WHITE PAPER

Information in Suppport of Chlorothalonil Use in the Western United States relative to Endangered Salmonid Species.
(revised)

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Summary

Chlorothalonil is a broad spectrum protectant fungicide with a unique multi-site mode of action, widely used in agriculture (Bravo) and on turf (Daconil). Chlorothalonil because of its mode of action is a critical tool in fungicide resistance management. This document contains Syngenta Crop Protection, Inc.'s assessment concerning risk to federally listed threatened and endangered salmonids and their critical habitat in the Western United States from the use of chlorothalonil. Chlorothalonil is classified as very highly toxic to fish based on laboratory studies and a screening level assessment, such as that performed by EPA in the Chlorothalonil Reregistration Eligibility Decision (US EPA 1999), indicates concerns for acute risk to fish. However, chlorothalonil rapidly dissipates in aquatic systems resulting in no potential for chronic exposure. Also higher tier effects data indicate that in the environment exposure and thus acute toxicity is substantially mitigated and any acute effects on fish are unlikely in aquatic ecosystems. In a screening level assessment, risk to organisms which may act as a food source could also raise concerns, however higher tier data indicate that chlorothalonil does not pose an adverse risk to these food organisms nor does it affect any other components of critical habitat. This absence of effects are explained by the fact chlorothalonil rapidly dissipates in aquatic environments. Of the 26 listed threatened and endangered Evolutionary Significant Units (ESUs) of Pacific salmon and steelhead, assessments based on ESU habitat and chlorothalonil use concluded that chlorothalonil will have no effect.

Introduction

The risk assessment process is described in "Hazard Evaluation Division – Standard Evaluation Procedure – Ecological Risk Assessment" by Urban and Cook (1986). In the initial assessment, the toxicity of a pesticide for species from various taxonomic groups is compared with an estimate of exposure. A risk quotient (RQ) is derived from exposure divided by toxicity and compared to an EPA established Level of Concern (LOC) trigger for various categories of organism and test type. Table 1 shows the LOCs used in previous EPA Field External Affairs Division (FEAD) endangered species assessments (http://www.epa.gov/oppfead1/endanger/effects).

Following the methods of Urban and Cook (1986), further aquatic toxicological data are available for chlorothalonil, in the form of tier 4 studies (fish/aquatic invertebrate population studies in the field; simulated and actual field effects data on aquatic organisms). These studies are used herein to refine the assessment where appropriate, for example if LOCs are exceeded or to confirm positions inferred at lower tiers.

Table 1. The Levels of Concern (LOCs) for aquatic organisms used in previous FEAD endangered species assessments.

Test Data	Level of Concern - where the Risk Quotient (RQ)	Reason for Risk Assessment Refinement/Further action
Acute LC_{50}	>0.5	Potentially high acute risk
Acute LC_{50}	>0.1	Risk that may be mitigated through restricted use classification
Acute LC_{50}	>0.05 [a]	Endangered species may be affected acutely, including sublethal effects
Chronic NOEC	>1 [a]	Chronic risk; endangered species may be affected chronically, including reproduction and effects on progeny
Acute Invertebrate LC_{50}	>0.5	May be indirect effects on endangered fish through food supply reduction
Aquatic Plant Acute EC_{50}	>1	May be indirect effects on aquatic vegetative cover for endangered fish

[a] Where the RQ is below the Level of Concern there is no effect on endangered species

Chlorothalonil Use Profile

Chlorothalonil is a broad-spectrum fungicide used on a wide variety of food and non-food crops across the Western US. There are also non-ag uses of chlorothalonil, it is labelled for use to control diseases on turf on golf courses, lawns around institutional, public, commercial and industrial buildings, parks recreational areas and athletic fields (use on home lawns is prohibited). However, the total poundage used in non-ag are insignificant (Kline & Company, Inc, 2000) compared to agricultural uses. Use of chlorothalonil on golf course turf and to lesser extent nurseries represents the majority of non-agricultural uses in western states.

For California, full pesticide use data are reported by all applicators, the latest information for California use is for 2001 and is available at http://www.cdpr.ca.gov/docs/pur/pur01rep/01_pur.htm. These data indicate for each crop, the amounts used and the acres treated, at a county level. In Oregon, Washington, and Idaho, Doane AgroTrak® (Doanes Marketing Research 2001) data was analyzed to determine where chlorothalonil was used in the Western US for the period of 1999-2001. Doane GolfTrak ® (Doanes Marketing Research 2001) data was used to represent non-crop data in Oregon, Washington, and Idaho. Detailed use information for crops and counties is available in the Appendix.

