.3	Same as above
Concentration 5 Nom/Meas (μg/L)	2.0/1.03	Same as above
Concentration 6 Nom/Meas (μg/L)	1.0/0.52	Same as above
Concentration 7 Nom/Meas (μg/L)	0.5/0.27	Same as above
Concentration 8 Nom/Meas (μg/L)	0.25/0.17	Same as above
Concentration 9 Nom/Meas (μg/L)	0.125/0.08	Same as above
Concentration 10 Nom/Meas (μg/L)	0.0625/0.04 (Test 2 only)	Same as above
Control	Solvent	Same as above
EC_{50} (95% confidence interval) (μg/L)	24 h: 5.04 48 h: 0.36	Method: Weighted linear regression

Notes:

EC_{50} calculated based on mean measured concentrations.

Reliability points taken off for:
Documentation: Hardness (2), Alkalinity (2), Conductivity (2), Hypothesis tests (8)
Acceptability: Measured concentrations w/in 20% of nominal (4), Concentrations >2x water solubility (4), Organisms randomized (1), Exposure type appropriate (2), Hypothesis tests (3).

Toxicity Data Summary

Daphnia magna

Study: Hamer MJ, Farrelly E, Hill IR. 1985b. PP321: 21 Day *Daphnia magna* life-cycle study. DPR report number 50907-089. ICI Plant Protection Division, Berkshire UK.

Relevance
Score: 90 (No standard method)
Rating: R

Reliability
Score: 84.5
Rating: R

Reference	**Hamer et al. 1985b**	***D. magna***
Parameter	**Value**	**Comment**
Test method cited	None cited	
Phylum	Arthropoda	
Class	Branchiopoda	
Order	Cladocera	
Family	Daphniidae	
Genus	*Daphnia*	
Species	*magna*	
Family in North America?	Yes	
Age/size at start of test/growth phase	< 24 h	
Source of organisms	Lab culture	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	NR at initiation, healthiest-looking chosen at Day 6	
Test vessels randomized?	NR	
Test duration	21 d	
Data for multiple times?	Yes, 9d	
Effect 1	Mortality	
Control response 1	5d: 93%, 6-21 d: 90%	
Effect 2	Length of adults	
Control response 2	9 d: 4.75 mm, 21 d: 4.87 mm	
Effect 3	Total young produced	
Control response 3	3104	
Effect 4	Number of young/female/day	
Control response 4	7.28	
Effect 5	Number of female reproductive days	
Control response 5	426 d	
Temperature	20 ± 1°C	
Test type	Static renewal	renewed every 12 h

Reference	**Hamer et al. 1985b**	***D. magna***
Parameter	**Value**	**Comment**
Photoperiod/light intensity	16 L: 8 D, 800 lux	
Dilution water	Dechlorinated tap water	
pH	7.7-8.4	
Hardness	275 mg/L	
Alkalinity	245 mg/L	
Conductivity	665 μS/cm	
Dissolved Oxygen	> 7.9 mg/L (> 86% sat.)	
Feeding	Twice daily in *new* test solution, *Chlorella* and yeast.	Would have been better to feed right before changing new solution to avoid sorption to food and dietary exposure
Purity of test substance	99.6% radiochemical purity	Determined by TLC
Concentrations measured?	Yes	
Measured is what % of nominal?	2.5 ng/L: t_0: 136%, 12 h: 150% All other conc: t_0: 85-98%, 12 h: 57-67%	
Chemical method documented?	Yes, LSC	TLC and HPLC to measure other aspects
Concentration of carrier (if any) in test solutions	0.005%	
Concentration 1 Nom/t_0 Meas/12 h Meas (ng/L)	2.5/3.75/3.4	2 reps, 0-5 d: 50 org/rep, 6-21 d: 30 females/rep
Concentration 2 Nom/ t_0 Meas/12 h Meas (ng/L)	5/4.9/3.1	2 reps, 0-5 d: 50 org/rep, 6-21 d: 30 females/rep
Concentration 3 Nom/ t_0 Meas/12 h Meas (ng/L)	10/8.5/5.7	2 reps, 0-5 d: 50 org/rep, 6-21 d: 30 females/rep
Concentration 4 Nom/ t_0 Meas/12 h Meas (ng/L)	20/18.3/13.4	2 reps, 0-5 d: 50 org/rep, 6-21 d: 30 females/rep
Concentration 5 Nom/ t_0 Meas/12 h Meas (ng/L)	40/37.2/25	2 reps, 0-5 d: 50 org/rep, 6-21 d: 30 females/rep
Control	Dil. water and Solvent	2 reps, 0-5 d: 50 org/rep, 6-21 d: 30 females/rep
NOEC	Total young: 4.9 ng/L	Method: 1-way

Reference	**Hamer et al. 1985b**	***D. magna***
Parameter	**Value**	**Comment**
	Female repro days: 8.5 ng/L Young/female/d: 3.75 ng/L 9 d length: 18.3 ng/L 21 d length: $\geq$ 18.3 ng/L (not enough surviving to assess at 40 ug/L) 5d mortality: not calculable 6-21 d mortality: not calculable	ANOVA p: 0.05 MSD: NR
LOEC	Total young: 8.5 ng/L Female repro days: 18.3 ng/L Young/female/d: 4.9 ng/L 9 d length: 37.2 ng/L 21 d length: > 18.3 ng/L (not enough surviving to assess at 40 ug/L) 5 d mortality: not calculable 6-21 d mortality: not calculable	Same as above
MATC (GeoMean NOEC,LOEC)	Total young: 6.45 ng/L Female repro days: 12.5 ng/L **Young/female/d**: **4.3 ng/L** 9 d length: 26.1 ng/L 21 d length: not calculable	
% control at NOEC	Total young: 73.7% Female repro days: 97.8% Young/female/d: 85.1% 9 d length: 91.6% 21 d length: 98.3%	
% of control LOEC	Total young: 67.7% Female repro days: 81.9% Young/female/d: 73.5% 9 d length: 86.1% 21 d length: not calculable	

Notes:
- NOEC and LOEC determined from Table 5 based on statistical difference at p = 0.05.
- NOEC, LOEC, and MATC are based on measured concentrations at t_0.
- The NOEC/LOEC were not recorded for mortality at 5 or 21 d because no statistical calculations were done on the raw data.
- Some isomerization and hydrolysis did occur during the test as demonstrated by HPLC and TLC of the solutions.
-After 5 d, the reps were reduced from 50 to 30 organisms by selecting only the healthiest looking females.
- There was no effect on the fertility of offspring transferred to untreated water for 13 d.

Reliability points taken off for:
Documentation: Statistical significance (2), Minimum significant difference (2), Point estimates (8)
Acceptability: Standard method (5), Organisms randomized (1), Appropriate feeding (3), Random design (2), Adequate replication (2), Point estimates (3).

Toxicity Data Summary

Daphnia magna

Study: Machado MW. 2001a. XDE-225 and Lambda-cyhalothrin: Comparative toxicity to Daphnids (*Daphnia magna)* under static-renewal conditions. EPA MRID 45447220. Springborn Laboratories, Inc, Wareham, MA.

Relevance
Score: 100
Rating: R

Reliability
Score: 91.5
Rating: R

Reference	**Machado 2001a**	***D. magna***
Parameter	**Value**	**Comment**
Test method cited	US EPA 1996, OECD	
Phylum	Arthropoda	
Class	Branchiopoda	
Order	Cladocera	
Family	Daphniidae	
Genus	*Daphnia*	
Species	*magna*	
Family in North America?	Yes	
Age/size at start of test/growth phase	$\leq$ 24 hr	
Source of organisms	Lab culture	Springborn labs
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	Yes	
Test vessels randomized?	Yes	
Test duration	48 hr	
Data for multiple times?	Yes, 24 hr	
Effect 1	Immobilization	
Control response 1	0% at all times	
Temperature	21 ± 1°C	
Test type	Static Renewal	Renewed at 24 hr
Photoperiod/light intensity	16 L: 8D, 50-80 footcandles	
Dilution water	Fortified well water	EPA hard water
pH	8.0-8.1	
Hardness	170 mg/L as $CaCO_3$	
Alkalinity	120 mg/L as $CaCO_3$	
Conductivity	500 µmhos/cm	
Dissolved Oxygen	8.4-8.9 mg/L (94-100% sat)	
Feeding	None during test	
Purity of test substance	99%	

Reference	**Machado 2001a**	***D. magna***
Parameter	**Value**	**Comment**
Concentrations measured?	Yes	
Measured is what % of nominal?	39.5-50%	
Chemical method documented?	Yes, GC/NCI-MS	
Concentration of carrier (if any) in test solutions	0.01%	
Concentration 1 Nom/Meas (μg/L)	0.013/0.0055	2 reps, 10 orgs/rep
Concentration 2 Nom/Meas (μg/L)	0.025/0.012	2 reps, 10 orgs/rep
Concentration 3 Nom/Meas (μg/L)	0.050/0.023	2 reps, 10 orgs/rep
Concentration 4 Nom/Meas (μg/L)	0.10/0.050	2 reps, 10 orgs/rep
Concentration 5 Nom/Meas (μg/L)	0.20/0.079	2 reps, 10 orgs/rep
Control	Solvent and dil. water	2 reps, 10 orgs/rep
EC_{50} (95% confidence interval)	24 h: >0.079 μg/L 48 h: 0.051 (0.034-0.10) μg/L	Method: Probit

Notes:

EC_{50} calculated based on measured concentrations.

Reliability points taken off for:
Documentation: Hypothesis tests (8)
Acceptability: Measured concentrations w/in 20% of nominal (4), Adequate replication (2), Hypothesis tests (3)

Toxicity Data Summary

Gammarus pulex

Study: Hamer MJ, Farrelly E, Hill IR. 1985a. PP321: Toxicity to *Gammarus pulex*. ICI Plant Protection Division. DPR study number 50907-086.