Environmental Fate and Exposure

Chlorothalonil is readily dissipated, particularly in aquatic environments. Data concerning the dissipation rate of chlorothalonil in freshwater and marine sediment/water systems has previously been reviewed by US EPA (Table 2). The published study by Davies (1988), investigating the half-life of chlorothalonil in laboratory systems, showed a range of dissipation rates. In water alone, half lives were 150 and 80 hours, respectively, at 5 and 15°C. However the presence of a biotic component, in the form of fish and algae, together with aeration, increased dissipation significantly with half-lives of 4.3 and 7.7 hours, respectively.

Table 2 : Dissipation in Laboratory Systems

Study Description	System Components	Nominal Conc. (μg/l)	Calculated Half-life (hours)	Reference
Shake Flask Study	Sediment, water	670	1.4 (fwater) 1.0 (marine)	Hatzenbeler and Doran 1991
96 hour Aquarium Study	Marine sediment, water	100	0.4	Kabler 1993
Disappearance in the Aquatic Environment	Stream water, fish Stream water, algae	20 20	4.4 7.7	Davies 1988

Since completion of the chlorothalonil RED (US EPA, 1999), additional data has been generated to characterize the dissipation of chlorothalonil in aquatic systems. The dissipation rate of chlorothalonil was studied in both indoor and outdoor microcosms, applied as a 720 g/l soluble concentrate formulation at nominally 25 μg ai/l (Gentle WE, 1999). In an indoor microcosm, containing water, sediment and aquatic plants, at approximately 18°C, chlorothalonil disappeared from the water with a half-life of 4 hours (see Figure 1).

In replicated outdoor systems containing water, sediment, aquatic plants and invertebrates at approximately 10°C, two applications of chlorothalonil formulated as a 720 g/l SC) one week apart all gave half-lives of approximately 8 hours (Gentle WE and Tattersfield LJ, 2000).

The conclusion from the environmental fate studies, is that due to the very rapid dissipation of chlorothalonil in natural aquatic environments (<8 h) there will be no long term exposure and consequently no long term risk. Therefore the following assessment focuses on the potential for effects from short-term exposures.

Figure 1 : Dissipation of Chlorothalonil in an Indoor Microcosm

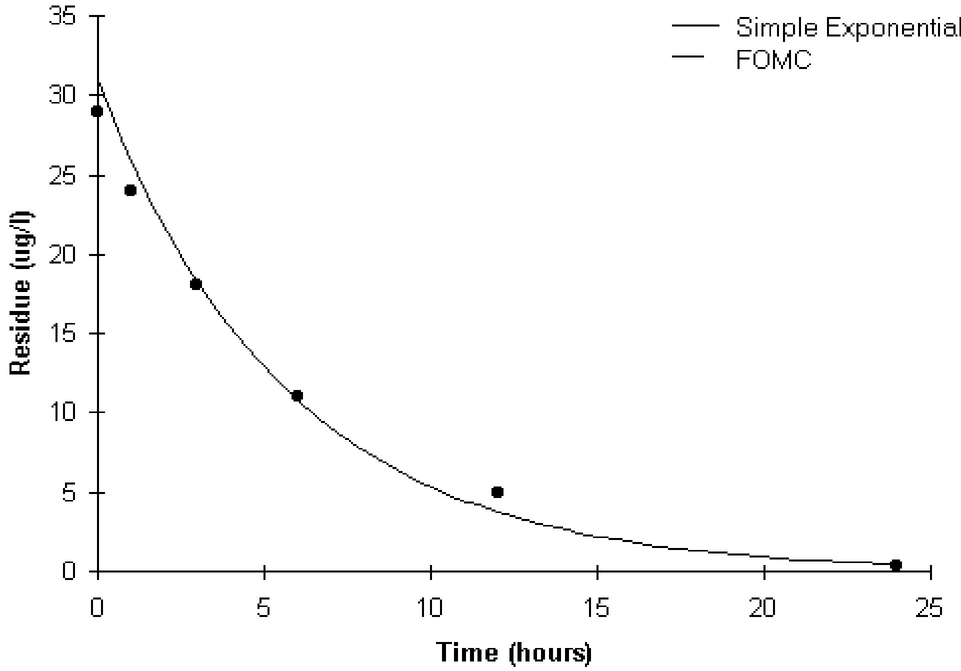
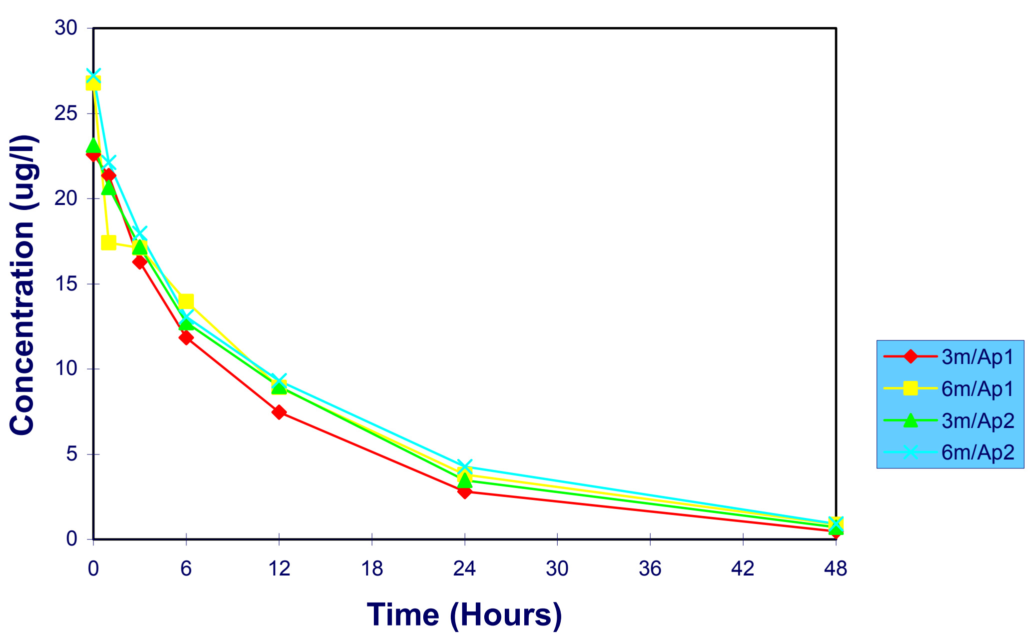


Figure 2 : Dissipation of Chlorothalonil in an Outdoor Microcosm



Estimated Environmental Concentrations of Chlorothalonil

An estimate of exposure is required to combine with an analysis of toxicity to determine risk to aquatic organisms. OPP uses a suite of established models, in a tiered process, to develop aquatic Estimated Environmental Concentrations (EECs).

The first and second tiers are GENEEC and PRZM/EXAMS, respectively. Below, in Table 3, copied from the chlorothalonil RED (US EPA, 1999), are the EECs for representative crops for the PRZM/EXAMS calculations. Due to the uncertainty at that time as to the aquatic half-life, there were 2 calculations done for each scenario, using half-lives of 2 and 44 hours. The different half-lives have little effect on the peak EEC, rather it affects the longer term EECs. The studies discussed above indicate the aquatic half-life is closer to the 2 hour value rather than the 44 hours. The other environmental fate parameters used in the modeling were Koc 1380, aerobic soil half-life 30 days.

Table 3: Estimated Environmental Concentrations for Chlorothalonil using PRZM2-EXAMS (from Chlorothalonil RED)

Crop	Aerobic Aquatic Half-life, in hours	Application Rate, lbs ai/A (# applications; interval, in days)	Peak EEC, in ppb	4-Day EEC, in ppb	21-Day EEC, in ppb	60-Day EEC, in ppb	90-Day EEC, in ppb
Cucurbits	2	1.75 (4;7)*	17.6	2.6	0.81	0.81	0.56
	44	1.75 (4;7)	18.5	8.8	3.6	2.4	1.7
	2	2.25 (8;7)	32.4	5.2	1.4	1.8	1.3
	44	2.25 (8;7)	33.1	16.9	6.0	4.9	3.6
	2	6.25 (1;-)	17.6	3.5	1.1	0.81	0.55
	44	6.25 (1;-)	20.1	11.9	4.5	2.3	1.6
Peanuts	2	1.125 (6;14)*	17.5	3.3	0.91	0.88	0.69
	44	1.125 (6;14)	20.3	9.9	3.4	2.4	1.8
	2	1.125 (9;10)	24.2	4.1	1.1	1.3	1.0
	44	1.125 (9;10)	25.8	13.6	4.3	3.4	2.8
Potatoes	2	1.125 (6;10)*	5.5	1.3	0.51	0.56	0.37
	44	1.125 (6;10)	7.7	4.3	2.2	1.5	1.0
	2	1.125 (10;7)	6.8	1.6	0.54	0.77	0.58
	44	1.125 (10;7)	9.4	5.1	2.3	2.0	1.5
Tomatoes	2	1.75 (5;7)*	26.1	4.2	1.1	1.0	0.69
	44	1.75 (5;7)	26.8	14.0	4.6	2.8	1.9
	2	2.25 (8;7)	42.3	6.8	1.7	1.9	1.3
	44	2.25 (8;7)	43.8	22.6	7.2	5.0	3.5