Relevance
Score: 100
Rating: R

Reliability
Score: 87.5
Rating: R

Reference	**Hamer et al. 1985a**	***G. pulex***
Parameter	**Value**	**Comment**
Test method cited	ASTM 1980	
Phylum	Arthropoda	
Class	Malacotraca	
Order	Amphipoda	
Family	Gammaridae	
Genus	*Gammarus*	
Species	*pulex*	
Family in North America?	Yes	
Age/size at start of test/growth phase	5 mm, > 3 weeks old (exact instar/age not given or known)	
Source of organisms	River Wye, England	
Have organisms been exposed to contaminants?	Maybe	
Animals acclimated and disease-free?	Yes, for 3 weeks	
Animals randomized?	NR	
Test vessels randomized?	Yes	
Test duration	96 h	
Data for multiple times?	Yes, 24, 48, 72 h	
Effect 1	Immobility	
Control response 1	Tests 1 & 2: 0%	
Effect 2	Mortality	
Control response 2	Test 1: 5% at 72/96 h Test 2: 0%	
Temperature	15 ± 0.5°C	
Test type	Flow-through	
Photoperiod/light intensity	16 L: 8 D, 700 lux	
Dilution water	Dechlorinated tap water	
pH	8.1-8.4	
Hardness	250 mg/L	
Alkalinity	250 mg/L	
Conductivity	660 µS/cm	

Reference	**Hamer et al. 1985a**	***G. pulex***
Parameter	**Value**	**Comment**
Dissolved Oxygen	>9.3 mg/L (>91% sat.)	
Feeding	None during test	
Purity of test substance	99.2%	
Concentrations measured?	Yes	
Measured is what % of nominal?	Test 1: mean 72-86% (range 54-109%) Test 2: mean 45-96% (range 20-109%)	Meas. at 0, 24, 48, 72, 96 h
Chemical method documented?	Yes, LSC	TLC to measure hydrolysis, HPLC to measure isomerization
Concentration of carrier (if any) in test solutions	None used	
Test 1 Concentration 1 Nom/Meas Test 2 Meas (ng/L)	Test 1: 65.5/54 Test 2: 39.5	1 rep/test, 20 org/rep
Test 1 Concentration 2 Nom/Meas Test 2 Meas (ng/L)	Test 1: 38.0/29.3 Test 2: 21.3	1 rep/test, 20 org/rep
Test 1 Concentration 3 Nom/Meas Test 2 Meas (ng/L)	Test 1: 20.5/14.6 Test 2: 10.0	1 rep/test, 20 org/rep
Test 1 Concentration 4 Nom/Meas Test 2 Meas (ng/L)	Test 1: 11.3/6.8 Test 2: 5.5	1 rep/test, 20 org/rep
Test 1 Concentration 5 Nom/Meas Test 2 Meas (ng/L)	Test 1: 5.3/3.9 Test 2: 3.4	1 rep/test, 20 org/rep
Test 1 Concentration 6 Nom/Meas Test 2 Meas (ng/L)	Test 1: 3.5/2.1 Test 2: 2.0	1 rep/test, 20 org/rep
Test 1 Concentration 7 Nom/Meas Test 2 Meas (ng/L)	Test 1: 1.8/1.2 Test 2: 1.0	1 rep/test, 20 org/rep
Test 1 Concentration 8 Nom/Meas Test 2 Meas (ng/L)	Test 1: 0.7/0.5 Test 2: 0.4	1 rep/test, 20 org/rep
Control	Dilution water	1 rep/test, 20 org/rep
LC_{50} (95% confidence interval) (ng/L)	<u>Test 1</u> 24 h: 854 (133-infinity) 48 h: 55.4 (32.6-127) 72 h:26.9 (18.0-47.8) 96 h: 11.7 (8.2-17.6) <u>Test 2</u> 24 h: 516 (0-infinity) 48 h: 95.0 (43.6-962) 72 h: 36.4 (24.3-74.3) 96 h: 13.8 (10.4-19.3)	Method: weighted linear regression

Reference	**Hamer et al. 1985a**	***G. pulex***
Parameter	**Value**	**Comment**
	Mean of 2 tests 24 h: 665 48 h: 71.2 72 h: 31.3 96 h: 12.7	
EC_{50} (95% confidence interval) (ng/L)	Test 1 24 h: 8.9 (6.6-12.1) 48 h: 6.9 (3.4-14.9) 72 h: 6.1 (1.9-21.3) 96 h: 5.9 (2.1-18.2) Test 2 24 h: 11.6 (5.8-36.4) 48 h: 9.1 (7.1-12.1) 72 h: 6.8 (5.2-9.0) 96 h: 5.9 (3.2-11.5) Mean of 2 tests 24 h: 10.2 48 h: 8.0 72 h: 6.4 96 h: 5.9	Method: weighted linear regression

Notes:

LC50 and EC50 calculated based on mean measured concentrations.

Some hydrolysis and isomerization did occur, but l-cyhalothrin always accounted for the majority of radioactivity.

Reliability points taken off for:
Documentation: Hypothesis tests (8)
Acceptability: Standard method (5), Measured concentrations w/in 20% of nominal (4), Appropriate age of organisms (3), Prior contamination (4), Organisms randomized (1), Adequate replication (2), Hypothesis tests (3).

Toxicity Data Summary

Gammarus pulex

Study: Hamer MJ, Ashwell JA, Gentle WE. 1998. Lambda-cyhalothrin Acute Toxicity to Aquatic Arthropods. ZENECA Agrochemicals, Jealott's Hill Research Station Bracknell, Berkshire, UK. DPR study number 50907-093.

Relevance
Score: 100
Rating: R

Reliability
Score: 81.5
Rating: R

Reference	**Hamer et al. 1998**	***G. pulex***
Parameter	**Value**	**Comment**
Test method cited	USEPA, OECD	
Phylum	Arthropoda	
Class	Malacostraca	
Order	Amphipoda	
Family	Gammaridae	
Genus	*Gammarus*	
Species	*pulex*	
Family in North America?	Yes	
Age/size at start of test/growth phase	NR	
Source of organisms	Pond	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	NR	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	48 h	
Data for multiple times?	No	
Effect 1	Immobility	
Control response 1	0%	
Effect 2	Mortality	
Control response 2	0%	
Temperature	20 ± 2°C	
Test type	Static	
Photoperiod/light intensity	16 L:8 D, 700-1000 lux	
Dilution water	Mixture of dechlorinated and RO filtered tap water	
pH	8.4-8.6	
Hardness	179 mg/L	
Alkalinity	150 mg/L	
Conductivity	NR	

Reference	**Hamer et al. 1998**	***G. pulex***
Parameter	**Value**	**Comment**
Dissolved Oxygen	8.2-9.1 mg/L	
Feeding	None during test	
Purity of test substance	≥ 88% radiochemical purity	
Concentrations measured?	Yes	
Measured is what % of nominal?	t_0: 99-122%; 48 h: 45-81%	
Chemical method documented?	Yes, LSC	
Concentration of carrier (if any) in test solutions	0.05%	
Concentration 1 Nom/Meas t_0/48 h (µg/L)	16/18/10	1 rep, 10 orgs/rep
Concentration 2 Nom/Meas t_0/48 h (ng/L)	31/31/25	1 rep, 10 orgs/rep
Concentration 3 Nom/Meas t_0/48 h (ng/L)	62/76/37	1 rep, 10 orgs/rep
Concentration 4 Nom/Meas t_0/48 h (ng/L)	125/131/59	1 rep, 10 orgs/rep
Concentration 5 Nom/Meas t_0/48 h (ng/L)	250/247/112	1 rep, 10 orgs/rep
Concentration 6 Nom/Meas t_0/48 h (ng/L)	500/534/266	1 rep, 10 orgs/rep
Control (ng/L)	Dil. water and solvent: <10	1 rep, 10 orgs/rep
EC_{50} (95% confidence interval)	14 (9.1-19) ng/L	Method: Iteratively re-weighted linear regression

Notes:
LC_{50} values not calculated.
EC_{50} calculated based on nominal concentrations.

Reliability points taken off for:
Documentation: Organism age (5), Conductivity (2), Hypothesis tests (8)
Acceptability: No standard method (5), Measured concentrations w/in 20% of nominal (4), Appropriate organism age (3), No prior contamination (4), Organisms randomized (1), Acclimation (1), Exposure type (2), Temperature variance (3), Conductivity (1), Random design (2), Appropriate statistical method (2), Hypothesis tests (3).

Toxicity Data Summary

Gasterosteus aculeatus

Study: Long KWJ, Shillabeer N. 1997a. Lambda-cyhalothrin: Acute toxicity to the three-spined stickleback (*Gasterosteus aculeatus*). DPR study number 50907-085.

Relevance	Reliability
Score: 100	Score: 84
Rating: R	Rating: R

Reference	**Long & Shillabeer 1997a**	***G. aculeatus***
Parameter	**Value**	**Comment**
Test method cited	USEPA, OECD	
Phylum	Chordata	
Class	Actinopterygii	
Order	Gasterosteiformes	
Family	Gasterosteidae	
Genus	*Gasterosteus*	
Species	*aculeatus*	Three-spined stickleback
Family in North America?	Yes	
Age/size at start of test/growth phase	NR -Mean weight and length at end of test were 0.41 g and 34 mm - > 2 weeks old	
Source of organisms	Lab culture	Blades Biological, Kent, UK
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	Yes	
Test vessels randomized?	NR	
Test duration	96 h	
Data for multiple times?	Yes; 24, 48, 72 h	
Effect 1	Mortality	
Control response 1	0%	
Temperature	12 ± 1°C	
Test type	Flow-through	
Photoperiod/light intensity	NR	
Dilution water	Dechlorinated tap water	
pH	7.03-7.31	
Hardness	46.0-47.3 mg/L	
Alkalinity	26.4 mg/L	

Reference	**Long & Shillabeer 1997a**	***G. aculeatus***
Parameter	**Value**	**Comment**
Conductivity	215-217 μS/cm	
Dissolved Oxygen	10.0-10.8 mg/L	
Feeding	None during test	
Purity of test substance	87.7%	
Concentrations measured?	Yes	
Measured is what % of nominal?	68-138%	
Chemical method documented?	Yes, GC-ECD	
Concentration of carrier (if any) in test solutions	0.01% dimethylformamide	
Concentration 1 Nom/Meas (μg/L)	0.10/0.068	1 rep, 23 org/rep
Concentration 2 Nom/Meas (μg/L)	0.20/0.16	1 rep, 23 org/rep
Concentration 3 Nom/Meas (μg/L)	0.40/0.68	1 rep, 23 org/rep
Concentration 4 Nom/Meas (μg/L)	0.80/0.79	1 rep, 23 org/rep
Concentration 5 Nom/Meas (μg/L)	1.6/1.5	1 rep, 23 org/rep
Concentration 6 Nom/Meas (μg/L)	3.2/2.5	1 rep, 23 org/rep
Control	Solvent and dilution water	1 rep, 23 org/rep
LC_{50} (95% confidence interval) (μg/L)	24 h: 0.73 (0.68-0.79) 48 h: 0.44 (0.36-0.56) 72 h: 0.43 (0.35-0.54) 96 h: 0.40 (0.33-0.50)	Method: Binomial (24 h), Moving average angle (48, 72, 96 h)

Notes:

LC_{50} calculated based on mean measured concentrations.

Reliability points taken off for:
Documentation: Organism age at beginning (5), Photoperiod (3), Hypothesis tests (8)
Acceptability: Measured concentrations w/in 20% of nominals (4), Appropriate age of organism (3), Photoperiod (2), Random design (2), Adequate replication (2), Hypothesis tests (3).

Water Toxicity Data Summary

Hyalella azteca

Bradley MJ. 2013. Lambda-cyhalothrin – Acute toxicity to freshwater amphipods (*Hyalella azteca*) under flow-through conditions. Submitted to: Pyrethroid Working Group, FMC Corporation, Ewing, NJ, 08628. Performing laboratory: Smithers Viscient, 790 Main St, Wareham, MA, 02571-1037; lab project ID: Smithers Viscient Study No. 13656.6166.