* "Typical" application rate

OPP use the EECs from the farm pond model to represent exposure in first order streams. In many areas these first order streams will be upstream from the agricultural areas where chlorothalonil is likely to be used. Many of the assumptions inherent in the farm pond simulations are highly conservative, even when considering a farm pond. For example, all runoff from a 10-ha field is received by a 1-ha static pond deep with no sources of water input – not even the water in runoff; no water from the treated field or rainfall enters the pond to dilute residues in runoff; there is no overflow or flow through the system; buffers from aquatic bodies are not considered. However, it is acknowledged that these farm pond models are not appropriate and overly conservative for larger streams, rivers and lakes where many of the threatened and endangered (T&E) salmonid species live (Turner 2003).

In addition to agricultural use, chlorothalonil is used in landscape maintenance, to control turf diseases. The major use is on golf courses, where up to 13.4 lb ai/A in a season may be applied. The reported application rate is obtained from the actual acre treated. The rate of application and the number of applications is dependent on what segment of the course is being treated. Chlorothalonil is not used in the "rough" areas, approximately 55% of the course. Fairways, approximately 41% of the total area, receive low rates, but that area is not commonly treated. Rate and number of applications increases on the 4% of the area that represents tees and greens of the course, with most use on the greens. But, the actual area being treated is very small, in comparison to the whole course. Thus, while the application rate appears high in relation to agricultural uses, the area being treated within a unit area (course total) is very small. Furthermore, the potential movement of chlorothalonil off-target on golf courses is reduced. Application equipment is normally handheld or powered by small engines and presents minimal potential for drift compared to the larger ground hydraulic equipment used in agriculture. Golf courses typically have trees to provide shade and for aesthetic reasons – these significantly reduce wind speeds – another factor in minimizing drift. Because of the characteristics of turf (100% ground cover, high organic matter increasing adsorption and degradation and also minimizing transport, high infiltration, minimal erosion), it is also significantly less subject to runoff than an agricultural field. The half-life of chlorothalonil in turf-grass has been determined at 4.9 days (Wu et al, 2002), reducing the amount available for run-off.

Much of the surface water into which run-off and drainage might occur on a golf course would likely be to ponds that are not an environment where endangered salmonids will live. As for streams, the farm pond model is not considered an appropriate scenario for turf. However, modelling golf-course applications using the tier 1 model GENEEC gives concentrations up to approximately 100 μg/l. GENEEC is an agricultural scenario and will overestimate run-off in turf by at least an order of magnitude. Dissipation is enhanced through increased microbial activity in the thatch and transport is reduced as the areas on which chlorothalonil is applied are not prone to sediment transport and the thatch acts as a vegetative filter strip. Worst-case turf EECs should be therefore below that from most agricultural applications.

In the conclusion of the chorothalonil RED, all of the maximum allowable application rates for chlorothalonil products on the uses above (Table 3 and turf) and several other uses were mitigated for ecological risk (US EPA 1999, pages 168-169). Also buffers between estuarine/marine water bodies and agricultural crops treated with chlorothalonil of 150' for aerial and 25' for ground applications were added to labels. Ecological risk assessments were not revised by OPP-EFED to reflect exposures and risk from revised use rates and buffers for estuarine/marine ecosystems and therefore over-estimate exposure associated with current use of chlorothalonil.

Actual Environmental Concentrations of Chlorothalonil

Chlorothalonil has been monitored in surface water monitoring programmes, however it is rarely detected. Monitoring data accounts for both spray drift and surface runoff routes of entry of chlorothalonil to water bodies should they occur. Monitoring data has limitations for determining acute exposures, in that frequency of peaks and duration of exposure is not fully characterized. However, this is in part compensated where monitoring data is extensive and the probability of capturing peaks is increased.

The South Florida Water Management District collected samples every 2 to 3 months from 27 surface water sites from November 1988 to November 1993. Chlorothalonil was detected in only 3.3 % of samples (27 from 810) at concentrations ranging from 0.003 to 0.035 μg/L.

The most relevant exposure concentrations are provided by the USGS National Water-Quality Assessment Program (NAWQA) for water bodies in California and the Pacific Northwest (Central Columbia Plateau, San Joaquin - Tulare Basin, Upper Snake River Basin, Puget Sound Basin, Willamette Basin, Yakima River Basin, Sacramento River Basin) that are known to support endangered steelhead and salmon. The USGS NAWQA program is comprehensive with a large number of sampling points to accurately portray exposure levels.