Relevance	Reliability
Score: 100	Score: 90.5
Rating: R	Rating: R

H. azteca	**Bradley 2013**	
Parameter	**Value**	**Comment**
Test method cited	Smithers Viscient protocol, USEPA OCSPP 850.1000, OCSPP 850.1020	There is not yet a final EPA method for this test
Phylum/subphylum	Arthropoda	
Class	Crustacea	
Order	Malacostraca	
Family	Hyalellidae	
Genus	*Hyalella*	
Species	*azteca*	
Family native to North America?	Yes	
Age/size at start of test/growth phase	9 days	
Source of organisms	In-house lab cultures	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	Yes	
Test vessels randomized?	Not reported	
Test duration	96 h	
Data for multiple times?	Yes, 24, 48, 72 h	
Effect 1	Mortality	
Control response 1	0%	
Temperature	23 $\pm$ 1 ^{o}C	
Test type	Flow-through	
Photoperiod/light intensity	16 h light: 8 h dark, 280-360 lux	
Dilution water	Laboratory well water	
pH	7.3-7.4	
Hardness	48-52 mg/L $CaCO_3$	

H. azteca	**Bradley 2013**	
Parameter	**Value**	**Comment**
Alkalinity	20-22 mg/L $CaCO_3$	
Conductivity	280 uS/cm	
Total organic carbon	0.70 mg/L	
Dissolved Oxygen	7.6-9.3 mg/L	$\geq$ 75% saturation
Feeding	1.0 mL YCT once daily	YCT: Yeast, cereal leaves, flaked fish food
Purity of test substance	93.2%	
Concentrations measured?	Yes	
Measured is what % of nominal?	75-94%	
Toxicity values calculated based on nominal or measured concentrations?	Measured	
Chemical method documented?	Yes, GC-MSD	
Concentration of carrier (if any) in test solutions	0.050 mL/L acetone	
Concentration 1 Nom; Meas (ng/L)	0.16; 0.12	2 reps, 10/rep
Concentration 2 Nom; Meas (ng/L)	0.31; 0.23	2 reps, 10/rep
Concentration 3 Nom; Meas (ng/L)	0.63; 0.49	2 reps, 10/rep
Concentration 4 Nom; Meas (ng/L)	1.3; 1.1	2 reps, 10/rep
Concentration 5 Nom; Meas (ng/L)	2.5; 2.3	2 reps, 10/rep
Control	Solvent and dilution water	2 reps, 10/rep
LC_{50} (95% CI) (ng/L)	0.30 (0.24-0.37)	Method: Spearman-Karber estimates

Notes: Typically organisms are not fed in acute exposures, but were fed daily in this test. EPA guidance recommends feeding at day 0 and day 2 in a static 96-h water only reference-toxicant test (USEPA 2000). Because this test was flow-through with 90% renewal of overlying water every 5 h, it is unlikely the particulate or dissolved organic matter was significantly increased in the tests, and unlikely that a significant amount of test chemical was adsorbed to the food and ingested by the organisms. Thus daily feeding was considered acceptable in this test.

Reliability points taken off for:
Documentation: Hypothesis tests (8). Total: 100-8=92

Acceptability: Measured concentrations within 20% nominal (4), Random design (2), Adequate replication (2), Hypothesis tests (3). Total: 100-11=89
Reliability score: mean(92, 89)=90.5

Toxicity Data Summary

Hyalella azteca

Study: Hamer MJ, Ashwell JA, Gentle WE. 1998. Lambda-cyhalothrin Acute Toxicity to Aquatic Arthropods. ZENECA Agrochemicals, Jealott's Hill Research Station Bracknell, Berkshire, UK. DPR study number 50907-093.

Relevance
Score: 100
Rating: R

Reliability
Score: 83.5
Rating: R

Reference	**Hamer et al. 1998**	***H. azteca***
Parameter	**Value**	**Comment**
Test method cited	USEPA, OECD	
Phylum	Arthropoda	
Class	Malacotraca	
Order	Amphipoda	
Family	Hyalellidae	
Genus	*Hyalella*	
Species	*azteca*	
Family in North America?	Yes	
Age/size at start of test/growth phase	NR	
Source of organisms	Lab culture	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	NR	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	48 h	
Data for multiple times?	No	
Effect 1	Immobility	
Control response 1	0%	
Effect 2	Mortality	
Control response 2	0%	
Temperature	20 ± 2°C	
Test type	Static	
Photoperiod/light intensity	16 L:8 D, 700-1000 lux	
Dilution water	Mixture of dechlorinated and RO filtered tap water	
pH	7.7-8.6	
Hardness	179 mg/L	
Alkalinity	150 mg/L	
Conductivity	NR	

Reference	**Hamer et al. 1998**	***H. azteca***
Parameter	**Value**	**Comment**
Dissolved Oxygen	7.5-8.3 mg/L	
Feeding	None during test	
Purity of test substance	≥ 88% radiochemical purity	
Concentrations measured?	Yes	
Measured is what % of nominal?	t_0: 98-131%; 48 h: 56-64%	
Chemical method documented?	Yes, LSC	
Concentration of carrier (if any) in test solutions	0.05%	
Concentration 1 Nom/Meas t_0/48 h (µg/L)	0.49/<10/<10	1 rep, 10 orgs/rep
Concentration 2 Nom/Meas t_0/48 h (ng/L)	1.0/<10/<10	1 rep, 10 orgs/rep
Concentration 3 Nom/Meas t_0/48 h (ng/L)	2.0/10/<10	1 rep, 10 orgs/rep
Concentration 4 Nom/Meas t_0/48 h (ng/L)	3.9/<10/<10	1 rep, 10 orgs/rep
Concentration 5 Nom/Meas t_0/48 h (ng/L)	7.8/10/<10	1 rep, 10 orgs/rep
Concentration 6 Nom/Meas t_0/48 h (ng/L)	16/16/10	1 rep, 10 orgs/rep
Concentration 7 Nom/Meas t_0/48 h (ng/L)	31/37/20	1 rep, 10 orgs/rep
Concentration 8 Nom/Meas t_0/48 h (ng/L)	62/61/35	1 rep, 10 orgs/rep
Control (ng/L)	Dil. water and solvent: <10	1 rep, 10 orgs/rep
EC_{50} (95% confidence interval)	2.3 (1.0-7.8) ng/L	Method: Iteratively re-weighted linear regression

Notes:
LC_{50} values not calculated.
EC_{50} calculated based on nominal concentrations.

Reliability points taken off for:
Documentation: Organism age (5), Conductivity (2), Hypothesis tests (8)
Acceptability: No standard method (5), Measured concentrations w/in 20% of nominal (4), Appropriate organism age (3), Organisms randomized (1), Acclimation (1), Exposure type (2), Temperature variance (3), Conductivity (1), Random design (2), Appropriate statistical method (2), Hypothesis tests (3).

Toxicity Data Summary

Hyalella azteca

Study: Smith S, Lizotte RE. 2007. Influence of Selected Water Quality Characteristics on the Toxicity of λ-cyhalothrin and γ-cyhalothrin to *Hyalella azteca.* Bull Environ Contam Toxicol, 79:548-551.

Relevance
Score: L (Low chemical purity)
Rating: 85

Reliability
Score: R
Rating: 76.5

Reference	**Smith & Lizotte 2007**	***H. azteca***
Parameter	**Value**	**Comment**
Test method cited	US EPA 1994	
Phylum	Arthropoda	
Class	Malacotraca	
Order	Amphipoda	
Family	Hyalellidae	
Genus	*Hyalella*	
Species	*azteca*	
Family in North America?	Yes	
Age/size at start of test/growth phase	1-2 weeks old < 600 µm, ≥ 425 µm	
Source of organisms	Lab culture	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	48 h	
Data for multiple times?	No	
Effect 1	Immobility	
Control response 1	99 ± 1%	
Temperature	23± 1°C	
Test type	Static	
Photoperiod/light intensity	16 L: 8 D	
Dilution water	Fortified, unfiltered pond waters	
pH	8.0	
Hardness	93 mg/L	
Alkalinity	55 mg/L	
Conductivity	360 µmhos/cm	
Dissolved Oxygen	7.7 mg/L	
Feeding	None during test	

Reference	**Smith & Lizotte 2007**	***H. azteca***
Parameter	**Value**	**Comment**
Purity of test substance	22.8% active ingredient in formulation stock	
Concentrations measured?	Stock solutions measured	
Measured is what % of nominal?	31-75%	
Chemical method documented?	Yes, GC	
Concentration of carrier (if any) in test solutions	NR, but formulation was used so several other chemicals were present	
Concentration 1 Nom/Meas (µg/L)	0.0009	6 reps, 5 orgs/rep
Concentration 2 Nom/Meas (µg/L)	NR	6 reps, 5 orgs/rep
Concentration 3 Nom/Meas (µg/L)	NR	6 reps, 5 orgs/rep
Concentration 4 Nom/Meas (µg/L)	NR	6 reps, 5 orgs/rep
Concentration 5 Nom/Meas (µg/L)	0.6	6 reps, 5 orgs/rep
Control	Dilution water	6 reps, 5 orgs/rep
48 h EC_{50} (95% confidence interval) – for 12 different waters tested	1: 2.8 (2.0-3.8) ng/L 2: 1.7 (1.3-2.2) ng/L 3: 2.4 (1.8-3.1) ng/L 4: 10.4 (8.3-13.6) ng/L 5: 1.5 (1.1-1.9) ng/L 6: 7.4 (5.9-9.2) ng/L 7: 3.9 (3.0-4.9) ng/L 8: 1.4 (1.1-1.8) ng/L 9: 3.6 (2.8-4.5) ng/L 10: 2.2 (1.7-2.8) ng/L 11: 11.1 (8.7-14.3) ng/L 12: 15.7 (12.5-19.7) ng/L	Method: Probit (if linear), Trimmed Spearman-Karber (if non-linear)

Notes:

EC50 values calculated based on nominal concentrations.

Mean water quality characteristics of 12 waters (Std dev)

Water body	Turbidity (NTU)	TSS (mg/L)	Chlorophyll a (ug/L)	DOC (mg/L)
1	7.0 (0.3)	10 (6)	3.8 (2.5)	10.6 (2.4)
2	3.1 (0.2)	2 (1)	2.9 (1.7)	1.4 (0.2)
3	0.7 (0.2)	4 (3)	5.3 (2.5)	1.0 (0.2)
4	6.6 (0.5)	13 (4)	35.9 (3.7)	16.7 (5.8)
5	1.2 (0.5)	4 (2)	1.7 (1.7)	1.9 (0.2)
6	16.0 (0.5)	15 (5)	76.1 (2.3)	11.4 (3.7)
7	3.5 (0.2)	5 (3)	3.0 (1.8)	2.7 (0.2)
8	1.9 (0.2)	1 (1)	1.7 (1.2)	2.8 (0.4)
9	2.0 (0.2)	6 (3)	1.2 (1.3)	5.3 (1.0)

10	1.4 (0.1)	2 (1)	5.6 (3.2)	1.7 (0.3)
11	19.9 (0.6)	14 (7)	36.2 (2.1)	11.4 (1.8)
12	67.2 (2.0)	79 (5)	102.0 (5.8)	32.9 (10.2)

Linear regression relationships between water quality parameters and toxicity:
Turbidity(x, NTU): EC_{50}=0.216x + 3.04, R^2=0.712, F = 24.7, p = 0.0006
TSS (x, mg/L): EC_{50} = 0.179x + 3.15, R^2 = 0.644, F = 18.1, p = 0.0017
DOC (x, mg/L): EC_{50} = 0.546x + 1.07, R^2 = 0.847, F = 55.3, p < 0.0001
Chlorophyll *a* (x, µg/L): EC_{50} = 0.123x + 2.61, R^2 = 0.742, F = 28.7, p = 0.0003

Interaction of increased DOC and phytoplankton (as chl *a*) decreases toxicity of l-cyhalothrin to *H. azteca* by more than 10-fold.

Reliability points taken off for:
Documentation: Hypothesis tests (8)
Acceptability: Appropriate control (6), Chemical purity (10), Measured concentrations w/in 20% of nominal (4), Carrier solvent (4), Organisms randomized (1), Exposure type (2), Dilution water (2), Number of concentrations (3), Random design (2), Dilution factor (2), Hypothesis tests (3)

Toxicity Data Summary

Hydracarina

Study: Hamer MJ, Ashwell JA, Gentle WE. 1998. Lambda-cyhalothrin Acute Toxicity to Aquatic Arthropods. ZENECA Agrochemicals, Jealott's Hill Research Station Bracknell, Berkshire, UK. DPR study number 50907-093.

Relevance
Score: 100
Rating: R

Reliability
Score: 81.5
Rating: R

Reference	**Hamer et al. 1998**	***Hydracarina***
Parameter	**Value**	**Comment**
Test method cited	USEPA, OECD	
Phylum	Arthropoda	
Class	Arachnida	
Order	Trombidformes	
Suborder	Hydracarina*	
Genus	NR	
Species	NR	
Family in North America?	Yes	
Age/size at start of test/growth phase	NR	
Source of organisms	Experimental ponds at research station	
Have organisms been exposed to contaminants?	Maybe	
Animals acclimated and disease-free?	NR	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	48 h	
Data for multiple times?	No	
Effect 1	Immobility	
Control response 1	0%	
Effect 2	Mortality	
Control response 2	0%	
Temperature	20 ± 2°C	
Test type	Static	
Photoperiod/light intensity	16 L:8 D, 700-1000 lux	
Dilution water	Mixture of dechlorinated and RO filtered tap water	
pH	8.0-8.7	
Hardness	179 mg/L	
Alkalinity	150 mg/L	

Reference	**Hamer et al. 1998**	***Hydracarina***
Parameter	**Value**	**Comment**
Conductivity	NR	
Dissolved Oxygen	8.4-9.0 mg/L	
Feeding	None during test	
Purity of test substance	≥ 88% radiochemical purity	
Concentrations measured?	Yes	
Measured is what % of nominal?	t_0: 110-119%; 48 h: 60-69%	
Chemical method documented?	Yes, LSC	
Concentration of carrier (if any) in test solutions	0.05%	
Concentration 1 Nom/Meas t_0/48 h (µg/L)	31/37/20	1 rep, 10 orgs/rep
Concentration 2 Nom/Meas t_0/48 h (ng/L)	62/74/37	1 rep, 10 orgs/rep
Concentration 3 Nom/Meas t_0/48 h (ng/L)	125/147/86	1 rep, 10 orgs/rep
Concentration 4 Nom/Meas t_0/48 h (ng/L)	250/288/168	1 rep, 10 orgs/rep
Concentration 5 Nom/Meas t_0/48 h (ng/L)	500/550/313	1 rep, 10 orgs/rep
Concentration 6 Nom/Meas t_0/48 h (ng/L)	1000/1139/646	1 rep, 10 orgs/rep
Control (ng/L)	Dil. water and solvent: <10	1 rep, 10 orgs/rep
EC_{50} (95% confidence interval)	47 (33-62) ng/L	Method: Iteratively re-weighted linear regression

Notes:
* The binomial name was not available, as these organisms were collected from the field and species identification is very difficult and not well-described in the literature. There were no other data available for similar organisms, so there is no question about combining values for a species mean value and the variability (as shown by the 95% confidence interval) is low, so it is reasonable to believe that the test organisms were all one species.

LC_{50} values not calculated.
EC_{50} calculated based on nominal concentrations.

Reliability points taken off for:
Documentation: Organism age (5), Conductivity (2), Hypothesis tests (8)
Acceptability: No standard method (5), Measured concentrations w/in 20% of nominal (4), Appropriate organism age (3), Organisms randomized (1), Acclimation (1), Prior contaminant exposure (4), Exposure type (2), Temperature variance (3), Conductivity (1), Random design (2), Appropriate statistical method (2), Hypothesis tests (3).

Toxicity Data Summary

Ictalurus punctatus

Study: Long KWJ, Shillabeer N. 1997b. Lambda-cyhalothrin: Acute toxicity to channel catfish (*Ictalurus punctatus*). ZENECA Agrochemicals. DPR study number 50907-085.

Relevance	Reliability
Score: 100	Score: 84
Rating: R	Rating: R

Reference	**Long & Shillabeer 1997b**	***I. punctatus***
Parameter	**Value**	**Comment**
Test method cited	USEPA, OECD	
Phylum	Chordata	
Class	Osteichthyes	
Order	Siluriformes	
Family	Ictaluridae	
Genus	*Ictalurus*	
Species	*punctatus*	
Family in North America?	Yes	
Age/size at start of test/growth phase	NR -Mean weight and length at end of test were 1.57 g and 48 mm - > 25 d old	
Source of organisms	Lab culture	Aquatic Research Organisms, Hampton, NH, USA
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	Yes	
Test vessels randomized?	NR	
Test duration	96 h	
Data for multiple times?	Yes; 24, 48, 72 h	
Effect 1	Mortality	
Control response 1	0%	
Temperature	17 ± 1°C	
Test type	Flow-through	
Photoperiod/light intensity	NR	
Dilution water	Dechlorinated tap water	
pH	7.24-7.70	
Hardness	43.0-47.7 mg/L	
Alkalinity	26.7 mg/L	

Reference	**Long & Shillabeer 1997b**	***I. punctatus***
Parameter	**Value**	**Comment**
Conductivity	201-211 μS/cm	
Dissolved Oxygen	8.8-10.0 mg/L	
Feeding	None during test	
Purity of test substance	87.7%	
Concentrations measured?	Yes	
Measured is what % of nominal?	25-57%	
Chemical method documented?	Yes, GC-ECD	
Concentration of carrier (if any) in test solutions	0.01% dimethylformamide	
Concentration 1 Nom/Meas (μg/L)	0.080/0.020	1 rep, 20 org/rep
Concentration 2 Nom/Meas (μg/L)	0.16/0.058	1 rep, 20 org/rep
Concentration 3 Nom/Meas (μg/L)	0.32/0.090	1 rep, 20 org/rep
Concentration 4 Nom/Meas (μg/L)	0.64/0.25	1 rep, 20 org/rep
Concentration 5 Nom/Meas (μg/L)	1.28/0.73	1 rep, 20 org/rep
Concentration 6 Nom/Meas (μg/L)	2.56/1.0	1 rep, 20 org/rep
Control	Solvent and dilution water	1 rep, 20 org/rep
LC_{50} (95% confidence interval) (μg/L)	24 h: 0.82 (0.67-1.1) 48 h: 0.43 (0.25-0.73) 72 h: 0.18 (0.15-0.23) 96 h: 0.16 (0.13-0.20)	Method: Binomial (48 h), Moving average angle (24, 72, 96 h)

Notes:

LC_{50} calculated based on mean measured concentrations.

Reliability points taken off for:
Documentation: Organism age at beginning (5), Photoperiod (3), Hypothesis tests (8)
Acceptability: Measured concentrations w/in 20% of nominals (4), Appropriate age of organism (3), Photoperiod (2), Random design (2), Adequate replication (2), Hypothesis tests (3).

Toxicity Data Summary

Ischnura elegans

Study: Hamer MJ, Ashwell JA, Gentle WE. 1998. Lambda-cyhalothrin Acute Toxicity to Aquatic Arthropods. ZENECA Agrochemicals, Jealott's Hill Research Station Bracknell, Berkshire, UK. DPR study number 50907-093.

Relevance
Score: 100
Rating: R

Reliability
Score: 81.5
Rating: R

Reference	**Hamer et al. 1998**	***I. elegans***
Parameter	**Value**	**Comment**
Test method cited	USEPA, OECD	
Phylum	Arthropoda	
Class	Insecta	
Order	Odonata	
Family	Coenagrionidae	
Genus	*Ischnura*	
Species	*elegans*	
Family in North America?	Yes	
Age/size at start of test/growth phase	NR	
Source of organisms	Experimental ponds at research stations	
Have organisms been exposed to contaminants?	Maybe	
Animals acclimated and disease-free?	NR	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	48 h	
Data for multiple times?	No	
Effect 1	Immobility	
Control response 1	0%	
Effect 2	Mortality	
Control response 2	0%	
Temperature	20 ± 2°C	
Test type	Static	
Photoperiod/light intensity	16 L:8 D, 700-1000 lux	
Dilution water	Mixture of dechlorinated and RO filtered tap water	
pH	8.2-8.7	
Hardness	179 mg/L	
Alkalinity	150 mg/L	

Reference	**Hamer et al. 1998**	***I. elegans***
Parameter	**Value**	**Comment**
Conductivity	NR	
Dissolved Oxygen	8.6-9.0 mg/L	
Feeding	None during test	
Purity of test substance	≥ 88% radiochemical purity	
Concentrations measured?	Yes	
Measured is what % of nominal?	t_0: 87-116%; 48 h: 50-82%	
Chemical method documented?	Yes, LSC	
Concentration of carrier (if any) in test solutions	0.05%	
Concentration 1 Nom/Meas t_0/48 h (µg/L)	31/27/22	1 rep, 10 orgs/rep
Concentration 2 Nom/Meas t_0/48 h (ng/L)	62/72/51	1 rep, 10 orgs/rep
Concentration 3 Nom/Meas t_0/48 h (ng/L)	125/125/63	1 rep, 10 orgs/rep
Concentration 4 Nom/Meas t_0/48 h (ng/L)	250/229/129	1 rep, 10 orgs/rep
Concentration 5 Nom/Meas t_0/48 h (ng/L)	500/436/313	1 rep, 10 orgs/rep
Concentration 6 Nom/Meas t_0/48 h (ng/L)	1000/1031/701	1 rep, 10 orgs/rep
Concentration 7 Nom/Meas t_0/48 h (ng/L)	2000/1857/1137	1 rep, 10 orgs/rep
Control (ng/L)	Dil. water and solvent: <10	1 rep, 10 orgs/rep
EC_{50} (95% confidence interval)	38 (23-93) ng/L	Method: Iteratively re-weighted linear regression

Notes:
LC_{50} values not calculated.
EC_{50} calculated based on nominal concentrations.

Reliability points taken off for:
Documentation: Organism age (5), Conductivity (2), Hypothesis tests (8)
Acceptability: No standard method (5), Measured concentrations w/in 20% of nominal (4), Appropriate organism age (3), Organisms randomized (1), Prior contamination (4), Acclimation (1), Exposure type (2), Temperature variance (3), Conductivity (1), Random design (2), Appropriate statistical method (2), Hypothesis tests (3).

Toxicity Data Summary

Lepomis macrochirus

Study: Hill RW. 1984b. PP321: Determination of acute toxicity to bluegill sunfish (*Lepomis macrochirus*). ICI Agrochemicals. DPR study number 50907-085.