Chlorothalonil was monitored by USGS in over 50 water systems across the US (1993-2001) - out of 6,439 surface water samples there were only 44 detects of chlorothalonil. Therefore, over 99% of the water samples had no detectable chlorothalonil residues and of the 44 detects, 40 were < 1 μg/L. All samples > 1 μg/L were from December 2001, 3.3 μg/L in GA, 4.2 μg/L in TX, 11.1 μg/L in OH and 62.2 μg/L in VA and all were from urban land use areas. It is difficult understand these high detects, as December is unlikely to be a month when chlorothalonil would be used. December 2001 resulted in a disproportionately high number of detects. Of the highest 18 detects, 14 were in this month.

December 2001 gave 14 detects out of 43 samples, whereas samples from December other years gave no detects out of 233 samples.

There were only four detects of chlorothalonil from 940 samples from this geographic area of relevance to listed steelhead and salmon in California and the Pacific Northwest. Three of these were from December 2001 from the Willamete Basin in Oregon and ranged from 0.32 – 0.64 μg/L. The other was 0.29 μg/L from the San Joaquin-Tulare Basins in February 1994.

It can be concluded that chlorothalonil is rarely detected in watersheds even though these overlap with areas of chlorothalonil use. When considering endangered steelhead and salmon, which inhabit these watersheds in California and the Pacific Northwest, it can be concluded that exposure concentrations would not exceed 0.64 μg /L.

Chlorothalonil is therefore rarely detected in watersheds even though these overlap with areas of chlorothalonil use. The RED does state that "sampling sites do not necessarily represent reasonable worst-case scenarios immediately downstream of heavily treated areas, especially for flowing waters". However, the conclusion of US EPA on reviewing these monitoring data for the Chlorothalonil RED (US EPA 1999) was that "they can probably be used for estimating actual typical risks in the flowing water portions of chlorothalonil treated watersheds". Therefore when considering endangered Pacific salmonids, which inhabit these watersheds, it can be considered that under typical conditions, exposure concentrations would not exceed 0.64 μg /L.

Effects

A large number of laboratory ecotoxicity studies have been conducted with chlorothalonil and aquatic organisms. These include Syngenta sponsored studies and other unpublished and published sources (Table 4).

Table 4 . Chlorothalonil toxicity to aquatic organisms

Fish			
Organism	Endpoint	Value (μg/L)	Source
Rainbow trout	96 h LC_{50}	17	Douglas et al 1992
	96 h LC_{50}	49	Shults et al 1980
	96 h LC_{50}	76	Ernst et al 1991
	96 h LC_{50}	32-57	Ernst et al 1993
	96 h LC_{50}	10.5 – 17.1	Davies & White 1985
	28 d LC_{50}	54	Ernst et al 1993
	96 h LC_{50}	18	Davies & White 1985
Bluegill sunfish	96 h LC_{50}	60	Shults et al 1980a
	96 h LC_{50}	84	Szalkowski et al 1979
	8 d LC_{50}	16	Sleight 1972
Carp	96 h LC_{50}	60	Douglas et al 1982a
	48 h LC_{50}	110	Hashimoto & Nishiuchi 1981

	48 h LC_{50}	67	Nishiuchi 1977
Channel catfish	96 h LC_{50}	43	Shults et al 1980b`
	96 h LC_{50}	52	Gallagher et al 1992
Fathead minnow	96 h LC_{50}	23	Shults et al 1980c
Common jollytail	96 h LC_{50}	16.3	Davies & White 1985
Spotted galaxius	96 h LC_{50}	18.9	Davies & White 1985
Golden galaxius	96 h LC_{50}	29.2	Davies & White 1985
Roach	48 h LC_{50}	100	Perevoznikov 1977
Guppy	48 h LC_{50}	200	Nishiuchi 1977
Japanese killifish	48 h LC_{50}	90	Nishiuchi 1977
	48 h LC_{50}	88	Hashimoto & Nishiuchi 1981
Loach	48 h LC_{50}	150	Hashimoto & Nishiuchi 1981
Mosquito fish	48 h LC_{50}	90	Nishiuchi 1977
Stickleback	96 h LC_{50}	27	Ernst et al 1993
Sheepshead minnow	96 h LC_{50}	32	Shults et al 1982d

Aquatic Invertebrates

Organism	Endpoint	Value (μg/L)	Source
Brachionus calyciflorus (rotifer)	EC_{50}	24	Hamer & Gentle (1999)
Leptocerus (caddis)	EC_{50}	38	
Crangonyx pseudogracilis (amphipod)		64	
Chydorus (cladoceran)		74	
Lymnaea stagnalis (snail)		100	
Chironomus riparius (midge)		110	
Planorbis (snail)		120	
Erpobdella (leech)		160	
Daphnia magna (cladoceran)		170	
Planaria (flatworm)		200	
Gammarus pulex (amphipod)		240	
Hyalella azteca (amphipod)		250	
Macrocyclops fuscus (copepod)		260	
Ostracoda	LC_{50}	390	
Asellus aquaticus (isopod)	EC_{50}	450	
Cloeon dipterum (mayfly)	LC_{50}	600	
Chaoborus crystallinus (m midge)	LC_{50}	>1600	
Dytiscus (beetle)	EC_{50}	>1600	
Ischnura elegans (damselfly)	LC_{50}	>1600	
Corixa (water boatman)	LC_{50}	>1600	
Daphnia magna	48 h EC_{50}	70	Killeen et al 1977
Crassostrea virginica (oyster)	96h EC_{50}	4.9	Shults et al 1983
Paenaeus duorarum (shrimp)	96 h LC_{50}	162	Shults et al 1982e
Mytilus edulis (blue mussel)	96 h LC_{50}	5940	Ernst et al 1991
Mya arena (soft-shell clams)	96 h LC_{50}	34780	Ernst et al 1991

Aquatic Plants

Organism	Endpoint	Value (μg/L)	Source
Selenastrum capricornutum	120 h EC_{50}	210	Hughes & Williams 1992
Selenastrum capricornutum	7 d IC_{50}	8500	Ernst et al 1993
Scenedesmus subspicata	96 h EC_{50}	450	Douglas et al 1992b
Anabaena flos-aquae	120 h EC_{50}	65	Smyth et al 1998
Navicula pelliculosa	72 h EC_{50}	5.1	Smyth et al 1998a
Skeletonema costatum	120 EC_{50}	11	Smyth et al 1998b
Lemna gibba	14 d EC_{50}	510	Smyth et al 1998c

Chlorothalonil is considered slightly to highly toxic to fish, most aquatic invertebrates and algae according to EPA classification criteria.

Toxicity in Water Sediment Systems

The acute toxicity of chlorothalonil to fish and aquatic invertebrates and the effects on algal growth have been determined under more realistic conditions. These studies were similar to standard static laboratory studies, but in the presence of sediment, to help approximate environmental conditions and provide a more realistic exposure scenario.

Table 5 : Toxicity of Chlorothalonil in Sediment-water Systems

Test Organism	Test type	LC/EC_{50} (μg/l)	NOEC (μg/l)	LOEC (μg/l)	Reference
Rainbow trout	96 h LC_{50}	72	32	80	Forster 1998
Daphnia magna	48 h EC_{50}	254	31	61	Forster 1998a
Navicula pelliculosa	96 h EC_{50}	In the range 48 – 96	48	96	Smyth & Shillabeer 2000

Toxicity of Degradates

Chlorothalonil is readily degraded in soil. The major metabolite is R182281 (SDS-3701), typically reaching 10 – 40% of applied. Aquatic toxicity tests have shown this metabolite to be considerably less toxic to fish, *Daphnia* and algae. It is therefore considerably less toxic than chlorothalonil and is not considered contributory to risk.

Table 6 : Toxicity of R182281 to Aquatic Organisms

Species	**Test type**	**Result (μg/l)**	**Reference**
Rainbow trout	96 h EC_{50}	9200	Ernst et al 1993
Bluegill sunfish	96 h LC_{50}	27800	Hutchinson 1972
		45000	Szalkowski *et al* 1979a
Daphnia magna	48 h LC_{50}	26000	Killeen *et al* 1977b
Selenastrum capricornutum	7 day EC_{50}	33700	Ernst et al 1993

No other metabolites exceed 10% in other aerobic or anaerobic studies. Other metabolites of chlorothalonil tested for toxicity to aquatic organisms are R613636 (SDS-19221) and representatives of the sulphonic and carboxylic acid class of metabolites, R417888 and R611965 (SDS-46851), respectively. All the metabolites are much less toxic than chlorothalonil and will not contribute significantly to risk.