Relevance
Score: 90 (No standard method)
Rating: R

Reliability
Score: 83
Rating: R

Reference	**Hill 1984b**	***L. macrochirus***
Parameter	**Value**	**Comment**
Test method cited	None cited	
Phylum	Chordata	
Class	Actinopterygii	
Order	Perciformes	
Family	Centrarchidae	
Genus	*Lepomis*	
Species	*macrochirus*	
Family in North America?	Yes	
Age/size at start of test/growth phase	Mean wt.: 1.51 g Mean length: 38.2 mm	
Source of organisms	Commercial – Sea Plantations Inc. Salem, MA	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	96 h	
Data for multiple times?	Yes; 24, 48, 96 h	
Effect 1	Mortality	
Control response 1	0%	
Temperature	22 ± 1°C	
Test type	Flow-through	
Photoperiod/light intensity	NR	
Dilution water	Freshwater reservoir	Not more specific
pH	7.4-8.6	
Hardness	68.2 mg/L	
Alkalinity	28.4mg/L	
Conductivity	137 µS/cm	
Dissolved Oxygen	7.0-8.4 mg/L	
Feeding	NR	
Purity of test substance	98%	

Reference	**Hill 1984b**	***L. macrochirus***
Parameter	**Value**	**Comment**
Concentrations measured?	Yes	
Measured is what % of nominal?	50-65%	
Chemical method documented?	Yes, GC-ECD	
Concentration of carrier (if any) in test solutions	9 mg/L acetone	
Concentration 1 Nom/Meas (μg/L)	1.8/1.17	1 rep, 20 org/rep
Concentration 2 Nom/Meas (μg/L)	1.0/0.65	1 rep, 20 org/rep
Concentration 3 Nom/Meas (μg/L)	0.56/0.31	1 rep, 20 org/rep
Concentration 4 Nom/Meas (μg/L)	0.32/0.16	1 rep, 20 org/rep
Concentration 5 Nom/Meas (μg/L)	0.18/0.10	1 rep, 20 org/rep
Concentration 6 Nom/Meas (μg/L)	0.10/0.06	1 rep, 20 org/rep
Control	Solvent and dilution water	1 rep, 20 org/rep
LC_{50} (95% confidence interval) (μg/L)	24 h: 0.45 (0.38-0.52) 48 h: 0.28 (0.23-0.32) 72 h: 0.28 (0.23-0.32) 96 h: 0.21 (0.18-0.25)	Method: Probit

Notes:

LC_{50} calculated based on mean measured concentrations.

Reliability points taken off for:
Documentation: Dilution water source (3), Photoperiod (3), Hypothesis tests (8),
Acceptability: Standard method (5), Measured concentrations w/in 20% nominal (4), Organisms randomized (1), Dilution water (2), Photoperiod (2), Random design (2), Adequate replication (2), Hypothesis tests (3).

Toxicity Data Summary

Lepomis macrochirus

Study: Marino TA, Rick DL. 2001. XR-225 and lambda-cyhalothrin: An acute toxicity comparison study with the Bluegill sunfish, *Lepomis macrochirus* Rafinesque. EPA MRID 45447216.

Relevance
Score: 100
Rating: R

Reliability
Score: 90
Rating: R

Reference	**Marino & Rick 2001**	***L. macrochirus***
Parameter	**Value**	**Comment**
Test method cited	US EPA, OECD	
Phylum	Chordata	
Class	Actinopterygii	
Order	Perciformes	
Family	Centrarchidae	
Genus	*Lepomis*	
Species	*macrochirus*	Rafinesque
Family in North America?	Yes	
Age/size at start of test/growth phase	Juvenile	
Source of organisms	Laboratory culture	Northeaster Aquatics, Rhinebeck, NY
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	Yes	
Test vessels randomized?	No	
Test duration	96 hr	
Data for multiple times?	Yes – 24 hr, 48 hr, 72 hr	
Effect 1	Mortality	
Control response 1	0% at all times	
Effect 2	<10% mortality	
Control response 2	0% mortality at all times	
Effect 3	Behavioral effects	
Control response 3	0% at all times	
Temperature	21.9 ± 0.3°C	
Test type	Flow-through	
Photoperiod/light intensity	16 L: 8 D	
Dilution water	Filtered Lake Huron water	
pH	7.0 ± 0.1	

Reference	**Marino & Rick 2001**	***L. macrochirus***
Parameter	**Value**	**Comment**
Hardness	55 mg/L as $CaCO_3$	
Alkalinity	30 mg/L as $CaCO_3$	
Conductivity	71.1 μ mho/cm	
Dissolved Oxygen	8.8 ± 0.6 mg/L	≥ 87% saturation
Feeding	None during test	
Purity of test substance	99%	
Concentrations measured?	Yes	
Measured is what % of nominal?	44-58%	
Chemical method documented?	Yes	
Concentration of carrier (if any) in test solutions	0.8 mL/L (0.08%)	
Concentration 1 Nom/Meas (ng/L)	27.2/13.7	2 reps, 5 fish/rep
Concentration 2 Nom/Meas (ng/L)	45.4/20.8	2 reps, 5 fish/rep
Concentration 3 Nom/Meas (ng/L)	75.6/34.0	2 reps, 5 fish/rep
Concentration 4 Nom/Meas (ng/L)	126/65.4	2 reps, 5 fish/rep
Concentration 5 Nom/Meas (ng/L)	210/104	2 reps, 5 fish/rep
Concentration 6 Nom/Meas (ng/L)	350/203	2 reps, 5 fish/rep
Control	< detection limit (10 ng/L)	2 reps, 5 fish/rep
LC_{50}	24 h: 224 (152-1742) ng/L 48 h: 124 (94.4-163) ng/L 72 h: 118 (94.4-155) ng/L 96 h: 106 (85.5-140) ng/L	Method: Probit and/or Trimmed Spearman-Karber

Notes:

Point estimates based on measured concentrations.

Reliability points taken off for:
Documentation: Hypothesis tests (8)
Acceptability: Measured concentrations w/in 20% nominal (4), Carrier solvent (4), Random design (2), Adequate replication (2), Hypothesis tests (3)

Toxicity Data Summary

Leuciscus idus

Study: Kent SJ, Shillabeer N. 1997a. Lambda-cyhalothrin: Acute toxicity to golden orfe (*Leuciscus idus*). ZENECA Agrochemicals. DPR study number 50907-085.

Relevance
Score: 100
Rating: R

Reliability
Score: 84
Rating: R

Reference	**Kent & Shillabeer 1997a**	***L. idus***
Parameter	**Value**	**Comment**
Test method cited	US EPA, OECD	
Phylum	Chordata	
Class	Osteichthyes	
Order	Cypriniformes	
Family	Cyprinidae	
Genus	*Leuciscus*	
Species	*idus*	
Family in North America?	Yes	
Age/size at start of test/growth phase	NR ➢ >17 d old ➢ mean control weight and length 2.15 g and 53 mm at end of test.	
Source of organisms	Lab culture	London Aquatic Co., UK
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	17 d acclimation in facility
Animals randomized?	Yes	
Test vessels randomized?	NR	
Test duration	96 h	
Data for multiple times?	Yes; 24, 48, 72 h	
Effect 1	Mortality	
Control response 1	0%	
Temperature	12 ± 1°C	
Test type	Flow-through	
Photoperiod/light intensity	NR	
Dilution water	Dechlorinated tap water	
pH	7.04-7.39	
Hardness	43.3-46.3 mg/L	
Alkalinity	25 mg/L	
Conductivity	212-218 µS/cm	

Reference	**Kent & Shillabeer 1997a**	***L. idus***
Parameter	**Value**	**Comment**
Dissolved Oxygen	9.2-10.4 mg/L, > 87% sat	
Feeding	None during test	
Purity of test substance	87.7%	
Concentrations measured?	Yes	
Measured is what % of nominal?	43-58%	
Chemical method documented?	Yes, GC-ECD	
Concentration of carrier (if any) in test solutions	0.01% dimethylformamide	
Concentration 1 Nom/Meas (μg/L)	0.030/0.017	1 rep, 20 org/rep
Concentration 2 Nom/Meas (μg/L)	0.060/0.026	1 rep, 20 org/rep
Concentration 3 Nom/Meas (μg/L)	0.12/0.056	1 rep, 20 org/rep
Concentration 4 Nom/Meas (μg/L)	0.24/0.11	1 rep, 20 org/rep
Concentration 5 Nom/Meas (μg/L)	0.48/0.28	1 rep, 20 org/rep
Concentration 6 Nom/Meas (μg/L)	0.96/0.48	1 rep, 20 org/rep
Control	Solvent and Dilution water	1 rep, 20 org/rep
LC_{50} (95% confidence interval) (μg/L)	24 h: 0.18 (0.11-0.28) 48 h: 0.078 (0.056-0.11) 72 h: 0.078 (0.056-0.11) 96 h: 0.078 (0.056-0.11)	Method: Binomial

Notes:

LC_{50} calculated based on measured concentrations.

Reliability points taken off for:
Documentation: Organism age (5), Photoperiod (3), Hypothesis tests (8)
Acceptability: Measured concentrations w/in 20% of nominal (4), Appropriate organism age (3), Photoperiod (2), Random design (2), Adequate replication (2), Hypothesis tests (3).

Toxicity Data Summary

Macrobrachium nippoensis

Study: Wang W, Cai DJ, Shan ZJ, Chen WL, Poletika N, Gao XW. 2007. Comparison of the acute toxicity for gamma-cyhalothrin and lambda-cyhalothrin to zebra fish and shrimp. Regulatory Toxicology and Pharmacology, 47: 184-188.

Relevance	Reliability
Score: 75 (No standard method, low chemical purity)	Score: 63
Rating: L	Rating: L

Reference	**Wang et al. 2007**	***M. nippoensis***
Parameter	**Value**	**Comment**
Test method cited	None cited	
Phylum	Arthropoda	
Class	Malacostraca	
Order	Decapoda	
Family	Palaemonoidea	
Genus	*Macrobrachium*	
Species	*nippoensis*	
Family in North America?	Yes	
Age/size at start of test/growth phase	90 d old, 5.0 g, 4.5 cm	
Source of organisms	Lab culture	Nanjing Institute of Environmental Sciences
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	96 h	
Data for multiple times?	Yes, 24, 48, 72 h	
Effect 1	Mortality	
Control response 1	0%	
Temperature	16 ± 2°C	
Test type	Static renewal, renewed every 24 h	
Photoperiod/light intensity	NR	
Dilution water	NR	
pH	7.1	
Hardness	6.8-8.0 °HG	
Alkalinity	NR	
Conductivity	NR	

Reference	**Wang et al. 2007**	***M. nippoensis***
Parameter	**Value**	**Comment**
Dissolved Oxygen	NR	
Feeding	None during test	
Purity of test substance	Kung Fu 25 EW formulation	
Concentrations measured?	Yes, but NR	
Measured is what % of nominal?	NR	
Chemical method documented?	Yes, GC-ECD	
Concentration of carrier (if any) in test solutions	None used	
Concentration 1 Nom/Meas (a.i. µg/L)	0.02	1 rep, 10 orgs/rep
Concentration 2 Nom/Meas (a.i. µg/L)	0.03	1 rep, 10 orgs/rep
Concentration 3 Nom/Meas (a.i. µg/L)	0.05	1 rep, 10 orgs/rep
Concentration 4 Nom/Meas (a.i. µg/L)	0.10	1 rep, 10 orgs/rep
Concentration 5 Nom/Meas (a.i. µg/L)	0.20	1 rep, 10 orgs/rep
Control	Dilution water	1 rep, 10 orgs/rep
LC_{50} (95% confidence interval) (µg/L)	24 h: 0.05 (0.04-0.07) 48 h: 0.05 (0.04-0.06) 72 h: 0.04 (0.03-0.06) 96 h: 0.04 (0.03-0.05)	Method: NR

Notes:

LC_{50} calculated based on nominal concentrations.