Table 7 : Toxicity of R613636 to Aquatic Organisms

Species	Test type	Result (μg/l)	Reference
Rainbow trout	96 h EC_{50}	18000	Magor & Shillabeer 1999
Daphnia magna	48 h LC_{50}	13000	Magor & Shillabeer 1999a
Selenastrum capricornutum	72 h EC_{50}	5300	Smyth et al 1999

Table 8 : Toxicity of R417888 to Aquatic Organisms

Species	Test type	Result (μg/l)	Reference
Rainbow trout	96 h EC_{50}	>100000	Magor & Shillabeer 1999b
Daphnia magna	48 h LC_{50}	>100000	Magor & Shillabeer 1999c
Selenastrum capricornutum	72 h EC_{50}	>100000	Smyth et al 1999a

Table 9 : Toxicity of R611965 to Aquatic Organisms

Species	Test type	Result (μg/l)	Reference
Rainbow trout	96 h EC_{50}	>120000	Magor & Shillabeer 2000
Daphnia magna	48 h LC_{50}	>120000	Magor & Shillabeer 2000a
Selenastrum capricornutum	72 h EC_{50}	45000	Magor & Shillabeer 2000b

Toxicity of End Use Product - Formulated Chlorothalonil

In addition to toxicity data on the technical material, acute toxicity data for fish, *Daphnia* and algae are available on formulated chlorothalonil, tested as a 500 g/l SC (Daconil 2787 Extra) and/or a 720 g/l SC (Bravo 720). These studies, expressed as ai, show negligible difference from the technical material, as would be expected for a compound with this toxicity profile (see Table 10). The toxicity is clearly driven by chlorothalonil. For the risk assessment, it is sufficient to consider the data on the active ingredient as representative.

Table 10 : Acute Toxicity of Chlorothalonil to Fish, *Daphnia* and Algae

Test Organism	Duration/ Endpoint	Test Chemical	Toxicity (µg ai/l)	Reference
Rainbow trout	96 hr LC_{50}	technical	17	Douglas, 1992
		500 g/l SC	79	Wuthrich, 1990
Daphnia magna	48 hr EC_{50}	technical	70	LeBlanc, 1977

		720 g/l SC	91	Gelin and Laveglia, 1992
Green algae	72 hr EC_{50}	technical	210 (*Selenastrum*)	Hughes and Williams, 1992
		500 g/l SC	210 (*Scenedesmus*)	Wuthrich, 1990

Field Studies

An outdoor aquatic mesocosm study looked at the effect of chlorothalonil on aquatic invertebrates, algae and aquatic plants (Ashwell et al, 2002). The test material was a 720 g/L SC formulation, applied at 3, 10, 30 100 and 300 μg ai/L to replicated systems at weekly intervals. The NOEC was at 10 μg/L, short-term effects on the phytoplankton community were apparent at 30 μg/L and above, however all concentrations showed recovery. At 100 and 300 μg/L there were effects on the zooplankton populations and although recovery was apparent, significant differences in the communities remained at the end of the study. Thus it can be concluded that concentrations up to 30 μg/l will have no significant impact on aquatic invertebrate and algal/plant communities.

Fish were studied in a field study using a small freshwater pond (2000 m^2 x 0.5 m mean depth) on Prince Edward Island, Canada (Ernst *et al*, 1991). Three direct applications of formulated chlorothalonil at a rate of 875 g ai/ha were made at weekly intervals to the surface of the pond. Each application was equivalent to a nominal concentration of 175 μg/ assuming 100% deposition, evenly distributed throughout the water column. Measured deposit on collectors after each spray event indicated mean deposition of 67 – 88 % of the application rate and measured concentrations sampled just below the water surface immediately after each treatment ranged from 150 - 2900 μg/l. One year-old rainbow trout were present in the pond prior to and during the three applications. Despite the nominal concentration being 10x the laboratory LC_{50}s there were no mortalities.

Incidents

In the Chlorothalonil RED, fish kill incidents associated with chlorothalonil were reviewed.

In 1976, a fill kill was reported in Texas after improper rinsing of equipment in a small lake.

In 1994, brook trout were found dead in a pond in New Brunswick, in an area where potatoes were grown. Maneb, esfenvalerate and chlorothalonil were found in fish tissues, but not in the water. The cause was considered "undeterminable" but "not likely solely due to pesticide runoff"

In 1984, fish were killed in Viburnum, MO, following application of several chemicals, including chlorothalonil, to a golf course. The specific cause was undetermined, but thought to be due to the chemicals applied to the golf greens.

In 1996 a fish kill was reported from the potato-growing area of Prince Edward Island, Canada. Salmon (parr stage) and trout were reported dead in and upstream of a pond, following heavy rainfall, which caused erosion and runoff. Water and sediment analysis detected chlorothalonil, which was being used in the area to control potato blight.

Given the widespread use of chlorothalonil over the last 20 – 30 years (an average of 8 – 9 million acres receiving ~9.5 million pounds in the US), there are an extremely low number of reported fish kills associated with its use and even these have not established chlorothalonil as the cause, with the probable exception of when improper rinsing of equipment occurred.

Discussion and General Risk Conclusions for Chlorothalonil

Fish

The lowest LC50 values for fish are for rainbow trout (*Onchorhyncus mykiss)* with 96-hour LC50 values ranging from 10.5 – 76 μg/l. In a water sediment system, which includes some dissipation similar to that which might occur in the natural environment, the 96 hour LC50 was 72 μg/l. In a field study, in which a pond was oversprayed at a rate which represented a nominal concentration of 175 μg/l, there were no effects on rainbow trout.

Taking the criteria set by Urban & Cook (1986), the LOC for endangered species is exceeded when the environmental concentration exceeds 0.05x the lowest fish LC50. Based on the laboratory toxicity data (lowest *Onchorhyncus mykiss* 96-hour LC50 value of 10.5 μg/L), this would be if the concentration exceeded 0.52 μg/l. Using the studies conducted under more natural conditions, in the sediment-water system and the field study, where the LC50s to rainbow trout were 72 and >175 μg/l, respectively, the LOC for endangered species would be exceeded if concentrations were > 3.6 and > 8.75 μg/l respectively. However, as the most sensitive species was rainbow trout (*Onchorhyncus mykiss*), a salmonid, this removes some uncertainty in the assessment with respect to interspecies sensitivity. In fact when endangered steelhead (*Oncorhynchus mykiss*) are considered, all uncertainty with respect to interspecies sensitivity is removed, as this is the most sensitive species tested. Uncertainties with respect to intra-species variation remain. However, this should allow some increase in the 0.05x factor applied.

Even using the most conservative LOC of 0.52 μg/l, the monitoring data from representative watersheds containing endangered steelhead and salmonids, with a maximum of 0.64 μg/l, only marginally exceeds this LOC. The LOCs based on the more environmentally relevant studies of 3.6 and 8.75 μg/L are not exceeded. This indicates that chlorothalonil will have "no effect" on endangered salmonids under actual use situations. Arguably, there is some uncertainty in use of monitoring data to represent any worst-case scenarios immediately downstream of heavily treated areas where endangered salmonids and steelheads might be exposed. However, this is offset by the extensiveness of the monitoring data, studies that demonstrate that an extremely short aquatic half-life and the studies that demonstrate effects on salmonids are significantly less in studies that more closely mimic a natural aquatic environment.

Invertebrates and aquatic plants

Another component of the endangered salmonid risk assessment is consideration of habitat. Two primary components of the habitat analysis are prey and cover. Only aquatic invertebrates as a prey source are considered in this assessment, as the fish will be protected as they are the focus of the endangered species assessment.

Firstly considering cover, chlorothalonil is of relatively low toxicity to aquatic macrophytes, based on a *Lemna* 14 day EC50 of 510 μg/l. Even using the worst-case modeled concentrations from Table 3, RQs are <0.1, demonstrating the low risk. Concerning prey and the aquatic community in general, aquatic invertebrates and algae show a range of sensitivities to chlorothalonil. However the outdoor microcosm study shows quite clearly that concentrations up to 30 μg/l will have no effect on invertebrate, algal and macrophyte communities (Gentle WE and Tattersfield LJ, 2000). This was a static study and so is a worse-case situation compared to the flowing waters which are the habitat for endangered salmonids and steelhead. Even based on worst-case modelled exposures, which will undoubtedly overestimate exposure in flowing waters, it is possible to conclude that chlorothalonil will not affect the prey or habitat of endangered salmonids and steelhead in the western United States.

Conclusions

Under typical conditions chlorothalonil will have no effect on endangered salmonids and their habitat. The high toxicity of chlorothalonil is based on hazard studies done in the laboratory under conditions of maintained exposure. Under more natural conditions, toxicity is significantly reduced due to the rapid dissipation of chlorothalonil reducing potential exposure of non-target organisms. The only predictive tools available to estimate exposure are based on farm-pond scenarios, which clearly do not represent the environments in which endangered salmonids can be found. Watershed monitoring, which represent typical exposures, indicate that in these watersheds there will be no effect of chlorothalonil on endangered salmonids, however this may underestimate actual risk in first-order streams. Nevertheless, higher tier studies on the acute toxicity of chlorothalonil to an endangered salmonid species (*Oncorhynchus mykiss*), which included direct overspray of a pond containing the fish, indicate that chlorothalonil will have no effect on endangered salmonids under actual use field conditions. Furthermore, the data available support the conclusion of no effect on critical habitat of endangered salmon. The rapid dissipation of chlorothalonil in the environment limits any potential for short-term acute or long-term chronic effects and the lack of any confirmed incident reports supports the no effect conclusion.

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