Reliability points taken off for:
Documentation: Chemical purity (5), Measured concentrations (3), Dilution water (3), Alkalinity (2), Dissolved oxygen (4), Conductivity (2), Photoperiod (3), Statistical methods (5), Hypothesis tests (8),
Acceptability: Standard method (5), Chemical purity (10), Measured concentrations w/in 20% nominal (4), Organisms randomized (1), Alkalinity (2), Dissolved oxygen (6), Conductivity (1), Photoperiod (2), Random design (2), Adequate replication (2), Statistical method (2), Hypothesis tests (3).

Toxicity Data Summary

Oncorhynchus mykiss (formerly *Salmo gairdneri*)

Study: Hill RW. 1984a. PP321: Determination of acute toxicity to rainbow trout (*Salmo gairdneri*). ICI Agrochemicals. DPR 50907-008.

Relevance
Score: 90 (No standard method)
Rating: R

Reliability
Score: 81
Rating: R

Reference	**Hill 1984a**	***O. mykiss***
Parameter	**Value**	**Comment**
Test method cited	None cited	
Phylum	Chordata	
Class	Osteichthyes	
Order	Salmoniformes	
Family	Salmonidae	
Genus	*Oncorhynchus*	
Species	*mykiss*	
Family in North America?	Yes	
Age/size at start of test/growth phase	Mean weight: 0.83 g Mean length: 38.3 mm	
Source of organisms	Continuous culture at testing facility	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	96 h	
Data for multiple times?	Yes; 24, 48, 72 h	
Effect 1	Mortality	
Control response 1	0%	
Temperature	12 ± 1°C	
Test type	Flow-through	
Photoperiod/light intensity	NR	
Dilution water	Freshwater reservoir	Not more specific
pH	7.7-7.9	
Hardness	72.4 mg/L	
Alkalinity	29.6 mg/L	
Conductivity	165 µS/cm	
Dissolved Oxygen	10.2-11.2 mg/L	
Feeding	NR	

Reference	**Hill 1984a**	***O. mykiss***
Parameter	**Value**	**Comment**
Purity of test substance	98%	
Concentrations measured?	Yes	
Measured is what % of nominal?	54-70%	
Chemical method documented?	Yes, GC-ECD	
Concentration of carrier (if any) in test solutions	9 mg/L acetone	
Concentration 1 Nom/Meas (μg/L)	1.0/0.63	1 rep, 20 org/rep
Concentration 2 Nom/Meas (μg/L)	0.56/0.37	1 rep, 20 org/rep
Concentration 3 Nom/Meas (μg/L)	0.32/0.21	1 rep, 20 org/rep
Concentration 4 Nom/Meas (μg/L)	0.18/0.11	1 rep, 20 org/rep
Concentration 5 Nom/Meas (μg/L)	0.10/0.07	1 rep, 20 org/rep
Concentration 6 Nom/Meas (μg/L)	0.056/0.03	1 rep, 20 org/rep
Control	Solvent and dilution water	1 rep, 20 org/rep
LC_{50} (95% confidence interval) (μg/L)	24 h: 0.52 (0.46-0.60) 48 h: 0.40 (0.35-0.45) 72 h: 0.27 (0.09-0.80) 96 h: 0.24 (0.08-0.70)	Method: Probit

Notes:

LC_{50} calculated based on mean measured concentrations.

Reliability points taken off for:
Documentation: Dilution water source (3), Photoperiod (3), Hypothesis tests (8),
Acceptability: No standard method (5), Measured concentrations w/in 20% nominal (4), Organisms randomized (1), Feeding (3), Dilution water (2), Photoperiod (2), Random design (2), Adequate replication (2), Hypothesis tests (8).

Toxicity Data Summary

Oncorhynchus mykiss

Study: Machado MW. 2001b. XDE-225 and Lambda-cyhalothrin: Comparative toxicity to Rainbow Trout (*Oncorhynchus mykiss)* under flow-through conditions.

Relevance
Score: 100
Rating: R

Reliability
Score: 90.5
Rating: R

Reference	**Machado 2001b**	***O. mykiss***
Parameter	**Value**	**Comment**
Test method cited	US EPA, OECD	
Phylum	Chordata	
Class	Osteichthyes	
Order	Salmoniformes	
Family	Salmonidae	
Genus	*Oncorhynchus*	
Species	*mykiss*	
Family in North America?	Yes	
Age/size at start of test/growth phase	39 mm, 0.52 g	
Source of organisms	Lab culture	Trout Lodge, Sumner, WA
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	Yes	
Test vessels randomized?	No	
Test duration	96 hr	
Data for multiple times?	Yes – 24 h, 48 hr, 72 hr	
Effect 1	Mortality	
Control response 1	0% at all times	
Temperature	12 ± 1°C	
Test type	Flow-through	
Photoperiod/light intensity	16 L: 8 D, 40-80 footcandles	
Dilution water	Well water	
pH	7.3	
Hardness	42-44 mg/L as $CaCO_3$	
Alkalinity	34-35 mg/L as $CaCO_3$	
Conductivity	140-150 µmhos/cm	
Dissolved Oxygen	8.6-10.0 mg/L (80-93% sat)	
Feeding	None during test	
Purity of test substance	99%	

Reference	**Machado 2001b**	***O. mykiss***
Parameter	**Value**	**Comment**
Concentrations measured?	Yes	
Measured is what % of nominal?	100-133%	
Chemical method documented?	Yes, GC/MS	
Concentration of carrier (if any) in test solutions	0.096 mL/L (0.0096%)	
Concentration 1 Nom/Meas (μg/L)	0.043/0.051	2 reps, 10 fish/rep
Concentration 2 Nom/Meas (μg/L)	0.071/0.078	2 reps, 10 fish/rep
Concentration 3 Nom/Meas (μg/L)	0.12/0.16	2 reps, 10 fish/rep
Concentration 4 Nom/Meas (μg/L)	0.20/0.20	2 reps, 10 fish/rep
Concentration 5 Nom/Meas (μg/L)	0.33/0.38	2 reps, 10 fish/rep
Control	0	2 reps, 10 fish/rep
LC_{50} (95% confidence interval)	24 h: >0.38 ug/L 48 h: 0.29 (0.25-0.33) ug/L 72 h: 0.22 (0.20-0.38) ug/L 96 h: 0.19 (0.16-0.20) ug/L	Method: nonlinear interpolation

Notes:

LC50 calculated based on measured concentrations.

Reliability points taken off for:
Documentation: Hypothesis tests (8)
Acceptability: Measured concentrations w/in 20% of nominal (4), Random design (2), Adequate replication (2), Hypothesis tests (3)

Toxicity Data Summary

Oncorhynchus mykiss (formerly *Salmo gairdneri*)

Study: Tapp JF, Sankey SA, Caunter JE, Harland BJ. 1989. Lambda-cyhalothrin: Determination of acute toxicity to rainbow trout (*Salmo gairdneri*). ICI Agrochemicals. DPR study 50907-085.

Relevance
Score: 100
Rating: R

Reliability
Score: 86.5
Rating: R

Reference	**Tapp et al. 1989**	***O. mykiss***
Parameter	**Value**	**Comment**
Test method cited	US EPA	
Phylum	Chordata	
Class	Osteichthyes	
Order	Salmoniformes	
Family	Salmonidae	
Genus	*Oncorhynchus*	Formerly *Salmo*
Species	*mykiss*	*gairdneri*
Family in North America?	Yes	
Age/size at start of test/growth phase	NR -mean weight and length of 1.12 g, 43 mm at end of test - > 19 d old	
Source of organisms	Commercial lab	Zeals Fish Farm, UK
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes, 19 d acclimatization	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	96 h	
Data for multiple times?	Yes; 24, 48, 72 h	
Effect 1	Mortality	
Control response 1	0%	
Temperature	12 ± 1°C	
Test type	Flow-through	
Photoperiod/light intensity	16 L: 8 D	
Dilution water	Dechlorinated tap water	
pH	7.4-7.8	
Hardness	63.0-65.7 mg/L	
Alkalinity	37.6 mg/L	

Reference	**Tapp et al. 1989**	***O. mykiss***
Parameter	**Value**	**Comment**
Conductivity	207-212 μS/cm	
Dissolved Oxygen	8.2-9.8 mg/L, >78 % sat	
Feeding	None during test	
Purity of test substance	81.5%	
Concentrations measured?	Yes	
Measured is what % of nominal?	59-82%	
Chemical method documented?	Yes, GC-ECD	
Concentration of carrier (if any) in test solutions	0.0005% acetone	
Concentration 1 Nom/Meas (μg/L)	1.0/0.72	1 rep, 20 org/rep
Concentration 2 Nom/Meas (μg/L)	0.56/0.33	1 rep, 20 org/rep
Concentration 3 Nom/Meas (μg/L)	0.32/0.20	1 rep, 20 org/rep
Concentration 4 Nom/Meas (μg/L)	0.18/0.12	1 rep, 20 org/rep
Concentration 5 Nom/Meas (μg/L)	0.1/0.076	1 rep, 20 org/rep
Concentration 6 Nom/Meas (μg/L)	0.056/0.046	1 rep, 20 org/rep
Control	Solvent and dilution water	1 rep, 20 org/rep
LC_{50} (95% confidence interval) (μg/L)	24 h: > 0.72 48 h: 0.57 (0.50-0.66) 72 h: 0.49 (0.43-0.58) 96 h: 0.44 (0.38-0.51)	Method: Moving average

Notes:

LC_{50} calculated based on mean measured concentrations.

Reliability points taken off for:
Documentation: Initial organism age (5), Hypothesis tests (8)
Acceptability: Measured concentrations w/in 20% of nominal (4), Appropriate organism age (3), Random design (2), Adequate replication (2), Hypothesis tests (3).

Toxicity Data Summary

Oryzias latipes

Study: Kent SJ, Shillabeer N. 1997d. Lambda-cyhalothrin: Acute toxicity to Japanese rice fish (*Oryzias latipes*). ZENECA Agrochemicals. DPR study number 50907-085.

Relevance
Score: 85 (not from N. America)
Rating: L

Reliability
Score: 84
Rating: R

Reference	**Kent & Shillabeer 1997d**	***O. latipes***
Parameter	**Value**	**Comment**
Test method cited	US EPA, OECD	
Phylum	Chordata	
Class	Actinopterygii	
Order	Beloniformes	
Family	Adrianichthyidae	
Genus	*Oryzias*	
Species	*latipes*	
Family in North America?	No	
Age/size at start of test/growth phase	NR ➢ >17 d old ➢ mean control weight and length 0.22 g and 25 mm at end of test.	
Source of organisms	Lab culture	Aquatic Research Organisms, Hampton, NH, USA
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	17 d acclimation in facility
Animals randomized?	Yes	
Test vessels randomized?	NR	
Test duration	96 h	
Data for multiple times?	Yes; 24, 48, 72 h	
Effect 1	Mortality	
Control response 1	Dil water: 20% Solvent: 0%	
Temperature	25 ± 1°C	
Test type	Flow-through	
Photoperiod/light intensity	NR	
Dilution water	Dechlorinated tap water	
pH	7.63-7.83	

Reference	**Kent & Shillabeer 1997d**	***O. latipes***
Parameter	**Value**	**Comment**
Hardness	40.0-48.7 mg/L	
Alkalinity	27.4 mg/L	
Conductivity	197-215 µS/cm	
Dissolved Oxygen	7.6-8.8 mg/L	
Feeding	None during test	
Purity of test substance	87.7%	
Concentrations measured?	Yes	
Measured is what % of nominal?	16-58%	
Chemical method documented?	Yes, GC-ECD	
Concentration of carrier (if any) in test solutions	0.01% dimethylformamide	
Concentration 1 Nom/Meas (µg/L)	0.30/0.047	1 rep, 10 org/rep
Concentration 2 Nom/Meas (µg/L)	0.60/0.24	1 rep, 10 org/rep
Concentration 3 Nom/Meas (µg/L)	1.2/0.25	1 rep, 10 org/rep
Concentration 4 Nom/Meas (µg/L)	2.4/0.95	1 rep, 10 org/rep
Concentration 5 Nom/Meas (µg/L)	4.8/2.5	1 rep, 10 org/rep
Concentration 6 Nom/Meas (µg/L)	9.6/5.6	1 rep, 10 org/rep
Control	Solvent and Dilution water	1 rep, 10 org/rep
LC_{50} (95% confidence interval) (µg/L)	24 h: 2.1 (1.5-3.3) 48 h: 1.5 (1.0-2.6) 72 h: 1.4 (0.93-2.3) 96 h: 1.4 (0.93-2.3)	Method: Moving average angle

Notes:

LC_{50} calculated based on measured concentrations.

Reliability points taken off for:
Documentation: Organism age (5), Photoperiod (3), Hypothesis tests (8)
Acceptability: Measured concentrations w/in 20% of nominal (4), Appropriate organism age (3), Photoperiod (2), Random design (2), Adequate replication (2), Hypothesis tests (3).

Toxicity Data Summary

Ostracoda

Study: Hamer MJ, Ashwell JA, Gentle WE. 1998. Lambda-cyhalothrin Acute Toxicity to Aquatic Arthropods. ZENECA Agrochemicals, Jealott's Hill Research Station Bracknell, Berkshire, UK. DPR study number 50907-093.

Relevance
Score: 100
Rating: R

Reliability
Score: 83.5
Rating: R

Reference	**Hamer et al. 1998**	***Ostracoda***
Parameter	**Value**	**Comment**
Test method cited	USEPA, OECD	
Phylum	Arthropoda	
Subphylum	Crustacea	
Class	Ostracoda*	
Family	NR	
Genus	NR	
Species	NR	
Family in North America?	Yes	
Age/size at start of test/growth phase	NR	
Source of organisms	Lab culture	From *H. azteca* culture
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	NR	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	48 h	
Data for multiple times?	No	
Effect 1	Immobility	
Control response 1	0%	
Effect 2	Mortality	
Control response 2	0%	
Temperature	20 ± 2°C	
Test type	Static	
Photoperiod/light intensity	16 L:8 D, 700-1000 lux	
Dilution water	Mixture of dechlorinated and RO filtered tap water	
pH	7.8-8.8	
Hardness	179 mg/L	
Alkalinity	150 mg/L	

Reference	**Hamer et al. 1998**	***Ostracoda***
Parameter	**Value**	**Comment**
Conductivity	NR	
Dissolved Oxygen	8.4-8.7 mg/L	
Feeding	None during test	
Purity of test substance	≥ 88% radiochemical purity	
Concentrations measured?	Yes	
Measured is what % of nominal?	t_0: 81-104%; 48 h: 37-43%	
Chemical method documented?	Yes, LSC	
Concentration of carrier (if any) in test solutions	0.05%	
Concentration 1 Nom/Meas t_0/48 h (µg/L)	250/202/100	1 rep, 10 orgs/rep
Concentration 2 Nom/Meas t_0/48 h (ng/L)	500/434/213	1 rep, 10 orgs/rep
Concentration 3 Nom/Meas t_0/48 h (ng/L)	1000/900/405	1 rep, 10 orgs/rep
Concentration 4 Nom/Meas t_0/48 h (ng/L)	2000/1988/838	1 rep, 10 orgs/rep
Concentration 5 Nom/Meas t_0/48 h (ng/L)	4000/4155/1722	1 rep, 10 orgs/rep
Concentration 6 Nom/Meas t_0/48 h (ng/L)	8000/8078/2988	1 rep, 10 orgs/rep
Control (ng/L)	Dil. water and solvent: <10	1 rep, 10 orgs/rep
EC_{50} (95% confidence interval)	3300 (2100-6600) ng/L	Method: Iteratively re-weighted linear regression

* The binomial name was not available, as these organisms were collected from the field and species identification is very difficult and not well-described in the literature. There were no other data available for similar organisms, so there is no question about combining values for a species mean value and the variability (as shown by the 95% confidence interval) is low, so it is reasonable to believe that the test organisms were all one species.

Notes:
LC_{50} values not calculated.
EC_{50} calculated based on nominal concentrations.

Reliability points taken off for:
Documentation: Organism age (5), Conductivity (2), Hypothesis tests (8)
Acceptability: No standard method (5), Measured concentrations w/in 20% of nominal (4), Appropriate organism age (3), Organisms randomized (1), Acclimation (1), Exposure type (2), Temperature variance (3), Conductivity (1), Random design (2), Appropriate statistical method (2), Hypothesis tests (3).

Toxicity Data Summary

Pimephales promelas

Study: Kent SJ, Shillabeer N. 1997e. Lambda-cyhalothrin: Acute toxicity to fathead minnow (*Pimephales promelas*). ZENECA Agrochemicals. DPR study number 50907-085.

Relevance
Score: 100
Rating: R

Reliability
Score: 84
Rating: R

Reference	**Kent & Shillabeer 1997e**	***P. promelas***
Parameter	**Value**	**Comment**
Test method cited	US EPA, OECD	
Phylum	Chordata	
Class	Osteichthyes	
Order	Cypriniformes	
Family	Cyprinidae	
Genus	*Pimephales*	
Species	*promelas*	
Family in North America?	Yes	
Age/size at start of test/growth phase	NR ➢ >31 weeks old ➢ mean control weight and length 0.37 g and 28 mm at end of test.	EPA recommendation 0.5-5 g, but smaller fish should be more sensitive
Source of organisms	Continuous lab culture	Brixham Environmental Laboratory
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	Reared in same conditions
Animals randomized?	Yes	
Test vessels randomized?	NR	
Test duration	96 h	
Data for multiple times?	Yes; 24, 48, 72 h	
Effect 1	Mortality	
Control response 1	0%	
Temperature	25 ± 1°C	
Test type	Flow-through	
Photoperiod/light intensity	NR	
Dilution water	Dechlorinated tap water	
pH	7. 23-7.60	
Hardness	39.3-44.6 mg/L	
Alkalinity	22.7 mg/L	

Reference	**Kent & Shillabeer 1997e**	***P. promelas***
Parameter	**Value**	**Comment**
Conductivity	222-229 μS/cm	
Dissolved Oxygen	7.6-8.0 mg/L	
Feeding	None during test	
Purity of test substance	87.7%	
Concentrations measured?	Yes	
Measured is what % of nominal?	38-68%	
Chemical method documented?	Yes, GC-ECD	
Concentration of carrier (if any) in test solutions	0.01% dimethylformamide	
Concentration 1 Nom/Meas (μg/L)	0.060/0.025	1 rep, 20 org/rep
Concentration 2 Nom/Meas (μg/L)	0.125/0.082	1 rep, 20 org/rep
Concentration 3 Nom/Meas (μg/L)	0.25/0.17	1 rep, 20 org/rep
Concentration 4 Nom/Meas (μg/L)	0.50/0.34	1 rep, 20 org/rep
Concentration 5 Nom/Meas (μg/L)	1.0/0.38	1 rep, 20 org/rep
Concentration 6 Nom/Meas (μg/L)	2.0/1.3	1 rep, 20 org/rep
Control	Solvent and Dilution water	1 rep, 20 org/rep
LC_{50} (95% confidence interval) (μg/L)	24 h: 0.89 (0.73-1.1) 48 h: 0.89 (0.73-1.1) 72 h: 0.70 (0.38-1.3) 96 h: 0.70 (0.38-1.3)	Method: Moving average angle (24, 48 h); Binomial (72, 96 h)

Notes:

LC_{50} calculated based on measured concentrations.

Reliability points taken off for:
Documentation: Organism age (5), Photoperiod (3), Hypothesis tests (8)
Acceptability: Measured concentrations w/in 20% of nominal (4), Appropriate organism age (3), Photoperiod (2), Random design (2), Adequate replication (2), Hypothesis tests (3).

Toxicity Data Summary

Pimephales promelas

Study: Tapp JF, Maddock BG, Harland BJ, Stembridge HM, Gillings E. 1990. Lambda-cyhalothrin (Karate PP321): Determination of chronic toxicity to fathead minnow (*Pimephales promelas)* full lifecycle. ICI Agrochemicals. Imperial Chemical Industries PLC, Brixham Laboratory, Brixham UK. MRID 41519001.

Relevance
Score: 100
Rating: R

Reliability
Score: 93.5
Rating: R

Reference	**Tapp et al. 1990**	***P. promelas***
Parameter	**Value**	**Comment**
Test method cited	EPA 1986 EPA 540/9-86-137	Some deviations from method, but determined to be scientifically sound
Phylum	Chordata	
Class	Osteichthyes	
Order	Cypriniformes	
Family	Cyprinidae	
Genus	*Pimephales*	
Species	*promelas*	Rafinesque
Family in North America?	Yes	
Age/size at start of test/growth phase	F_0: eggs when first exposed (chronic), larvae (acute) F_1: larvae when first exposed	
Source of organisms	Lab culture	Sea Plantation Eng. Tech. Salem, MA
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	Yes	
Test vessels randomized?	NR	
Test duration	300 d	
Data for multiple times?	Yes	96 hr, 7, 14, 21, 28, 42, 56 d
Effect 1	Hatching	
Control response 1	F0: 87.3% F1: 96.1%	Solvent and Dil water control pooled bc no sig differences found
Effect 2	Survival	

Reference	**Tapp et al. 1990**	***P. promelas***
Parameter	**Value**	**Comment**
Control response 2	F_0: 96 hr 100%, 28d 93%, 56d 91%, 300 d 81.3% F_1: 56 d 79.6%	Solvent and Dil water control pooled bc no sig differences found
Effect 3	Length	
Control response 3	F_0: 20.95 mm (28 d), 31.4 mm (56 d), 52.5 mm (300 d) F_1: 25.0 mm (56 d)	Solvent and Dil water control pooled bc no sig differences found
Effect 4	Weight	
Control response 4	F_0: 3135.6 g (300 d) F_1: 240.4 g (56 d)	Solvent and Dil water control pooled bc no sig differences found
Effect 5	Egg production	
Control response 5	F_0: 74 eggs/batch 5918.8 total eggs produced	Solvent and Dil water control pooled bc no sig differences found
Temperature	25 ± 1°C	
Test type	FT	
Photoperiod/light intensity	16L:8D, 1100-1806 lux	
Dilution water	Filtered and dechlorinated tap water	
pH	6.09-8.36 (mean 7.2)	
Hardness	45.1 mg/L as $CaCO_3$ (mean)	Range 32.6-57.0
Alkalinity	26.1 mg/L as $CaCO_3$ (mean)	Range 18.6-33.9
Conductivity	100-160 uS/cm (mean 125 uS/cm)	
Dissolved Oxygen	7.06 mg/L (mean)	Not aerated
Feeding	Yes, differed as fish aged	Not fed w/in 24 hr of weighing
Purity of test substance	97%	
Concentrations measured?	Yes	
Measured is what % of nominal?	65-72% total cyhalothrin 50-56% l-cyhalothrin	
Chemical method documented?	Yes, LSC	GC/MS confirmation
Concentration of carrier (if any) in test solutions	0.00125% 12.5 uL/L	Triethylene glycol
Concentration 1 Nom/Meas (µg/L)	0.03/0.019/0.015	Duplicates and 40 eggs/rep, then 25 larvae/rep, then 4 mating pairs/rep

Reference	**Tapp et al. 1990**	***P. promelas***
Parameter	**Value**	**Comment**
Concentration 2 Nom/Meas (µg/L)	0.06/0.040/0.031	Same as above
Concentration 3 Nom/Meas (µg/L)	0.12/0.081/0/062	Same as above
Concentration 4 Nom/Meas (µg/L)	0.25/0.180/0.139	Same as above
Concentration 5 Nom/Meas (µg/L)	0.50/0.354/0.273	Same as above
Concentration 6 Nom/Meas (µg/L)	1.0 – 96 hr test only	Same as above
Control	Dilution water and solvent	Same as above
LC_{50} (95% confidence interval) (µg/L)	F_0 72 hr: 0.407 (0.316-0.675) F_0 96 hr: 0.360 (0.252-0.765) F_0 28 d: 0.114 (0.101-0.130) F_0 56 d: 0.108 (0.095-0.124) F_1 56 d: 0.059 (0.052-0.067)	Method: Moving average
NOEC (µg/L)	F_0 generation Hatch: ≥ 0.273 28 d Survival: 0.062 56 d Survival: 0.062 28 d Length: ≥ 0.139 56 d Length: ≥ 0.139 150-300 d Survival: ≥ 0.139 300 d Length: ≥ 0.139 300 d Weight: ≥ 0.139 Egg production: 0.062 F_1 generation 3-5 d Hatch: 0.062 **56 d Survival: 0.031** 56 d Length: ≥ 0.139 56 d Weight: ≥ 0.139 Overall: 0.031	Method: exact 2x2 contingency table test (Hatch & % survival), Dunnett's t-tests, t-tests, 1 way and 2 way ANOVA (length & weight), t-tests & 1 way ANOVA (egg production) p: 0.05 MSD: NR
LOEC (µg/L)	F_0 generation Hatch: > 0.273 28 d Survival: 0.139 56 d Survival: 0.139 28 d Length: > 0.139 56 d Length: > 0.139 150-300 d Survival: > 0.139	Same as above

Reference	**Tapp et al. 1990**	***P. promelas***
Parameter	**Value**	**Comment**
	300 d Length: > 0.139 300 d Weight: > 0.139 Egg production: 0.139 F_1 generation 3-5 d Hatch: 0.139 **56 d Survival: 0.062** 56 d Length: > 0.139 56 d Weight: > 0.139 Overall: 0.062	
MATC (GeoMean NOEC,LOEC)	0.044 ug/L (>0.031, <0.062)	
% control at NOEC	NR	
% of control LOEC	NR	

Notes:

- All toxicity values calculated based on measured concentrations – corrected mean measured concentrations of lambda-cyhalothrin (accounts for isomerization)
- The 72/96 hr LC_{50} test was run as a separate test but with the same organisms as from the F_0 tests

Bioconcentration factors (BCF)
F_0 adults: 4982 (SD=1233) µg/L
F_1 eggs: 1311 (SD=130) µg/L
F_1 larvae: 4299 (SD=806) µg/L

Reliability points taken off for:
Documentation: Statistical significance (2), Minimum significant difference (2), % control at NOEC/LOEC (2)
Acceptability: Measured conc w/in 20% nominal (4), Random design (2), Minimum significant difference (1)

Toxicity Data Summary

Poecilia reticulata

Study: Kent SJ, Shillabeer N. 1997b. Lambda-cyhalothrin: Acute toxicity to the guppy (*Poecilia reticulata*). ZENECA Agrochemicals. DPR study number 50907-085.

Relevance
Score: 100
Rating: R

Reliability
Score: 84
Rating: R

Reference	**Kent & Shillabeer 1997b**	***P. reticulata***
Parameter	**Value**	**Comment**
Test method cited	US EPA, OECD	
Phylum	Chordata	
Class	Osteichthyes	
Order	Cyprinodontiformes	
Family	Poeciliidae	
Genus	*Poecilia*	
Species	*reticulata*	
Family in North America?	Yes	
Age/size at start of test/growth phase	NR ➢ >17 d old ➢ mean control weight and length 2.15 g and 53 mm at end of test.	
Source of organisms	Lab culture	London Aquatic Co., UK
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	17 d acclimation in facility
Animals randomized?	Yes	
Test vessels randomized?	NR	
Test duration	96 h	
Data for multiple times?	Yes; 24, 48, 72 h	
Effect 1	Mortality	
Control response 1	0%	
Temperature	12 ± 1°C	
Test type	Flow-through	
Photoperiod/light intensity	NR	
Dilution water	Dechlorinated tap water	
pH	7.04-7.39	
Hardness	43.3-46.3 mg/L	
Alkalinity	25 mg/L	
Conductivity	212-218 µS/cm	

Reference	**Kent & Shillabeer 1997b**	***P. reticulata***
Parameter	**Value**	**Comment**
Dissolved Oxygen	9.2-10.4 mg/L, > 87% sat	
Feeding	None during test	
Purity of test substance	87.7%	
Concentrations measured?	Yes	
Measured is what % of nominal?	43-58%	
Chemical method documented?	Yes, GC-ECD	
Concentration of carrier (if any) in test solutions	0.01% dimethylformamide	
Concentration 1 Nom/Meas (μg/L)	0.030/0.017	1 rep, 20 org/rep
Concentration 2 Nom/Meas (μg/L)	0.060/0.026	1 rep, 20 org/rep
Concentration 3 Nom/Meas (μg/L)	0.12/0.056	1 rep, 20 org/rep
Concentration 4 Nom/Meas (μg/L)	0.24/0.11	1 rep, 20 org/rep
Concentration 5 Nom/Meas (μg/L)	0.48/0.28	1 rep, 20 org/rep
Concentration 6 Nom/Meas (μg/L)	0.96/0.48	1 rep, 20 org/rep
Control	Solvent and Dilution water	1 rep, 20 org/rep
LC_{50} (95% confidence interval) (μg/L)	24 h: 0.18 (0.11-0.28) 48 h: 0.078 (0.056-0.11) 72 h: 0.078 (0.056-0.11) 96 h: 0.078 (0.056-0.11)	Method: Binomial

Notes:

LC_{50} calculated based on measured concentrations.

Reliability points taken off for:
Documentation: Organism age (5), Photoperiod (3), Hypothesis tests (8)
Acceptability: Measured concentrations w/in 20% of nominal (4), Appropriate organism age (3), Photoperiod (2), Random design (2), Adequate replication (2), Hypothesis tests (3).

Toxicity Data Summary

Procambarus clarkii

Study: Barbee GC, Stout MJ. 2009. Comparative acute toxicity of neonicotinoid and pyrethroid insecticides to non-target crayfish (*Procambarus clarkii)* associated with rice-crayfish crop rotations. Pesticide Management and Science, 65:1250-1256

Relevance
Score: 100
Rating: R

Reliability
Score: 83.5
Rating: R

Reference	**Barbee & Stout 2009**	***P. clarkii***
Parameter	**Value**	**Comment**
Test method cited	ASTM static renewal method	2002
Phylum	Arthropoda	
Class	Malacostraca	
Order	Decapoda	
Family	Cambaridae	
Genus	*Procambarus*	
Species	*clarkii*	
Family in North America?	Yes	
Age/size at start of test/growth phase	3 months 6.7 cm long, 9.0 g	
Source of organisms	Outdoor university culture canals	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	Yes	
Test vessels randomized?	NR	
Test duration	96 h	
Data for multiple times?	No	
Effect 1	Mortality	
Control response 1	0 %	
Temperature	21.7 ± 1.5°C	
Test type	Static renewal	
Photoperiod/light intensity	16 L: 8 D	
Dilution water	Filtered tap water	
pH	7.3	
Hardness	268 mg/L	
Alkalinity	214 mg/L	
Conductivity	NR	
Dissolved Oxygen	> 60 % saturation	
Feeding	None during test	

Reference	**Barbee & Stout 2009**	***P. clarkii***
Parameter	**Value**	**Comment**
Purity of test substance	99.1%	
Concentrations measured?	No	
Measured is what % of nominal?	n/a	
Chemical method documented?	No	
Concentration of carrier (if any) in test solutions	% NR, acetone	
Concentration 1 Nom (µg/L)	0.1	2 reps, 5 orgs/rep
Concentration 2 Nom (µg/L)	0.2	2 reps, 5 orgs/rep
Concentration 3 Nom (µg/L)	0.3	2 reps, 5 orgs/rep
Concentration 4 Nom (µg/L)	0.6	2 reps, 5 orgs/rep
Concentration 5 Nom (µg/L)	1.0	2 reps, 5 orgs/rep
Control	Solvent and dilution water	2 reps, 5 orgs/rep
LC_{50} (95% confidence limits)	0.16 (0.06-0.27) µg/L	Method: Probit

Notes:

LC50 calculated based on nominal concentrations.

Reliability points taken off for:
Documentation: Analytical method (4), Measured concentrations (3), Conductivity (2), Hypothesis tests (8)
Acceptability: Measured concentrations w/in 20% of nominals (4), Carrier solvent (4), Conductivity (1), Random design (2), Adequate replication (2), Hypothesis tests (3)

Toxicity Data Summary

Various species (16)

Study: Schroer AFW, Belgers JDM, Brock TCM, Matser AM, Maund SJ, Vann den Brink PJ. 2004. Comparison of Laboratory Single Species and Field Population-Level Effects of the Pyrethroid Insecticide l-cyhalothrin on Freshwater Invertebrates. Arch Environ Contam Toxicol, 46: 324-335.

Relevance
Score: 67.5 (No standard method, low chemical purity, control response not acceptable)

Rating: N